Freistaat Bayern

Regione Emilia-Romagna

Catalunya

7th EUREGEO

Bologna | Italy | june 12th - 15th 2012

EUropean Congress on REgional GEOscientific Cartography and Information Systems

Sustainable Geo-Management

Proceedings Volume I

The Congress Proceedings are published in two volumes.

Volume I : Opening Papers
Abstracts of Sessions 1 – 2 – 3 – 4 - 5 – 6

Volume II: Abstracts Sessions 7 – 8 – 9 – 10 – 11
Programme of Special Sessions
Programme of Hosted Meeting

The proceedings were prepared by
Simonetta Scappini and Silvio Zapparoli

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- ✓ Eni spa.

Organizing Committee

Freistaat Bayern

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European Commission

Patronage

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

CONSIGLIO NAZIONALE DEI GEOLOGI
VIA VITTORIA COLONNA, 40 00193 ROMA
Tel 06 68807736 - 68807737 - Fax 06 68807742
email: info@cngeologi.it

GEOITALIA,
Federazione Italiana di Scienze della Terra, Onlus

Società Geologica Italiana

G&T

Sponsor

ELIOFOTOTECNICABARBIERI Srl,
via Reggio 45/a, 43100 Parma
www.eft.it info@eft.it +390521944911

Fondata all'inizio degli anni settanta, la ditta opera in due settori "contigui"; quello della "**elaborazione e stampa di cartografia tecnica e tematica"** e della "**riproduzione disegni, documenti, cartografia e servizi connessi"**.

I servizi sono erogati alla Pubblica Amministrazione, alle Università, alle Aziende, ai Professionisti; da oltre 25 anni è operativo ed in costante aggiornamento e sviluppo il comparto che **progetta, elabora e riproduce** cartografia con **tecnologie digitali** negli ambienti GIS, CAD e Grafico.

Recentemente sono stati aperti nuovi reparti che erogano servizi accessori dedicati alla grafica pubblicitaria e alla comunicazione.

La **struttura operativa** è distribuita su una superficie di oltre 1.000 mq ed è composta da due soci amministratori e 21 addetti alla produzione.

Fra gli oltre 900 clienti, dei quali circa 600 sono abituali, i nostri committenti operano nei settori, urbanistico pianificazione e governo del territorio, ambiente, topografico, geologico, progettazione e costruzione di infrastrutture viarie e civili.

MAP SERVICE Srl
Sede legale: Via Bologna 12/1, 43122 Parma
Sede operativa di Parma: Via Reggio 45/a
Sede operativa di Bologna: via dello Scalo 3/2
presso l'Archivio cartografico della Regione Emilia-Romagna,
archiviocart@regione.emilia-romagna.it
+390516493230

Il desiderio e l'opportunità di valorizzare l'esperienza di un gruppo di cartografi acquisita in numerosi anni di attività nel settore che produce, elabora e divulga la cartografia nei suoi vari aspetti e contenuti, e' il motivo che ha portato alla "nascita" di MAP SERVICE nel 1996.

Il periodo in cui si e' costituita, e' coinciso con l'inizio della fase evolutiva dell'Archivio Cartografico della Regione Emilia-Romagna che, attraverso l'esternalizzazione della sua gestione operativa, ha iniziato un percorso finalizzato ad incrementare la disponibilità di prodotti e servizi da erogare agli utenti, interni ed esterni ad essa, imponendo come obiettivo al gestore incaricato il perseguimento del costante miglioramento del livello qualitativo degli stessi.

Attualmente MAP SERVICE è aggiudicataria di un incarico triennale per la gestione dei servizi di consultazione e cessione dei prodotti che l'Archivio cartografico regionale riceve dai vari Servizi regionali. Nella sua sede di Bologna operano 5 addetti alla gestione ed al rapporto con gli utenti. nella sede di Parma operano 3 addetti alla riproduzione e all'amministrazione.

I principali ambiti di attività di Arpa, attribuiti dalla L.R. 44/1995 e ss.mm. sono: monitoraggio dell´ambiente; vigilanza e controllo del territorio e delle attività dell´uomo; attività di supporto e consulenza agli enti pubblici nella valutazione degli effetti sull´ambiente di piani e progetti e per la previsione di rischi per il territorio e per la gestione delle emergenze ambientali; effettuazione di attività analitica di laboratorio; informazione ambientale; realizzazione e gestione del Sistema informativo regionale sull´ambiente.

Consistent e è l'attività relativa a progetti di supporto della Regione e degli Enti Locali: piani di risanamento, indirizzo e gestione su tematiche ambientali; analisi territoriali e valutazioni complesse; studio di sistemi ambientali; ricerche per la prevenzione ambientale nei cicli produttivi; studi e ricerche in tema di ambiente e salute; attività osservative e previsionali operative e di ricerca e sviluppo, in meteorologia, climatologia, idrologia.

Sponsor and exhibitor

S.E L.C A. - Firenze
società elaborazioni cartografiche

S.EL.CA. dal 1978 ai vertici della produzione cartografica nazionale, cura la rappresentazione del "mondo" in cui viviamo: la geografia, le scienze della terra, la botanica, la pedologia, le scienze forestali, la fotogrammetria, il telerilevamento e tutto il settore della pianificazione territoriale e urbanistica.

S.EL.CA. nel corso degli anni ha sempre seguito ed assecondato l'evoluzione tecnologica e culturale del mondo della cartografia. Oggi tutta l'organizzazione tecnico-produttiva aziendale è regolata dall'uso degli strumenti informatici più avanzati. Grande attenzione ed impegno viene dedicato ai Sistemi Informativi Geografici (GIS): la S.EL.CA. si adopera, con unanime riconoscimento, nel coniugare il rigore dei numeri (Banche Dati) con l'altrettanto rigorosa produzione cartografica.

S.EL.CA. nel mondo della cartografia oltre ad una organizzazione che è in grado di fornire tutti i servizi ad essa connessi, onora l'arte della stampa litografica, producendo Carte che comunicano scienza, evocano paesaggio e trasmettono cultura.

semenda
INFORMATICA PER IL TERRITORIO

SEMENDA opera in modo esclusivo nella progettazione e realizzazione di Sistemi Informativi Territoriali.

La società si rivolge in particolare alla Pubblica Amministrazione: Regioni, Province, Comuni, Aziende Municipalizzate, Consorzi di Bonifica, Università proponendosi soprattutto come partner qualificato in grado di affiancare l'utenza in tutte le fasi del progetto dall'analisi dei requisiti fino all'inserimento del sistema nei processi amministrativi ed organizzativi dell'Ente.

SEMENDA è impegnata fin dalla sua costituzione a perseguire un'intensa specializzazione tecnologica ed applicativa e ad impiegare tutte le sue risorse nella ricerca di soluzioni innovative per meglio rispondere alle esigenze degli utenti.

La società progetta e sviluppa il proprio software applicativo avvalendosi delle più avanzate tecnologie hardware e software disponibili sul mercato.

SEMENDA e' Partner Silver Premium di esri Italia Business Network.

SYSTEMCART
Servizi di Cartografia Computerizzata
Computerized Cartographic Services

SystemCart S.r.l. is a Company created in 1991 by the fusion of experts in traditional cartography and printing, who have perceived how wide was the potential of the new available geospatial technologies, for the future development of maps production.

The Company aims at offering a wide range of services mainly referring to land description and management, carried out by means of methodologies developed in GIS environment (e.g. ESRI, Intergraph).

The professional skills and experience acquired by the Company in the traditional preparation of any kind of scientific mapping (geology, seismology, volcanology, hydrogeology, land use, pedology etc.), together with the extensive knowledge of the new available platforms, allows the SystemCart S.r.l. to be an ideal interface between the stakeholders and a series of innovative products, resulting from the application of highly-qualified information systems.

Exhibitor

TRE
Sensing the Planet

TRE measures ground deformation to millimeter accuracy by analyzing SAR (Synthetic Aperture radar) satellite images with our latest algorithm: SqueeSAR™ - a unique tool for detecting, measuring and monitoring geophysical phenomena such as: subsidence, uplift, landslides, seismic faults, etc., and verifying the stability of individual structures. Maps of surface deformation provide a quantitative understanding of ground response to both natural and anthropogenic activities.

TRE, the first spin-off company from the Politecnico di Milano, was founded in 2000 with the patenting of its first proprietary algorithm: PSInSAR™. Continuous investment in research and development lead to the unveiling of the new algorithm SqueeSAR™ in 2010, providing a significantly more powerful deformation mapping tool - firmly identifying TRE as leader in ground monitoring with SAR satellite data.

TRE's has two offices: TRE (Milan) and TRE Canada (Vancouver).

esri Italia

Esri Italia S.p.A.
Via Tiburtina, 755 - 00159 Roma (Italy)
Tel. +39 06 40696.1 Fax +39 06 40696.333
www.esriitalia.it
info@esriitalia.it

Esri Italia è l'azienda di riferimento in Italia nelle soluzioni GIS per la Pubblica Amministrazione e per le Imprese.

La Mission aziendale,"essere centro di eccellenza nelle soluzioni e servizi di intelligenza del territorio, facendo leva sulle tecnologie GIS di Esri", riflette la volontà di proporsi come partner di riferimento per i propri clienti, per tutte le attività legate all'uso dell'informazione geospaziale a supporto dei processi operativi e decisionali. Esri Italia è parte integrante della Esri One Company, un sistema di oltre 80 aziende a livello internazionale che opera in network in circa 200 paesi e fa riferimento a Esri Inc., leader mondiale nelle tecnologie software GIS. Esri Italia è Esri Official Distributor per il mercato italiano, dove opera in network con importanti Partner per rispondere in modo sempre più efficace alle esigenze del mercato. Grazie all'Offerta integrata di Software GIS, Dati Geospaziali, Corsi di Formazione e Professional Servicesqualificati, Esri Italia ha sviluppato, in oltre 20 anni di attività, una forte presenza nel mercato italiano delle soluzioni GIS. I Clienti di riferimento sono prevalentemente nei settori Pubblica Amministrazione Centrale e Locale, Difesa e Intelligence, Telecom & Utilities, Aziende industriali e di servizi, Università e Enti di Ricerca.

FSRER

The Speleological Federation of the Emilia-Romagna Region (FSRER) co-ordinates the caving activities of the regional speleological Clubs: most of them are performed in areas of high natural value, like the Triassic Gypsum outcrop in the Upper Secchia Valley, and the Messinian Gypsum in the Reggio Emilia, Bologna and Romagna Apennines. FSRER co-operated with the University of Bologna in the development of speleological research since long time: presently it is involved in a LIFE project to study the karst water quality and preserve the bat habitats. The main task of FSRER is to implement the regional register of natural cavities, which is available on line thanks to the Geological Service of the Emilia-Romagna Region. The co-operation with the Regional Government includes also the study of karst geosites and their safeguard. Finally FSRER periodically organizes Symposia and Workshops on selected karst areas or speleological themes, the proceedings of which have been printed in its official journal (Speleologia Emiliana).

Exhibitor

Litografia Artistica Cartografica S.r.l.
Via del Romito, 11-13R, 50134 FIRENZE
Tel +39 055 483 557 – Fax 055 483 690
www.lac-cartografia.it info@lac-cartografia.it

La Litografia Artistica Cartografica, in breve LAC, viene fondata a Firenze nel 1949 come prima Azienda di produzione cartografica specializzata nelle lavorazioni conto terzi, in particolare per enti pubblici. Dall'inizio degli anni '60 è stato realizzato un Catalogo aziendale che oggi, dopo oltre mezzo secolo di continua attività, si presenta come uno dei più prestigiosi e completi nello scenario cartografico internazionale ed è interamente in vendita nel proprio store on-line. LAC è l'unica Azienda privata italiana e fra le poche in ambito europeo che produce cartografia a rilievo. Da molti anni LAC realizza carte tematiche complete, chiare, leggibili ed insieme di altissima qualità di stampa, per tutti i principali Enti pubblici italiani ed internazionali. Dal 2003 la LAC pubblica un magazine trimestrale referato, inviato a oltre 2.000 utenti e appassionati. Da alcuni anni l'utilizzo delle migliori tecnologie presenti sul mercato e le risorse dedicate alla ricerca e sviluppo hanno consentito di aprire ad alcuni progetti innovativi fra i quali portali cartografici e applicazioni. Dal Febbraio 2012 è disponibile on-line e scaricabile gratuitamente dall'Apple Store, la App "Mappe d'Italia". La applicazione gratuita Mappe d'Italia permette di utilizzare sul proprio iPhone e iPad carte geografiche ad alta qualità, consultabili in modalità off-line, "navigabili" e con la possibilità di inserire punti di interesse personali geo-localizzati.

Exelis Visual Information Solutions fornisce soluzioni avanzate per l'elaborazione di immagini e l'estrazione di informazioni da immagini geospaziali. ENVI ed il nuovo E3De, dedicato alla visualizzazione ed analisi di dati Lidar alla produzione di DSM, DEM , profili , offrono strumenti per analizzare ed elaborare immagini e dati geospaziali in modo semplice e rapido, integrato nel mondo ESRI, permettendo a utenti GIS di compiere operazioni sulle immagini facilmente e con estremo rigore.

LEICA GEOSYSTEMS S.p.A.
Via Codognino, 12 – 26854 Cornegliano Laudense (LO)
Tel. 0371 6973.1 Fax 0371 6973.33
E-mail surveying@leica-geosystems.it
Sito Internet: www.leica-geosystems.it

Leica Geosystems S.p.A. è la filiale italiana della multinazionale Leica Geosystems AG leader mondiale nel mondo della misura. Nel 2005 è entrata a far parte del Gruppo Hexagon AB, mantenendo il proprio marchio.

La Società ha quale attività principale, la distribuzione di strumenti di misura, strumenti topografici, strumenti GPS per il rilievo satellitare, strumenti per il monitoraggio di eventi sul territorio e/o di infrastrutture, sistemi laser scanner per il rilievo 3D, sistemi e software in ambito GIS Mobile con strumentazione GPS/GIS di accuratezza metrica, sub metrica e centimetrica offrendo integrazione su piattaforma GIS di strumentazione topografica. Leica Geosystems, offre inoltre una serie di servizi come: Servizi di correzione differenziale (ItalPoS), Servizi aggiuntivi per applicazioni GPS/GNSS (Polar) basati sulla infrastruttura di stazioni di riferimento, Formazione all'utente per qualsiasi applicazione di misura, Contratti personalizzati di manutenzione.

Exhibitor

Intergraph è leader mondiale nella fornitura di software per il settore ingegneristico e geospaziale per la gestione ed analisi di dati complessi. Opera attraverso due divisioni: Process, Power & Marine (PP&M) e Security, Government & Infrastructure (SG&I). La divisione SG&I fornisce soluzioni geospaziali, includendo le tecnologie ERDAS, ai settori della difesa e dell'intelligence, della sicurezza, della pubblica amministrazione, dei trasporti, della fotogrammetria, delle telecomunicazioni e dei servizi pubblici. Intergraph Government Solution (IGS) è una conosciata autonoma della divisione SG&I che opera per il Governo Federale degli Stati Uniti e le forniture classificate. Planetek Italia S.r.l., partner Intergraph-ERDAS in Italia, è una società leader nella consulenza multi-disciplinare per lo sviluppo di Sistemi di Informazione Geografica (GIS) e di Osservazione della Terra (E.O.), orientati alla gestione del territorio. La sua mission è creare valore sviluppando soluzioni di archiviazione, gestione, analisi e condivisione di dati geospaziali, coniugando la sostenibilità tecnologica ed economica e l'attenzione all'evoluzione dei desiderata degli utenti.

CODEVINTEC – Tecnologie per le Scienze della Terra
Via Labus, 13 20147 MILANO
Tel +39 02 4830 2175 – Fax 02 4830 2169
www.codevintec.it info@codevintec.it

Dal 1973 la passione e la preparazione di Codevintec hanno portato sui mercati italiani sitemi innovativi ed efficaci, spesso diventati standard per gli studiosi dei diversi settori.: Vulcanologia e Monitoraggio sismico, Geologia, Protezione Civile, Archeologia, Rilievo Urbanistico, Geofisica terrestre, Controlli non distruttivi, Monitoraggio del Territorio, Geofisica marina, Oceanografia, Rilievi costieri integrati sopra e sott'acqua, Laser Scanner e LIDAR, 3D Imaging.

Per i Sistemi ad alta tecnologia per le Scienze della Terra e del Mare: Studio del sottosuolo - georadar, sismografi, geoelettrica, logger da foro, inclinometri; Vulcanologia e Monitoraggio sismico – sismometri, magnetometri, gravimetri, inclinometri, reti con trasmissione VSAT; Rappresentazione dei fondali e delle coste - Multibeam Beamformer e Interferometrici, SideScanSonar e SubBottom Profiler; Navigazione e posizionamento di precisione ad alta dinamica – DGPS, IMU (Inertial Measurement Unit), sistemi subacquei; Rilievi laser statici, dinamici, da barca, auto, aereo e per applicazioni speciali; Laser Scanner 3D a lunga portata, LIDAR, software, sistemi complessi; Sistemi per la rappresentazione della realtà in 3D – terrestre, sott'acqua, sottocosta, anche in dinamico. Per i servizi specializzati: Qualificato laboratorio di assistenza tecnica, stimato e riconosciuto dai Fornitori; Centro assistenza Europeo per i laser scanner terrestri Optech; Sistemi disponibili a noleggio.

EuroGeoSurveys

EuroGeosurvesy is the organisation of the Geological Surveys of Europe, the national institutions responsible for geological inventory, monitoring, knowledge and research. Our principal purpose is to provide public Earth science knowledge to support the EU's competitiveness, social well-being, environmental management and international commitments. In our day-to-day activities, we promote the contribution of geosciences to European Union affairs and action programmes underpinning European policies and regulations for the security, health and prosperity of society, and providing technical advice for the European Union Institutions.

Exhibitor

European Commission - DG JRC
Via E. Fermi, 2749
I-21027 Ispra (VA)
ITALY
http://ec.europa.eu/dgs/jrc/

Joint Reserach Centre
The European Commission in-house science service

The mission of the Joint Research Centre (JRC) is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

The JRC's vision is to be a trusted provider of science-based policy options to EU policy makers to address key challenges facing our society, underpinned by internationally-recognised research. The seven JRC institutes are located on five separate sites in Belgium, Germany, Italy, the Netherlands and Spain. The Ispra Site, the third biggest Commission site after Brussels and Luxembourg, covers an area of 167 hectares with ca 138 heated buildings hosting ca 1 850 staff, and hosts five of the seven JRC Institutes.

Freistaat Bayern

RegioneEmilia-Romagna

Catalunya

Bayerisches Landesamt für Umwelt

For more than 150 years the Bavarian Geological Survey has been the authoritative source of geodata-based knowledge. Up to 140 experts in the various geoscientific fields work to improve everyday life. They explore geothermal potential, mitigate geo-hazards, protect soil and groundwater and search for raw materials. The Survey strives to produce reliable Geo-information, which is useful, easily understood, web-based and self-explanatory.

Servizio Geologico Sismico e dei Suoli Regione Emilia-Romagna

The Survey was created in 1976 as a technical entity to support the regional government policies dealing with the environment and land planning. The mission of the Survey is to provide the Administration and society with basic, up-to-date geological, pedological and geothematic information. The remit of the Survey at present encompasses activities related to the monitoring of natural risks which affect the territory of Emilia-Romagna, the reduction of seismic risk and the study of natural resources. This work is made largely available to the public through the Survey's website.

Institut Geologìc de Catalunya

The Institute was created in 2005 through a law passed by the Catalan Parliament and is intended to provide the Administration and society with basic, up-to-date geological, pedological and geothematic information. The Institute takes over from the pre-existing Geological Survey created in 1979, which in turn inherited more than 100 years of works carried out by previous geological institutions. From this legacy, the Institute has accumulated a large amount of data and information, which is added to that currently obtained, managed and supplied through the work of more than 60 experts.

Short programme

TUESDAY 12th JUNE

14.00 Opening Ceremony

15.00 Special session — Natural resources and hazards in the Mediterranean
Chairperson: Luca Demicheli Secretary General of EuroGeoSurveys

18.30 Opening of the exhibit

19.00 Welcome party

WEDNESDAY 13th JUNE

9.00-13.00 Special session — Soil: sealing and consumption
Chairpersons: Thomas Strassburger European Commission Directorate General Environment, Luca Montanarella European Commission Directorate General Joint Research Centre.

14.00-18.00 Session 2 — Soil and land planning
Convenors: Emilio Ascaso, Nicola Filippi, Robert Traidl.
Chairperson: Luca Montanarella European Commission Directorate General Joint Research Centre.

9.00-18.00 Hosted meeting — EuroGeoSurveys National Delegates Forum

Hosted meeting — Geology and Information Technology-GIT
Annual Meeting of Geological Society of Italy - open to the EUREGEo participants

Session 3 — Subsurface geology
Convenors: Carmen Puig, Luca Martelli, Gerold Diepolder.
Chairperson: Francois Robida Bureau de Recherches Géologiques et Minières

THURSDAY 14th JUNE

9.00-13.00 Special session — Geological cartography in Italy and in Europe: perspectives and opportunities
Chairperson: Silvio Seno Federazione Italiana Scienze della Terra

Session 4 — Popularisation of geoscience and geoheritage
Convenors: Mariona Losantos, Maria Carla Centineo, Johann Rohrmüeller.
Chairperson: Wim de Gans TNo Geological Survey of the Nederlands

14.00-18.00 Session 7 — Urban geology
Convenor: Giuseppe Nardi. Chairperson: Andreas Hoppe Technische Universität Darmstadt

Session 9 — Seismic risk
Convenor: Xaviér Goula. Chairperson: Gian Vito Graziano Consiglio Nazionale dei Geologi

9.00-18.00 Special session — INSPIRE/Spatial Data Infrastructures
Chairpersons: Robert Tomas European Commission Directorate General Joint Research Centre, Kristine Asch Federal Institute for Geosciences and Natural Resources, Francois Robida Bureau de Recherches Géologiques et Minières, Carlo Cipolloni Ist. Superiore per la Protezione e la Ricerca Ambientale

Session 1 — Slope instability
Convenors: Marta Gonzales, Giovanni Bertolini, Karl Mayer.
Chairperson: Nicola Casagli Università degli Studi di Firenze - Dip. Scienze della Terra

Session 10 — Regional geochemical mapping and its environmental application
Convenors: Marina Guermandi, Alessandro Amorosi.
Chairperson: Benedetto De Vivo Università degli Studi di Napoli Federico II - Dip. Scienze della Terra

Hosted meeting — Local forum of the European project Geo.Power - open to the EUREGEo participants

FRIDAY 15th JUNE

9.00-13.00 Session 5 — Coastal system management
Convenor: Luisa Perini. Chairperson: Yann Balouin Bureau de Recherches Géologiques et Minières

Session 6 — Water resources
Convenor: Bernhard Wagner. Chairperson: Thomas Walter Geological Survey of Saarland

Session 8 — Mining and natural aggregate resources
Convenor: Slavko V. Solar. Chairperson: Jouni Vuollo Geological Survey of Finland

Session 11 — Mapping data and Information systems
Convenor: Kristine Asch. Chairperson: Silvio Seno Federazione Italiana Scienze della Terra

13.30 Closing Ceremony

SATURDAY 16th JUNE

8.00-18.00 Field trips — Secchia Valley

Opening ceremony

Date: **Tuesday 12th June 2012** 14.00-15.00

Location: Meeting room A (Viale della Fiera, 8)

Chairman:

Mr. Giuseppe Bortone – Direttore Generale Ambiente. Difesa del suolo e della costa. Regione Emilia-Romagna

Institutional welcome:

Regione Emilia-Romagna: **Ms. Paola Gazzolo**, Assessore Sicurezza Territoriale. Difesa del suolo e della costa. Protezione Civile

Freeistat Bayern: **Mr. Franz Josef Pschierer,** Staatssekretär im Bayerischen Staatsministerium der Finanzen und CIO

Generalitat de Catalunya: **Mr. Damià Calvet**, Secretario de Territorio y Movilidad

EUREGEO Organizing Committee: **Mr. Raffaele Pignone**, Head of Servizio Geologico Sismico e dei Suoli Regione Emilia-Romagna

Welcome addresses:

EuroGeoSurveys: **Mr. Luca Demicheli**, General Secretary of EuroGeoSurveys

European Commission: **Mr. Luca Montanarella**, European Commission Directorate General Joint Research Centre

Dear participants of the 7th EUREGEO in Bologna 2012,

At the present time, Emilia-Romagna is dealing with a national emergency – the earthquake measuring 5.9 on the Richter scale which struck at 4.03 am on Sunday 20th May, hitting the provinces of Modena, Ferrara and Bologna. An earthquake that claimed the lives of seven people, who are foremost in our thoughts today. We are left counting the cost: 47 injured, around 5 thousand people unable to return to their homes plus extensive damage to houses, businesses, historic town centres and buildings of inestimable cultural and religious importance.

In the face of this emergency, our number one priority was to give immediate aid to the population, through the Regional mobile column of the Civil Protection operating in tandem with units provided by the Autonomous Province of Trento, by Friuli Venezia Giulia, Marche, Tuscany and Umbria Regions and by Anpas (National association for public assistance) and Ana (National organization of mountain police), all coordinated by the Department for Civil Protection. The major task now is to check the stability of dwellings to help residents return to their homes, and that of schools to allow students to complete the academic year with as little upheaval as possible. The Regional civil protection agency, assisted by the National department for civil protection, the Servizio Geologico Sismico e dei Suoli and the Servizi Tecnici di Bacino, is also compiling a census of damage. This activity is carried out in close coordination with town mayors and provincial authorities, the Fire Service and the Architectural Heritage Department.

Our regional civil defence system has once again risen to the challenge, proving its preparedness for such an emergency; now we must work together to repair and rebuild: this is the task that lies before us.

This tragic event casts a different light on our Congress. I feel that this meeting, which I have believed passionately in since day one, is an incredibly important occasion. It is important because of its precious contribution in terms of knowledge, its excellent example of inter-regional collaboration, and its ambitious plans to bring together the worlds of technical expertise and research. I believe that these three elements provide a good starting point for our “reconstruction”.

Today, more than ever, we need readily available detailed knowledge of the territory, both above and below the earth’s crust, which represents an essential requisite for territorial planning, for efficient and sustainable use of natural resources and for the prevention and mitigation of natural risks; in other words, for the safety and wellbeing of our population.

Today, more than ever, we need to **work together -** Government, Regions and Local Authorities – in order to begin seamless **reconstruction. But we also need fine examples, like the collaboration between Emilia-Romagna, Bavaria and Catalonia, which have been working together for 20 years, driven by the desire to share best practices and methods, improve technological capabilities and** develop an integrated and multidisciplinary approach to Earth Sciences. The main goal, therefore, is to keep improving the technology at our disposal and the technical-scientific capabilities of our collaborators so that we can benefit from tools for risk mitigation and for resilience policies.

I invite the geo-scientific community which will gather in Bologna to take on a key role, accepting responsibility for the contribution that Earth Sciences can make to society as a whole, and not just during emergencies such as that ongoing in Emilia-Romagna. Your contribution is vital and depends on your ability to provide data, information and the knowledge needed to influence decision-making in the political arena and within public administrations.

All that remains, therefore, is for me to wish you all the very best in your work!

Bologna, 23rd May 2012

Paola Gazzolo
Assessore Sicurezza Territoriale.
Difesa del suolo e della costa
Protezione civile. Regione Emilia-Romagna

Dear participants of the 7th EUREGEO in Bologna 2012,

since 1992, for exactly 20 years now, the three regions Emilia-Romagna, Catalunya and Bavaria cooperate closely in the field of geosciences and exchange their knowledge in working groups and in the EUREGEO congress series. Since then, the triennial congresses have evolved to a Europe-wide recognised forum.

This series of congresses is truly unique, bridging the gap between decision-makers, environmental associations and software engineers: “developer” and “user” meet on a common platform. Geoscientific knowledge from the regions is processed and presented user-friendly on issues such as environmental protection and renewable energies.

This congress series is dedicated to digital geodata. They are of great benefit for urban and land use planning, hazard mitigation or in case of disasters.

But geo-information systems also are to be considered as communication systems – in order to support users and decision-makers. Bavaria is currently setting a good example with its Energy Atlas.

The great benefit of digital geodata and maps has been addressed by the Geological Surveys of the three regions Emilia-Romagna, Bavaria and Catalunya quite early in their EUREGEO congress series. By now, more than 3000 representatives in the fields of science and administration from 80 countries took part.

The vision of the cooperation of the three regions is to give the regions extra weight. After all it will be the regions, that will have to manage the implementation of EU guidelines such as INSPIRE. An informal exchange increases the chances for best practice solutions and interaction with Brussels at an early stage.

Now, after the successful EUREGEO congress 2009 in Munich, I would like to wish all participants a successful and interesting congress in the anniversary year 2012 in Bologna!

Marcel Huber MdL

Bayerischer Staatsminister für Umwelt und Gesundheit

Dear participants to the 7th EUREGEO,

This Congress, which is mainly devoted to Sustainable Geo-Management, completes the second circle of a series that started 20 years ago in 1992 here in Bologna. Since then the cooperation among Bayern, Emilia-Romagna and Catalunya has strengthen not only in the organization of this congresses but also with the constitution of active technical working groups dealing with common interest fields which have close direct application to many aspects in the daily life of our communities.

The production of basic technical and scientific geoinformation by the regional geological surveys is of great usefulness in crucial topics related to the safety and welfare of our citizens especially those regarding land and urban planning and sustainability as water, soil and subsurface management, geohazard assessment and prevention, new energies, infrastructures planning and development, coastal systems management or geological heritage awareness, among other issues of great economical impact.

The government of Catalunya put a special effort for gathering and providing geological, pedological and geothematic data, information and knowledge as fundamental pieces needed for governance. Interaction between Earth sciences information providers and users as promoted in this congress is fundamental to fulfill society needs.

I am sure that this 7th edition will yield to significant conclusions for being applied to future sustainable developments.

I wish all participants a fruitful Congress.

Lluís Recoder i Miralles
Conseller de Territori I Sostenibilitat
Generalitat de Catalunya

OPENING SPEECH OF THE ORGANIZING COMMITTEE

The 21st century pushed Geological Surveys all over Europe to centre stage. Never before had Earth Sciences played such a fundamental role in everyday life. The challenges of climate change, the increasing scarcity of fossil fuels, intensive use of the soil and subsurface for production and storage activities, natural risks of geological origin and the loss of arable land and drinking water affect more people than ever in the history of mankind. In October 2011, the world population exceeded 7 billion people; by 2025 it is estimated to reach 8 billion.

Europe has enjoyed many decades of growth in wealth and wellbeing, based on intensive use of resources. But today it faces the dual challenge of stimulating the growth needed to provide jobs and well-being to its citizens, and of ensuring that the quality of this growth leads to a sustainable future.

This scenario makes clear the strategic role that Earth Sciences knowledge must play for the safety and wellbeing of societies in the 21st century and to ensure a fair society for future generations. The geo-scientific community cannot shy away from this period of reflection and experimentation with possible alternatives and, to do so, it must accept the ethical implications of its activities. In-depth knowledge about the Planet – above and below the Earth's crust – is an essential requisite for territorial planning, as well as for efficient use of natural resources and mitigation and prevention of risks. The geo-scientific community, holder of this complex knowledge, is today's key player in managing and building a sustainable world and has to contribute to this huge transformation, improving its capability to deliver the data, information and knowledge required for political decisions and public administration choices.

That is why this 7th edition of the EUREGEO congress opening today in Bologna with the subheading "Sustainable Geo-Management", will focus on the contribution that Earth Sciences must give to ensure that the quality of growth in the future leads to a sustainable future.

I remember 20 years ago, in 1992, when I travelled to Barcelona to meet our friends and colleagues of Catalonia and Bavaria in order to formalize the cooperation between our Regions, which resulted two years later in the first Congress in Bologna.

At that time, like many Geological Surveys in Europe, we were faced with a more rapidly changing world: we were witnessing a shift from analogue working processes to the digital world and geo-information systems. This huge transformation called for a greater involvement in most of our fields of expertise and we soon recognized the need for an exchange of ideas and knowledge with a view to developing an integrated and multidisciplinary approach to applied Earth Sciences and to further develop our on-line information systems (including metadata, data and thematic maps). Our partnership has led to the organization of joint advanced technical and professional training activities to implement the available technologies and to develop common methodologies. The long-term objective of our collaboration is to establish common methodologies in the various fields of the Earth Sciences to be applied at the appropriate level of detail in the various stages of geoscientific information, including primary field data capture, data and information management and final dissemination of the acquired knowledge. Since 2009 the three regions have consolidated their partnership through a number of working groups (WG) focused on topics relevant for all three surveys, including: soil and planning, land instabilities, popularization of geosciences and subsurface geology. An effective part of our cooperation is also collaboration within the framework of European projects, such as the European AdaptAlp Project dealing with the Adaptation to climate change in the Alpine space, in which Bavaria was a Project Partner and Emilia-Romagna and Catalonia acted as observers.

The Geological Surveys of the Regions of Bayern, Emilia-Romagna and Catalonia quickly came to appreciate the great benefits of this cooperation and decided to promote good relations and fruitful exchange of ideas and methodologies also between the geoscientists working in the European Geological Survey Organizations, both Regional and National, and with Academia. Starting from this idea, the three regions decided to organize the "EUropean Congress on REgional GEOscientific Cartography and Information Systems - EUREGEO" which was held for the first time in Bologna in June 1994. EUREGEO is the most visible result of our collaboration and it represents the only congress in Europe directly organised by public technical surveys with the support of the European Soil Bureau Network of the European Commission and EuroGeoSurveys - members of the EUREGEO Organizing Committee since 2000. The great success of this congress demonstrated its capacity to bridge the gap between highly specialized research and the daily work of the Geological Surveys, and proved extremely useful for facilitating direct contact between their geoscientists. Since then, EUREGEO has notched up an impressive record : over the years in Bologna (1994, 2003, 2012), Barcelona (1997, 2006) and Munich (2000, 2009) more than 3000 geoscientists from over 80 countries spread across four continents have participated in the successive congresses.

Besides EUREGEO, Bayern, Emilia-Romagna and Catalonia remain committed to working together in order to highlight the importance of the Regions in Europe. As we know, many European, or EU supported, policies must be implemented and enforced following the principle of subsidiarity. At regional level the application of Earth Sciences knowledge, information and data is critical to support policy making, regulatory developments and implementation of policies related to land and urban planning, as well as mitigation of natural risks, efficient use of natural resources and environmental issues in general. The regional Geological Surveys are involved in the implementation of many European political and decisional processes like, for example:

- the Water Framework Directive and the Directive on the Protection of Groundwater against pollution
- the proposed EC Soil Directive
- the Raw Materials Initiative and the European Technology Platform on Sustainable Mineral Resources
- the INSPIRE Directive
- the Directive on the geological storage of CO_2
- the Marine Strategy Framework Directive
- the European Technology Platform on Geological Disposal of Radioactive Wastes

Today, as always, we have the duty to help support these processes, working in partnership with the other relevant organizations and agencies at Regional, National and International level.

Despite the fact that individual national governments are reluctant to strengthen geological surveys with additional financing, mainly due to the financial crisis, the European Union is showing an increasing tendency to consider geological surveys as important partners. We can say with utter certainty that geosciences can help governments and society in coping with the financial crisis. It is crystal clear that kick-starting development needs geo-sciences and geo-sciences need more research.

As part of the public sector, Geological surveys are affected by the widespread revision of public policies, with a generalized tendency for reducing staff and costs. At the same time, research and innovation remains a priority, as does specialized training that offers new opportunities in sectors which, until recently, were not necessarily very high on the list of public policies. This calls for better synergies with academic research as well as better collaboration with demanding private and public sectors. This is increasingly essential in Europe. Europe is experiencing a sluggish construction phase in a fast changing world and needs to adjust its strategy and outlook. Due to the dispersion, at national level, of diplomatic as well as technical capabilities, there is a lack of centralized views of the planet, notably in terms of natural resources and risk assessment. The EU is crying out for a shared view of the world based on permanent survey and assessment capabilities .

Coming back to this 7th edition of the EUREGEO congress: in five days more than 700 participants from regional and national geological surveys, universities, research institutes and professionals will take part in eleven scientific sessions and four special sessions. EUREGEO once again will serve as a platform for bridging the gap between scientific research and practical application, and for bringing attention to significant technical-scientific contributions from the numerous participants from all over Europe and North Africa. With the subheading “Sustainable Geo-Management” the congress summarises the need for high-quality geo-data, for expertise and knowhow of geo-experts and accessible, easy-to-use information systems for the public and for decision-makers. Natural disasters, ore deposits, arable land and drinking water transcend political boundaries; geology is cross-border! Thus, thematic geological maps are the fundamental tool to inform policy makers, land and urban planners and environmental managers how to minimize natural hazards, protect arable land, exploit raw materials or find new groundwater sources.

Before to open officially the 7th edition of EUREGEO I would like to thank the patronizing of this event: ISPRA (National Institute for Environmental Protection and Research), FIST (Italian Federation of Earth Sciences), CONSIGLIO NAZIONALE DEI GEOLOGI (National Council of Geologists) and the Association of Geologia e Turismo and all the sponsors.

On the behalf of the Organinzing Committee I would like to welcome all participants to Bologna and I wish you all a very fruitful days of work.

Claus Kumutat, Roland Eichhorn, Raffaele Pignone, Michela Grandi,
Antoni Roca, Xavier Berástegui, Luca Demicheli, Luca Montanarella

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THE 3-REGIONS WORKING GROUP SLOPE INSTABILITIES (SLOPEIN); COMMON LANGUAGE, COMPARABLE HAZARD MAPPING AND SHARED EXPERIENCES ACROSS EUROPE.

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KEY WORDS: glossary, hazard maps, trans regional, minimum requirements

INTRODUCTION

In the year 1992 the Geological Surveys of Emilia-Romagna, Catalonia and Bavaria started an informal and innovative collaboration in the fields of the Earths Science and Information Systems that led to the organisation of conferences in Bologna (1994), Barcelona (1997), Munich (2000) and Bologna (2003). Based on this collaboration programme an Agreement Protocol between the Free State Bavaria, the Regione Emilia-Romagna and the Generalitat de Catalunya was signed in November the 19th, 2004. Amongst others one of the main targets of the protocol was to "assess hazards, minimising risks and maximising awareness to enhance sustainable development and quality of life". The protocol was signed by the responsible politicians of the three regions and following conferences in Barcelona (2006) and Munich (2009) were organised. At the last conference in Munich the Organising Committee decided to implement different working groups in order to strengthen the collaboration in particular areas of interest of the three regions. One working group was called "Land Instabilities". The authors of this paper, who were responsible for the working group, started to plan activities and projects in the beginning of 2010 always taking the focus on the main agreements mentioned in the Agreement Protocol of 2004:

- continuing with the organisation of congresses and international meetings to stimulate the exchange of knowledge and methodologies between technicians and scientists of Europe and the Circum-Mediterranean area
- promoting technical and scientific projects focused on the definition of standards in hazard assessment and mapping
- organising joint advanced technical and professional training activities to implement the available technologies and adopted methodologies by each survey, particularly in the sector of information systems and applied earth science mapping
- promoting common initiatives to make general geological information available and understandable to a wider public, working in particular to enhance the geological heritage of Emilia-Romagna, Catalonia and Bavaria
- submitting to the European Community and to other institutions common projects in the field of geosciences
- involving in their activities and in the international projects other partners coming from East-European and Circum-Mediterranean countries.

Following the common activities are described:

ACTIVITIES

In the context with the Interreg-Project AdaptAlp, co-financed by the European Union, in the Work Package 5 different common activities of the three regions have been realised between 2010 and 2012. Beside **harmonization of terminology** concerning landslides an important issue tackled by this Work Package was to create **minimum requirements for hazard mapping** for geological risks. Due to the long lasting collaboration of the three regions it was self-evident to profit from this relationship and to invite the geological surveys of Emilia-Romagna and Catalonia as official observers, to take part in the project. Bavaria had the role of Project Partner (Bavarian Environment Agency) and Lead Partner (StMUG) of the Alpine Space Project. In order to cover also the standards and requirements for hazard mapping of Catalonia and Emilia Romagna, it was a great benefit for the whole AdaptAlp Project, due to the experience in the range of landslides in

Apennine and Pyrenean areas.

To harmonise the terminology an obvious possibility was to create a web-based multilingual glossary, taking the most important languages of Europe into account. For Italian and Spanish (Catalan and Castellan) language the geological Surveys of Emilia Romagna and Catalonia took the responsibility. For German language (Germany) the Bavarian Environment Agency was responsible according to prior agreement with the other German Federal Länder.

MULTILINGUAL GLOSSARY

Purpose and motivation for the glossary were the difficulties when using or defining mass wasting related terms in scientific papers. This results in different methods and concepts being used by geological surveys and leads to misunderstanding and problems when cooperating in international projects. In order to tackle that complexity and ambiguity, found not only in the German-speaking geology, but generally throughout Europe, a multilingual glossary was created. This glossary aims at an international harmonization by providing the user with a selection of official terms used by the geological surveys in the specific country and by setting relations to similar terms employed in other countries.

To fill the complex database-structure of the glossary the approach in getting the topics had central importance. Unlike many other glossaries, which are rather dictionaries working with direct translation, this glossary is consisting of terms definitions and explanations, which do not necessarily have to be part of a scientific nomenclature or literature, but really be used by the official surveys within the involved countries.

In order to facilitate this filling process all the terms were structured in different topics. To simplify the comparability between the languages this classification was very useful. For example it is much easier to get the Italian or Catalan term for "Stauchwulst" if the responsible of the respective region knows that an accumulation term is searched for. This topical limitation helps the translator to get the different experts on the right track.

Basically the data acquisition was made within short visits in the involved countries. Building on the German "Basic-list" within these talks "term after term" was discussed with the respective persons responsible. Especially in this work the relation between the three regions based on our collaboration was very helpful. The elaborated terms were related in the following three forms:

- Same meaning (The term has the same meaning in both languages)
- Similar meaning (The term has a similar meaning in both languages)
- Not existing (No term with the same or similar meaning does exist)

Altogether the major findings of this glossary can give an important contribution to one of the main goals of our collaboration, namely the improvement of the cooperation by the three regions in dealing with geological hazards by finding a common

Figure 1 – Screenshot of the Mulitlingual Glossary http://www.lfu.bayern.de/geologie/massenbewegungen/glossar/index.htm

MINIMUM REQUIREMENTS OF GEOLOGICAL HAZARD MAPPING

In dealing with geological hazard today geotechnical (active) and spatial (passive) measures are applied to minimize risk. Because of time limitation of active measures (e.g. protective walls and catch fences) and the decrease of space for permanent settlings, spatial planning gets more and more important. Countless types of susceptibility and hazard maps are produced to all kinds of risks. With regard to natural hazards especially for geological processes a large variety of maps and methods are used in our countries to prevent from natural disasters. Exactly this variety, which reaches from simple susceptibility mappings to legally binding "Hazard Zone Plans", requires a development of a "least common denominator" which includes the minimum requirements for the creation of susceptibility and hazard maps.

Within an expert hearing in Bolzano the "Land Instability Working Group (SlopeIn)" met with other representatives from the AdaptAlp Project, presenting their "status quo" in dealing with geological hazards. The main outputs of this hearing were published in a joined publication in the Journal of "Torrent and avalanche control" in Austria. The "state of the art" contributions from each involved region are shown in this publication.

To come to minimum requirements for susceptibility and hazard maps in a **first step** the definition of these maps had to be given:

LANDSLIDE SUSCEPTIBILITY MAP LEVEL 1

A Landslide Susceptibility Map (Level 1) is used for the first identification of areas showing conflicts of interests or areas under suspicion to be hazardous. It is a map created on objective, scientific criteria with information on hazard susceptibility, which are not analysed, identified and localised in detail. With empirical, statistical or deterministic methods these maps show the basic disposition for the development of landslides. In general only the potential detachment zone of the landslides is shown and no classification of different hazard levels (probability and intensity) is done.

LANDSLIDE SUSCEPTIBILITY MAP LEVEL 2

A Landslide Susceptibility Map (Level 2) is used for the first identification of areas showing conflicts of interests or areas under suspicion to be hazardous. It is a map created on objective, scientific criteria with information on hazard susceptibility, which are analysed, identified and localised. With empirical, statistical or deterministic methods these maps show the basic disposition for the development of landslides. In general the whole process areas of the landslides and the propagation areas are shown (potential detachment and runout zone) and no classification of different hazard levels (probability and intensity) is done.

HAZARD MAP

A Landslide Hazard Map builds the base for urban land use planning and the development and the costing of protective measures. It is a map created on objective, scientific criteria with information to hazard, which are analysed, identified and localised in detail. With empirical, statistical or deterministic methods in general the whole process areas of the different types of landslides, including the propagation areas are considered (potential detachment and run out zone) and a classification of different hazard levels based on probability and intensity is done.

In a **second step** the existing maps of the particular countries were allocated to the definitions, so that it was easy to see, how comparable the maps are and even though they have different names and contents, how they are corresponding to the elaborated definitions.

Country	Process	Landslide Suscep. Map (L1)	Landslide Suscep. Map (L2)	Hazard Map
Germany (Bavaria)	slide		Susc. Map (1:25.000)	
	fall		Susc. Map (1:25.000)	
	shallow landslides		Susc. Map (1:25.000)	
Italy (Emilia Romagna)	slide		Susc. Map (1:10.000)	
	fall			
	shallow landslides	Susc. Map (1:10.000)		
Spain (Catalonia)	slide		Geological Risk Prevention Map (1:25.000)	
	fall		Geological Risk Prevention Map (1:25.000)	
	shallow landslides		Geological Risk Prevention Map (1:25.000)	

Figure 2 – Existing maps in the three regions corresponding to the given definitions

In a **third step** the minimum requirements for these maps were elaborated. For example a landslide inventory, a digital elevation model and optical areal photos are mandatory for every type of maps and landslide process as well as modelling for fall processes and shallow landslides. A complete overview of the minimum requirements can be seen and downloaded from the AdaptAlp homepage (http://www.adaptalp.org) under Final Reports (Final Report WP5 "Hazard Mapping").

TECHNICAL EXCURSION ON LANDSLIDES AND DEBRIS FLOWS IN CATALONIA

A further activity of the SlopeIn working group was the organization of an international excursion to landslide, debris flow and mine subsidence sites in Catalonia in October 2010. This activity was performed together with the "Munich Forum on Mass Movements". With the participation of 28 experts from geological surveys, water and road authorities and universities of Catalonia, France, Austria and Germany this excursion was an excellent opportunity to complete the theoretical approach of our hazard map and glossary project with concrete situations in the field. The three day excursion was organised and guided by the collaborators of the Institut Geològic de Catalunya. It covered 9 sites between Montserrat near Barcelona and Port de la Bonaigua in the north of Catalonia. The sites visited were:

- Sallent (Subsidence)
- Vallcebre (Landslide)
- Pont de Bar (Landslide and floods)
- Guingueta (Debris flow and floods)
- Estany de Senyora (Landslides)
- Port de la Bonaigua (Snow avalanches)
- Portainé (Debris flow)
- Puigcercós (Landslide)
- Montserrat (Rock fall and floods)

Figure 3 – Excursion sites in Catalonia

By giving a profound insight into the country, into the geotechnical problems Catalonia has to deal with and into the work of the geological survey (Institut Geològic de Catalunya) and their collaborators (Universitat Politècnica de Catalunya, Universitat de Barcelona, Conselh Generau d'Aran, GEOCAT, Geobrugg) it was a very fruitful exchange of experiences and a perfect possibility to deepen the scientific and practice exchange of the specialists. The discussions at the different excursion sites between the experts of the different countries were very fruitful to all participants.

The Institut Geològic de Catalunya published the comprehensive excursion guide under the name "Münchener Forum Massenbewegungen. Excursion 2010 in Catalunya" (Codi: AP-060/10).

Figure 4 – Excursion site Portainé torrent with completely filled debris flow protection fences

SLOPE INSTABILITY SESSION IN THE EUREGEO CONGRESS 2012

The most actual activity of the SlopeIn working group is the organisation of the "Slope Instability Session (Session 1)" in the EUREGEO congress 2012. Taking the chairmanship the working group took the responsibility of this session. The great response of congress participants according to this session indicated the great importance of this topic. More than 48 submitted abstracts from 10 different countries and 3 continents, including oral and poster presentations with reference to hazard and susceptibility mapping as well as remote sensing, monitoring and case studies, only for this session brought us to expand the session from a half-day in a full-day session. The long lasting collaboration of the SlopeIn group was very helpful in sharing the incoming works without problems.

SUMMARY

To give a résumé of the 3 years lasting work of the working group "Land Instability (SlopeIn)", it has to be outlined, that the work of the SlopeIn group on the more detailed and subject-specific level was a big success. On the basis of the Agreement Protocol from 2004 it was possible to institutionalise the relationship between the three regions on a not only administrative level, but also on a topic related expert level. From our (SlopeIn group) point of view it was a very helpful and fruitful collaboration which is absolutely recommendable for other specialist fields. Even though thereby apparently assaults more work for the persons in charge, the benefits of such collaborations are far beyond the disadvantages.

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A MULTI-SCALE REGIONAL LANDSLIDE SUSCEPTIBILITY ASSESSMENT APPROACH: THE SUFRA_SICILIA (SUSCETTIBILITÀ DA FRANA IN SICILIA) PROJECT

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KEY WORDS: regional landslide susceptibility assessment, Sicily, SUFRA_SICILIA, PAI.

INTRODUCTION

The PAI ("Piano Assetto Idorgeologico") program has been applied to the whole Sicilian territory with the aim of producing a landslide risk map (ARTA_SICILIA, 2004). Due to time and data limitations, national governmental authorities drove the PAI to characterize hazard and risk conditions connected to the re-activation of the past landslides rather than to hazard or susceptibility modeling.

Landslide susceptibility assessment poses specific methodological issues when performed for regional mapping (Guzzetti et al., 2005). In fact, in regional application the overall predicting performance is greatly lowered by the lack or roughness of the required data: landslide inventories and thematic maps of the controlling factors. At the same time, no matter the resolution of the processed data, some basic issues of the model building procedures, such as modeling approach, mapping units, landslides classification and representation, and validation strategies (Guzzetti et al., 1999), need to be optimized for regional multi-scale assessment procedures.

To the aim of defining European commonly shared approaches for landslide susceptibility mapping, a European landslide experts group has recently proposed criteria for a multi-level method (TIER: Hervás, 2007). Three susceptibility TIER levels are proposed and reference data and model building procedures are recommended for each. The TIER approach is strictly dependent on the quality of the available landslide inventories and thematic maps, which are needed for the whole European territory.

The SUFRA (SUscettibilità da FRANA) project moves from the same methodological analysis of TIER but, in light of the availability for the Sicilian territory of highly detailed geological l.s. and landslide data, it diverges both in the worked data and in the model building methods which are exploited for the three level landslide susceptibility assessment in Sicily.

LANDSLIDES IN SICILY

Landslides in Sicily are mainly connected to its geologic setting (Fig. 1), which can be resumed as made by three main sectors: the chain sector (running along the northern side); the fore-deep sector occupying the southern inner areas southward to the Sicilian Channel; the fore-land, in the extreme south-eastern side.

Large areas, where continental or torbiditic clayey sequences outcrop on hilly denudation slopes or steep structurally controlled slopes, are affected by slides and flows; the rigid carbonate and metamorphic units which typically mark the head of the slopes, are affected by falls, topples and lateral spreads. Carbonatic rocks, outcropping in the fore-land sector, are almost exclusively affected by falls. Both the ductile clayey formations and the weathered top coverage of the metamorphic units can be interested by rapid debris avalanche/debris flows phenomena.

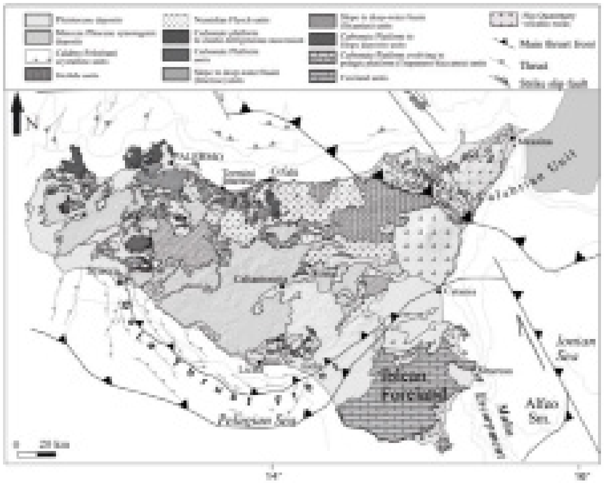

Figure 1 – A geological scheme of Sicily (Valenti et al., in print).

Rainfall, man, volcanic eruptions, and earthquakes are, in the order, the main triggering factors.

The more complete landslide archive for Sicily is the one which was prepared in the framework of the PAI program, consisting of about 30,000 events (Fig. 2).

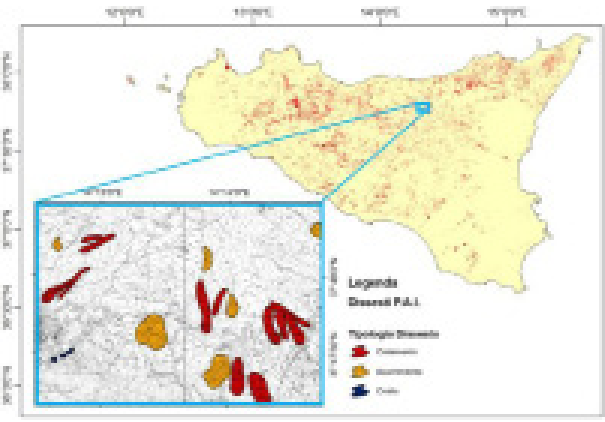

Figure 2 – The PAI landslide inventory (ARTA_SICILIA, 2004).

THE SUFRA_SICILIA PROJECT

The SUFRA project is based on a three level susceptibility mapping. According to the availability of more detailed data, the three scale for susceptibility mapping are increased respect to the ones suggested by the TIER group to 1:100,000, 1:50,000 and 1:25,000/1:10,000.

The mapping levels exploit climatic, soil use (CORINE2009) and seismic informative layers, differentiating in the details of the core data (geology and topography), in the quality and resolution of the landslide inventory and in the modelling approach (Tab. 1).

SUFRA_100 is based on a heuristic approach which is applied by processing a geologic layer (produced by ARTA integrating pre-CARG 1:100,000 geologic maps); the DEM exploited are IGMI 250m and the mapping units are 1km side square cells. Models are validated with respect to the PAI LIPs (Landslide Identification Points) which are reclassified adopting a simplified scheme. Output cuts of SUFRA100 will be referred to administrative boundaries (provinces).

SUFRA50 is based on statistical analysis of new CARG geologic maps and 20m (ITA2000) - 2m (ATA2007) DEM. The mapping units are 500m and 50m cells, hydrographic and hydro-morphometric units. The landslide inventory is the IFFI2012_LIPs (first level) which is the result of the conversion in IFFI format of the PAI archive, which will be supported by remote landslide mapping (exploiting the ATA2007 aerial photos), according to the IFFI first level approach. Validation of the models will be performed exploiting both random spatial partition and temporal partition methods. Output cuts of SUFRA50 will be based on physiographic (basin) and administrative (municipalities) boundaries.

SUFRA10/25 is based on statistical analysis of new CARG geologic maps (remotely and field adapted) and 2m (ATA2007) DEM. The mapping units are the slope units (SLUs) which are derived by further partitioning the hydro-morphometric units so to obtain closed morphodynamic units. The landslide inventories is the IFFI2012 which is the results of a field supported (on focus) landslide remote systematic mapping, according to the IFFI full level approach.

Examples of SUFRA_100, SUFRA_50 and SUFRA_10 are presented for some representative key sector of Sicily. First results attest for the feasibility and goodness of the proposed protocol.

The SUFRA program aims at enabling the regional governmental administration to cope with landslide prevision, which is the required operational concept in land management and planning. PAI has been a great advance with respect to the "pre-SARNO" conditions, but it is very exposed to fail: it is a blind approach for new activations; it is critically dependent on the quality of the landslide inventories; it cannot project the susceptibility outside the landslide areas.

MAP	SUFRA100	SUFRA50	SUFRA25/10
SCALE	1:100,000	1:50,000	1:25,000 / 1:10,000
METHODOLOGY	HEURISTIC	STOCHASTIC	STOCHASTIC/DETERMINISTIC
MAPPING UNIT	1 km CELLS	500/50 m CELLS - HYDROGRAPHIC UNITS	HYDROMORPHOMETRIC UNITS / SLUs
LANDSLIDE INVENTORY	PAI aerial [illegible]	IFFI 2012 remotely checked	IFFI2012 field checked
GEOLOGY	PRE-CARG MOSAIC	CARG	CARG
DEM	IGMI 250m/NASA SRTM 90m	ITA2000 20m - ATA2007 2m	ITA2000 20m - ATA2007 2m
CLIMATE	MARS/ARTA	ARTA	ARTA
LAND USE	CORINE	CORINE remotely checked	CORINE remotely checked
SEISMICITY	ESPON's GSHAP project	INGV	INGV
VALIDATION	GOODNESS OF FIT	RANDOM SPATIAL PARTITION	RANDOM SPATIAL PARTITION/TIME PARTITION

Table 1 – Scheme of the SUFRA aproach.

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ASSESSING LANDSLIDE SUSCEPTIBILITY FOR SPATIAL PLANNING IN PORTUGAL

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KEY WORDS: Landslides, Susceptibility, Prediction-Rates, National Ecological Reserve, Municipal Planning.

INTRODUCTION

Landslide susceptibility assessment and consideration of unstable slopes within town and country planning would help to reduce the damage caused by landslides. In Portugal, the law that requires the consideration of the areas which are susceptible to natural hazards at the municipal level is the National Ecological Reserve (NER) decree. The main objectives of this study are the followings:

- Assessment and mapping of the landslide susceptibility of Loures, which is a municipality located in the Metropolitan Area of Lisbon, by using a bi-variate statistical method called Information Value (IV) Method.
- Creation of three landslide prediction models for three different types of landslides, and independent validation of these models.
- Selection of the potentially unstable slopes that must integrate NER and should be restricted for development purposes according to the Portuguese law.

DATA AND METHODS

Interpretation of ortophotomaps and aerial photographs and use of standard geomorphologic techniques in field work permit to construct a landslide inventory comprising 686 polygons, each polygon representing a rotational, a deep translational or a shallow translational slide.

Dependence of landslide probability densities on landslide area is estimated using the probability density function proposed by Malamud and co-authors (2004), considering two landslide groups (shallow and deep landslides). Probability of landslide size, which is a proxy for landslide magnitude (Guzzetti et al., 2005), is also assessed.

Seven landslide predisposing factors (slope angle, slope aspect, slope curvature, inverse of topographic wetness index, geology, soil types and land use) are used as independent variables for the elaboration of the landslide susceptibility maps. Landslide susceptibility is evaluated using algorithms based on statistical/probabilistic analysis (Information Value Method) over unique-condition terrain units in a raster basis. Three susceptibility models are elaborated independently according to the type of slide (rotational, deep translational, shallow translational), and are validated independently. Prediction-rate curves are computed, and their Area Under Curve permit to quantify the robustness and accuracy of the landslide susceptibility models.

Unstable slope areas that have to be included into the NER are extracted from the three susceptibility maps following the general rules to draw the NER that state that the area to be included in the NER should guarantee the inclusion of at least 70% of the landslides identified in the landslide inventory.

At last, buildings and main roads which are present within the NER are identified.

RESULTS

The probability assessment of landslide areas in the Loures municipality confirms that magnitude of deep landslides is higher than magnitude of shallow landslides (Zêzere et al., 2008).

To compute the IV scores, the total affected area of landslides belonging to the three landslide modelling groups is cross-tabulated with each predisposing factor. According to the obtained results, the ideal conditions for landslide occurrence in the study area are: a concave slope (or convex in the case of deep translational slides) oriented to North, West or Northwest (for rotational and shallow translational slides), and South or Southwest (for deep translational slides) with a gradient above 15°, an inverse of the wetness index above 0.001, a geology containing marl and marly limestone of Albian – Cenomanian age, soils being brown vertisols or kastanozems and covered by dense shrubs. The prediction-rate curves and the high Area Under Curves (AUC) values attest that the predictive models obtained are robust. For each landslide susceptibility model, four susceptibility classes were defined in function of the landslide predictive capacity according to the following rules (Figure 1): Class I (high susceptibility) includes the area of Loures Municipality with the highest IV scores that validate 70% of landslide validation group. Class II (moderate susceptibility) comprises the surface that validate the following 20% of landslide validation group (aggregate 90%); Class III (low susceptibility) represents the area that validate the following 5% of landslide validation group (aggregate 95%); and Class

IV (very low susceptibility) comprises the remaining study area that validate the last 5% of landslides belonging to validation group. The NER, shown in Figure 2, results from the union of the three landslide susceptibility Class I areas and the generalization of the resulting area (i.e. smaller than 1000 m² isolated areas classified as NER were reclassified as no-NER, and vice versa). The generalization permits to facilitate the NER exploitation in term of territorial management. According to the results, appropriate measures (e.g. land division and urban development prohibition) taken in this zone, which constitute 20.3% of the surface of Loures, would make it possible to potentially avoid approximately 70% of the damage caused by future landslides.

At last, crossing the NER and the exposed elements of Loures municipality, we conclude that 2.06% of total built area and respectively 5.71%, 6.55% and 10.36% of total motorways, national roads and municipal roads of Loures municipality are not according to the existing law. Moreover, the Civil Protection Authority should pay special attention to these elements, namely through preventive evacuation during high intensity rainfall periods.

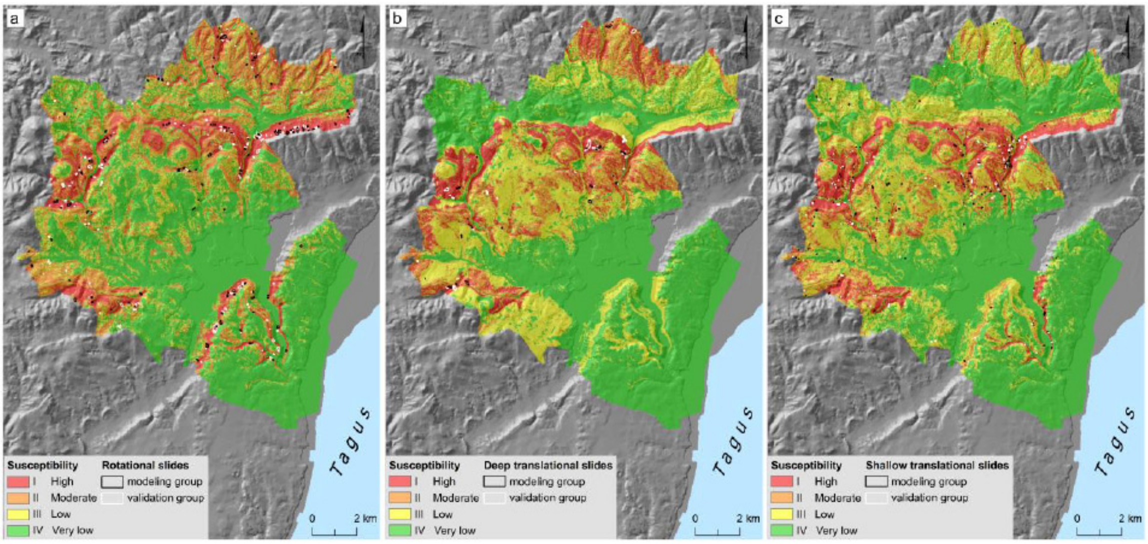

Figure 1 – Landslide susceptibility models of rotational slides (a), of deep translational slides (b), and of shallow translational slides (c)

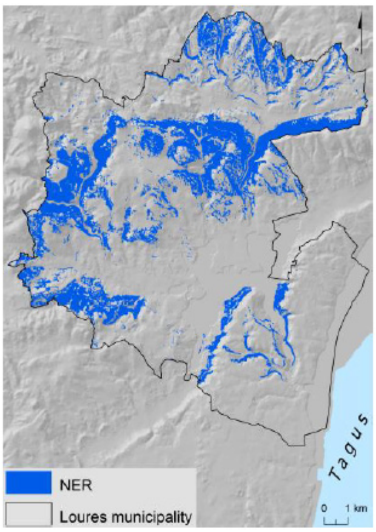

Figure 2 – National Ecological Reserve (NER)

CONCLUSIONS

Assessment of landslide susceptibility is the first step toward allowing the authorities dealing with town and country planning to make good decisions about urban development on the zones identified as being susceptible to landslide occurrence. Indeed, in the NER extracted from obtained landslide susceptibility models, operations of land division, urban development, road works, cuts and landfills and destruction of the vegetation cover are forbidden. Possible future work is landslide hazard assessment, which can be made integrating triggering information in the modelling procedure. Moreover, assessment of vulnerability and value of exposed elements will permit an estimation of potential losses, which, crossed with the hazard, would permit to assess the landslide risk.

ACKNOWLEDGEMENTS

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MODELLING OF 3D GEOLOGY AND LANDSLIDE HAZARD IN THE LESSER HIMALAYA, CENTRAL NEPAL

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KEY WORDS: 3D modelling, GIS, landslide, hazard, prediction, Nepal Himalaya

BACKGROUND

Modelling of three dimensional (3D) geology and landslide hazard are carried out in the Lesser Himalaya, central Nepal. The modelling site is located west of Kathmandu (latitudes: 27°37’ to 27°45’ N & longitudes: 84°58’ to 85°07’ E) and is characterized by complex mountainous terrain. Lithostratigraphy comprises six different units consisting of sedimentary, metamorphic and igneous rocks; Precambrian to Palaeozoic in age (Stöcklin & Bhattarai 1977). Low- to medium-grade metamorphic rocks such as meta-sandstones, slates, phyllites, marbles, quartzites and schists are the main lithology. Limestone crops out in the eastern region whereas granite intrusion occurs in the western and southern parts. Geodynamically the area represents the closure of the Mahabharat Synclinorium.

MODELLING 3D GEOLOGY AND LANDSLIDE HAZARD

A comprehensive process was adopted to model 3D geology from optimum available data which include lithological boundaries, representative cross section and orientation vectors. Considering nature of data, the model setup is made by means of implicit approach (Caumon et al. 2007). ArcGIS functions were used to create a spatial database. GIS shapefiles were imported in geological object computer aided design (GOCAD) as point or curve objects and converted into analytical format. Orientation vectors (v) were implemented from the dip direction θ and dip angle ϕ (Eq. 1). To support interpolation, the 3D vectors have to be oriented normal (perpendicular) to the stratigraphic layers.

Various GOCAD plugins were utilised to interpolate rock strata geometry and then discrete surfaces were computed from the implicit property (Fig. 1) and their meshes were optimised by running discrete smooth interpolation (DSI) algorithm (Mallet 2002). A systematic sequence of steps has followed to get the rock strata units from base to top and the operations are automatic or interactive with a possibility to improve the modelling.

$$v = \begin{bmatrix} \sin(\theta)\cdot\cos(\phi) \\ \cos(\theta)\cdot\cos(\phi) \\ \cos(\phi) \end{bmatrix} \quad (1)$$

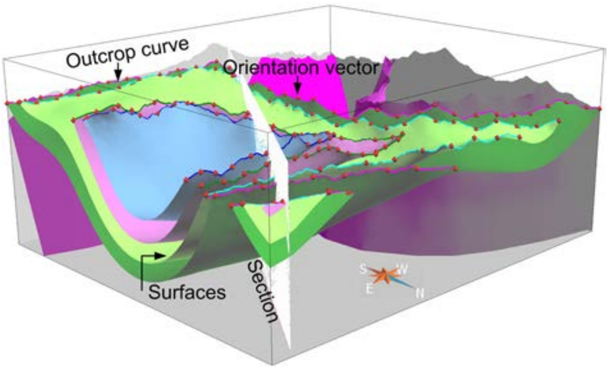

Figure 1 – Model configuration (orientation vector, outcrop curve, section) and computed surfaces.

The modelling of subsurface geometry and properties is a key element to understand geo-hazards and for which landslide hazard map was evaluated using logistic regression method (Eq. 2). In the landslide hazard model, relationship of multi-layered data was derived by defining the role of each factor according to its computed relations with the spatial pattern of landslide distributions.

$$Ᵽ\left(event\right) = 1/\left(1 + e^{-Z}\right) \quad (2)$$

where Pr(event) is the probability of an event occurring. In the present situation, the Pr(event) is the estimated probability of landslide occurrence. As Z varies from $-\infty$ to $+\infty$, the probability varies from 0 to 1 on an S-shaped curve. Z is the linear combination (Eq. 3):

$$Z = B_0 + B_1X_1 + B_2X_2 \cdots + B_nX_n \quad (3)$$

where B_0 is the intercept and $B_1, B_2, \ldots, B_n$ are the coefficient estimated from the sample data, which measure the contribution of independent variables (X_1, X_2, . . ., X_n).

Verification of the assessment indicated satisfactory correlation between the presumptive hazard/susceptibility map and existing data on landslide locations. Areas in high to very high hazardous zones that are devoid of landslides indicate potential landslide zones. The area under the curve (AUC) in the calculated success and prediction rates varied from 0.9031 to 0.9471 showing a range from 90% to 94% with prediction accuracy of 0.5 to 1 (total area). Thus, the model is valid and has succeeded in evaluating land units into five different hazard levels (very high, high, medium, low and very low). The predicted highly hazardous zones of landslides are spatially localised in southern steep hill-slopes of the area.

Conclusively, predicted landslide hazard was integrated in 3D geological model volume (Fig. 2). The modelling procedure has regional significance and is applicable to other areas of similar geophysical characteristics taking consideration in site-specific scale where local geo-environmental heterogeneities may prevail. The highly hazardous zones derived in this assessment process should be avoided. Where this is not possible, it is necessary to implement protection measures.

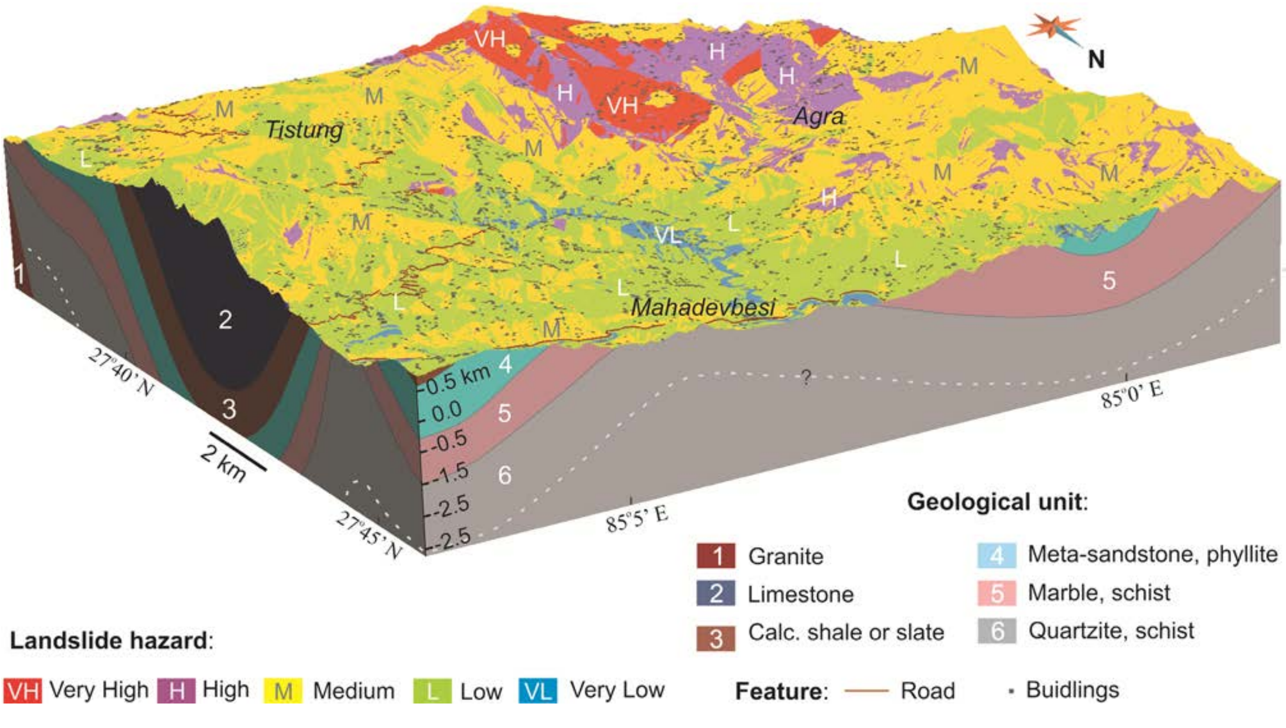

Figure 2 – Landslide hazard integrated in 3D geological model, Lesser Himalaya of the central Nepal.

ACKNOWLEDGEMENTS

We are grateful to the Alexander von Humboldt Foundation for providing a research fellowship to the first author.

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ASSESSMENT OF LANDSLIDES SUSCEPTIBILITY AND REACTIVATION LIKELIHOOD IN THE EMILIA ROMAGNA REGION

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KEY WORDS: landslide susceptibility, multivariate, logistic regression, reactivation likelihood, Emilia-Romagna, Apennines.

INTRODUCTION

The Emilia Romagna (RER) Apennines is a very landslides affected and prone area, with 24% of the area covered by landslide accumulations and hundreds of events/year. Most of the landslides events see the partial or total reactivation of pre-exixting landslide accumulations and take place like earth-slides, earth-flows and complex landslides (Cruden and Varnes, 1996). The main triggering factors are intense and prolonged rainfalls. The reactivation mechanism often see the main scarps retrogression followed by the progressive reactivation of the past events accumulations through an "undrained loading mechanism" (Hutchinson and Bhandari, 1971). With this mechanism even deep seated dormant landslides may be reactivated by "shallow" landslides (fig. 1).

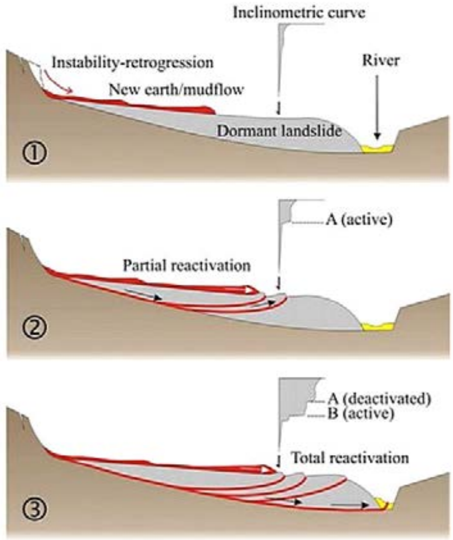

Fig. 1 – Scheme of typical landslides reactivation in RER's Apennines (da Bertolini e Pizziolo, 2008).

In RER most of the land-use planning is based on the 1:10'000 Landslide Inventory Map (LIM) developed and constantly updated by the RER Geological Service (SGSS) and on the landslides activity state distinction in active and dormant. This approach has several shortcomings but mainly:

1) Areas outside mapped landslides have not any site specific distinction based on ladslides susceptibility assessments.
2) Despite of the subjectivity of distinction between active and dormant landslides and the low forecast significance and fast ageing of this observations, there is an important and stiff divergence in the laws that are porely adaptable to the "natural continuity".

To try to overcome such shortcomings, starting from the 1:10'000 LIM we developed two different forecast models:

1) The first is a statistic landslide initiation susceptibility model, focused in the identification of the areas (mainly outside the mapped landslides) most prone to trigger "new" landslides (or to the further developement of the pre-existing ones).
2) The second model use a statistical plus an heuristic-geomorphological approach to assess the mapped (dormant) landslides reactivation likelihood.

SUSCEPTIBILITY MODEL FOR OUT OF LANDSLIDE AREAS

Since our main issue was to focus the reactivation processes, we realized a multivariate statistical model using logistic regression method, assuming the mapped landslide depletion areas as unstable areas (112'500 points) and a set of random point sampled at a certain distance from the mapped landslides. Despite the wide area to model (≈11'000 Km^2), as land unit we used the 10x10m DEM cells.

The independent variable preparation saw the realization of > 20 continuous variables through DEM raster analysis and the preparation of two categorical variable: Lithotecnical map (derived from the 1:10'000 geological map), and Land-Use map (used in the 1976, 1:10'000 version, to guess it was a more independent variable respect the landslides, at least for the active ones). To chose the variable to use in the multivariate model we realized a cross-correlation matrix (to avoid the use of variables too much correlated with each other), and a bivariate bayesian analysis to assess the influence of each variable with the dependent [landslide yes (1) / no (0)].

We performed the calibration on 80% of the dataset and validation on remaining 20%, using the ROC curve to evaluate the model performance improvement correlated to models complexity increase. The final model has eight continuous DTM variables combined, in interference, with two categorical variables, such to evaluate, for instance, the effect of the slope in conjunction with each lithotechnical class.

The maximum performance with all landslides is 78% but calibrating the model on the only active ones, it raised to 85%, so we used this last as definitive model.

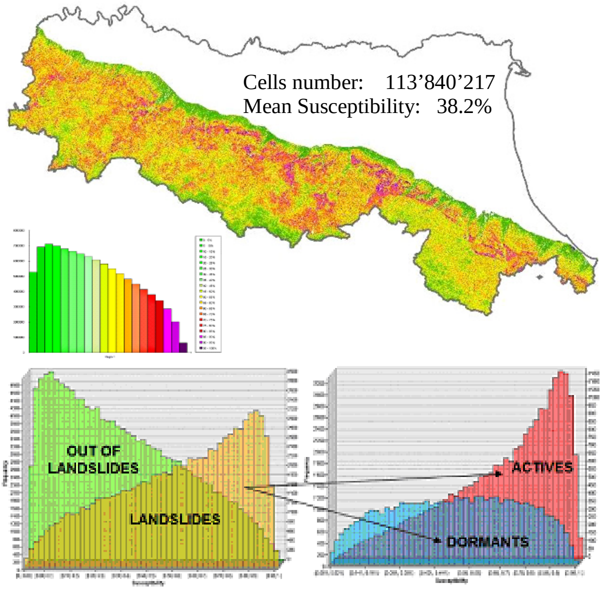

Fig. 2 – Above the susceptibility map of the whole RER Apennine with its frequency distribution. Below the frequency distributions obtained by the model for stabe and unstable points.

REACTIVATION LIKELYHOOD MODEL FOR MAPPED LANDSLIDES

Starting from the same concept of landslides triggered by undrained loading processes (fig. 1), we developed this heuristic-geomorphological model that try to traduce and code the geologist experience criteria such to be automatically extended to an area like RER that counts >70’000 mapped landslides. The model involves three different sub-analysis.

1) INFLUENCE OF THE UPSLOPE SURROUNDING SUSCEPTIBILITY CONDITIONS.

We used the result of the previous model, and assumed that the higher the susceptibility on the areas immediately upslope the mapped landslide, the higher the likelihood that landslide will be reactivated. Then for each landslide we evaluated the mean susceptibility on the 50m uphill along the water flow accumulation grid.

2) INFLUENCE OF GEOMETRICAL RELATIONS BETWEEN ADJACENT LANDSLIDES;

In RER >37% of the dormant landslides are “touched” someway by at least one active landslide. Many examples show that this issue can strongly affect the dormant landslide reactivation likelihood but obviously not all the landslides will be affected in the same way. To quantify the relative influence active/dormant we calculated for each landslide and for each “contact area” several geometric parameters and realized an heuristic model for

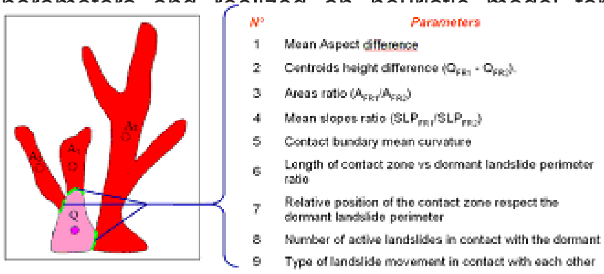

Fig. 3– List of the geometrical relationship between actives and dormants landslides, considered.

Each relation has been divided in classes, each of which received an “influence score”. The total influence is calculated with additive and multiplicative scores synthesis.

3) PRESENCE OF DOCUMENTED PAST REACTIVATIONS.

RER has collected so far a database of ≈11’000 landslide events historical data. The presence of documented past reactivation has been considered as the testimony that the landslide can reactivate, so it’s assumed as one of the factor that confirm the reactivation likelihood.

Combining these three sub-analysis we identified different level of reactivation likelyhood of the ≈35’000 dormant landslides of the 1:10’000 lansdlide inventory map.

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A GIS LANDSLIDE DATABASE OF NORTHERN PORTUGAL SUPPORTED BY DOCUMENTAL SOURCES

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KEY WORDS: Landslides; Northern Portugal; Disaster Databases.

INTRODUCTION

In recent years a huge effort to collect, record and analyze information about disasters occurrence and impacts has been made worldwide.

The development of natural disasters databases is crucial for risk management purposes, because it allows improving systems of indicators on disaster risk and vulnerability at national and sub-national scales. In addition, the analysis of social, economic and environmental impact of disasters needs to be transferred to decision-makers and integrated in land use management and civil protection policies in order to prevent and mitigate disaster losses.

Landslides databases are essential to assess landslide hazard and risk. However, landslide databases may have different spatial resolution associated with different goals, scale and data capture methods. Limitations related with spatial resolution and data capture procedures of landslide databases need to be considered when data is transferred and applied by end-users.

STUDY AREA AND OBJECTIVES

During the last century, Portugal was affected by several destructing natural disasters, namely of hydrologic (floods) and geomorphologic (landslides) origin. The basic information on past damaging landslides occurred in Portugal from 1900 to 2008 can be found in the academic work performed at national scale by Quaresma (2008).

At the regional scale, a landslide database was made for the North Region of Portugal including the complete landslides occurrences identified exploring documental sources for the period lasting from 1900 to 2008 (Pereira, 2010).

In this work we present the Northern Portugal Landslide Database (NPLD) which was updated to 2011. In particular we want to answer the following questions: (1) What is the degree of completeness and the temporal and spatial accuracy of landslide distribution? (2) What are the advantages and limitations of landslides databases supported by documental sources?

METHODOLOGY

The NPLD is a geodatabase that includes the following information for each landslide occurrence: ID, date and hour of occurrence, location, x and y coordinates, landslide type, data source, and damages (fatalities, injuries, homeless people, disruptions in rail and road circulation and destructed buildings).

Data collection was exclusively based on documental sources: regional newspapers (daily and weekly), academic works and reports of the civil protection authorities. Most of landslide occurrences (68.6%) were identified in newspapers while landslides reported by the civil protection and academic works are only 26.1% and 5.3% of total, respectively.

Documental sources were carefully analyzed in order to identify and georeference landslides. Road maps, rail road maps and the Google Earth were used as additional tools to support the location of slope movements. Landslides were mapped in topographic maps (1:25 000 scale) with a point in the centroid of the rupture zone.

When descriptions about landslide location were not enough precise landslides were mapped in the parish centroid.

Spatial and temporal distribution of landslides belonging to NPLD was compared with a national database (Quaresma, 2008) of landslide damaging events occurred in Portugal, which generated fatalities, injuries, missing people, homeless and evacuated people. This database was originally for the period 1900-2008 and was further updated until 2010.

RESULTS

The NPLD has 640 occurrences, 79% of them georeferenced in the centroid of the landslide rupture zone (Fig. 1, Table 1). The National database has only 63 landslides, which is explained by the criteria used for landslide inventory (Table 1). Nevertheless, the spatial distribution of landslides of both databases is quite similar. Landslides are located mainly along the Douro valley and in the Oporto metropolitan area.

Falls and debris flows are the most frequent landslides within the NPLD. More than half of these landslides caused disruptions in railroad and road circulation (37.5% correspond to line closed and 13.3% to road block).

More than 70% of landslides of the NPLD occurred in winter rainy months, especially in December (31%) and January (24.5%). The National database has the same monthly landslide distribution.

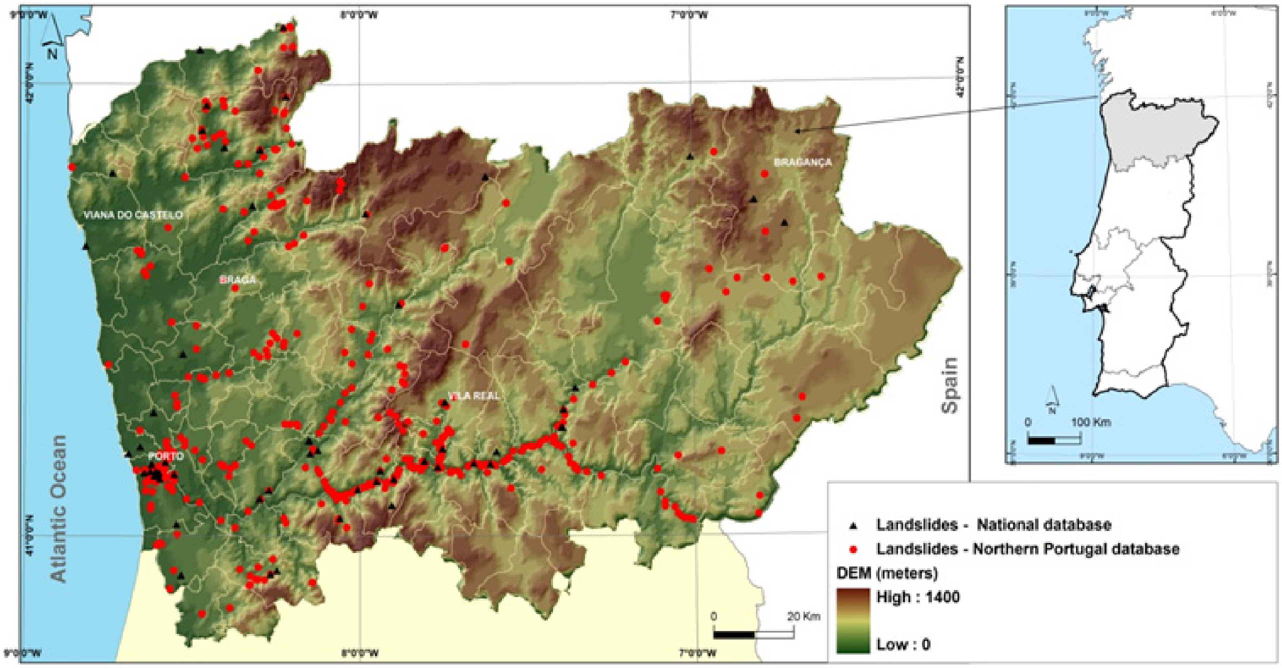

Figure 1 – Landslides distribution in the Northern Portugal according to the national and regional landslide databases.

For a similar reference period, the NPLD includes a higher number of deaths and homeless people in comparison with the national database. Therefore, we can conclude that information reported by newspapers at the national level (used to construct the national database) is not enough representative of landslide damages occurred at the regional scale. In addition, the regional newspapers also provide more accurate information regarding location of landslides.

	Northern Portugal Landslide Database	National Database
Period	1900-2011	1900-2010
Main Sources	Regional newspapers (daily and weekly)	National newspaper (daily)
Nr. landslides	640	63
Landslides/year	5.8	0.6
Nr georeferenced landslides	505	63
Georeferencing	Point (centroid of landslide)	Point (nearest toponymy)
Criteria for landslide inventory	All landslides	Landslides that caused fatalities, injuries, missing people, homeless and evacuated people
Nr. deaths	129	60
Nr. injuries	124	122
Nr. homeless	381	279

Table 1 – Landslide databases details.

CONCLUSIONS

Temporal distribution of landslides is strongly associated with wet months reflecting the rainfall triggering of slope movements. Although the NPLD theoretically includes all landslides, in practice the spatial distribution of landslides reflects the pattern of landslides that generated direct damages in population (e.g. fatalities, injuries, homeless), buildings and infra-structures (e.g. road, railroads). Therefore, landslide inventories based in documental sources can be easily transferred to emergency planning and societal risk assessment. Nevertheless, these landslide inventories are not enough complete to generate landslide susceptibility assessment which is crucial for land use planning.

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HOW GOOD IS MY HAZARD MAP?

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KEY WORDS: landslide hazard, spatial prediction, quality of modelling results, prediction rates.

INTRODUCTION

The construction of spatial databases to represent the typical settings of the occurrence of slope failures is nowadays a convenient procedure to generate susceptibility and hazard maps. The focus of research, however, has moved to the interpretation of such thematic maps in quantitative terms. This contribution provides two of several strategies to deal with a cogent question: "How good is my hazard map?" Clearly, the answer has to be relative to the quality of the database and must deal with robustness, effectiveness and number of the hazard classes selected. To exemplify how such answer can be sought, a case study database is used that is part of the training material in courses of spatial prediction modelling in natural hazard for researchers and decision makers (Fabbri and Chung, 2009).

THE FANHÕES-TRANCÃO DATABASE

The Fanhões-Trancão study area is located in Portugal just north of Lisbon. Its database has been constructed at the University of Lisbon to experiment on quantitative landslide hazard assessment (Zêzere, 1996). Its digital resolution is of 5m x 5m pixels and each of its seven data layers covers 760 pixels x 700 lines, i.e., 13.3km^2. We can term direct supporting pattern, **DSP**, the data layer with the distribution of the 92 trigger zones of shallow translational landslides, divided in our case into 43 pre-1979, and 49 post-1980. We can also term as indirect supporting patterns, **ISP**, the set of geology map (6 units), lands-use map (6 units), surficial-materials map (5 units), categorical maps, and elevation (19-335m), aspect (0-360) and slope (0-90), continuous maps. The term supporting pattern refers to the numerical support of the spatial relationship, expressed as a mathematical proposition, between the distribution of the hazardous events, the landslide trigger zones, and that of the integrated units in the other data layers that hopefully represent the typical settings.

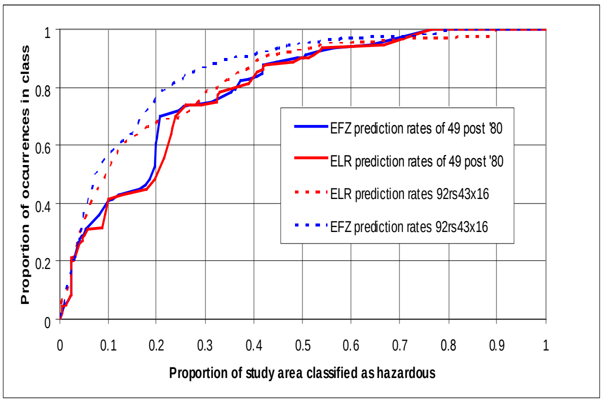

Figure 2 – Four cumulative prediction-rate curves for landslide hazard in the Fanhões-Trancão study area, Portugal.

MODELLING LANDSLIDE HAZARD

Several statistical models can be used to establish the integrated spatial support (e.g., Fuzzy Sets, Empirical Likelihood ratio, Logistic or Linear Discriminant Analysis, Bayesian Prediction). Here we will use the first two, identified as EFZ and ELR, respectively. The spatial relationships can be established, for instance, for six pairs of **DSP-ISP** and then integrated for the database to generate an index of hazard over the entire study area, separating the settings of occurrences from those of the no-occurrences. The indexes from the different models can then be classified, after reordering in descending order and selecting equal-area classes, whose ranks can now be studied as hazard prediction classes. At this point, several strategies can be used to characterize the relative quality of the classes.

Figure 1 shows an integrated hazard prediction map obtained using an EFZ model with a gamma operator with gamma = 0.5. The prediction was obtained using all the 92 shallow translational landslide trigger zones as **DSP** and the six **ISP**. Another hazard map was obtained using the ELR model. The most complete spatial relationship is obtained using the entire set of 92 landslides.

However, in this way we do not know the quality of the hazard map in Figure 1, as a prediction. For that we need particular analytical strategies.

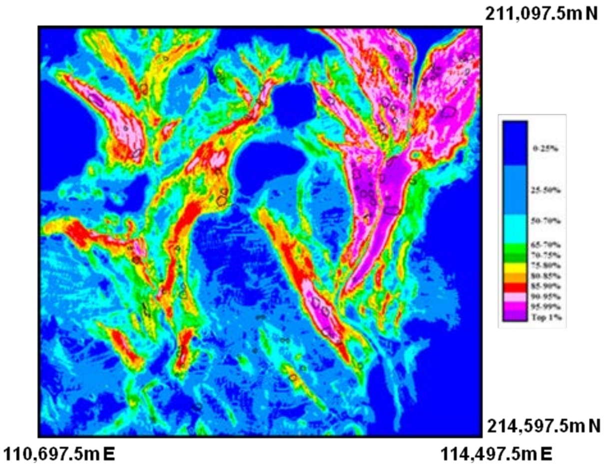

Figure 1 – Fuzzy Set prediction hazard map of the Fanhões-Trancão study area in Portugal, obtained using all the 92 shallow translational landslides and the six data layers, geology, land-use, surficial-materials, elevation, aspect and slope.The trigger zones of the 92 shallow translational landslides are shown as black contours.

RELATIVE GOODNESS OF THE HAZARD MAP

Fortunately, the database had separated the landslides into 43 pre-1979 and 49 post-1980. We can repeat the analysis then using only the 43 pre-1979, the older set, to generate a hazard map and then studying the distribution of the 49 post-1980, the younger set, across the hazard classes. Figure 2 shows on the horizontal axis the cumulative proportion of study area equal-area classes ranked according to the decreasing order of the predicted values for each pixel. On the vertical axis we have the corresponding proportion of the 49 post-1980 landslides for each class. The prediction-rate curves obtained from the FS (solid blue) and the ELR (solid red) models can now be characterized and compared. A second pair of experiments was performed 16 times per model, using 43 randomly selected landslides out of the 92 to study the distribution of the remaining 49, thus pretending not to know the period of occurrence of the landslides. The 16 prediction-rate curves were then integrated to obtain the two averaged curves (broken blue and red) to compare with the previous ones. Clearly, these second experiments provide an overestimation of the predicted hazard.

This contribution deals with a critical aspect of spatial prediction modelling, the characterization of the quality of the prediction results, the hazard maps. This aspect has been mostly ignored or misunderstood up to now, so that in many applications the goodness of the hazard maps are unknown (Fabbri and Chung, 2008). There are different strategies that can be used for the validation of spatial predictions that are a function of the characteristics of the database (Chung and Fabbri, 2003, 2008). Clearly, the statistical model applied for a prediction is less important than the strategy of testing the quality of the prediction results. Therefore, a hazard map can be considered as good as its prediction-rate curve!

ACKNOWLEDGEMENTS

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EVALUATION OF DEBRIS FLOW SUSCEPTIBILITY MAPS IN A REGIONAL SCALE

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KEY WORDS: debris flow, susceptibility map, modelling, RAMMS

INTRODUCTION

In the year 2008 the Bavarian Environment Agency started to produce landslide susceptibility maps in alpine areas of Bavaria. Based on empiric and numeric models in these maps areas, potentially prone to the different types of landslides like rock falls and deep seated landslides, are shown. By giving a first overview of endangered regions, the susceptibility maps are the basis of further land use planning.

For the water related process debris flow such maps are not yet area-wide evaluated, even though this process is one of the most dangerous in the Bavarian Alps. It is obvious that, according to the dangerous impacts of debris flows, also for this processes susceptibility maps have to be established. Additionally there is a legal request based on the German WHG § 73 & § 74 and the related Bavarian BayWG § 46 (1) & (2) to allocate areas endangered by torrential processes.

For the evaluation of a method to work out debris flow susceptibility maps in a regional scale a pilot project had been set up. The works are not yet finished, so this abstract gives a short overview of the first results, the used methods and the required input data for the modelling features.

THE METHOD

One main demand for the project was, to use a method which allows a numeric calculation of the debris transport in torrents and the run out zone with the typical characteristics of a debris flow. As in reality a debris flow always changes its characteristics in the run out zone towards a pure hydraulic event by loosing debris, the discharge of water without debris was not necessary to be taken into account. Modelling was focused on the run out of the debris of the torrent.

The aim was to develop a method for the regional scale (1:25.000) which is based on already existing data available in the Bavarian Environment Agency, so that in general no further field investigations will be necessary. Additionally the method should afford a very economic and rapid way to assemble area-wide susceptibility maps.

To reach this aim it was very helpful, that important digital and comprehensive datasets already exist as results of other projects (see below). These data could be used as input data for the modelling.

In the pilot project 4 different scenarios have been modelled:

- Szenario 1: 100-year event without check dams and bridges
- Szenario 2: 100-year event with check dams and bridges
- Szenario 3: Extrem event without check dams and bridges
- Szenario 4: Extrem event with check dams and bridges

THE DISPOSITION MODEL

To find the potential debris flow source areas, following approach was chosen:

There is relationship between the slope angle of the debris flow source areas and the torrential catchment area above these sites. As a basis for the determination of debris flow source areas, following empirical approach by Zimmermann et al. (1997) is used in the model:

$$J = 0,32 * EG^{-0,2}$$

with J as critical slope angle [-] and EG as the size of the torrential catchment above the debris flow source area [km^2].

The closer the slope angle of a loose material depot is located at the critical slope angle, the lower the tractive force has to be for sediment mobilization. The mobilization of sediment depends both on the stability of loose material and on the tractive force of the water. The stability of the loose material depends on the material properties and the slope angle of the loose material area. Further the tractive force depends on the water runoff.

To find possible debris flow source areas with GIS, in a first step the critical slope angles are calculated for all torrent-raster-cells. Subsequently, the calculated critical slope angle is compared with the channel slope angle and those raster cells are selected as potential debris flow source area, were the channel slope angle is greater than the calculated critical slope angle.

On the regional scale (susceptibility map) the cubature of loose material, which is allocated to the debris-flow prone raster cells can be roughly estimated, based on the geological maps and the landslide susceptibility maps. This is necessary to run in a second step the process model (RAMMS).

THE PROCESS MODEL

For the calculation of debris transport and run out areas the numeric model RAMMS was used. RAMMS (Rapid Mass Movements) is a two dimensional debris flow simulation program and was developed by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). Formally it was designed as a simulation model for snow avalanches and later adapted to debris flow modelling in a local and regional scale. The basis for the model is the well known friction model of Voellmy-Salm. Following parameters, which are essential for the behaviour of debris flows, are included in the model:

- Turbulent friction
- Dry friction
- Density
- Flow pressure

Additionally to the Voellmy-Salm - Model important continuum mechanical approaches have been integrated in RAMMS. In general the main equations are based on the conservation of momentum and conservation of mass.

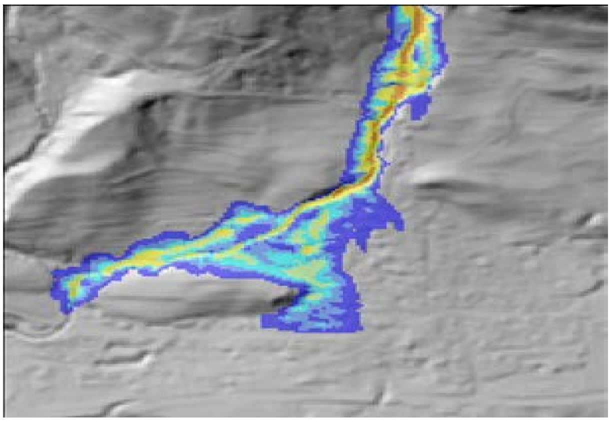

Figure 1 – Modelling result in the pilot area

INPUT DATA FOR MODELLING

The main demand for the modelling input data was that these data had to be available area-wide for the whole alpine space of the Bavaria. Regarding this, following input data could be provided:

- Digital elevation model (1 m resolution)
- Geological map
- Analysis of the geological map regarding the specific values of soil mechanics of the weathering products
- Susceptibility map for deep seated landslides
- Susceptibility map for shallow landslides
- Susceptibility map for rock falls
- Orthograpfic areal photos
- Location of existing technical debris flow protection measurses and buildings like bridges and water ducts (especialy for scenario building)
- Debris flow cadastre for evaluation and calibration of the model results
- Maps of vegetation
- Maps with runoff coefficients

Additional required data like an elevation-coded river network or the implementation of check dams and bridges for the scenario building had to be generated.

SUMMARY

Based on the digital data, which are available in the Bavarian Alps, the described way to work out debris flow susceptibility maps in a regional scale is a fast and economic possibility. As it is shown in the pilot project the results are perfectly fitting together with the already existing landslide susceptibility maps. The kinds of scenarios, which have to be modelled in the future regarding the legal requirements in Bavaria, have to be evaluated.

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ADVANCE INSAR TECHNIQUES FOR LANDSLIDE ASSESSMENT AT REGIONAL AND LOCAL SCALE

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KEY WORDS: Interferometry – PSInSAR™ - SqueeSAR™ – landslide – mapping – monitoring. (max 10)

INTRODUCTION

SqueeSAR™ interferometry, the latest evolution of PSInSAR™ technology, is one of today's most advanced technologies for ground deformation analysis and monitoring. It exploits long temporal series of satellite radar data, acquired over the same area of interest at different times, to identify "natural radar targets" (Measurement Points or MP), that return stable radar reflections over time back to the satellite, where very precise displacement information can be retrieved (Ferretti et al., 2000; Ferretti et al. 2001, Colesanti et al. 2003, Hilley et al. 2004, Ferretti et al., 2011) .

Thanks to its capability in detecting millimetre level displacements over long periods and large areas, SqueeSAR™ analysis can be considered complementary to conventional geological and geomorphological studies in landslide detection and monitoring, supporting also the effectiveness of landslide inventories at regional scale.

The availability of surface displacement time series for all the radar targets identified also makes it possible to change the scale of analysis from regional to local, allowing in depth studies into the evolution of single instability phenomena, supporting the design of traditional monitoring networks and even verifying the efficiency of remedial works.

In this paper, examples of integration of SqueeSAR™ data with other conventional geological and geomorphological studies at local and regional scale will be presented, pointing up the benefits offered by an integrated approach.

APPLICATION AT REGIONAL SCALE

During the last years several Italian Regions were studied with SqueeSAR™ in order to detect and monitor slope instability phenomena. One of the most successfully application was carried out on the whole Valle d'Aosta Region (NW Italy) area (Fig. 1). The study covered a time span of about twenty years, from mid 1992 to late 2011. Aim of the study was supporting the landslide inventory performed within the framework of the Italian Landslide Inventory (IFFI) Project, partly funded by APAT (Italian Agency for Environmental Protection and Technical Services).

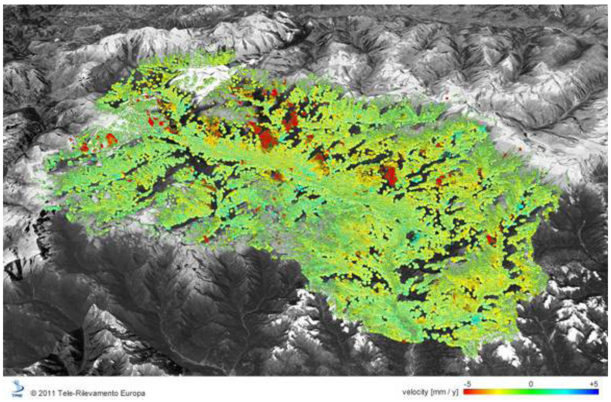

Figure 1 – SqueeSAR tm RSAT-ascending geometry) over the Valle d'Aosta Region (NW Italy) - velocity map.

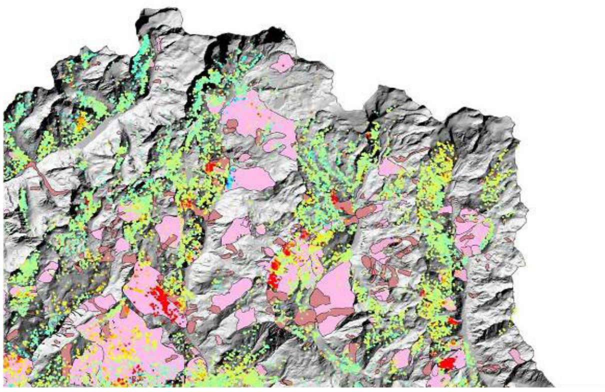

Figure 2 – MP distribution and velocity map (ERS-ascending geometry) over the Valle d'Aosta Region (NW Italy). Base map: DGSD perimeters from IFFI Project (Italian Landslide Inventory).

The integration of the outcomes of the conventional geological-geomorphological studies with the results of the SqueeSAR™ analysis improved the results of the landslide inventory, in terms of landslide areal extent evaluation, unmapped phenomena detection and activity assessment (Fig. 2), and it is currently yearly updated.

The increasing interest of Italian regional and local authorities in the application of SqueeSAR™ resulted in a national project, Piano Straordinario di Telerilevamento (PST), founded by the Ministry of the Environment. Aim of the project was to create the first database of interferometric information on a national scale for mapping unstable areas. First stage of this project requested the processing of more then 12,000 ERS SAR scenes acquired over Italy (Fig.3), while the second stage is updating these results with the Envisat images available up to 2010.

This Project is somewhat an evidence of the fact this technology has become a standard monitoring tool to help hydrogelolgical risk assessment,

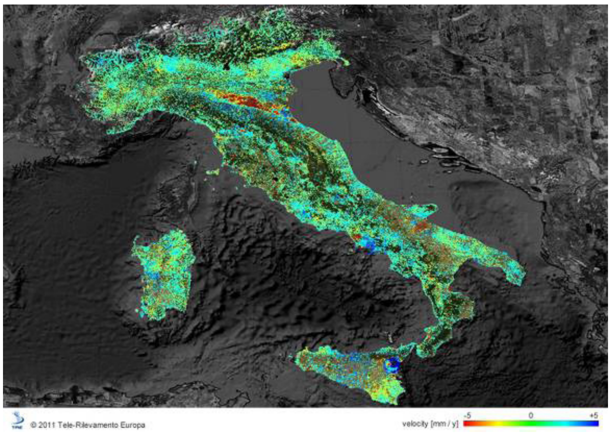

Figure 3 – MP distribution and velocity map (ERS data-descending geometry) over Italy, from the PST Project .

APPLICATION AT LOCAL SCALE

SqueeSAR™ analysis is particularly suitable for the study of Deep-seated Gravitational Slope Deformations (DGSD), characterized by large areal extent and surface displacement rate is very low, ranging from few millimeters to tens of millimeters per year. Here is presented in detail the case study of the Berceto DSGS (Parma, Italy) (Fig.3). By processing satellite SAR data relevant to the 1992-2000 time span and combining results obtained in both ascending and descending acquisition geometries, it was possible to retrieve both vertical and E-W components of surface displacements. Further investigations (geophysical surveys and borehole investigations) were then carried out in order to gather more subsurface data.

The results obtained with the SqueeSAR™ technique were correlated with geophysical and borehole investigation outcomes, enabling a preliminary interpretation of the surface displacement trends in the upper part of the slope. The results of the analysis suggested that the evolutional model proposed for the Berceto DSGSD is nevertheless more complex than expected.

A new ground based monitoring system is being installed, in order to integrate the results obtained by satellite radar interferometry and improve the knowledge of the landslide dynamics.

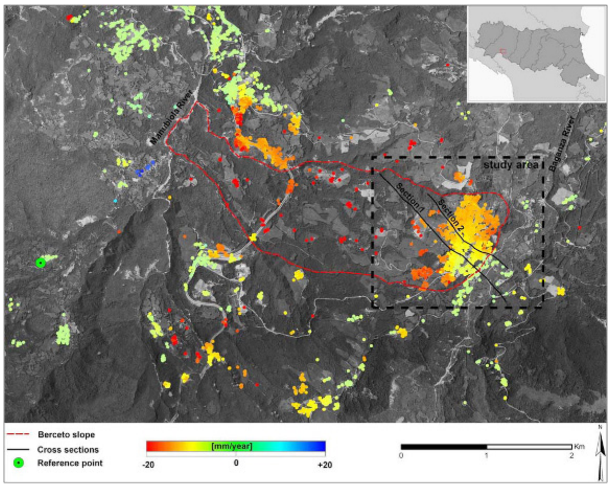

Figure 4 – Location map of the Berceto landslide area, with the average yearly surface displacement velocity measured along the satelliteLine of Sight.

CONCLUSIONS

The results archived so far and in particular the activities carried out in agreement with local and national Authorities confirm that SqueeSAR™ is a complementary tool for accurate landslide mapping, monitoring and characterization at national as well as at local scale.

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ROCKFALL HAZARD MAPPING METHODOLOGY APPLIED TO THE GEOLOGICAL HAZARD PREVENTION MAP OF CATALONIA 1:25000

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KEY WORDS: Rockfall, Susceptibility, geological hazards, risk, reach angle, Catalonia.

INTRODUCTION

The Parliament of Catalonia approved, by Law 19/2005, the creation of the Geological Institute of Catalonia (IGC), assigned to the Ministry of Land and Sustainability (TES) of the Catalonian Government.

One of the functions of the IGC is to “study and assess geological hazards, including avalanches, to propose measures to develop hazard forecast, prevention and mitigation and to give support to other agencies competent in land and urban planning, and in emergency management”. To accomplish these functions, the IGC began the Geological Hazard Prevention Map of Catalonia (MPRG25M) in 2007, comprising of a total amount of 304 sheets covering the whole of Catalonia. This mapping plan is a component of the Geoworks of the IGC, the strategic program aimed at acquiring, elaborating, integrating and disseminating the basic geological, pedological and geothematic information concerning the whole of the territory in the suitable scales for land and urban planning. The MPRG25M is designed as a multi-hazard map, indicating the overlapping of different hazard zones in the same area (Oller et al., 2011).

This article presents the methodology used for assessing the rockfall hazard.

METHODOLOGY

The MPRG25M mapping procedure, for each phenomena represented on the map, consists of three steps: firstly, preparing an inventory of phenomena and evidences, based on information obtained from the collection and analysis of available historical documentation, analysis and photointerpretation of old and recent aerial photographs, on field surveying and on population inquiries. Secondly, determination of the susceptibility to slope failure (starting zone) and to areas that may be affected (run-out zone). Thirdly, hazard assessment (Oller et al., 2011).

Rockfall hazard analysis includes two steps: (a) estimating the magnitude-frequency relationship of the events and (b) estimating the travel distance, based on the angle of reach (Corominas, 1996). The evaluation is done in areas previously identified as susceptible. Susceptibility is defined by the combination of lithology with slope angle. Rockfall frequency and magnitude is obtained by field work. The subsequent processing of these data includes the angle of reach analysis, which determines the area affected by the rock fall trajectories and the degree of hazard. This analysis is systematic and uniform for the whole of the territory to obtain comparable results.

The hazard matrix (Table 1) classify the hazard as high, medium and low. The upper frequency boundary is 50 years, justified by the return period of the rains responsible for major flooding and widespread landsliding in Catalonia, which is between 40 and 70 years (Corominas et al., 2010). To set the boundary for low frequency (return period of 500 years) we used a logarithmic scale, because it minimizes the uncertainty in its assessment in the absence of many historical records exceeding 100 years.

		Frequency		
		Low	Medium	High
Intensity	Low	Low	Low	Low
	Medium	Low	Medium	Medium
	High	Medium	High	High

Table 1 – Hazard matrix depending on the intensity and frequency or activity.

ROCKFALL INVENTORY AND ACTIVITY EVIDENCE

The inventory includes the location and mapping of rockfalls, activity indicators, detached volume, height of the cliff, volume of fallen blocks, etc.

SUSCEPTIBILITY DETERMINATION

Preliminary susceptibility is determined from GIS analysis by crossing slope and lithologic layers (Table 2). The final susceptibility map refined with the rockfall inventory, activity features, activity evidence and the identification of favorable terrain morphologies.

Lithology	Terrain Slope		
	> 70º Cliff	70-45º Rocky slope	45-35º
Hard rock and unfavorable structural setting	High	High	Medium
Hard rock and favorable structural setting	Medium	Medium	Low
Alternating hard and soft rocks and favorable structural setting	High	High	Low
Soft rocks	High	High	Medium

Table 2 - Output susceptibility matrix of rockfall based on lithology and slope angle.

HAZARD ASSESSMENT

To assess hazard, it is necessary to define the volume of the largest characteristic rock block of the sector concerned (magnitude), the area affected by the trajectory of the blocks and the probability of occurrence of this characteristic rockfall (frequency).

The most appropriate procedure to determine the frequency and magnitude of rockfall would be from the analysis of the recorded events. However in most cases it is not possible to have enough data to determine return periods, or representative data of output volumes. Thus, the frequency is determined based on the following features: (i) recent observed rockfalls; (ii) density and size distribution of rockfall scars; (iii) number and volume of fallen blocks (Table 3). Once the source area of rockfalls is parameterized in terms of magnitude of the block susceptible to detach, the area potentially affected by the rockfall trajectories is defined according the criteria of Table 3. To this purpose, the Conefall program is used (Jaboyedoff, 2003). It is designed to calculate the area that could be affected by the fallen blocks.

Rockfall volume (m^3)	Volume of individual rock blocks observed on the slope (m^3)	Angle of reach
< 1t0	< 2	48 – 40º
10-100	< 5 (2-5)	40 – 33º
100-1000	< 50 (5-50)	33 – 26º
> 1000	> 50	< 26º

Table 3 - Correlation between the volume of the rockfall, the volume of the rock blocks accumulated on the slope, and angle of reach (Corominas et. al, 2010).

Figure 1 shows, as an example, a schematic profile with the hazard analysis of a cliff with a height between 10 and 100 meters, with instability features and potential rockfall volumes between 100 and 1000 m^3.

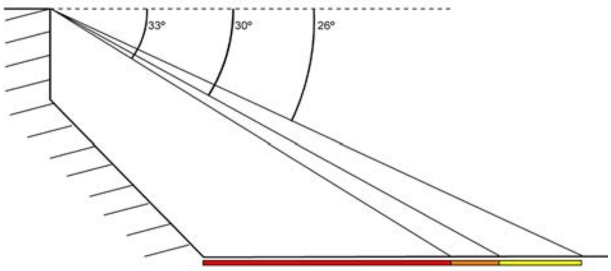

Figure 1- Hazard boundaries based on the angle of reach for a 10-100 m high cliff, instability evidences and potential rockfall volumes between 100-1000 m3.

Figure 2 shows the final rockfall hazard map, obtained with the methodology presented in this contribution.

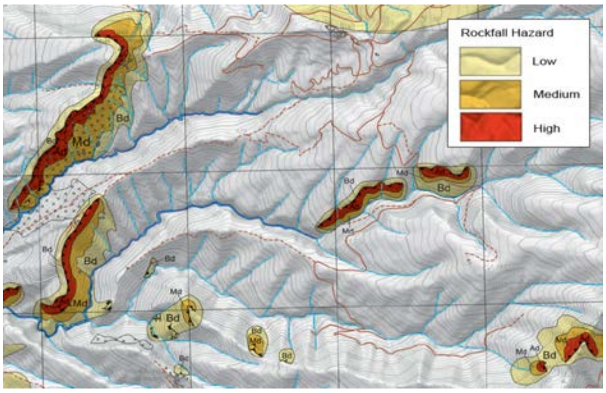

Figure 2 - Rockfall hazard map. Example of Isona (66-23) sheet. The epigraph consists of two characters. The first, in capital letters, indicates the hazard level or rank (A for high hazard, M for medium hazard and B for low hazard), and the second, in lower-case, indicates the type of phenomena (in this example, letter d indicates rockfall).

CONCLUSIONS

The methodology developed for determining the rockfall hazard on the MPRG25M, in which it is ranked as high, medium and low, allows us to obtain a homogeneous and comparable results for the whole territory.

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MONITORING OF THE COSTA CONCORDIA CRUISE SHIP WRECKED ON THE COAST OF GIGLIO ISLAND

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KEY WORDS???

ABSTRACT

On January 13th, 2012 the Cruise flagship Costa Concordia partially sank off the coast of Giglio Island (Tuscany, Italy). During the hours after the sinking, the Search and Rescue (SaR) activities started despite the vessel went into an unstable equilibrium state. The Italian authorities in charge of the emergency management commissioned the Earth Science Department of the University of Firenze to design, arrange and manage an Early Warning System (EWS) with the aim of increasing the safety of SaR operators. Due to the complexity of the scenario and to the lack of similar case studies we decided to use several instruments to improve the reliability of this EWS.

Eight different monitoring instruments were activated and they begun to acquire data within a time frame of 36 hours. All instruments were configured to work in real-time within the Early Warning System (EWS), as the SaR activities involved scuba divers specialists who worked inside the sunk ship for several hours every day. The EWS allowed to enhance the safety of workers and to consequently increase the probability to find survivors.

A big effort was made to simultaneously manage all the instruments composing the monitoring system and the big amount of acquired data; data, in fact, had to be transferred and stored, and, most of all, processed, in order to understand the ship behavior and the associated kinematics. A single synthetic document about the vessel deformation pattern is daily dispatched to all management and operational units involved in SaR operations and recovery of the wreck.

The choice of instruments was made taking into account the characteristics of the scenario and the requirements of the emergency and salvage teams.

The monitoring system was installed in cooperation with a number of Companies and Institutions, and was conceived to detect both fast and slow movements, to improve the EWS reliability and to better understand the long term deformation pattern. Remote sensing technique as Ground Based and Satellite Borne RADAR, Laser Scanning, Topographic Total Stations and Thermal Camera were used together with others, in physical contact with the ship like accelerometers, GPS and Extensometer. A micro-seismic monitoring network was also installed on the coast close to the ship to detect micro-tremors transmitted by vessel deformation events.

Thanks to this integrated monitoring system, deformation maps and images of the ship are retrieved, which show the spatial distribution of detected displacement with high accuracy.

A huge amount of data were collected up to now, these allow us to make several type of correlation between different measurements acquired by whole monitoring instruments.

RECENT FLASH FLOOD IN ITALY: ENVIRONMENTAL IMPACT AND URBAN AREAS PROTECTION

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KEY WORDS???

Over the past three years there have been significant geological disasters, with about 40 victims, from the South to the North of Italy on the coastal and interior areas, crossed by Cumulus Nimbus, in the period between September and November.

On October 1, 2009 the southern part of Messina (SE Sicily) was devastated by intense rainfall (over 200 mm in a few hours which have caused damage and victims in particular to Scaletta Zanclea and Giampilieri Superiore.

The September 9, 2010 event by about 120 mm of rain in less than two hours has created a powerful stream of muddy water that swept the only road of Atrani causing a victim.

On 25 October and November 4, 2011 two exceptional events with over 400 mm in a few hours affected the Cinque Terre and the Lunigiana (the first) and the city of Genoa (second) causing a dozen victims.

The disaster occurred in the Cinque Terre has aroused wonder as the towns of Monterosso and Vernazza were recognized by UNESCO in 1997, world heritage of humanity (582 sites worldwide) with the following motivation: “The Ligurian coastal region in the area of the Cinque Terre is a heritage of high landscape value”.

Today, the Cinque Terre are a National Park and marine protected Area.

The Cinque Terre are described as “a blend of culture, history and immense labours expense over the centuries by its inhabitants to model a hostile territory by building thousands of miles of dry rugged hills.

They are a place where nature and man in complete harmony have built a unique landscape.

Thousands of kilometers of dry stone walls and olive trees planted with vines; countries of medieval origin and cultural heritage of great value; poor

building expansion and few avenues: are the peculiarities of the Cinque Terre.

It was just the man, through a thousand years of work to create this unique landscape made up of terracing steep flanks of mountains, which sometimes come straight to almost touch the sea.

It is said that the environmental safety of the Cinque Terre has been guaranteed in decades of isolation, naturalistic knowledge of the territory and by hard work based on farmer’s engineering genius.

Until they covered the streams which flow through the coastal villages.

Until the farmer’s engineering genius prevailed, the coastal villages were separated by the streams growing right and left bank.

Then came the “modernity”, the era of comfort, economic development, unfortunately not too much “ecomodernity”!

Figure 1

Engineers not farmers have covered the streams to derive, above, a convenient way of penetration.

Often the only way of coastal village. Thanks to these public urban transformation made by engineers not farmers were created the premises for the disaster of 25 October.

Certainly the rain fall has been great, too much to be absorbed by the soil and to be evacuated by the covered streams.

Widespread erosion and landslides involving huge volumes of soil and weathered bedrock with various boulders and trees, powered many muddy-debris flows who have crossed the coastal villages devastating the urban areas.

Similar catastrophic phenomena have occurred recently in Casamicciola Terme (Ischia Island) on November 10, 2009, Atrani (Amalfi Coast) on September 9, 2010, Mili San Pietro (Messina) March 1, 2011, Genova on November 4, 2011.

The events of 25 October and 4 November 2003 showed that the covered streams need river sections much more extensive those that the engineers, non farmer, imposed creating dangerous conditions for human settlements.

Areas that recently and according to geoarcheological data are mainly affected by the crossing of the Cumulus Nimbus are schematically represented in Figure 1.

To avoid victims we propose a new Hydrogeological Instant Alert System.

The research evidenced that the curves recorded in the areas crossed by cumulonimbus are similar and that it is possible the location, in real time, of the beginning of the rainy event that can cause a catastrophe.

From this point there are several tens of minutes to activate the civil protection plan.

It is known what will be the flow path; so it is possible safely put citizens out of danger;.

It is possible to limit the damages in the urban areas by closing doors and windows on the ground floor with watertight doors.

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LONG-TERM CONTINUOUS TOPOGRAPHIC LANDSLIDE MONITORING: CASE STUDIES IN THE APENNINES OF EMILIA ROMAGNA REGION

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KEY WORDS: Landslides, Continuous Monitoring, Automated Total Station

INTRODUCTION

Continuous displacement monitoring can help unrevealing the relationships between landslide displacement and precipitations and can support structural and non structural landslide's risk mitigation strategies. Topographic monitoring networks based on automated total stations (ATS) are consolidated means for continuous monitoring of surface displacement. They can be controlled from remote and can produce near-real time data and processed information.

The contribute deals with long-term ATS monitoring of three landslides in the northern Apennine of Emilia Romagna characterized by quite different movement type and rates: an earth flow moving tens of meters per year, a rockslide moving some dm per year, an earth slide moving some cm per year. They all cause risk to roads and hamlets, and are therefore of relevance for civil protection and land use management policies.

MONITORED SITES AND RESULTS

The monitored sites are located in the northern Apennines of Emilia Romagna in the Secchia river basin (administrative Provinces of Modena and Reggio Emilia): the Valoria earth flow, the Piagneto rock slide, the Succiso earth slide (Fig.1).

Three ATS devices are controlled by integrated software systems located both on sites and on remote location at the University of Modena and Reggio Emilia. Communication between sites and remote control centre is based on GPRS. The ATS's are equipped with Automated Target Recognition (ATR) functionalities.

In Valoria monitoring started in July 2008, with about 30 to 40 prisms measured using an ATR search radius of 5 m and a measuring cycle schedule variable from 3 to 6 hrs.

In Piagneto and Succiso monitoring started in November 2009, with more than 20 prisms in each site. In both sites ATR search radius is 0.5 m and measuring cycle schedule is 6 hrs.

Displacement time series in the Valoria earth slide- earth flow cover several reactivation events during each of which maximum movements in the main flow have been in the order of tens to more than hundred meters (Fig. 2).

Data show that relationships between acceleration, deceleration and rainfall events cumulated in days to weeks are complex, making hard the identification of unique triggering threshold.

Displacement time series in the Piagneto rockslide show cumulated yearly displacements up to 20 cm that have a clear relationship with seasonal rainfall regime (Fig. 2). In this case single rainfall events or even rainfall cumulated in days have a limited effect on displacement velocities.

Displacement time series in the Succiso earth slide show cumulated displacements up to a few cm/year (Fig. 2). They are limitedly affected by seasonal rainfall regime and have little or no relationship with rainfall cumulated in days to weeks.

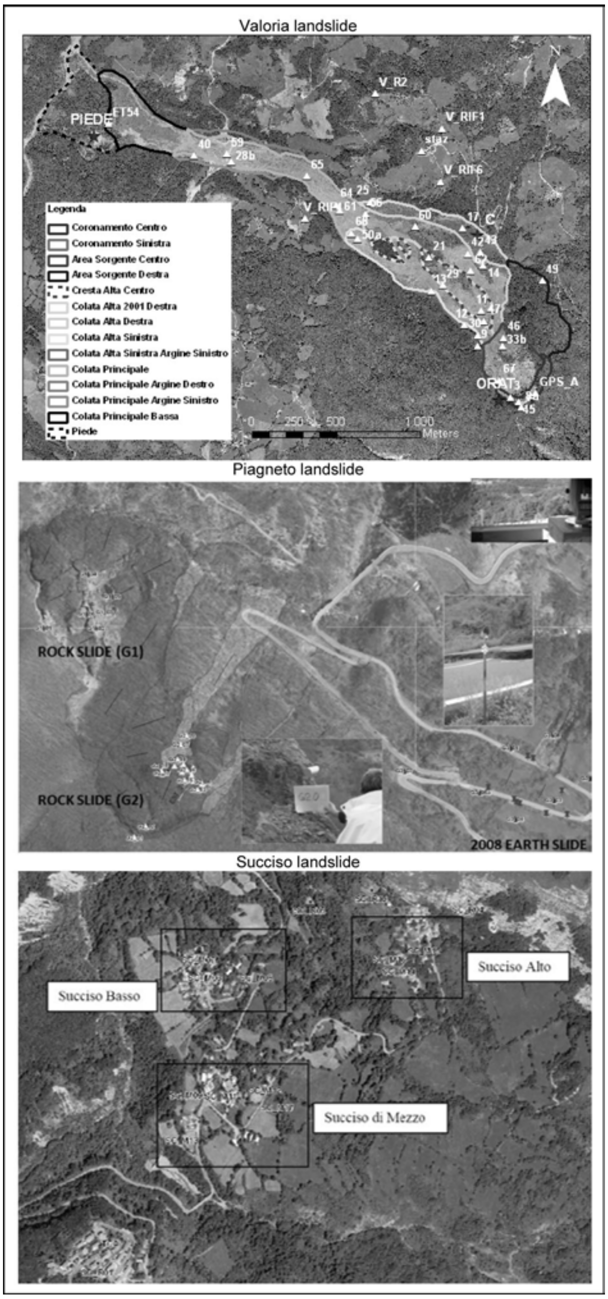

Figure 1 – Monitored landslides

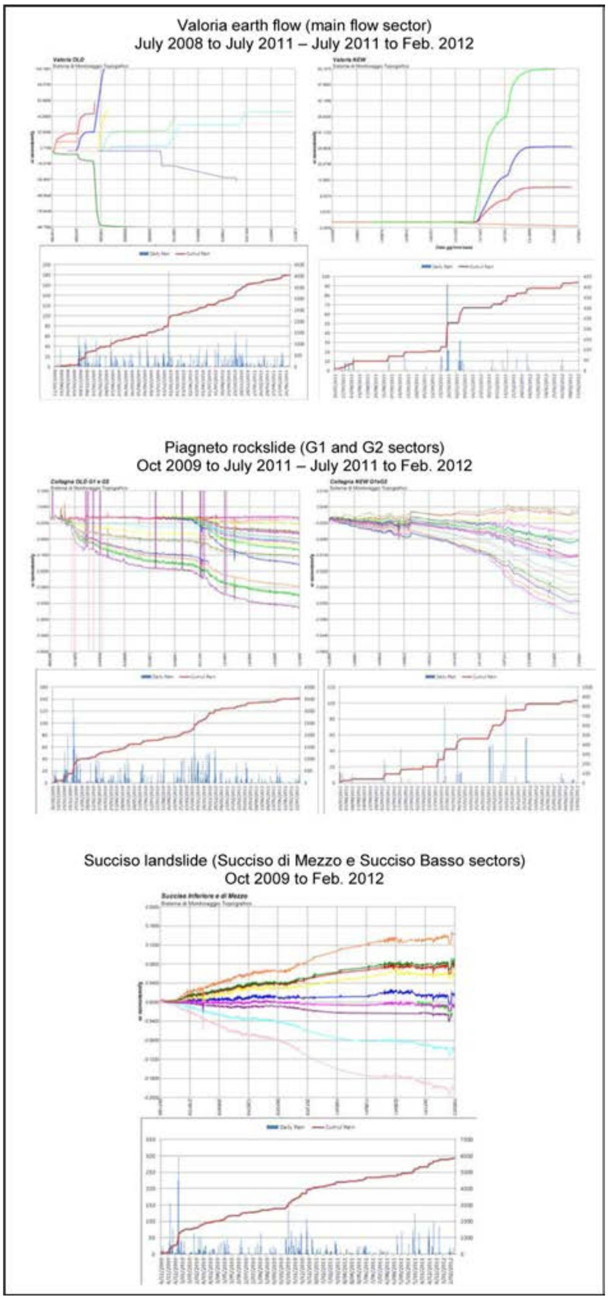

Figure 2 – Examples of displacement plots

As regards practical issues, such as set-up, maintenance and management effort, the experience proved that in relatively fast moving landslides, such as in Valoria, the geotechnical stability of the ATS location and of the reference prisms is not crucial for the interpretation of data as measurement errors in the order of few cm do are orders of magnitude lower than displacement.

At the same time, high mobility of the landslide implies high prism's replacement and re-orientation effort, meaning frequent fieldwork during reactivation events and, sometimes, the impossibility to access the slope because of too softened soil.

On the contrary, in Piagneto and Succiso the stability of the ATS installation and of reference prisms is crucial, as tilting and re-alignment of the ATS results in a non-fixed instrumental centre. This can cause systematic errors that, cumulated in the long term, can be in the same order of magnitude of measured displacements.

Therefore, a correct interpretation of data requires extensive GPS-based field work for periodical check of the stability of the ATS and references, and also an extensive computation effort for post-processing correction of data.

CONCLUSION

The geomorphic and dynamic differences between the monitored sites made it possible to tackle two aspects related to the usage of continuous landslide monitoring using ATS: the differences in relationships between movements and rainfall; the differences in set-up, maintenance and management effort. While the first topic has a direct impact on risk management policies and strategies, the second one must not be underestimated, as it can determine the success or failure of long-term monitoring projects.

ACKNOWLEDGEMENTS

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Authors wish to acknowledge the contribute of several officials of Emilia Romagna Region that at various title contributed to the activities presented in the abstract.

LANDSLIDE MONITORING IN URBAN AREA; REACTIVATING OLD INCLINOMETERS.

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This paper describes the present state of the study in an area affected by a slow landslide movement on the south-eastern slope of Monteverde /Gianicolo Hill in Roma, Italy (Figure1).

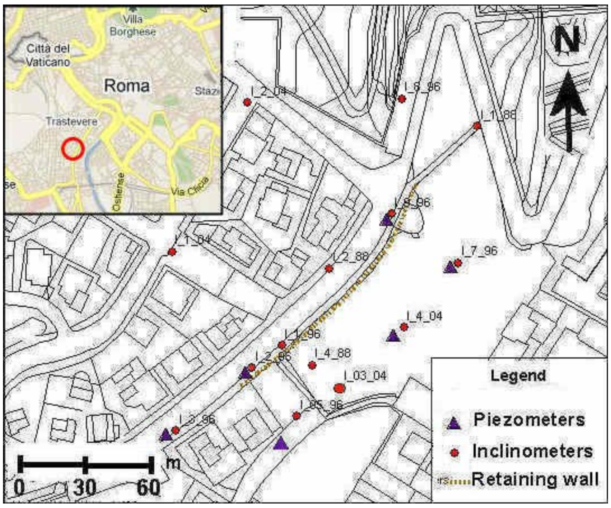

Figure 1 – Location of the studied area and position of instruments

In the last 150 years the slope was heavily modified by human intervention, passing from a sunny vineyard gentle landscape in the second half of 19th century to the present steep hill with a winding road and flights of stairs. Both the top and the foot of the slope are occupied by inhabited buildings.

First slope movements are recorded at the end of the 19th century, while since 1907 to the 80' of the 20th century almost 3 large reactivation occurred (Amanti & Catalano, 2011).

The major event occurred in 1963, when an area of almost 5 hectares was hit by rotational sliding movements which destroyed walls, the main road, Via Aurelio Saffi, the drainage and sewer system, and caused the closure of the area for a long time. No victims are fortunately recorded.

Roma Municipality therefore financed a series of monitoring campaigns (in 1964, 1979, 1988, 1996, 2004) and some retaining works (in 1984-85), mainly consisting in positioning a superficial and deep drainage system and building of a bored pile retaining wall at the foot of the buildings standing on the top (Geosonda, 1983; Amanti & Catalano, 2011).

During the cited monitoring campaigns many instruments were installed on the slope, in particular more then 20 inclinometers and piezometers.

Position	instrument ID	Depth (m)
Via Saffi	I_2_96	28
	I_9_96	29
	I_3_96	30.3
Via Dall'Ongaro	I_5_96	26.5
	I_4_04	24.5
	I_4_88	11
	I_7_96	20.5
	I_3_04	21
Scala Righetto	I_1_88	19

Table 1 – Depths of the monitored instruments

In 2012 Roma Municipality commissioned the Geological Survey of Italy to study the area to evaluate the slope stability, to monitor the prospective movements along the slope and to produce Guidelines for remediation works if needed.

As a first step we decided to check all the existing instruments, to evaluate their present existence, position, functionality and reliability, before starting an actual measurement campaign.

We performed then a difficult research of the original measurement data of 1988, 1996, 2004-2005 and 2009 campaigns, and were able to obtain a large quantity of the previously measured inclinometer logs from technical and scientific papers.

Considering the age of many instruments, as well as their rate of use (only periodic) and the different measuring probes used, a very careful evaluation of the reliability of the old inclinometer measures was mandatory before any new monitoring as suggested by Simeoni (2006).

The re-utilization of instruments installed more than 20 years ago (many of them were also restored in 2004), needed a special care both in measuring and in processing the obtained data.

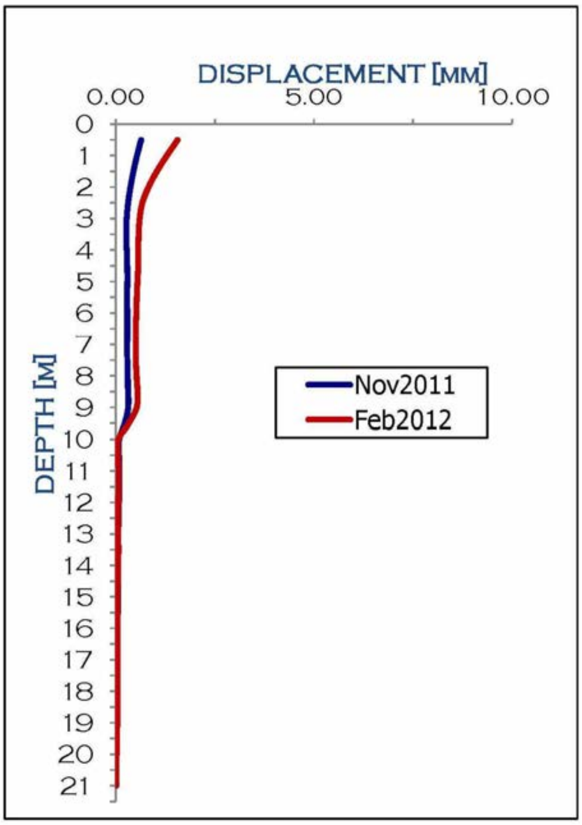

Figure 2 – Cumulate displacement in inclinometer I_3_04 after 4 months.

Analyzing the existing data and comparing them with the ones coming from the present measurement of the 8 still working instruments, it was possible to make some important considerations on the phenomenon in act.

Preliminary results can be described as follow:

- a general trend of movement downhill was present at the time of installation of the equipment and it is still currently measurable;
- movements are small in magnitude and located along the slope in the instruments installed downhill of the bored pile retaining wall built in 1984-85.
- in order to evaluate residual risk, a classification of the measured movements will be possible only after a complete critical review of old measures and a continuous monitoring campaign.

For the current measures we used a statistical approach, according to Simeoni & Mongiovì (2007), in order to evaluate the significance of very small displacements and to define the displacement evolution model of the landslide and surrounding areas.

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LIDAR AND ROBOTIZED TOTAL STATIONS DATA INTEGRATED FOR A 3-D REPRESENTATION: THE MONTAGUTO EARTHFLOW CASE-STUDY

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KEY WORDS: Montaguto landslide, landslide monitoring LiDAR, Robotized Total Station.

INTRODUCTION

The Montaguto landslide is a large earthflow located in the southern Italian Apennines. The slope failure extends for a total length L = 3.1×10^3 m, has an average width W = 4.2×102 m, a total area A = 6.6×105 m^2, and an estimated total landslide volume V = 2.5×106 m^3. We studied the recent geomorphological and kinematic evolution of the earthflow in the 7-year period 2004 – 2011 using complementary information obtained by exploiting different investigation techniques, including: (i) quantitative analysis of six Digital Elevation Models covering the landslide area at irregular intervals in the period from 2004 to June 2011, and (ii) a large set of high accuracy 3-dimensional topographic measurements obtained by three Robotized Total Stations from a dense network of benchmarks located in the landslide area, between 29 April and 31 January 2012. Processing of the high resolution DEMs allowed measuring the amount of material eroded from the landslide crown area (V ~ 1.4×106 m^3) and deposited in the landslide toe area (V ~ 1.2×106 m^3). Analysis of the topographic measurements revealed the kinematical characteristics of different sectors of the active landslides, and allowed the reconstruction of the temporal and spatial surface deformation of the moving earthflow. The insights obtained investigating the Montaguto earthflow are significant for the geo-mechanical modelling of similar earthflows in the same physiographical area, for geomorphological regional landslide mapping, and for the determination of the hazard and risk posed by earthflows in southern Italy.

INTEGRATION OF LIDAR AND RTS DATA FOR A 3D-ANALYSIS

The identification and interpretation of surface displacements plays an important role in many landslide scenarios (Liu et al., 2004; Rizzo & Leggeri, 2004). In these contexts, the use of Robotized Total Stations (RTS) is frequently preferred due to its relatively simple installation, its straightforward operational use and data processing modalities, as well as its limited costs compared with new-generation instruments employed for topographic surveys. By using RTS is possible to retrieve changes of the x, y and z coordinates of a set of targets (usually optical prisms) with sub-centimetre accuracies. Moreover, depending on the number of prisms installed and on the availability of power supply, RTS may allow following the temporal evolution of the surface displacements of a landslide in near-real-time.

In RTS surveys, measurements occur at the point targets only, thus the spatial representation of surface displacements is intrinsically limited. In order to overcome this limitation, especially when the landslide phenomenon presents complex spatial heterogeneities (e.g. areas with different directions and velocities of motion), it is envisaged an accurate planning of the network and an increase of the prisms number installed in the monitored area. Depending on the complexity of the phenomenon, the understanding of its kinematic with the classical visualization of RTS displacement time series might be very difficult. In addition, since the surface displacement monitoring is frequently aimed also at guaranteeing safety conditions of people and/or infrastructures, many operators of different scientific and technical backgrounds collaborate. Therefore, a straightforward and clear representation of the surface displacement evolution in near-real-time is necessary in order to support authorities and decision makers.

In this work, we describe a procedure that allows retrieving in near-real-time three-dimensional models of the surface displacements by using RTS measurements. After the acquisition step, the measurements are opportunely pre-processed and then implemented in 3D surface deformation maps, including also vector arrows representative of their intensity and direction of motion. The procedure may consider different interpolation algorithms and includes also the possibility to take into account as input a set of constraints, which may involve geological and/or structural discontinuities. We first describe the procedure and then we present the results of a real application to the large-scale Montaguto landslide.

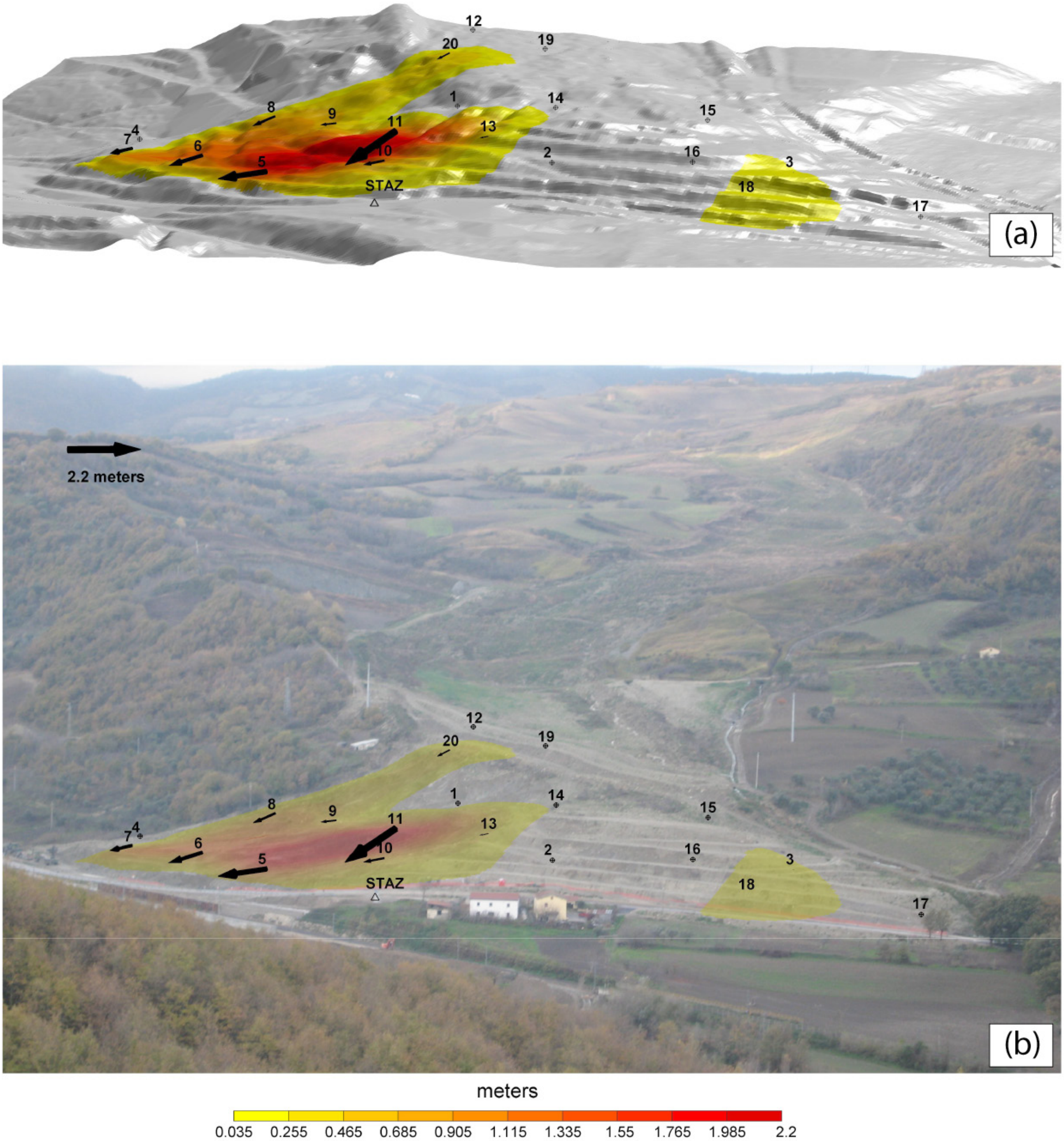

Figure 1 – 3D representation of the surface displacements measured at the Montaguto landslide relevant to February 2011. STAZ is the location of the RTS. Arrows represent the intensity (note scale in Figure top left) and direction of the displacements prism in the corresponding time interval; (a) 3D deformation overlain on a DTM (airborne LiDAR survey June, 2010) of the monitored area; (b) 3D deformation overlain on a picture of the monitored area taken in November 2011.

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LIVING WITH LANDSLIDES: THE ANCONA CASE

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KEY WORDS: real time monitoring, early warning system, risk management, population safety.

INTRODUCTION

The Early Warning system designed by Ancona Municipality is a real excellence.

The instrumentation installed is technologically advanced and combined with the evacuation plan allows the population to live with the landslide, limiting the risk through a 24H active control.

Living with landslide is possible since 2007 thanks to an integrated Early Warning project of Ancona municipality developed by the Geological Unit of the technical office. This unit was created with the scope to let the inhabitants living in their homes without being housed away.

This project follows the 2002 law of the Marche Region, which delegates to Ancona Municipality the issue of a “conditioned habitability” for population living in landslide area under certain conditions: activation of a real time monitoring system and execution of an evacuation plan for people living in the affected area. System reliability comes from redundancy of different technologies used, high specialization of sensors installed and skilled staff on duty H24.

Ancona monitoring system could be defined as a fully integrated Early Warning system which works with sample intervals settable in real time. It is composed by 3 subsystems perfectly linked together: a surface monitoring system, a geotechnical subsurface monitoring system and a landslide data transmission system from sensors in field to the monitoring room.

MONITORING SYSTEMS

Surface monitoring system is composed by 8 automatic total stations with more than 230 reflecting prisms, 34 GPS antennas, both single and double frequency, and 33 surface biaxial inclinometers. **Sensors are placed on 3 control levels:**

The geotechnical system, for subsurface displacement monitoring, is composed by 3 DMS (Differential Monitoring of Stability) multiparametric columns, 86 meters long, installed inside 3 vertical boreholes, 100 meters depth, placed inside the landslide body.

Each module of the column includes a 2D inclinometric sensor and a temperature sensor, moreover at depth -35 and 45 meters two piezometric sensors are installed to monitor the water table. At the bottom of each column a digital compass is installed to control its azimuth.

In 2011 two rain gauges with temperature control and heater have been installed with real time acquisition.

Finally, data transmission system is performed by GSM/GPRS and HyperLan network which guarantees immediate data acquisition to servers in the monitoring room.

EVACUATION PLAN

The whole system is regulated by an evacuation plan drawn by Civil Protection and made known to population.

Briefly, in the unlucky case of landslide activation, a warning alarm would be recorded on the mobile devises of the technicians on duty, available H24. Technician, when recognises the warning, immediately visualizes the graph of the sensor in alarm and makes a first verify, to avoid interferences or errors. Once the warning is verified and validated, the technician calls the head of scientific area that validates the warning. After these controls and displacement validations, the head of scientific area calls the “Direttore di area LL.PP. “ (Public construction manager) and the Major to activate sirens, which order evacuation cause to landslide event.

The entire procedure is performed in less than 30 minutes.

Once the sirens are activated population follows the plan which includes: gathering places, transfer places, police patrols for road enclosure, advises to fire brigade etc…

RELATIONSHIP WITH POPULATION

The EW system is based on signals coming from in field sensors and on the evacuation plan. People living inside the landslide area funded a committee “Comitato Frana”, after the 1982 event, to explain their needs and requests to municipal administration.

Marche region enacts the 5 April 2002 law to guarantee their safety after the start of EWS and evacuation plan. Meetings between the committee, EWS technicians and civil protection staff to inform the population on what will be changed and what to do in case of alarm are hold yearly about the 12th December, 1982 landslide anniversary.

The person in charge of the EWS once a week calls the committee president to know their requests and to schedule site inspections.

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GROUND-BASED IN-SAR MONITORING OF LANDSLIDES IN EMILIA ROMAGNA

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KEY WORDS: landslides, displacement monitoring, ground-based SAR.

INTRODUCTION

Ground-based interferometric SAR (GB-InSAR) has nowadays become a consolidated near-sensing monitoring technique for analysis of slope movements (Antonello et al., 2004; Barla et al., 2010).

Monitoring campaigns spanning from about a week to a moth each were carried out on ten landslides in 2010-11 in the frame a collaborative project between Emilia Romagna Region and the universities of Modena-Reggio Emilia and Bologna.

Specific objectives were: rapid assessment of moving areas and rate of displacement; standardization of installation, data acquisition and processing procedures; analysis of constraining factors of GB-SAR techniques in common landslide types of the Apennine.

MONITORED LANDSLIDES

Monitored landslides were rotational earth slides – earth flows and rock slides causing risk to roads and houses throughout Emilia Romagna Region (Fig. 1).

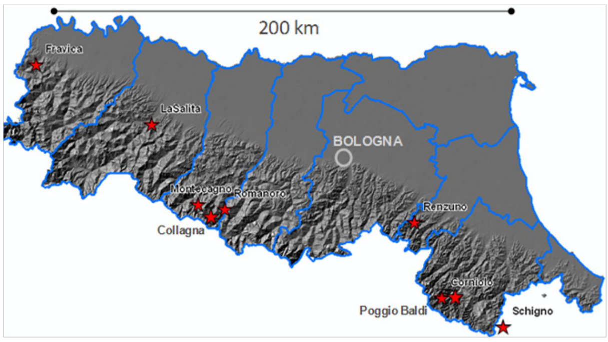

Figure 1 – Location of monitored landslides

Priority was given to recently reactivated or very slow moving mass movements with the aim to identify or exclude rapidly evolving areas and generalized movements. Investigated slopes were in most cases partly vegetated, making GB-InSAR quite challenging.

SEED RESULTS

Results showed that monitoring campaigns of few days to few weeks with GB-InSAR allow the rapid assessment of landslide activity even in partially vegetated slopes, and that radar data can help focalizing and constraining expected landslide scenarios. Some of the analyzed case studies have been presented in previous works (Corsini et al.,2010; Corsini et al., 2011).

A so far unpublished example is the Renzuno rockslide (Fig. 2), were the development of a trench in the upper slope in late march 2010 was pointing to an ongoing evolution of the landslide that might have led to acceleration and collapse of the slope.

Figure 2 – Renzuno landslide (Ravenna)

The survey conducted from 15th to 20th May 2010 allowed excluding such a scenario, evidencing that the rockslide had come to a deceleration and could actually be considered suspended (Fig. 3).

At the same time, the survey highlighted a rapidly evolving area inside the suspended rockslide. Such area was moving without any significant evidence on the surface, and would have probably gone unnoticed without GB-InSAR survey. The analysis of time series outlined that active movements were rapidly responding to rainfall input (Fig. 3). Such behaviour is more distinctive of earth flows than of rockslides. Further field investigation, focused on the moving spot, allowed ascribing the phenomena to an earth slide overlaid to the larger rockslide unit and confirming the scenario of practically suspended rockslide movements.

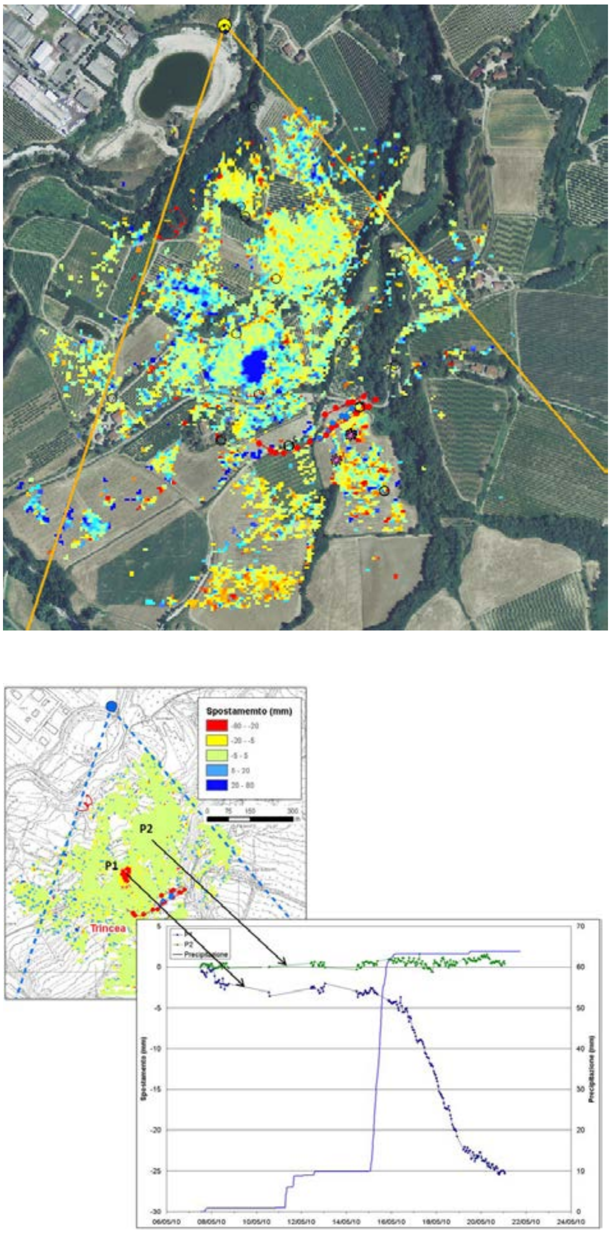

Figure 3 – GB-InSAR results at the Renzuno landslide (Ravenna). Upper: displacement map on ortophoto: blu areas denote "rapidly" evolving zones. Lower: time series of displacement during the survey.

DISCUSSION AND CONCLUSION

The experience gathered by monitoring several landslides with GB-InSAR helped delineating potentiality and criticality of the system in monitoring partially vegetated slopes.

The effect of vegetation shows quite evidently by reducing the number of remaining data-bearing pixels in the monitored scene at the variation of adopted coherence threshold, due to loss of mid-term coherence. At the same time trees can shed some portions of the slope, inhibiting radar the beam to reach the ground. Also, the presence of vegetation affects the estimates of the atmosphere-related phase component. That can result in a certain variability of displacement values in function of the temporal sampling rate of radar scenes.

Nevertheless, results were encouraging from an end-user perspective, as the device and the processing chain proved to be flexible and adaptable to different landslide types and ground conditions.

ACKNOWLEDGEMENTS

The research is part of the activities carried out in the frame of the collaborative project ASPER-RER "Special activities on support to the forecast and emergency planning of Civil Protection with respect to hydrogeological risk" (Regione Emilia Romagna, Università di Modena e Reggio Emilia, Università di Bologna).

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REMOTE SENSING OF LAND USE CHANGES AND LANDSLIDING FROM 1955 TO 2006 IN ROCCHETTA S. ANTONIO, THE DAUNIA APENNINES

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KEY WORDS: Active landslides, Land use, Daunia Apennines, Ikonos

INTRODUCTION

In this work, landsliding and changes in land use from 1955 to 2006 are investigated in an area of the southern Apennines very susceptible to slope instability.

The study area is located in the municipality of Rocchetta Sant'Antonio, (province of Foggia, Apulia region), and it is delimited as the union of sub-basins including the portion of SP99bis road between Rocchetta S. Antonio and the Ofanto river. This road portion is 11-km long and is affected by over 30 landslides. This work builds upon our earlier study on the relative impacts of land use change and climate on landslide activity in the whole municipal territory of Rocchetta Sant'Antonio in the period 1976-2006 (Wasowski et al., 2010), extending the documentation of land use changes and variations in landslide activity until 1955.

The study area covers 15.6 km^2, with elevation between 170 m a.s.l. (near the Ofanto river) and 700 m. The prevalent lithological units are clay-rich, whose relatively poor geotechnical properties result in conditions suitable for landsliding. Sandstones and limestones are sporadic.

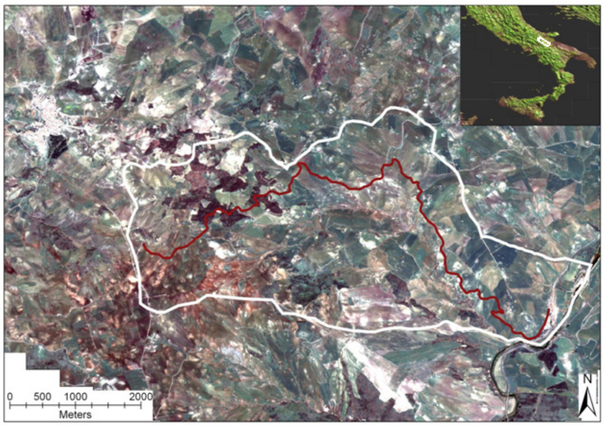

Figure 1 - Ikonos satellite image of the study area. SP99bis road is shown in red. Inset shows location in southern Italy (Daunia Apennines region).

MATERIALS AND METHODS

Historical airphotos of 1955 and 1976 have been used to map landslides and land use at these dates. An Ikonos satellite image (April 2006) with 1-m resolution in pan-sharpened true color visualization has been used to map recent landsliding. Recent (2002 to 2006) airphotos allowed refining the land use map derived from a semi-automatic classification of an ASTER image from 2000. Technical cartography (1:5000) and a 4-m resolution DEM were also employed. The analyses were performed in a GIS where all the data were organized. In particular, the Ikonos image was draped over the DEM and visualized in 3D, thus partially supplying to the lack of stereoscopy.

RESULTS

In Tab. 1 the results of the landslide inventories are summarized. A strong increase in the landslide areal frequency in 2006 is evident: even more evident is the increment of landslide density. This last result is partially explained considering the use of different observation techniques, with the Ikonos image allowing the detection of smaller landslides or resolving large mass movements into smaller coalescent landslides. However, the analysis of landslide density over the whole municipality area of 72 km^2 (Lamanna et al., 2009), where data from 1976 and 2006 are very similar to the results on the 16 km^2 study area, confirms the significance of the areal frequency increment between 1976 and 2006.

Year	*Active landslides*		*Inactive landslides*	
	%	n°/km^2	%	n°/km^2
1955	1,53	3,28	11,01	5,57
1976	2,12	7,93	6,86	7,99
2006	5,6	60,3	1,8	10,4

Table 1 - Areal frequency (%) and density (n°/km^2) of landslides in the 15.6 km^2 study area.

On the contrary, the lack of stereoscopy in the 2006 image limited the detection of inactive landslides, and the corresponding results have to be considered underestimated, although the incidence of reactivations in 2006 could have reduced the areal frequency of inactive landslides.

Given that all the three landslide inventories followed rainy seasons (autumn-winter) with comparable precipitation, the results were investigated considering their distribution with respect to land use and slope.

Tab. 2 shows the land use in the study area at the dates of landslide inventories. Three classes are considered: sown fields (mainly for wheat cultivation), trees and "other" (mostly grassland pasture-dominated).

Year	sown fields	trees	other
1955	25.7%	9.4%	64.9%
1976	49.3%	7.5%	43.2%
2006	75.6%	7.0%	17.4%

Table 2 - Land use statistics for the dates of landslide inventories.

The results demonstrate a pronounced change from the grassland pasture-dominated land use (over 60%) in 1955 to the wheat-based agriculture (over 75% of land) by 2006.

The highest susceptibility to shallow landsliding (areal frequency over 10%) is recently registered on the sown fields, which initially (1955) have been used for pasture and grazing. Furthermore, the data reveal that with time the steeper and apparently more landslide-prone grassland pasture have been given over to new wheat cultivation. If the incidence of sown field is calculated for each slope class, it is found that in 1955 the incidence of sown fields in the class 10°-15° was relatively low (below 20%) and negligible above 15°. In 1976 sown fields covered more than 40% of the area between 10° and 15°, but their extension over 15° is still very low. In 2006 more than 70% of the 10°-15° class is cultivated, as well as 45% of the class 15°-20° and nearly 30% of slopes exceeding 20°. This indicates that the extension of sown field between 1955 and 1976 regarded moderate slopes and agricultural practices with limited impact on local drainage and soil strength. However, after 1976, following UE incentives, durum wheat cultivations were extended also on very steep slopes, and on areas already susceptible to instability.

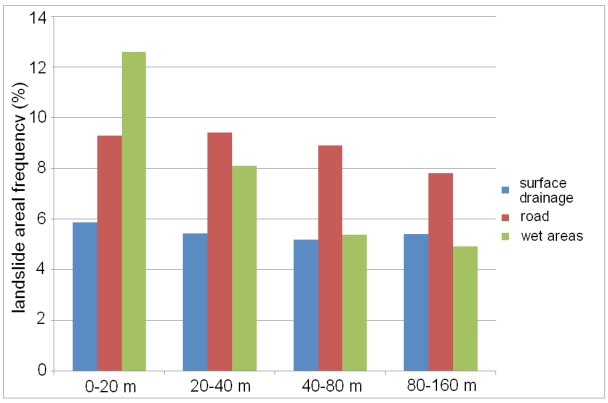

Figure 2 - Areal frequency of landslides in buffers around surface drainage, road and wet areas.

In fig. 2 the areal frequency of landslides is shown considering different buffers around three types of surface features: natural surface drainage network, SP99bis road, wet areas mapped from the IKONOS image. It can be observed that the landslide incidence in the buffers around the road is significantly higher than the average; the increment in landslide areal frequency near the wet areas is even more evident, but it concentrates in their immediate proximity (< 40 m). The natural drainage network seems uncorrelated to the landslide distribution: this result is different from that found on the whole 72 km^2 municipality area (Lamanna et al., 2009); a possible explanation is that the natural drainage is significantly altered by the road.

CONCLUSIONS

The observed relations between increased landslide susceptibility, cultivation on steep slopes, wet zones (mostly associated to very shallow groundwater) and the road track suggest that the anthropic action can influence stability conditions modifying both surface-groundwater interaction and soil mechanical properties.

The modification of the existing cover from the all-year-present grass to the wheat characterized by a few month growth period per year can affect the soil-water balance and, therefore, groundwater levels and effective strengths of slope materials. The strengths of soils can also be negatively influenced by the mechanical disturbance caused by tillage. Therefore, the introduction of ploughing for the new wheat cultivation on the often steep slopes that had originally been covered by grass is considered to be a likely factor of the increased susceptibility to landsliding. The reconstruction of the changes in land use and the associated increases in slope failure frequency thus offers a useful historical perspective to soil degradation risks and poses questions on the long-term sustainability of wheat agriculture in the southern Apennines, as well as in other mountainous areas potentially susceptible to widespread landsliding.

ACKNOWLEDGEMENTS

Thanks are due to Amedeo Magnotta (1966-2012), an architect and local administrator who cared very much for the sustainable development and land management in the Daunia Apennines. We will miss his know-how, enthusiasm and, most of all, friendship.

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DISPLACEMENT ASSESSMENT BY VECTOR-BASED GIS POST PROCESSING OF RADAR SATELLITE DATA FOR LANDSLIDE DETECTION AND INVENTORY: A COMPARISON OF RESULTS FROM LARGE ALPINE AND APENNINE DATASETS

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KEY WORDS: Landslide detection, Landslide inventory, GIS, South Tyrol, Emilia Romagna region, Permanent Scatterers, Radar Interferometry.

INTRODUCTION

Within the last decade, researches aimed at landslide detection and inventories were upgraded by using data derived by remote sensing, and more specifically by Synthetic Aperture Radar interferometry (InSAR). At present, large datasets are available for the entire national territory from the PST-A (Piano Straordinario di Telerilevamento Ambientale) and from several specific demonstration and application projects.

An open issue is still the post-processing of Line of Sight (LoS) displacement data derived from different satellites and orbits in order to obtain integrated datasets in which displacement is referred to the planar and vertical components and/or slope movement direction.

This work shows an original suite of GIS-based tools that can contribute solving such problems and can improve the usability of PSI (Persistent Scatterers Interferometry) datasets for landslide detection and inventories from a regional to a site specific scale.

BACKGROUND

PSI-based displacement data are mono-dimensional along the LoS of the satellite. The module and sign of LoS displacement is therefore dependent on the relationships between acquisition geometry, topographic aspect and slope and the real direction of movement. This is critical when dealing with landslides, as only a fraction of slope movement component can be captured in the LoS. Moreover, the same slope movements can be recorded by PSI with opposite sign and different module from ascending and descending orbits, making the interpretation of slope dynamics on that basis not immediately intelligible.

Datasets should therefore be post-processed in order to homogenize information and to extract the most significant data on a geomorphic perspective. A raster based approach to extract slope-direction movements from single orbits and to combine ascending and descending dataset has been proposed as nation-wide guidelines (Ciminelli et al, 2009). Being raster based, that approach risks to couple PSs belonging to very different slope surfaces and, possibly, slope instability phenomena. This work presents a vector-based approach that extends and integrates the above mentioned procedures, in order to account more specifically for topographic and geomorphic conditions of slopes in regional and site-specific landslides analysis.

VECTOR-BASED GIS POST-PROCESSING TOOLS

A suite of GIS tools for post processing PSI data has been developed for filtering and homogenizing displacement data on a vector-basis.

A first tool allows combining velocities obtained from ascending and descending orbit. Coupling of PSs pairs from different orbits (one PS ascending with one PS descending) is based on geometric relationships between neighbour points (i.e. minimal relevant distance customized by the user) as well as their similarity in terms of morphological conditions (determined by aspect and slope classes customized by the user). Once the two PSs are reduced to a single combined PS (spatially located at intermediate position between the two parent PSs), the East-West and the Vertical component of displacement are calculated by using the same projection rules described in literature (Ciminelli et al, 2009). The tool inputs are: θ_{Asc}, being the angle between the satellite azimuth in ascending geometry and the Geographic North; θ_{Desc}, being the angle between the satellite azimuth in descending geometry and the Geographic North; δ_{Asc}, being the angle between the incidence angle of the electromagnetic wave emitted by the satellite in ascending geometry and the ground nadir; δ_{Desc}, being the angle between the incidence angle of the electromagnetic wave emitted by the satellite in descending geometry and the ground nadir; the GIS vector file, containing PS coupled from ascending and descending geometry, according to the geometric and geomorphic rules described above.

A second tool allows re-projecting velocities along slope direction when only a single orbit is available. As an evolution of the re-projection method described by Ciminelli et al (2009), it assumes that displacement occurs along the dip direction of the slope surface but it applies to PSs filtered by means of rules based on simple statistical analysis and morphological criteria. PSs assumed to move in direction close to the perpendicular to the LoS are excluded from the analysis since they will probably return misleading results (e.g. large overestimates of displacements in relation to small angular uncertainties). The inputs are: Digital Elevation Model (DEM); θ, being the angle between the satellite azimuth (in ascending or descending geometry) and the Geographic North; δ, being the angle between the incidence angle of the electromagnetic wave emitted by the satellite (in ascending or descending) geometry and the ground nadir; the GIS file containing PS in one single geometry (ascending or descending).

TEST DATASETS

GIS based post-processing tools have been tested with two large PS datasets covering very different Alpine and Appennine geological contexts: the western sector of South Tyrol (10.000 km^2) and the Emilia Romagna Region (22.500 km^2). Examined datasets consist in SqueeSAR™ data from a specific project carried out in South Tyrol and PS-inSAR™ from PST-A (“Piano Straordinario di Telerilevamento Ambientale”), that are based on different C-band satellite SAR sensors (Radarsat-1, EnviSat and ERS).

CONCLUSION

The application of the vector-based GIS tools to the test datasets has demonstrated its effectiveness in reducing the dataset preserving, at the same time, the relevant and more statistically significant data that can be used as kinematic indicators. Both tools were successful in improving the geomorphic significance of the resulting reduced dataset, and in producing simplified velocity field maps, depurated of measurements referring to uncorrelated morpho-dynamic conditions.

Moreover, the implementation of tools in GIS environment results to be user friendly, easing the procedure of PSI dataset post-processing, with a particular advantage for community of hazard mapping experts with limited experience in SAR-based multi-interferometry techniques.

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SLOPE STABILITY PROBLEMS IN NORTH – EAST PART OF TEHRAN, IRAN

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KEY WORDS: Landslides, Rock Slide, Slope Stability, Morphology.

INTRODUCTION

Instability of soil and rock slopes in North East part of Tehran is one of the most important problems that every year causes enormous damages to the surrounding building, Villas and the main access road in this region. The study area is located in North East part of Tehran along the Zardband - Fasham road. Different parameters such as lithology, climate, human activities, topography and geomorphology are affected on the instability of slopes in this region (Nasiri 2004). The most important types of instability are debris slide, rock fall, toppling and rock slides. Among these types, debris slides and rock slides are the most common in frequent (Nasiri & Rezai 2004).

GEOMORPHOLOGY AND GEOLOGICAL SETTING OF THE STUDY AREA

Shemiran city is located in North East of Tehran. It has two parts: First part is in East and second is Roudbar-Ghasran in West part of Shemiranat. Roudbar-Ghasran is located in central part of Alborz Mountains which is limited to the Mazandaran Province from the North and limited to Shemiranat from the South. The highest point of the Roudbar-Ghasran (Kolonbastak Mountains) is 4000m above the sea level. Study area is a part of 1/100000 geological map which is prepared by Geological Society of Iran and contains Tehran and Fasham regions Geological units. Location of the study area is shown in Figure 1. The study area is located in Middel Tuff (Etk) unit. With Green Tuff (Karaj Tuffs), Tuffy shale, a little bit Lava and Braccia.

The Study of Instability Risk through the Fasham – Maygon Region

Based on the studies by Nasiri (2004) in the study area, Zardband – Maygon road is recognized as a region with high and very high risky landslides. According to Nasiri`s studies, most of the risky areas are located in residential zones, linear constructions or agricultural plains. Figure 2 shows the position of the highly risk stations which are studied in this research. It should be noted that the first station is located near Amin-Abad village. Based on the results from field studies and slope stability analysis, it has the potential of debris slide. Figure 3 shows a general view of the first station.

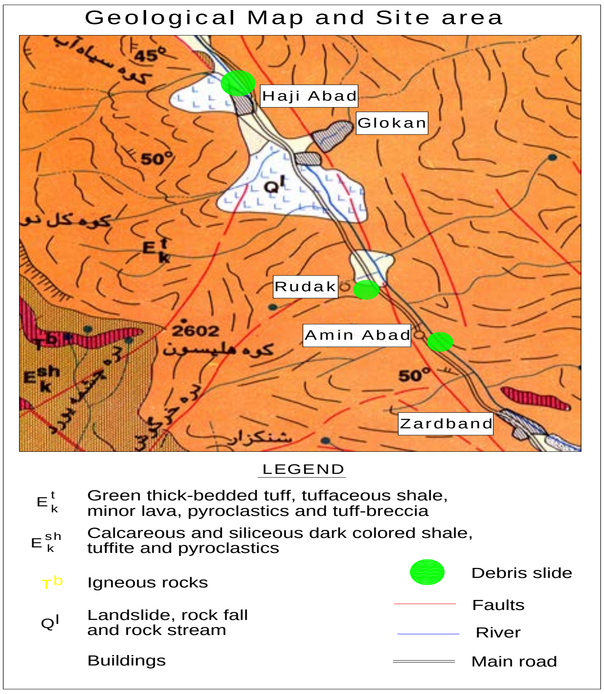

Figure 1 – Geological map of the study area. Geological Society of Iran (1997).

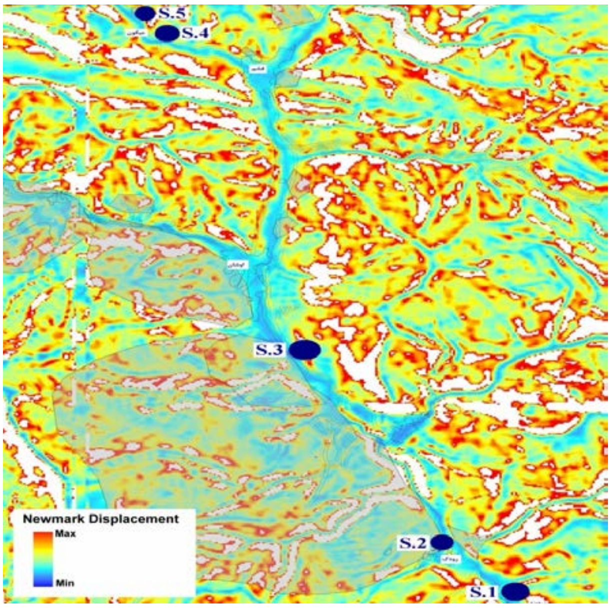

Figure 2 – Location of S_1-S_5 stations in the study area. Nasiri & Rezai (2004).

Figure 3 - A general view of first station.

The second station is located near the Varjin village. General slope in this area is 35º and it has a potential of debris slide.

Figure 4 – A general view of second station

The third station is located near the Haji-Abad village where large scale landslide occurred in March 2004. General slope in this station is 30º and the slide was a debris one. Figure 6 shows a general view of station 4.

Figure 5 – A general view of third station.

Figure 6 – A general view of station 4 (Maygon area).

CONCLUSIONS

The main aim of engineering geological investigations in this research was, recognition of relationships between the parameters affecting to instability of slopes. Both field investigations and a comprehensive laboratory tests have been carried out in order to asses the potential of instability of s_1-s_5 stations in the study area. According to the results, geotechnical properties, climate conditions, topography, lithology, hydrology and hydrogeology are the most important factors affecting to the instability of slopes in the study area. It should be noted that, other parameters such as rock cutting and trenching, excavation and removing of the toe of the slopes, lack of the vegetation and plants, and variations in natural drainages are additional factors affecting to the instability of slopes in this region. Because of some limitation the results of computational analysis are express here but, some valuable software such as Dips (V.5.0), Slide (V.5.0), Swedge and RocPlane (V.5.0) have been employed for the stability computational analysis of the slopes.

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LANDSLIDE AND ALLUVIAL HAZARD HIGH-RESOLUTION MAPPING OF THE SOMMA-VESUVIUS VOLCANO BY MEANS OF DTM, REMOTE SENSING, GEOPHYSICAL AND GEOMORPHOLOGICAL DATA GIS-BASED APPROACH.

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KEY WORDS: Landslides, lahar, Somma-Vesuvius, DTM, GIS.

The aim of this paper is to recognize and map the Somma-Vesuvius volcano landslide-prone areas by means of multi-disciplinary terrain analysis and classification; in detail, high-resolution DTM of landslides areas occurred over long time periods, remote sensing, and geophysical and geomorphological data are presented for assessing hydrogeological hazard parameters of this volcanic district.

The Somma-Vesuvius volcano, due to its explosive volcanism and the dense urbanization of the surrounding area with a population exceeding 650,000, is one of the most dangerous active volcanoes of the world. The main hazard of the perivolcanic area is associated to effusive eruptions and explosive Plinian and sub-Plinian eruptions, alternated to long-lasting quiescence periods.

Moreover, additional hazard is related to lahars: flows of unconsolidated debris and water that typically include fragments of volcanic origin, colluvium, and soil. The features of lahars can range from debris flow to hyperconcentrated flow. The most important lahars phenomena of the Somma-Vesuvius occurred with the main historical eruptions of 79 A.D., 472 A.D., and 1631 (Mastrolorenzo et al. 2002; Rosi et al. 1993; Rosi et al. 1996). Recently, remobilization of the pyroclastic cover has produced several debris flows and alluvial phenomena that invaded the surrounding plains affecting towns and roads.

Our methodological approach is based on landslides data recognizing and mapping both from geological maps, papers, historical chronicles, and from aerial photos, orthophoto, and available DTM image analysis of the Somma-Vesuvius complex. Through detailed study of this material the main landslides depositional areas have been surveyed; moreover, other geophysical and geomorphological parameters have been considered jointly with the landslides occurrence in order to correlate and interpret the soil movements phenomena. The analysis of several space-time series of data, together with the updated territorial information has been carried out through the Geographic Information System (GIS) (software ArcGIs 9.3), in order to store, manage and process large amount of spatial data.

Finally, the achievement of landslide hazard high-resolution mapping of the Somma-Vesuvius volcano is performed in this paper through investigation of the flowslides deposits (lahar) of this area (Di Crescenzo et al. 2008). Actually, the recent heavy urbanization of landslide-prone areas has increased their vulnerability, consequently buildings and infrastructure could be seriously damaged and safety of the people endangered (Davoli et al., 2001). Therefore the obtained maps are necessary for identifying the future inundation areas and for evaluating the possible hydrogeological risk scenarios

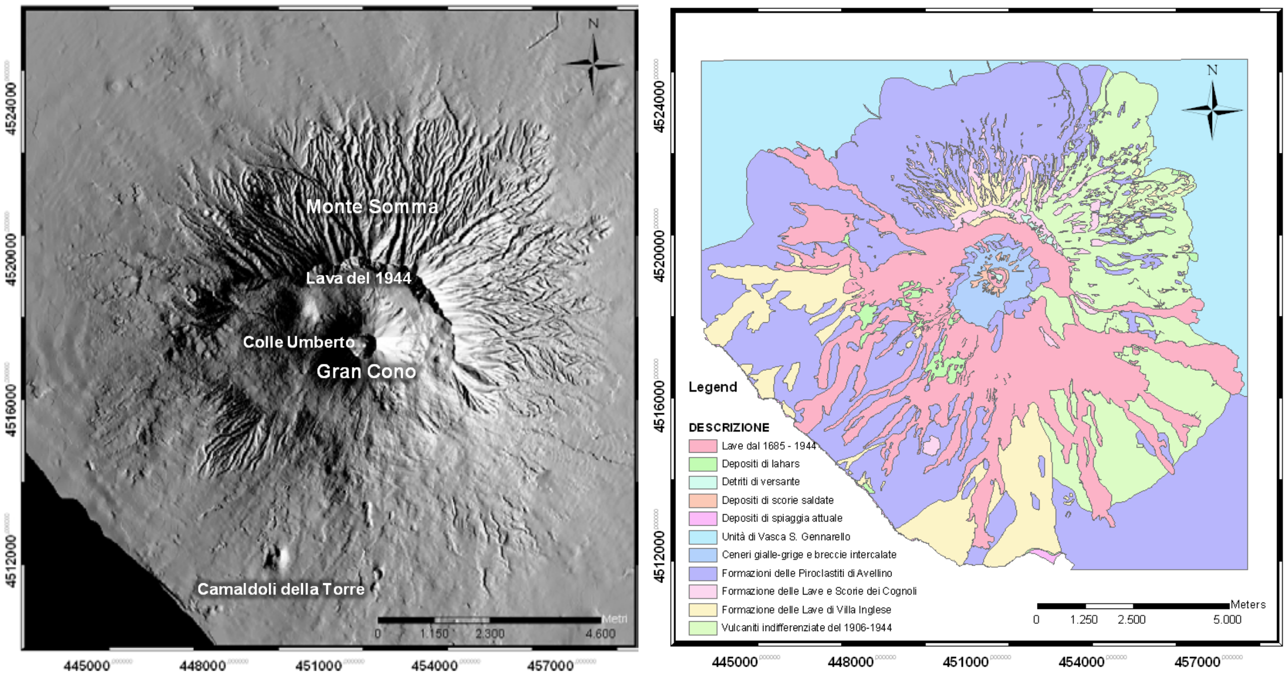

Figure 1 - Shaded relief of Somma-Vesuvius volcanic complex and geological map modified from Santacroce et al., 2003.

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LANDSLIDE HAZARD ASSESSMENT IN SICILY: EXPERIENCES AND FUTURE PROGRAMME

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KEY WORDS: risk analysis, risk management, regional planning.

ABSTRACT

The Regional administration of Sicily realized, between 2003 and 2007, the first edition of the "Piano Stralcio per l'Assetto Idrogeologico (P.A.I.)", an administrative plan concerning 107 hydrographic units, able to address land use authorization and programming national investments for the mitigation of landslide risk.

Over 32.000 landslides and geomorphological processes has been classified and they intercept more than 23.000 elements at risk.

The census activities, the hazard and risk evaluation and the design and printing of 1:10.000 scale maps, has been realized with internal personals and within the collaboration of Local Authorities and The Regional Civil Protection.

The evaluation from field experiences and data statistical analysis provide an overview able to address the methodological approach, the work organization and legal regulatory requirements to tackle the main problems encountered in relation to:

- natural characteristics,
- interferences between anthropogenic and natural dynamics and;
- weaknesses of the administration.

Based on the analysis of local situations and the comparison with the experiences of many Italian Basin Authority and the scientific community could be identified some areas and arguments of activities, in specific:

- an in depth study on landscape mapping methodologies,
- a program of institutional activities to increment the coordination of land use policies and
- proposals to improve the administrative structure designed to manage risk

The analysis have made possible to identify the main geomorphological characters of the Sicilian territory and to define areas particularly exposed from the evolutionary dynamics of the slopes.

Between the determined parameters, it was possible to verify that starting from winter 2005-2006 there was an increase of meteorological extreme phenomena with highly dangerous phenomena in terms of speed and dimension.

The poster illustrates two aspects of the actual renovation process of the landslide hazard assessment in the region of Sicily: first, the analysis of the data collected and the definition of logical framework approach to adopt the correct methodologies useful to better define the susceptibility of the territory; second, the measures in place for in-depth activities to be developed in sample areas.

Such pilot activities will be able to establish which choices are useful and place them in a functional administrative structure, taking into account the sustainability of the system as a whole.

Some graphs and maps illustrate the results of the statistical analysis and the territorial connections between the predisposing factors and the landslide and the erosion phenomena distribution.

Among the activities undertaken, for the needed methodological examination, are mentioned and explicated some ongoing experiences with the Municipality of Messina that has commissioned to the ENEA and Messina University a study on landslide susceptibility and on hydraulic hazard, according to the European Directive on risk floods management. The pilot area is one of the most risk area of Sicily.

A further experimentation started between the Regional Administration and the University of Palermo with the project SUFRA_SICILIA; pilot Project for the realization of multilevel cartography of landslide susceptibility in Sicily. The first step is located in the Imera river catchment.

ACKNOWLEDGEMENTS

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CORRELATION ANALYSIS BETWEEN RAINFALL CHARACTERISTICS, TOPOGRAPHICAL FEATURES AND LANDSLIDES

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KEY WORDS: landslide, rainfall, topographical features.

INTRODUCTION

In Korea, small and large landslides occur during the period of a typoon and a heavy rainfall every year. In recent years, unusual weather phenomena have caused a huge increase in the daily precipitation, which in turn has led to a increase in the scale of landslide damage. In 2011, causalties caused by heavy rainfall increased significantly during the rainy season, compared to previous year. Landslides mainly occur in areas with vulnerable geological and soil conditions hugely affected by frequent typoons and heavy rainfall. However, as a result of field survey on the rainfall conditions, it tunred out that there are some cases where landslides occur even in areas with the small amount of rainfall, which indicates that there may be another cause of the landslide occurrence. In this study, the effect of topographic conditions on the landslides is to be evaluated through the analysis of rainfall characteristics and topographical features.

RESULTS AND DISCUSSION

For analysis, data on the landslide occurrence were collected, and the rainfall-related materials of the landslide points were surveyed. Research on the rainfall was carried out based on the landslide data collected from 24 locations from 2004 to 2010, targeting 7 days of rainfall befoe and after the landslide occurrence(Refer to Table 1).

Table 1. Landslide area and rainfall

No.	Year	Date	Location	7 days of rainfall (before and after the landslide occurrence) (mm)							Total (mm)	Rainfall measurement points
				4 days before the collapse	3 days before the collapse	2 days before the collapse	1 day before the collapse	Date of the landslide collapse	1 day after the collapse	2 days after the collapse		
1	2005	August 10	Sa-ri, Sicheon-myeon, Sancheong-gun, Gyeongsangnam-do	16	0.1	0.5	1.0	84.5	27.0	1.5	130.6	Jinju
2		Auguest 5	Gongjin-ri, Anseong-myeon, Muju-gun, Jeollabuk-do	0	1	0.0	1.5	19.5	2.0	7.0	31.0	Jeongju
3		August 19	Haesanryeong, Pungsan-ri, Hwacheon-eup, Hwacheon-gun, Gangwon-do	0	0	4.0	8.0	49.5	0.5	0.0	62.0	Chuncheon
4	2006	July 16	Namjeon-ri, Nam-myeon, Inje-gun, Gangwon-do	2.5	176.5	8.0	63.0	202.0	130.5	17.5	600.0	Inje
5		July 10	Mandeok 2-dong, Buk-gu, Busan	0	0	30.5	136.5	134.0	12.5	26.5	340.0	Changwon
6		July 9	Mt. Bulmo, Yongho-dong, Euichang-gu, Changwon, Gyeongsangnam-do	0	0	30.5	136.5	134.0	12.5	26.5	340.0	Changwon
7		July 18	Wonsan-ri, Byeonggok-myeon, Hamyang-gun, Gyeongsangnam-do	0	42	4.0	7.0	72.5	25.0	10.0	160.5	Namwon
8	2007	September 16	Ongam-ri, Daedeok-myeon, Jangheung-gun, Jeollanam-do	0	0	16.5	50.5	102.0	3.0	0.0	172.0	Mokpo
9	2008	July 25	Naechon-myeon, Hongcheon-gun, Gangwon-do	11.5	1.5	0.0	0.5	184.5	37.0	2.5	237.5	Wonju
10			Gyeran-ri, Susan-myeon, Jecheon, Chungcheongbuk-do	13.5	1	3.5	0.5	96.5	32.5	3.0	150.5	Jecheon
11		August 15	Jangmok-ri, Jangmok-myeon, Geoje, Gyeongsangnam-do	0.1	20	0.3	53.0	77.0	5.0	0.0	155.4	Geoje
12	2009	July 16	Sim-ri, Gusan-myeon, Masan, Gyeongsangnam-do	7.5	79.5	5.0	86.5	189.5	0.0	0.0	368.0	Changwon
13		July 14	Gyeongchun National Road, Guam-ri, Namyangju, Gyeonggi-do	0	2	102.0	3.0	143.5	0.0	7.0	257.5	Dongducheon
14			Wasu-ri, Seo-myeon, Cherwon-gun, Gangwon-do	0	1.5	102.0	3.0	132.5	0.5	0.0	239.5	Gherwon
15			Dongdeok-ri, Yeongok-myeon, Gangneung, Gangwon-do	0	132	0.0	0.5	132.0	0.0	29.0	293.5	Gangneung
16	2010	August 13	Yijeon-ri, Bibong-myeon, Wanju-gun, Jeollabuk-do	0	28.5	24.0	0.1	128.5	0.5	83.0	264.6	Jeonju
17			Yeosan-myeon, Iksan, Jeollabuk-do	0	19.5	1.5	3.0	112.0	75.0	28.5	239.5	Gunsan
18		September 21	Mungok-ri, Buk-myeon, Yeongwol-gun, Gangwon-do	0	0	9.0	23.5	139.5	2.0	0.1	174.1	Jecheon
19		July 17	Baekryeon village, Yeonsan-dong, Mokpo, Jeollanam-do	9	0	0.0	26.5	64.5	0.0	0.0	100.0	Mokpo
20			Hwaam-ri, Unsu-myeon, Goryeong-gun, Gyeongsangbuk-do	18.5	0	0.0	0.4	97.0	9.5	0.0	125.4	Milyang
21		July 16	Omi-ri, Myeongseok-myeon, Jinju, Gyeongsangnam-do	1.5	25	0.0	3.5	165.5	4.0	0.0	199.5	Jinju
22		August 14	Gangyeon-ri, Iljik-myeon, Anong, Gyeongsangbuk-do	2.5	45.5	32.5	0.0	86.5	24.5	48.5	240.0	Andong
23		July 11	Hoengcheon-myeon, Hadong-gun, Gyeongsangnam-do	0	0	0.0	5.5	148.0	1.5	25.0	180.0	Jinju
24		July 10	Wangji-dong, Suncheon, Jeollanam-do	0	0	0.0	11.5	154.5	2.5	11.5	180.0	Suncheon

As shwon in Table 1, 15 locations had over 100mm of rainfall on the day of the landslide occurrence, and the preceding rainfall was maintained at 26.5mm to 53mm in 4 locations among areas with less than 100 mm of rainfall. The results of the previous studies found that the landslides occur from 200mm rainfall conditions when applied to association with rainfall to landslie prone areas. From this study results, there were 16 locations with the cumulative rainfall of more than 150mm. It is well known that landslides are caused by combination of internal and external factors, but thiis study suggests there is a high probability that various internal factors such as geology, topography and vegetation characteristics have a larger effect on the landslide occurrence than rainfall factors in case of the areas with the cumulative rainfall of less than 150mm.

To evaluate topographical features of landslide areas, address and GPS location information of 4 sites where landslides occured in 2011 was collected from the data on the location of the landslide sites (Refer to Table 2). As shwon in Table 2, causalties including deaths have frequently occurred in the recent landslides.

Table 2. Landslide area and damage status

No.	The place of occurrence	Location information		Causalties			Remarks
		Latitude	Longitude	Death	Injury	Disappearance	
1	Singok-ri, Sangdong-myeon, Milyang, Gyeongsangnam-do	35° 35′22.1″	128° 49′16.2″	3		1	A
2	Hoesin-ri, Okjong-myeon, Hadong-gun, Gyeongsangnam-do	35° 11′21.9″	127° 50′10.8″	2			B
3	Yijeon-ri, Bibong-myeon, Wanju-gun, Jeollabuk-do	36° 00′34.5″	127° 12′17.0″	1			C
4	Daebang-ri, Subuk-myeon, Damyang-gun, Jeollanam-do	35° 19′01.9″	126° 53′43.8″		12		D

Figure 1 shows the landslide locations in the topographical maps of landslide areas using GPS coordinates of Table 2. As shwon in Figure 1, landslides mainly occured in valley type terrain (a, d) and areas with relatively severe terrain curvatures(b, c).

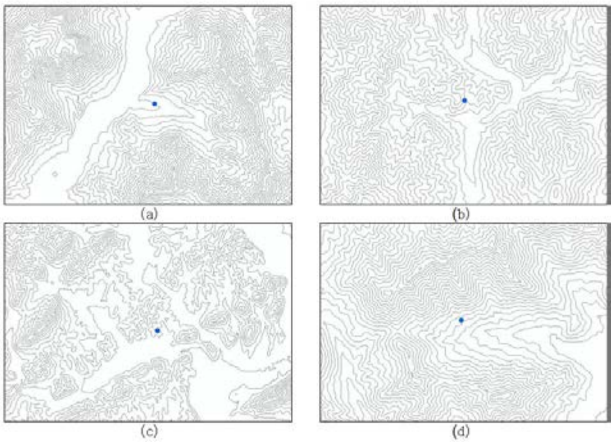

Fig. 1 Topographical feature of landslide area

CONCLUSIONS AND FUTURE RESEARCH CONTENTS

A localized torrential downpour and a heavy rainfall are blamed as major causes of the landslide occurrence. However, it turned out that there are some areas where landslides occur despite low rainfall, and in these areas, internal factors such as geology, topography and vegitation have a larger effect on the landslide occurrence than external factors such as rainfall. In the future research, major internal factors of the landslide occurrence is to be analyzed and evaluated through analysis on the landslide areas which are rarely affected by rainfall, and it is expected that the successful implementation of the future research will contribute to maintenance and prevention of damage due to landslides.

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ARPAL SUPPORT FOR MANAGEMENT OF THE REGIONAL NETWORK FOR HILL-SLOPE MONITORING

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KEY WORDS: inclinometer, piezometer, landslide, kinematics, rock mass complex, precipitations

PREFACE

ARPAL manages on behalf of "Regione Liguria" an unstable hill-slope monitoring network (REMOVER): network duties are valuation of soil conservation works, and data collection for planning and design of any others settlement works. Monitoring instrumentation consists of inclinometers and piezometers which were installed in past years by various public authorities (civil service engineers, territorial associations, local administrations, etc), but which in many cases remained unused and at risk of damage.

Activities meet control-and-planning requirements for soil conservation works, as specified by regional law 20/06 art. 32 ("Nuovo ordinamento dell'Agenzia Regionale per la Protezione dell'Ambiente Ligure e riorganizzazione delle attività e degli organismi di pianificazione, programmazione, gestione e controllo in campo ambientale") and, also, as specified by specific successive agreements signed by "Regione Liguria" and ARPAL.

The first operative stage (2007-2008) consisted of a general reconnaissance of 50 gauged sites within regional boundaries: reconnaissance results are shown in the following table.

Total instruments searched for:	419 (233 incl. E 186 piez.)
Found instruments:	278 (66%) (161 incl. and 117 piez.)
Working inclinometers:	132 (82% of found incl.)
Working piezometers:	113 (97% of found piez.)

Figure 1 – Results of the first operative stage

The second stage, started in 2008 and still operational, consists of authentic monitoring activity on the 23 selected sites included in the "Italian Landslide Phenomena Inventory" (IFFI); where there are at present 68 inclinometers and 47 piezometers, generating to-date a total of about 500 inclinometric readings and 340 phreatimetric measurements.

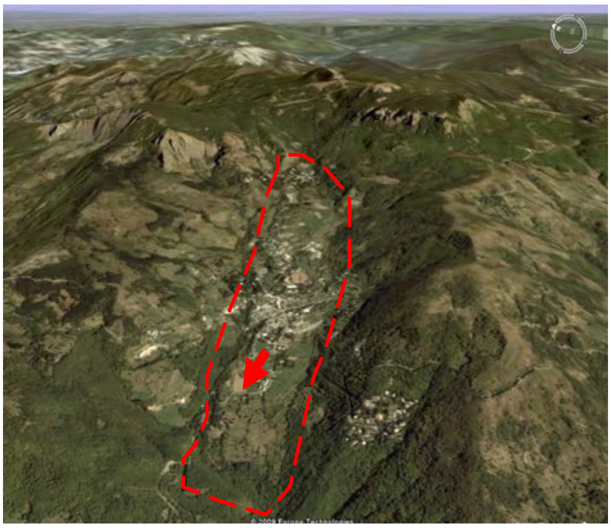

Figure 2 – S.Stefano d'Aveto landslide

METHODOLOGY AND INSTRUMENTS

Inclinometric data were completed thanks to both phreatimetric readings and synthetic aperture radar analyses. These inclinometric data, together with meteo-climate data of the CMIRL or Meteo-Hydrologic Operative Centre of Regione Liguria (Centro Funzionale Meteoidrologico della Regione Liguria) and data acquired thanks to geophysical analyses by means of seismic refraction, and also available older data, allowed the realisation of an integrated cognitive framework of observed landslides and their kinematics

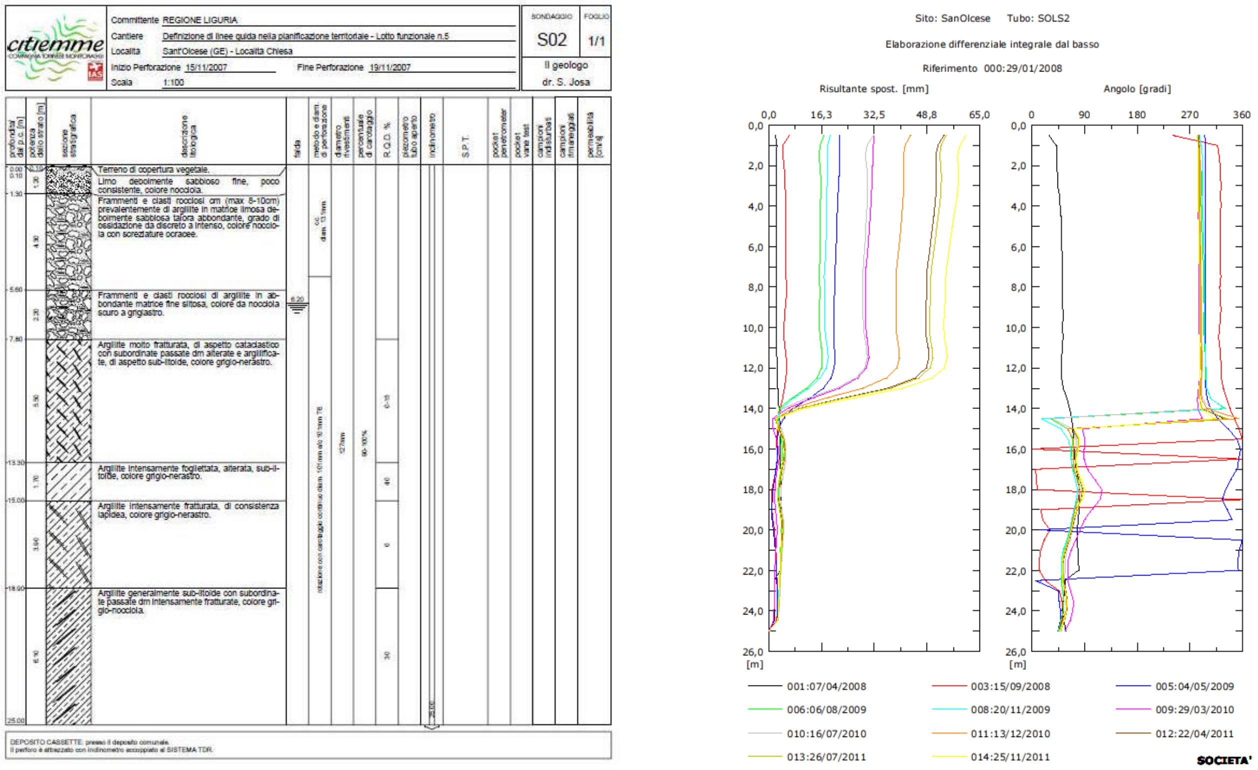

Figure 3 – Stratigraphic and inclinometer data of a single borehole

RESULT OF THE STUDY

The features of the main landslides were, in most of cases, within the group designated “reactivated complex slides, with a complex stress path”. In some cases, especially for debris-slides, kinematics definitively appears related to seasons and precipitations: the typical monthly distribution of slides, characterized by two peaks and two troughs, is well-matched with monthly frequency of rainfall, represented by two-peaks and two-troughs (autumn and spring peaks, summer and winter troughs).

Otherwise landslide trigger causes are many and complex in those cases when sliding surfaces are significantly deep, and rock masses are considerable and influenced by the presence of remarkable faults. This situation appears mostly with regard to partially-mobilized hill-slopes, characterized by poor-quality geo-mechanical features, whose sliding is regular within the rock mass complex.

Regarding significantly-deep sliding surfaces phenomena, the following features - landslide body dimensions and typologies, hill-slope orientation, hydrological network, intensity and duration of precipitations - are complexly connected, without any general pattern. Such factors can produce a wide range of sliding phenomena, frequently with reactivations and accelerations of existing movements.

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THE POGGIO BALDI LANDSLIDE (HIGH BIDENTE VALLEY): EVENT AND POST-EVENT ANALYSIS AND GEOLOGICAL CHARACTERIZATION.

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KEY WORDS: Corniolo, complex landslide, river dam, reactivation, GPS, GB-InSAR monitoring.

INTRODUCTION

After a prolonged rain and snowfall period, on March 18th 2010 in the high Forlivese Apennine, a large landslide occurred (≈$4*10^6$ m^3); it interested, in about 24h, three houses, the provincial and municipal roads, a large evergreen pine bush, occluding, at the end of its movement, the Bidente River and creating an obstruction lake.

Before the event there where no evidences of displacement of the main accumulation but the main headscarp was affected by periodical rockfall phenomena since the last activation in 1914.

This paper describe the event history and evolution, the geological and morphometric characterization and the monitoring survey, carried out by traditional direct methods for deep component (inclinometers, piezometers) and topographic methods (GPS and GB-InSAR).

Fig. 1 – Panoramic view of the landslide area on 2010 march 27th.

GEOLOGICAL SETTING AND LANDSLIDE EVOLUTION

The landslide area partly lies on an isocline slope and partly on transverse attitude strata-slope. The bedrock is constituted by flyschoid marls and sandstones of Marnoso-arenacea Formation (Corniolo Member, Langhian).

This gravity movement can be classified as complex, in which we recognize translational rock slides (on structural surface) with rock falls in the headscarp that evolve in translational and rotational debris and earth slides (Varnes 1978).

The main accumulation was correctly identified and mapped as dormant landslide in the Emilia Romagna Region Landslide Inventory Map (LIM), where it was hanged over by an active area, corresponding to the thick debris deposits outcropping discontinuously even till the top of headscarp, whose dimensions were extended about the same of today.

The geological observations highlight that the area has been repeatedly affected by landslides since thousands of years. Despite of this, only one total reactivation, in 1914, was recorded before the 2010 event. In that case, the reactivation phase involved the same triggering area of the 2010 event. During about one century, the wide and sub-vertical headscarp kept on releasing debris that at 2010 rose about 40m of thickness. Its overload combined with the intense and prolonged rainfalls and snow melt, in March 2010 triggered the reactivation of the landslide, characterized by the first movement on the upper part of the slope and progressively evolved far downward (by “undrained loading”), to dam the river and lean against the opposite slope. Fig. 2 shows that the maximum depletion in the upper part was >50m of thickness whereas the maximum topography rise at the foot was >40 m.

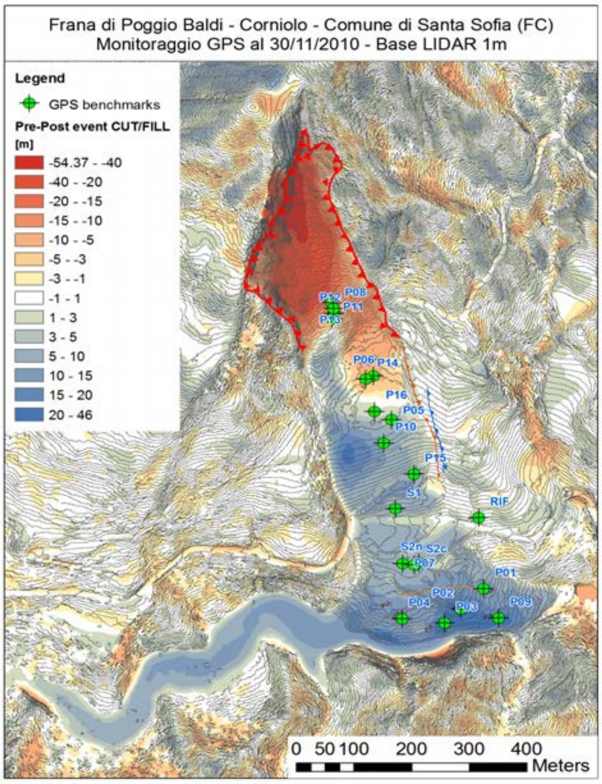

Fig. 2 – Cut/fill map derived by the pre-landslide CTR 1:5’000 and an high resolution post-event 1m LIDAR survey. It’s also visible the landslide dam lake. Green dots shows the distribution of the GPS survey benchmarks.

GEOLOGICAL SURVEY

Geognostic survey has been realized through n° 3 boreholes (max depth: 43 m), 1200 m of seismic lines, micro-seismic passive methods (Tromino®), Down Hole, n° 3 samples and permeability tests in borehole. From this it’s been possible to define the maximum depth of the landslide (41 m) and the asymmetric shape of the paleo-valley that the landslide accumulation fills.

During the period March 2010 – December 2011, the area was deeply and repeatedly field surveyed by the authors. Field work aimed to survey spring points, tectonic structures, deformation evidence, bedrock-colluvium boundaries and all the elements necessary to define kinematics and evolution of the landslide from the emergency phase to the present days.

MONITORING DATA

In the emergency phase, a quick topographic monitoring system has been realized. This showed the rapid decrease in velocity from the ≈1 m/h until March 23th morning to the 5 m/day in the 23th afternoon, < 1m/day on march 24th, few cm/day on march 26th and negligible deformation from April.

GPS survey has been initially carried on to measure the landslide dam geometry and the dam lake filling; later it has been used in NRTK (VRS) acquisition mode to evaluate the residual landslide movements (fig. 2). The main accumulation and landslide foot have never shown displacements higher then the method resolution (few cm), whereas on the upper part of the accumulation, displacement of several mm/day kept on going at least until the end of 2010, following the continuation of rockfalls and debris contribution from the main scarp and the main rainfall events.

GB-InSAR survey has been realized on December 2010 to assess the main scarp evolution and, in particular, to identify possible movements of a portion of debris and very fractured rock, deformed but not involved on the parossistic event. The result of the survey (fig. 3) showed that residual displacement involved only shallow portion of debris.

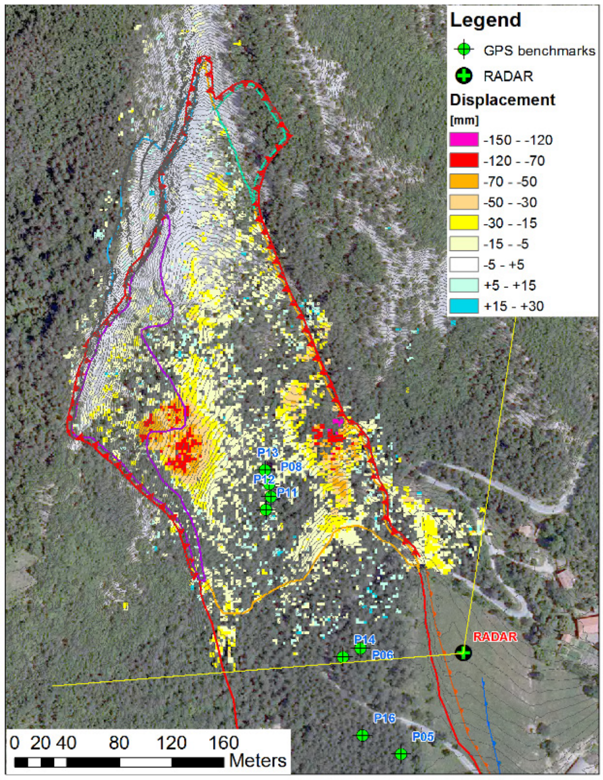

Fig. 3 - GB-InSAR displacement map.

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LARGE REACTIVATED EARTH FLOWS IN THE NORTHERN APENNINES (ITALY): AN INTRODUCTION TO THE FIELDTRIP IN THE SECCHIA VALLEY

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KEY WORDS: Landslides, earth flows, reactivation, Northern Apennines, Italy.

INTRODUCTION

From 1994 to 2006 several large, ancient earth flows reactivated in the Northern Apennines causing damages and destruction of villages, hamlets and roads. Many of these landslides were object of studies and interventions by the part of the regional technical services, with the investment of a great amount of public money for investigation, monitoring, reconstruction and consolidation works.

In few cases they were the subject of scientific papers and communications in thematic conferences, but the majority remained confined in mere technical papers, internal reports, even simple discussions among experts. The aim of this paper is to collect all these experiences and to draw, in a synthetic way, all the possible elements of knowledge that may be useful in the future to forecast similar scenarios in analogous cases.

All considerations made herein are the result of studies performed by the technical surveys of the Emilia-Romagna regional authority by direct experience and observation of these events. Particular attention has been paid to the survey of field evidences and cinematic indicators observable on the terrain or by means of field instrumentation.

GEOLOGY AND SUSCEPTIBILITY

The Cretaceous *Argille Scagliose,* consisting of tectonic and sedimentary melanges (i.e. “olistostromes”), due to their clay content and bimrock structure, here represent the main source of landslides. As for Helmintoid Flysch (Cretaceous - Eocene in age), despite its well-preserved stratified structure, the high content of shale and clay makes it very susceptible to weathering processes, producing thick colluvial deposits where erosion and landslides easily occur.

According to the regional 1:25000 Landslide Susceptibility Map (Bertolini et al. 2002), the *Argille Scagliose*’s Landslide Density Index (ratio between the sum of landslide areas affecting these geological units and their total mapped surface) is varying from 20 to 40 %.

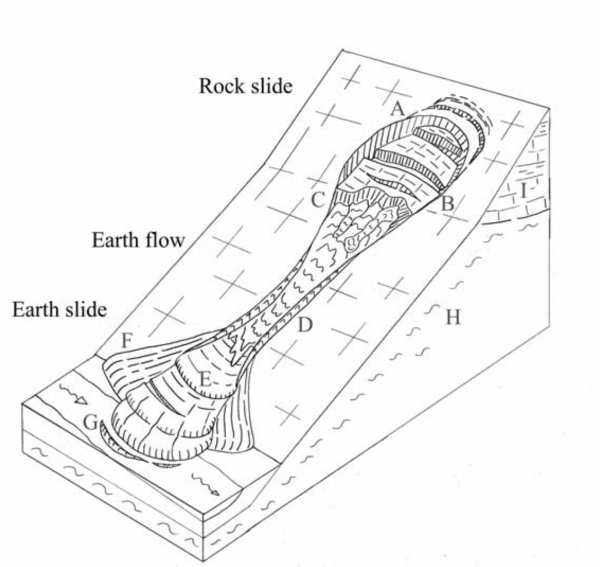

Figure 1 – This sketch summarises, in a simplified way, the main features that are visible in the field. A = Main scarp; B = tension cracks and trench; C = Minor scarp; D = Lateral levee; E = Listric imbricate thrust faults cutting the reactivated foot; F = Portion of the ancient foot that remains inactive; G = Uplifting of clay breccias as first symptom at the early stage of the foot reactivation; H = Argille Scagliose; I = Helmintoid Flysch.

FEATURES

In most cases, from plan view, these landslides show a typical “hourglass” shape: a large crown, a relatively narrower middle “channel” – corresponding to the area of flow – and a wide basal fan reaching the valley floor, with a modest or null slope inclination (Fig. 1).

Thanks to their simple morphology, these landslides are easily identifiable through geomorphological analysis. Calculations based on 46 different landslides, whose movements are monitored by 190 inclinometers, show that the majority of them (52 %) reaches a depth ranging from 10 to 30 meters and about 12 % of them exceeds 40 m. The depth has seldom reached a magnitude of 80–100 metres, as in the Corniglio and in the Cervarezza case.

THE REACTIVATION

In the majority of the reactivations of ancient earth flows occurred within the 1994-2006 period, a recurring behaviour was evident. In many documented or observed events the movement initiates in the source area, causing a retrogression of the main scarp, which is the most unstable part of the slope.

Instability often produces the displacement of a sliding portion of rock, which is rapidly affected by a progressive differentiate subsidence and disjointed by tensional cracks, normal faults and gravitational tranches. A minor scarp forms downslope (Fig. 1) and from there the displaced material reaches the liquid state, thus producing earth flows moving downward as far as the landslide body's mid-section.

The undrained surcharge triggers a series of listric and imbricate thrust faults inside the underlying main landslide body. They come to light as steep, curve scarps dipping upslope, whose dip (of the fault plane) becomes shallower with increased depth. They are transversely interrupted by long vertical straight-slip fault, directed downslope.

This pattern migrates valleyward, propagating the progressive failure along the base of the ancient landslide, which may entirely reactivate by sliding. This sequence of events with many variations and sometimes only partially achieved, was observed in many cases during the 1994-2006 period and was reported in literature in many other cases.

The complete reactivation of the entire landslide body was achieved in the cases of Corniglio (both in 1902 and in 1994 events), Cà Lita (2002), Costa di Casaselvatica (1994), Casa Ravera (1997), Lavina di Roncovetro (1994), Casoletta (1995), Sologno (1996), Cà di Sotto (1994), Cervarezza (in 1472, 1560, 1697 and partially 1936 events), Lezza Nuova (1998); for other references, see Bertolini 2010 and Bertolini & Pizziolo 2008.

Among the many observed events, in only few cases the movement led to a significant advancement of the toe (e.g.10, 28, 56 and 330 metres respectively in the Boschi di Valoria, Corniglio, Cerrè Sologno and Cà Lita cases. In Tables 1 and 2 some examples of velocities, measured by instruments or by benchmarks displacements, are reported.

As evident, the scale of deformations and displacement velocities decrease moving from the source sector in the direction of the toe, which, as already stated, is generally the last section of the landslide to reactivate.

In the majority of cases, if the earth flow coming from the main scarp covers hundreds of metres, the deformation of the ancient basal fan is limited to several or tens of metres. The usual maximal velocity is up to few decimetres per day.

FINAL REMARKS

Experience teaches us that the instability is often prepared, months and years in advance, by the overburden on the original landslide body, due to the gradual superimposition of new earth flows.

Exceptional levels of precipitation are not always necessary to trigger reactivation if the landslide body is already in condition of limit equilibrium, due to the progressive accumulation of material in the mid-upper sector. In fact, when the limit equilibrium is reached, few precipitations may produce apparently disproportionate effects.

In general, the observation of past events has proved to be an useful mean for understanding which are the conditions and behaviours that usually lead to the reactivation of an ancient landslide body.

This knowledge plays a fundamental role in all the activities aimed to the management of risk, like territorial planning, the strategies for the assessment of their dangerousness, the implementation of preventive or after-event consolidation works. Above all, the main usefulness of this experience is its contribution to the scenario predictability of future events.

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ROCK FALL IN AOKAS, ALGERIA

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KEY WORDS: rock fall, limestone, conglomerates, karst, fractures, Aokas city, slope stability,

1. INTRODUCTION

A spectacular cliff rock fall occured on May, 9th 2005 (photo 1) on the national road n° 9, near Aokas city (Algeria), and stopping trafic

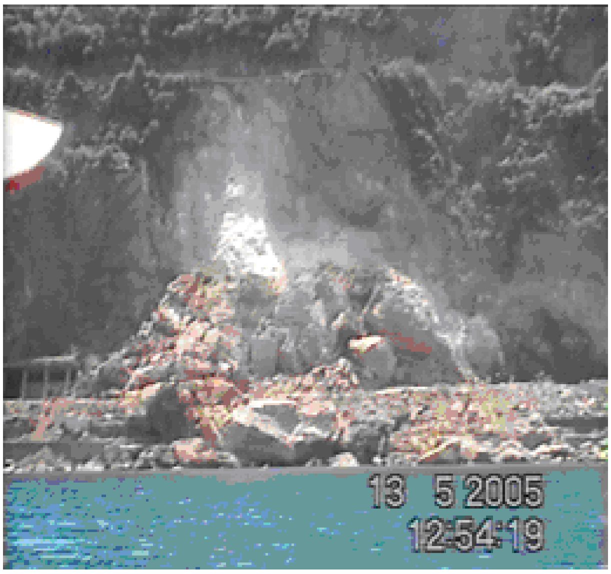
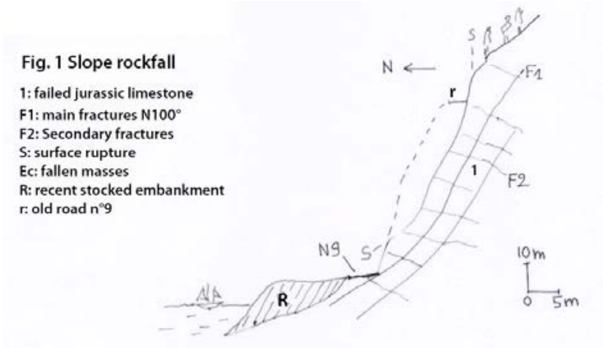


Photo1. Global view of slope rock fall on national road n°9, near Aokas coastal city

This road is the only way of communication between neighboring districts: Jijel and Bejaïa and its obstruction isolated the small tourist city of Aokas, at the beginning of summer hollidays. A large part of population working in Bejaïa was also disturbed.

Excavation works were quickly undertaken and monitoring of rock slope was considered.

The rock fall mobilised 20 to 30 000 m3 of rock material happened in a fractured massive formation, at the entrance of a tunnel leading to Aokas city. The old national road, located 30m beneath the modern one, was destroyed by the rock fall. The fallen blocks ranged up to100m3 in size.



2. GEOLOGY

Aokas village and its surrounds are bordered in the south by a mountain surrounded by steep cliffs. The national road 9 (RN9) is constructed at the mountain edge, with very steep bank slopes tens of meters in height. At the west village entrance, the extension of the mountain reaches the sea, requiring the construction of a tunnel through a massive and stable limestone formation. The eastern portal is extended by a reinforced concrete protection work, perpendicular to a slope, of probable rock fall debris. The fall occurred within two geomorphologic zones above the RN9 (photo 2).

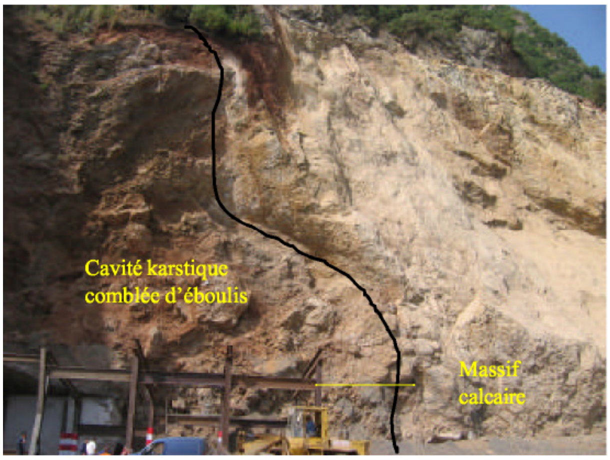


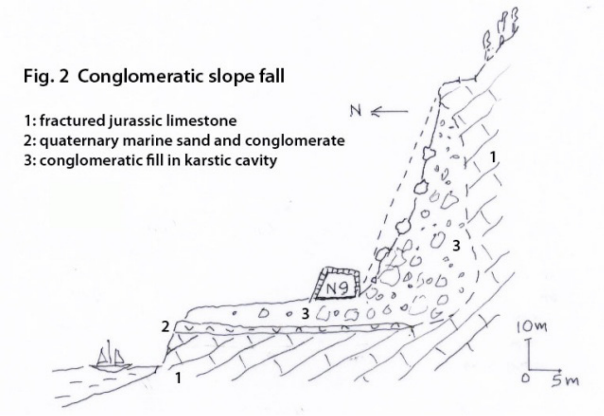
*Photo 2. Failure surface rupture (**S**) in massive limestone on the left and karstic cavity fold by conglomerate on the left*

The rock fall exposed a persistent discontinuity (photo 2 and figure 1), along the failed slope. The discontinuity (F1), N10°E (parallel to the RN9), and dipping 60 to 75 °, is very unfavourable for slope stability. The rockfall also exposed weakly cemented conglomerate (photo 2, fig2). The poor stability of this slope section justified construction of protection works (a rockfall shelter) extending the tunnel. This shelter was destroyed by the massive rockfall of May 9, 2005. It was intended to protect road users and resist to smaller block fall impacts.

In the future, the highest risk is not another massive rock fall, but fall of unstable blocks, especially at the next rain season.

Water infiltration into either rock fractures or rock conglomeratic pores, is main cause of the rockfall.

In January and February 2005, precipitation levels were very high, including many snowy days. These caused numerous landslides in mountainous areas of North Algeria.



3- KARSTIFICATION AND SLOPE STABILITY

The geomorphologic perculiarity of Aokas Jurassic limestone is the numerous cavities (Karsts) that weaken the rock mass. The "feeriques grottes" (fairy caves), close to the rockfall illustrate this perculiarity.

Close observation of the conglomeratic slope cleared by the fall at the tunnel entrance show that it is a fill material of a large karstic cavity (photo 3,fig 2) indicated by numerous stalactites visible at the contact limestone-conglomerate.

This large cavity (25 to 30 m diameter) had extended up from RN9 with an open and narrowed section that allowed rock accumulation. It is very close to fairy caves.

It could be either its continuation or separated from it by a narrow rock separation.

These observations already suggest that the rock mass is weak, future slope modification should avoid any new excavation of the conglomeratic slope section or use of explosives that may result in a large destabilisation that could affect the fairy caves and the tunnel.

The presence of marine conglomerate (sand and sandstones with fossil debris) outcropping at the cavity base (fig2), near the shore (photo 3), shows that this cavity was opened to the sea, before its filling.

Photo3. Marine quaternary conglomerate (Cg) sand and gravel (S+G), at the base of karstic cavity

Elevation differences between the marine terrace of probable old to middle quaternary age, and the actual sea level (photo 3), confirm on going uplift.

4 - COMFORTATIVE MEASURES AND RECOMMANDATIONS

The geomorphologic and structural observations of the slopes cleared by the rockfall, indicate that the road trafic reopening on RN9 is possible with acceptably low risk of new instability. In fact, massive rock, with few fractures and inclined toward the slope, was exposed by the surface failure. At the height of the conglomeratic slope (eastern side of rockfall), the rock is less favourable to rock and boulder fall and require require protection works.

Remedial works required are :

- clear the unstable boulders left, located at the top of the rock slope section, with means other than explosives.
- rebuilt the damaged rock fall shelter at the conglomeratic slope. This work must be extended to the west, up to the conglomerate and massive limestone boundary, that is the west boundary of the karstic cavity. It must be calculated to resist 1 to 3 m3 rock falls which form part of the conglomeratic slope,
- install a double metallic netting along the whole slope in the area of the rock fall (rock and conglomerate section). This wire-netting is aimed to control future small rock fall, will be ballasted at the slope base and sufficiently anchored to the limestone rock at the bottom, near the old RN9.

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STABILITY ASSESSMENT OF KARST SINKHOLE IN CHEREA AREA, N E ALGERIA

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KEY WORDS: Sinkhole, Karst, RMR, GSI, Hazard zoning, Tebessa.

ABSTRACT

The catastrophic collapse of residual soil covers overlaying solution cavities in karstic limestone areas constitutes a serious geological hazard around the world. It is a well known phenomenon related to the occurrence of underground solution cavities in limestone, dolomite and gypsous terrains. It is a real challenge for land use planners and engineers as it affects seriously the foundations stability and performance. In urban areas, generally the sudden collapse causes damages to properties, infrastructures, and even lives.

Sinkhole collapse is well known in Cherea area, N E Algeria (fig. 1).

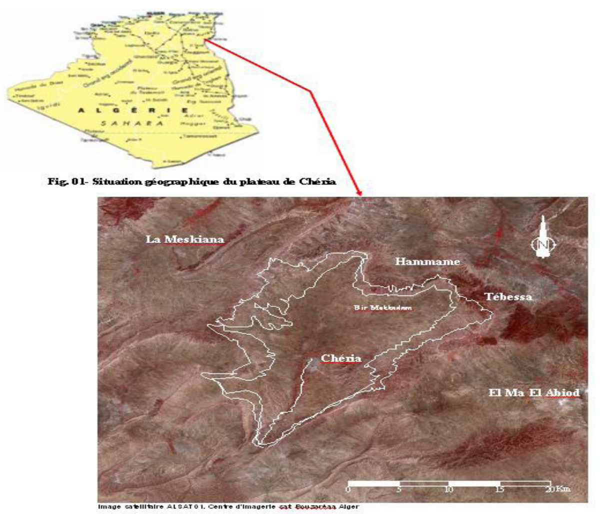

Fig.1, Geographic location of Cherea basin, Tebessa.

In recent years two large events of covers collapse over sinkholes were recorded. The first event resulted in a crater of more than 50 meters, in diameter, occurs in a non populated locality called Douamis (fig. 2). This first event has caused no damage and did not receive any attention from the local authorities. Recently on the 29 th February 2009 at 03 am a spectacular sinkhole collapsed with a diameter of more than a hundred meters occurs in the center of the town of Cherea (fig. 3).

Fig.2, The first spectacular sinkhole in Douamis locality.

This later event has caused severe damage to several houses, roads, water main supply, and sewages. It has caused a widespread panic among the population mainly those living too close to the crater. This time, as the phenomenon start to affect the security and the economy of the population, the local authorities have become very aware about the danger threatening several tens of thousands of peoples. The collapse is due to a sudden rupture of the roof of a large underground karst cavity. Karst cavities are in fact widespread in the Eocene limestone forming the upper formation under the quaternary cover in the Cherea syncline.

Both local authorities and residents are aware about the fact that every structure in the area could well be build totally or partially on a potentially collapsible void. The extension plans of the area could no more be established without a thorough knowledge of the underground conditions including the occurrence, depth, geometry and dimensions of the karst cavities.

Fig. 3, Damage caused by sinkhole collapse in the Cherea town center

Several exploration methods for the localization of underground cavities can be considered. Geological study, resistivity survey and borehole drilling were undertaken in order to locate the underground cavities and assess their depth, geometry, dimensions, etc.

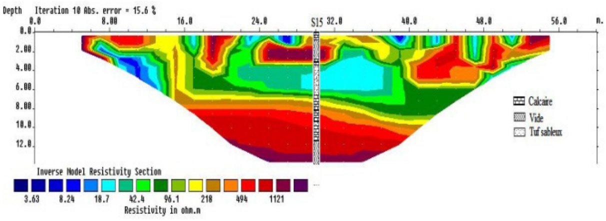

Fig.4, Geo-electric cross section with a calibrating borehole.

Rock mass properties such as RMR, GSI along with other geo-mechanical parameters are assessed in order to estimate the stability of these underground features **Waltham (2002, 2004)**. It has been found that under an imposed loading of the stability of the karst cavities depends on the geo-mechanical parameters (RMR, GSI, and E), of the host rock as well as the depth and dimensions of the gallery (fig. 5). It increases with RMR, GSI, E and depth; it decreases as the cavity width increases. The calculation results shows that a ratio (roof thickness to gallery width) of of 0.2 and more indicate a stable conditions.

Waltham (2005) cited several case studies from the USA and Britain where caves were stable with a roof thickness to width ratio varying from 0.1 to 0.5.

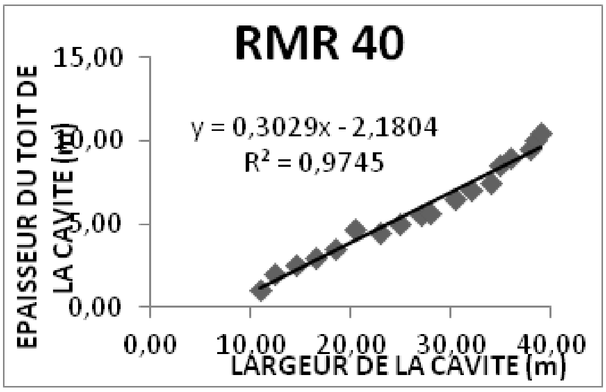

Fig. 5, Itasca modeling results showing the relationship between roof thickness and cavity width of 1 MPa imposed load.

The results obtained in this work allow identifying and assessing the stability of underground karst cavities and thus establish a hazard map related to the studied phenomenon. This map will be a useful tool for the future urban extension.

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EFFECTS OF LAND USE CHANGES THROUGH DIACHRONIC INVESTIGATION IN CLAYEY DRAINAGE BASINS, RADICOFANI, CENTRAL ITALY

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KEY WORDS: erosion; badlands; reforestations; Radicofani; diachronic confrontation.

SLOPE INSTANBILITIES

Hillslopes of the Radicofani area, in the upper valley of the Orcia River (southern Tuscany region, Italy), consist mainly of early Pliocene clayey sediments and are widely affected by badlands erosion. Reforestation with frugal conifers has been carried out in the area over the last 50 years (Fig.1).

The goal of the present study is to evaluate the impact of reforestation and land use change on erosion rates in nine small drainage basins through a multidisciplinary approach. Geological, geomorphological, hydrological and land use characteristics were analyzed by a diachronic confrontation between pre-reforestation (1954) and post-reforestation (2007) situations. Aerial photo interpretation and processing in GIS allowed changes in areas affected by badlands erosion (Fig. 2), land use and variations in erosion rates to be quantified.

The erosion rates and their variations have been estimated by calculating the hydrologic parameters of the nine basins (index of hierarchical anomaly and drainage density; t km-2 year-1) (Ciccacci et al., 1980; Della Seta et al., 2007) and comparing the actual DEM and the pre-reforestation period DEM (cm year-1; Fig.3), this last one being obtained due to digitalizing the historical cartography.

Moreover, dendrometric data was gathered from eighteen circular sample plots in forest stands of 40 years old. This allowed both the adaptability of different forest species to the clayey substrate and reforestation fragmentation to be evaluated.

The differences between the pre- and post-reforestation situations which emerge are increases in arable land and forest areas and a considerable decrease in erosion rates and badlands areas. However, no significant correlation between the erosion rates and the forest area emerged. This is probably due to the excessive fragmentation of reforestation cores, which have a scarce surface as compared to the total extension of the single basins. In this area the agricultural reclaiming seems to have played a predominant role in reducing erosion of clayey substrates: in fact since the beginning of the 20th century these zones have been affected by hydraulic works and remodeling of slopes in order to obtain that degraded areas could be cultivated.

The integrated method presented here is an important tool useful either to understand the morphological dynamics of badlands areas in relation to forest vegetation, or for land planning and management.

Figure 1 – Reforestation with Arizona cypress in a slope affected by badlands erosion.

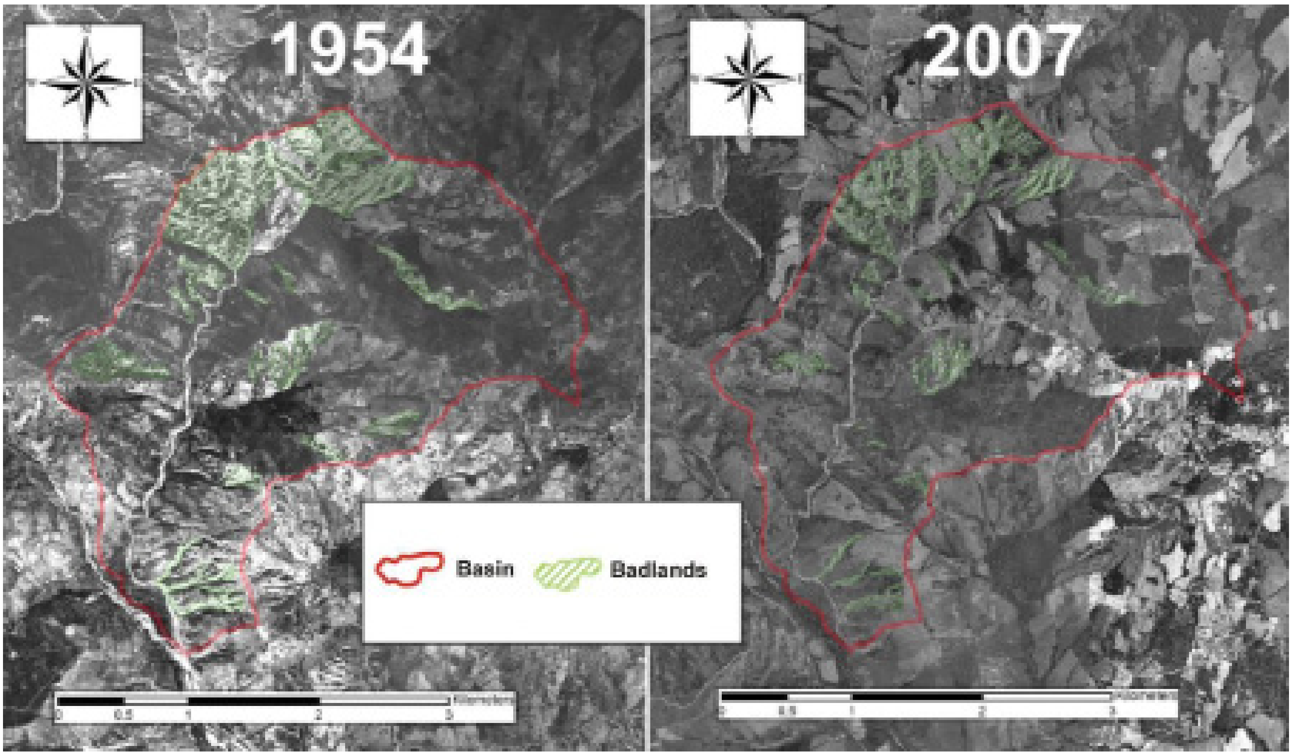

Figure 2 – The badlands and biancane areas in 1954 and 2007 in the Torrent Cacarello basin.

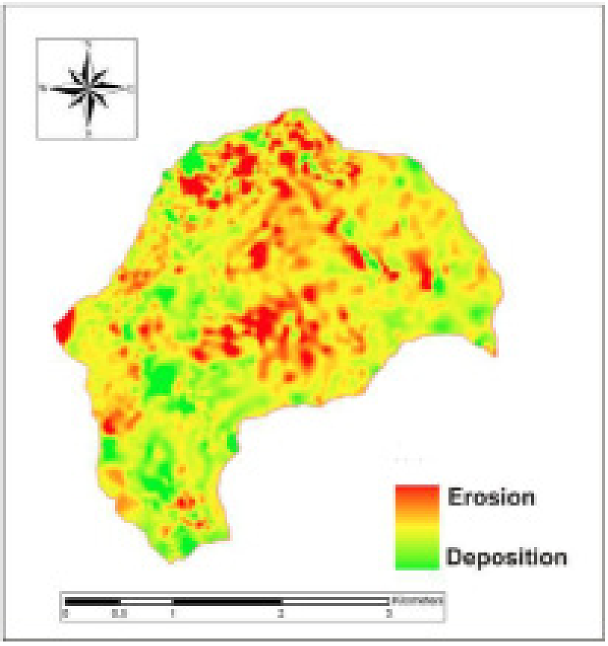

Figure 3 – Zones of erosion/deposition obtained by comparing between DEM of the Torrent Cacarello basin.

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ASSESSMENT OF FLOOD HAZARDS IN THE HAMIZ WADI EASTERN ALGIERS – ALGERIA

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KEY WORDS: flood, return periods rainfall, Hamiz wadi, Algiers.

ABSTRACT

The eastern Mitidja plain, which northern part is highly urbanized, is crossed by the Hamiz wadi, along which buildings are constructed anarchically. The maximum discharges are calculated for different return periods, based on the analysis of climatic and morphologic parameters, and used for evaluating the overflow on transversal profiles along the wadi. Finally, hazard maps enhance zones potentially under the threat of heavy flooding along the wadi.

INTRODUCTION

The eastern Mitidja basin is crossed by main rivers, the Hamiz wadi, along which houses has been haphazardly built during the last decades. In 1973, the Hamiz wadi overflowed, causing a flood with a 50- to 60-centimeter high water wave in Rouiba city. On 25 November 2007 heavy rainfall (117 mm in 24 hours) produced a similar water wave. Previously, on 11 November, 2001 flood and mudflow in the Bab el Oued neighborhood (Algiers) took over 700 lives and caused enormous damage (Argence et al., 2006 ; Cheikh lounis and al., 2009, Hegglin and al., 2004 ; Santos-Munoz, and al., 2006 ;).

The analysis of climatic and morphologic parameters permitted defining the intensity level, extension, return period and frequency of floods. These results, combined with anthropogenic factors, have been used to identify vulnerable zones within the floodplains of the Hamiz wadi. (Figure 1).

FLOODING HAZARD ASSESSMENT

A statistical adjustment of daily rainfalls using the Gumbel distribution shows maximal rainfalls over 100 mm for 5-, 10-, 50, 100, and 200-year return periods (Table 1). Flooding hazard maps (Figures 2) were obtained by combining natural and anthropogenic parameters so as to differentiate between four zone types, according to the hazard level, from white (weak) to red (high).

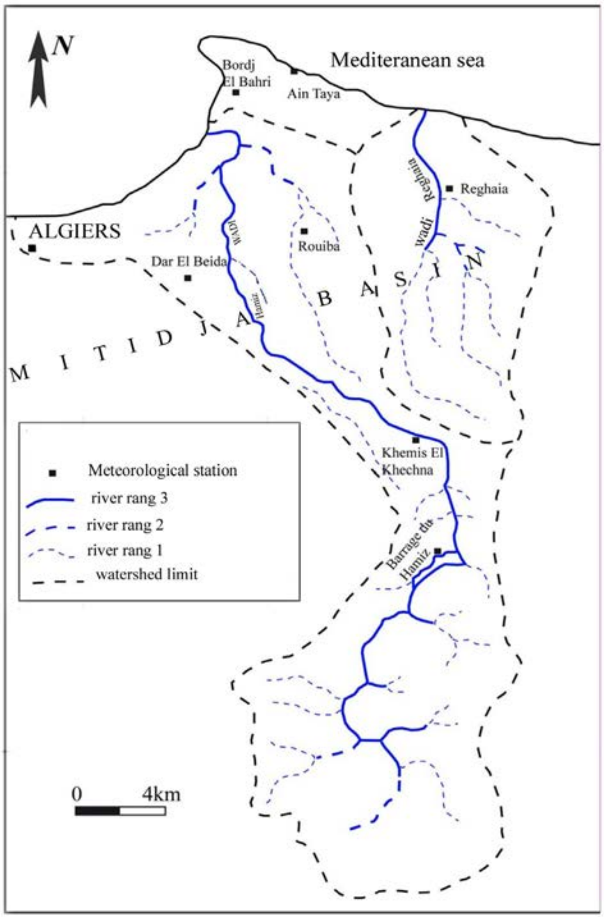

Figure 1 – Map of the hydrographical network and delimitation of the two catchments.

Return period (years)		P5	P10	P50	P100	P200
Frequency		0.8	0.9	0.98	0.99	0.99
Stations	Hamiz dam	87	103	132	148	164
	Réghaïa	62	76	102	116	124
	Dar El Beïda	103	124	162	178	195

Table 1 .Values of maximal daily rainfall (in mm) for different return periods

Flood levels have then been evaluated on transversal profiles along both wadis for 50- and 100-year return periods (Table 2). Flooding hazard is mainly linked to the small depth of their beds (Figures 2) and its inability to efficiently evacuate the eastern Mitidja basin water. 100-year return period flooding is sure to happen on the transversal profiles 4 to 6 (Figure 2), in between the cities of Hamiz and Bordj El Bahri. The latter is located at the wadi mouth where flood is expected to spread much more than upstream where the wadi bed is deeper. The growing anarchical urbanization of flood prone areas increases the vulnerability and will considerably amplify the consequences of these floods.

Discharges	Qmax (m3/s)		
Return periods	Hamiz dam	Réghaïa	Dar El Beïda
P5	283.32	102.15	335.43
P10	335.43	125.22	403.82
P50	431.83	191.13	527.57
P100	483.28	191.13	579.68
P200	534.09	204.31	635.05

Table 2 – Values of maximal discharges (Qmax in m3/s) for different return periods at eachstation

DISCUSSION AND CONCLUSION

Flood hazard in the eastern Mitidja basin related to direct overflowing of the Hamiz wadi produced by exceptionally heavy rainfalls is potentially high.

Moreover, anarchical urbanization in the alluvial plain of the wadi as well as construction in flood prone zones considerably increase the potential for damage from heavy overflowing. It is urgent to move people living in shantytowns installed in-between the major wadi bed dykes at Hamiz city as well as in between the latter city and Benzerga I. It is also necessary to (1) arrange the Hamiz wadi mouth so as to help water run out, and (2) build an efficient rainwater drainage system. In the flat and swampy zones, the raising of future constructions by about 80 centimeters to 1 meter should be strongly taken into consideration.

Finally, for future urban planning it is highly recommended to undertake a hazard prevention plan, based on these hazard maps.

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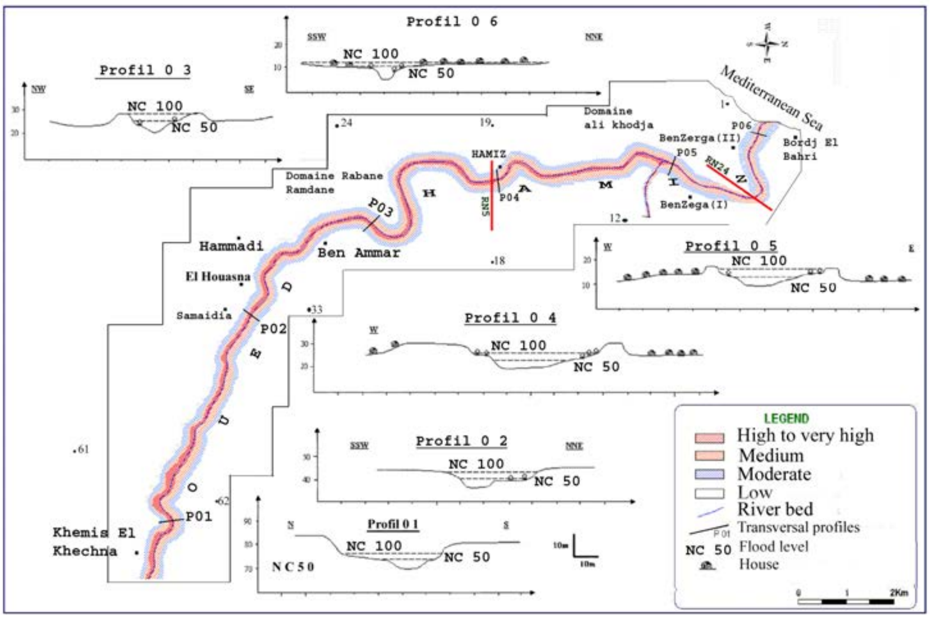

Figure 2. Hamiz river flood hazard map showing 50- and 100-year return period flood level on cross sections.

RAINFALL-TRIGGERED LANDSLIDES IN PIEDMONT: A CASE STUDY FROM ARPA PIEMONTE LANDSLIDES MONITORING SYSTEM (RERCOMF)

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KEY WORDS: landslides, Piemonte, rainfall-triggered landslide, inclinometers.

ABSTRACT

Arpa Piemonte is in charge of the maintenance of the framework about the hydrogeological instability of the Piemonte region.

Starting from the end of '70, the Geological Survey of Piemonte Region collects information concerning flooding, landslides, geomechanical characteristics of earths and rocks and is in charge of the management and the development of the regional landslide-monitoring system. In 2002 all this topics was moved into the ARPA Piemonte (Regional Agency for Environmental Protection) where the Thematic Department "Geologia e Dissesto" continues to maintain this valuable resource up to date.

Arpa manage several devices installed all over Piemonte to monitor landslides that occur close to facilities or built-up areas. The network includes about 300 monitored sites, up to now. The monitoring network includes many sites with few, mostly conventional instruments (inclinometers, piezometers, extensometers, and topographic benchmarks). Displacements are recorded in about 120 cases.

The present paper describes a study which has been carried out with the main purpose to gain insights into the understanding of the rainfall-triggered landslides, specifically for the plane shear slope instabilities, which are quite commonly met in the Piemonte Region (Italy).

This study is part of the European Project RISKNAT (ALCOTRA Program 2007-2013), where the working package B2, provides for the development of tools and methods for the natural hazards analysis.

Four cases of slope instability are considered, two from the southern hilly area of the Tertiary Piemonte Basin called Langhe and two from Alps region.

For each landslide site we consider inclinometers, grandwater condition and rainfall data. Horizontal cumulative displacement-depth diagram (inclinometric profiles) allow to define landslide types, slope movements and depth.

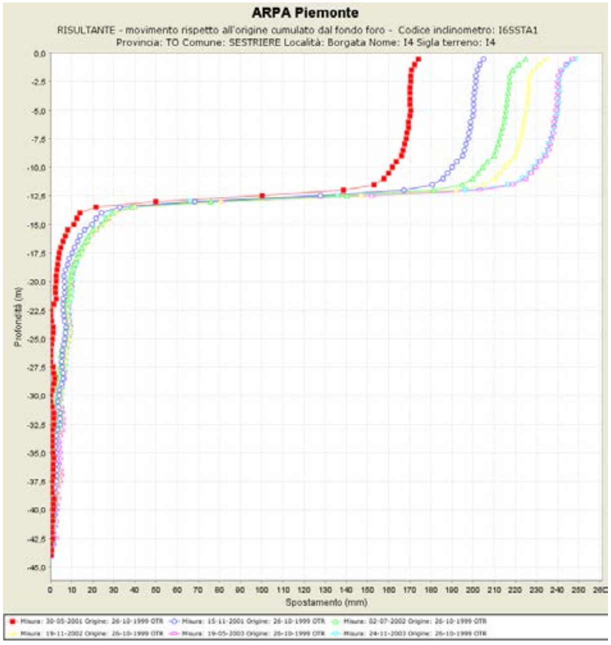

Figure 1 – Inclinometric profile with single failure surface

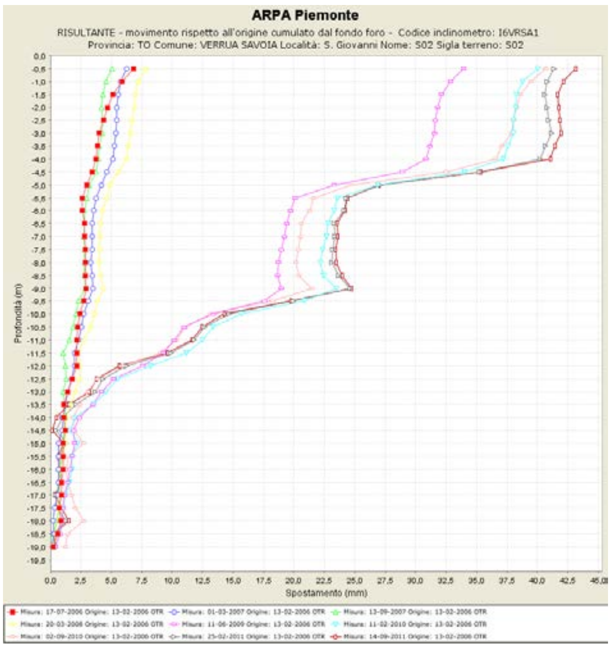

Figure 2 – Inclinometric profile with multiple failure surfaces

Landslides can have several causes, including geological, morphological, physical and human but only one trigger. Moreover, attention is focused on a quantitative assessment at the specific sites where landslide movements have been triggered by significant rainfall, including the contribution of snow melt.

An empirical approach has been applied. By using the data recorded during rainfall events triggering instabilities between 2000 and 2010, it was possible to assess a preliminary rainfall threshold for different seasons and to state the importance of the cumulative amount of precipitations in the previous period (60-120 days).

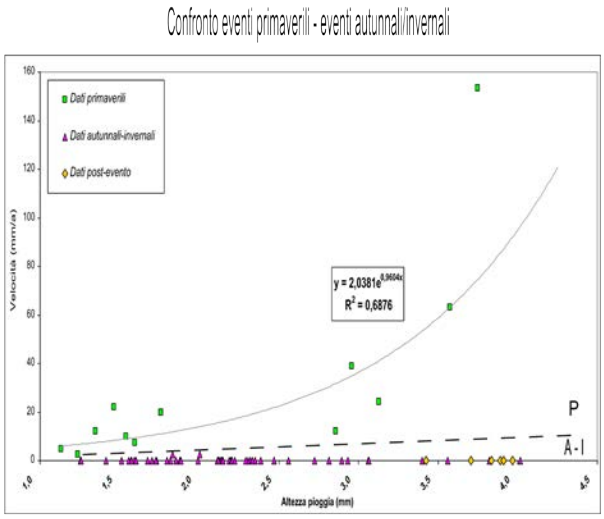

Figure 3 – Cumulated rainfall displacement correlation on a seasonal base.

The study results allow to assess a simple tool for identification and mapping of rainfall/rapid snowmelt triggered landslides (from the regional landslides monitoring network).

INSTABILITY OF DIFFERENT GENETIC SLOPE TYPES

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KEY WORDS: slope, coast, landslide, rock fall, mud flow, erosion, weathering, man-made influence.

INTRODUCTION

Use of territories with inclination, that exceeds some determined significance for urbanisation purposes is always accompanied by gravitational mass movements. This often cause damage for artificial objects, building and constructions.

On genesis slopes divide into: structural (primary); structurally denudational (secondary); man-made slopes (fig. 1). Each class of slopes divided on genetic signs is characterized certain morphometric parameters (height, steepness), and also certain set of slope processes. Development of slopes is closely related to the evolution of geological structures which determine relief of territory, and also influence of climatic factors.

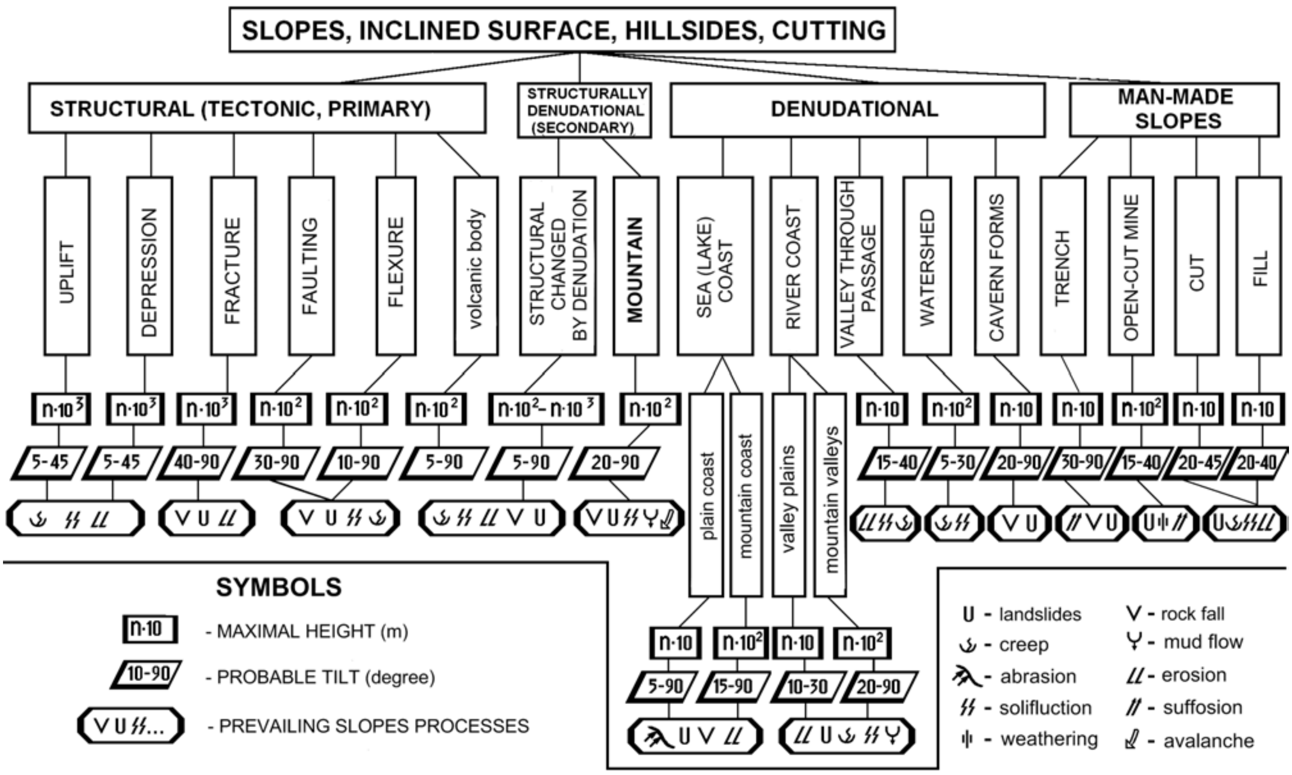

Figure 1 – Scheme of slopes divide.

The localisation of action of separate events is caused by situation of slopes. Catastrophic landslides in mountain consider in (ZARUBA, MENCL, 1982), and also landslides on plain territories, which join seismogenic zones in (DEMCHYSHYN, 1992).

FACTORS OF SLOPES INSTABILITY

Hazard of destructive, disastrous or catastrophic landslides on slopes exist because the following factors were not timely taken into account (DEMCHYSHYN 1997):

- all peculiarities of slope composition and of soil properties;
- presence of rock massive adjoining the slope surfaces and zones of weakness;
- hardly predictable natural phenomena (earthquake, rainfalls, floods, tempests, storms,

- sea-way etc.), that often influence slopes as triggering events;
- lack of special measures for engineering protection, corrective measures in construction designs,
- infringement of regulations to perform corrective measures and keeping-up in these areas.

Landslide-triggering events impact slopes in different directions and in different ways. Time and scale of landslide occurrence depend first of all on the current state of slopes and also on character of the triggering events (DEMCHYSHYN, 2000). Changes which take place under influence of a triggering event, happen suddenly or slowly, they have destructive or disastrous character as it is shown in table 1.

Table 1. Main factors of slopes instability.

tSlope types	Tectonic	Height (m)	Kinds of distraction	Triggering factors
Sea coast	submergen-ce of coast	10-100	landslides	storm, rainfall, earthquake, overmoistening
River coast	rising of territory	10-100	landslides	downpours, flood, snow melting, rainfall, earthquake, overmoistening
Mountain	submergence of coast or rising	100-1000	landslides rock fall, mud flow	earthquake, downpours, overmoistening

Considering, that in upper layers of ground, and furthermore on slopes in operative ranges, constant tangential stress is highly sensitive to external influences, it is necessary to consider that factor of stability of a slope constantly changes.

On a figure 2 changes in factor of stability and its basic meaning are shown, on which it is necessary to be guided at an estimation of stability of a slope and its sensitivity in relation to action of provoking events.

Besides its meaning of limit equilibrium (F=1) and of a safety factor (F=1+a) we single out also threshold of sensitivity (F=1+b), the decrease of factor of stability up to which a slope is sensitive to action of provoking events.

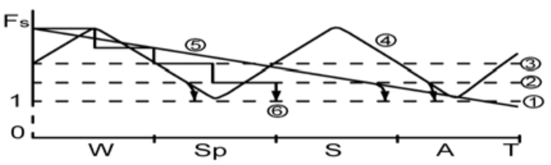

Figure 2 – Scheme of changes of factor of stability of a slope. 1 - line of limit equilibrium, 2 - a threshold of sensitivity, 3 - line of safety, 4 -seasonal changes, 5 - irreversible changes, 5-gradual changes.
Letters correspond to: W - Winter, Sp - Spring, S - Summer, A - Autumn.

Influence of earthquakes, and also of movement of heavy transport, at explosions, influence stability of slopes by changes of pressure caused by oscillations of different frequency. Special factor on urban areas of activation slopes processes is technogenetic dynamic loadings such as motion of different kinds of surface and underground automobile and rail transport. It exceed the level of microseismic natural oscillations in four times (SHCHERBINA, KRIL, 2011, KRIL, 2008). As a result, in loose soils there is disturbed cohesion between particles, that results in decrease of its shearing resistance. At saturated condition such soils under seismic influence liquefaction and form landslides-flows.

The action of downpours as landslide-triggering events is the factor noted on slopes in mountains and on plains. Always and everywhere we meet examples of development of the slopes' gravitational processes caused raising quantity atmospheric precipitation.

The atmospheric moisture, acting on slopes, results in increase of mass of rocks and consequently increases active moving together pressure and also reduces durability of rocks, their shearing resistance. Simultaneously erosion processes became more active also at the expense of increase of water and speeds of current in constant and temporary streams. Replenish aquifers which drain on slopes.

Occurrence and activation of landslides, triggered by storms was noted on mountain slopes, slopes valleys of the plain rivers, on slopes of sea coasts. The effect of storms on coastal slopes is different, it is reflected depending on morphology and geological structure.

To avoid undesirable development of processes, it was not difficult at least to practice attentive attitude to slopes as to natural structures, requiring proper assessment of their condition and necessary operation, duly acceptance of proper measures of engineering protection.

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EVALUATION OF THE POTENTIAL ACTIVITY OF LARGE AND SLOW LANDSLIDES USING SPATIAL DATA ANALYSIS TECHNIQUES: AN ATTEMPT IN THE DRAGONE VALLEY (NORTHERN APPENINES, ITALY)

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KEY WORDS: hazard, earth flow, susceptibility models, likelihood ratio, prediction-rate curves, cross-validation

INTRODUCTION

Landslide susceptibility analyses based on probabilistic or statistic methods have been applied to different types of mass movements. Although these techniques seem to be most adapted to study shallow and rapid landslides (PIACENTINI et al., 2012); deep-seated, large and slow landslides have also been analyzed using them (e.g. ERMINI et al., 2005; GENERALI and PIZZIOLO, in press). Shallow landslides susceptibility models arrange the terrain points or areas from the less slide-prone to the most slide-prone defining the places where new future landslides will occur most likely. Landslides susceptibility models obtained analyzing large and slow mass movements can not be interpreted in the same way. In this case, the objective of susceptibility models should be to know which existing landslide could be active or reactivation-prone (e.g. DEMOULIN and CHUNG, 2007) instead of indicating areas where we could expect new ones. Thus, the characteristics of the known active landslides could be used to define the tendency to reactivation or the probable actual, but not documented, movement of the other landslides located in a study area. In that way, a susceptibility model, validated using a landslide inventory of past events, for large and slow mass movements has been generated as a first step to develop subsequent landslide hazard analysis in an area of the Northern Apennines intensively affected by those processes.

STUDY AREA

The method proposed, it has been tested in a mountainous watershed (Dragone valley, Modena Province, Northern Appenines), in order to verify its applicability and reliability. The selected area is 275 km^2 wide with altitude ranging from 2053 m to 300 m a.s.l. (Figure 1) In the north-east part of the valley, the Ligurian Unit, constituted of Cretaceous flysch and clay including ophiolites, outcrops whereas Tuscan Unit, mainly composed of sandstones, limestones and chaotic shales, are present in the south-west sector (Figure 1).

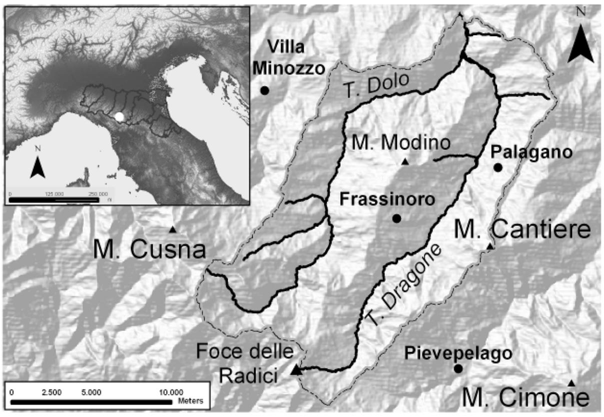

Figure 1 – Location of study area.

This area has been selected due to its high density of large and slow mass movements besides abundant historical information of landslide past events. In this valley the overlapping of lithologies with different mechanical behaviour has, in fact, favoured the presence of large landslides starting from Holocene (BERTOLINI et al. 2004). Landslides recognized can be defined as earth slides, earth flows or complex landslides and occupy the 30% of the entire valley.

METHODOLOGY

A susceptibility analysis was carried out using a probabilistic approach by means of Spatial Data Analysis techniques. The working hypothesis has been that the correlation between known active landslides and variables related to slide and flow processes provides the means to define the reactivation-prone or the probability of current movement of landslides with uncertain activity. The procedure carried out includes the following phases: data preparation, analysis of the statistical relationships between known active landslides and potential conditioning factors, cross-validation for selecting the best combination of variables to identify active landslides, and finally, elaboration of the ranking of all landslides describing their relative susceptibility to reactivation or current movement.

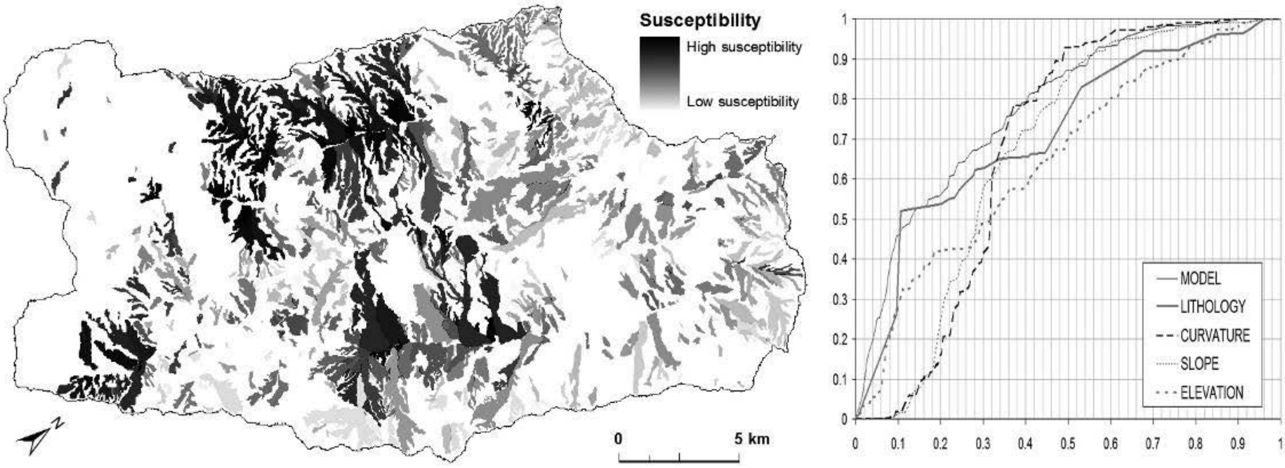

Figure 2 – Susceptibility model and prediction-rate curves resulted from cross-validation.

PRELIMINARY RESULTS

The most significant factors governing the activity of landslides in the study area are, in this order (Table 1): (1) the bedrock lithology, (2) the general curvature of the hillside, (3) the slope, and (4) the elevation from the base level (river channel). Figure 2 shows the susceptibility model produced and the *prediction-rate curves* obtained through a cross-validation technique. The model arranges the landslides according to their relative probability to be affected by current or near-future movement.

Variables	AUPRC	Pred20
Bedrock lithology	0.71	52%
Hillside general curvature	0.68	13%
Slope	0.67	22%
Elevation from base level	0.65	41%
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Susceptibility model	0.78	56%

Table 1 – Prediction power of variables and the best model. AUPRC: Area under prediction-rate curves. Pred20: Percentage of active landslides within the 20% of the area with the highest susceptibility.

The landslide inventory analyzed has 942 landslides, 225 of them defined as active. The 87% of the originally active landslide area is included in the 50% of the landslides with the most susceptibility to reactivation or present movement according to our model (50 quartile). According to that, 474 landslides of the study area could be active nowadays or reactivated in the near-future. This would represent that the 18% of the slopes of the study area has instability problems. The 70% of the landslides included in the 50 quartile was defined as dormant in the original spatial database. The susceptibility model produced (Figure 2) has been validated using a landslide past-event database. In the last 100 years, 450 damage events related to mass movements has been documented in the study area. The 71% of those events has occurred inside the 50 quartile of the generated reactivation-prone landslide ranking.

CONCLUSIONS

The large landslides susceptibility models obtained and the validation of them with independent data related to damage events show that it is possible to produce reasonably satisfactory models about potential activity of landslides. These models could be fundamental to estimate the spatio-temporal probability of future damage events and produce hazard and risk models related to large and slow landslides.

ACKNOWLEDGEMENTS

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LANDSLIDE SUSCEPTIVITY MAP OF THE MARECCHIA AND CONCA RIVER BASINS (EMILIA-ROMAGNA, MARCHE AND TOSCANA, ITALY)

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KEY WORDS: Geomorphology, Photogeology, GIS, DTM, Landslide, Hazard Map

INTRODUCTION

The aim of the research project was to develop a landslide susceptivity map at 1:25000 scale, related to the most common types of landslides in the area of the Marecchia and Conca rivers: flows, slumps, slides, falls, creep.

The geomorphological map was updated with a simplified legend specifically composed just for this kind of map.

The general criterion is to identify and describe the landslide susceptivity in all areas, even in those where existing geo-morphological maps do not indicate the presence of movements.

Two types of map are presented:

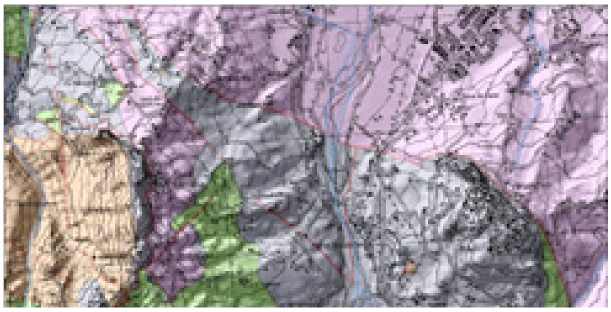
- a geomorphological map, at 1:25000 scale, derived from geothematic maps of the Emilia-Romagna, Mar-che, and Toscana Regions, from their digital databases and from a new ad-hoc photogeology analysis;
- landslide hazards maps, at 1:25000 scale, one for each type of landslide.

GEOLOGICAL MAP

In the compilation of this map, we compared all the formational units of the available geological maps, different in scale and content, with the aim to standardize and to merge the legends into homogeneous units, with comparable responses to morphogenetic processes. These units have been grouped into four main lithological types, having similar behavior in morphogenetic processes, as erosion and landsliding.

GEOMORPHOLOGICAL MAP AND PHOTOGEOLOGY ANALYSES

The main geomorphological task was to standardize the information from the available maps, drawn from three different regions: Emilia Romagna, Marche and Toscana.



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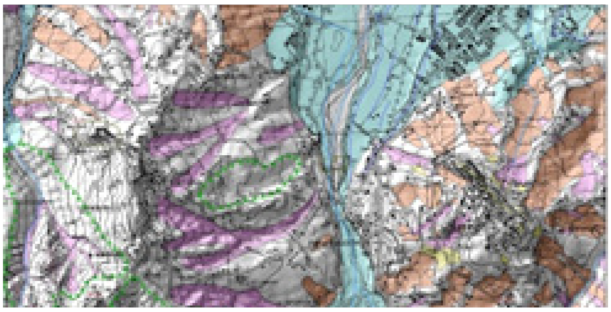

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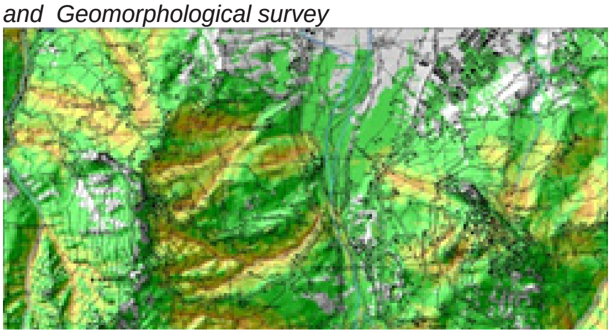
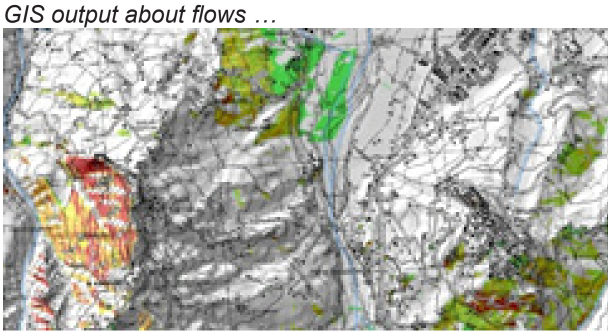


GIS output about flows …



and from sliding hazard

The homogenization was carried out on the basis of an overall simplification, adapted to the scale of the work (1:25000) as well as to the purpose of the map.

So were discarded all the items pertaining to a purely taxonomic description of the land forms, the use of which would limit the readability of the map.

A new geomorphological map for the whole territory of the Marecchia and Conca Basin Authority has been drawn through a new photo-interpretation.

We used aerial photos from flights IGMI/RER 1985, IGMI 1996 and Quik Bird 2002: the study of different strips covering the span of twenty years allowed us to document the landslides evolution, to have an overview of the most vulnerable areas and to identify indicators of increased hazard.

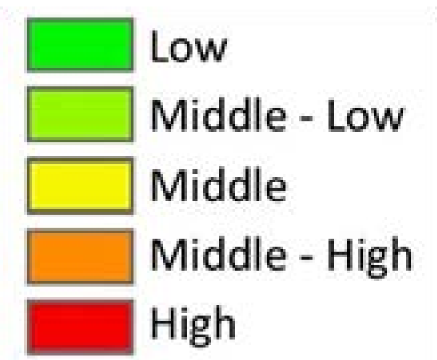
LANDSLIDE SUSCEPTIVITY MAP

The main purpose is to analyze the susceptibility to landslides of the whole area, obtained from all available maps (DTM, geological, geomorphological maps), supplemented by extensive controls by means of aerial photographs and ground survey.

The method consists of two steps: first we statistically analyzed the morphological, lithological and topographical attributes of landslides and we defined the combinations of geomorphological features observed in landslides.

In the second step we estimated for the whole area a “landsliding susceptibility index” based on the geomorphological features: the index is higher where all the conditions identified in the first step simultaneously occurr, and decreases as far from the conditions of greatest danger.

The classification criteria, rather simple, start from the need to identify the propensity of a slope to collapse, without cataloging forms not fitting to be used for land managing purposes.



The approach in terms of “susceptibility” has led to define a degree, ranging from low to medium-low, medium, medium-high, high, which shows that any potential landslide area is characterized by a probability of occurrence and intensity, evaluated on the basis of its geomorphological characteristics, geometry and kinematics.

CONCLUSIONS

The maps of landslide susceptivity constitute an element of knowledge very useful for environmental planning.

The susceptibility is in fact understood as the propensity of the territory to the occurrence of landslides, in relation to different combinations of preparatory factors, regardless of past occurrence of such events.

This analysis is not based directly on the land survey and its forms derived by “past” phenomena, but on models of unstable slopes or on the statistical analysis of the geomorphological parameters of the area affected by landslides. From this point of view, the *susceptibility maps* are more useful than the *inventory maps* for land planning.

In fact, the susceptibility maps, estimating the propensity to the occurrence of an event based on all collected and available data and not only on recorded past events, offer a more complete understanding of the area, in terms of “forecasting” the space of a hazardous event.

Type	*Lithology*	*Criteria*
Flows	Peliti Structurally complex terrain	• Area of watershed • Downstream of an area with a high slope (> 35 °) more clay • storage area with a slope less than 10 ° • Concave Slope
rocks block slide (structural)	alternating sandstone and calcareous-pelitic stratified rocks generally	• Slopes structural • Grade 10 to 11 ° • stratified formations • Probability of landslides increases with the distance from the watershed
Fall topple lateral spread	Sandstone, limestone massifs, calcarenites plaster	• Slope greater than 40 °
Irregular slopes (creep)	Clays, marly clays alternating sandstones, mudstones-structurally complex terrain	• Slope around 8 ° • Area of potential accumulation of water in the soil (gutter) • Slope up • counterslope • Variability of the slope • "Toboga" = repeated undulations of the slope

Figure 2 – Landslide types and their features

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LANDSLIDES IN THE SCURA VALLEY (CENTRAL APENNINES, ITALY)

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KEY WORDS: Landslides, Scura Valley, Central Apennines, Italy.

INTRODUCTION

This paper presents the preliminary results of a study conducted by the Institute for Environmental Protection and Research, Rome, Italy (ISPRA) and the National Research Council Sesto Fiorentino, Italy (IFAC-CNR), finalized to the slope instability analysis in the T. Scura Valley (Central Apennines, Italy).

GEOLOGICAL AND GEOMORPHOLOGIC SETTING

The Scura Valley is a 16 km^2 square basin, that flows into the Velino River River after having crossed the built-up area of Sigillo (Fig. 1), a hamlet near the town of Posta (Province of Rieti).

The landscape is very uneven, sometimes steep and rugged. In the upper part of valley, the profile is characterised by morphological jumps attributable to the glacial erosion (Angelini *et al.* 2004), to Malopasso a fall with a jump of around 50 m sets the limit of probable maximum of the wurmian glacier; in the terminal line, the hydraulic works (embankments and weirs) have intercepted the alluvial material and formed sub-level areas.
The morphological setting is sharply conditioned by the tectonic structure, that is characterized by the Umbro-Sabine pelagic deposits tectonically overlap those of Gran Sasso-Cittareale Unit (Italian Geological Survey, 1967; Bigi et al., 1992).

The calcareous and calcareous-dolomitic platform succession (so called "Massiccio") outcrops in the high and central parts of the Scura Valley, as does the Umbro-Sabine pelagic succession, which consists of limestone and marly limestone. Moving valleyward to the Velino River, the marly-calcarenitic complex marks the passage between carbonatic and terrigenous sedimentation (Upper Eocene – Upper Miocene).

In the upper part of the valley, which is modelled by a group of glacial circles, the chaotic moraines deposits are formed by medium-fine elements which are slightly cemented and are characterised by the presence of very large blocks. In the middle and low parts, the slopes are covered with detritus and fans which consist of loose and extremely variable in size elements. The alluvial deposits present along the sides and on the valley bottom are represented by masses, more or less evolved pebbles, sands and silts.

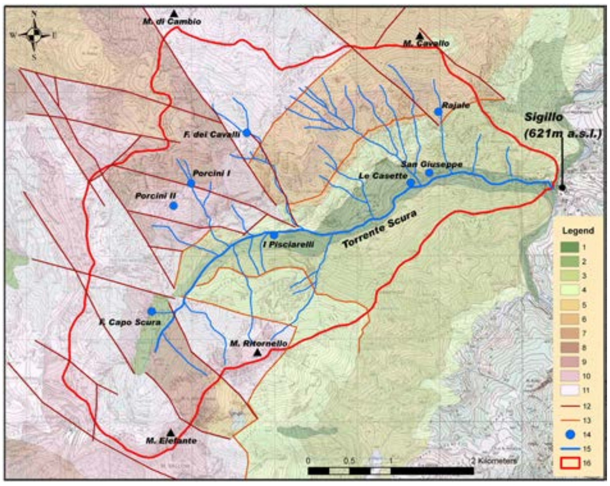

Figure 1 – Geological sketch map of the Scura Valley.

Legend: 1) alluvial deposits (Holocene); 2) slope debris (Holocene); 3) marls of the Scaglia Cinerea formation (Miocene); 4) marly limestones of the Scaglia Rossa and Scaglia Variegata formations (Eocene-Cretaceous); 5) marls with Fucoidi (Lower Cretaceous); 6) limestones and marls of the Maiolica formation (Lower Cretaceous – Upper Jurassic); 7) limestones with chert of the Scisti ad Aptici formation (Upper Jurassic); 8) limestone (Jurassic); 9) limestones and marls of the Rosso Ammonitico formation (Lower Jurassic); 10) limestones with chert of Corniola formation (Lower Jurassic); 11) bioclatic calcarenites of the Massiccio formation (Lower Jurassic); 12) fault; 13) thrust; 14) spring; 15) hydrographic net; 16) watershed. Adapted from Italian Geological Survey, 1967.

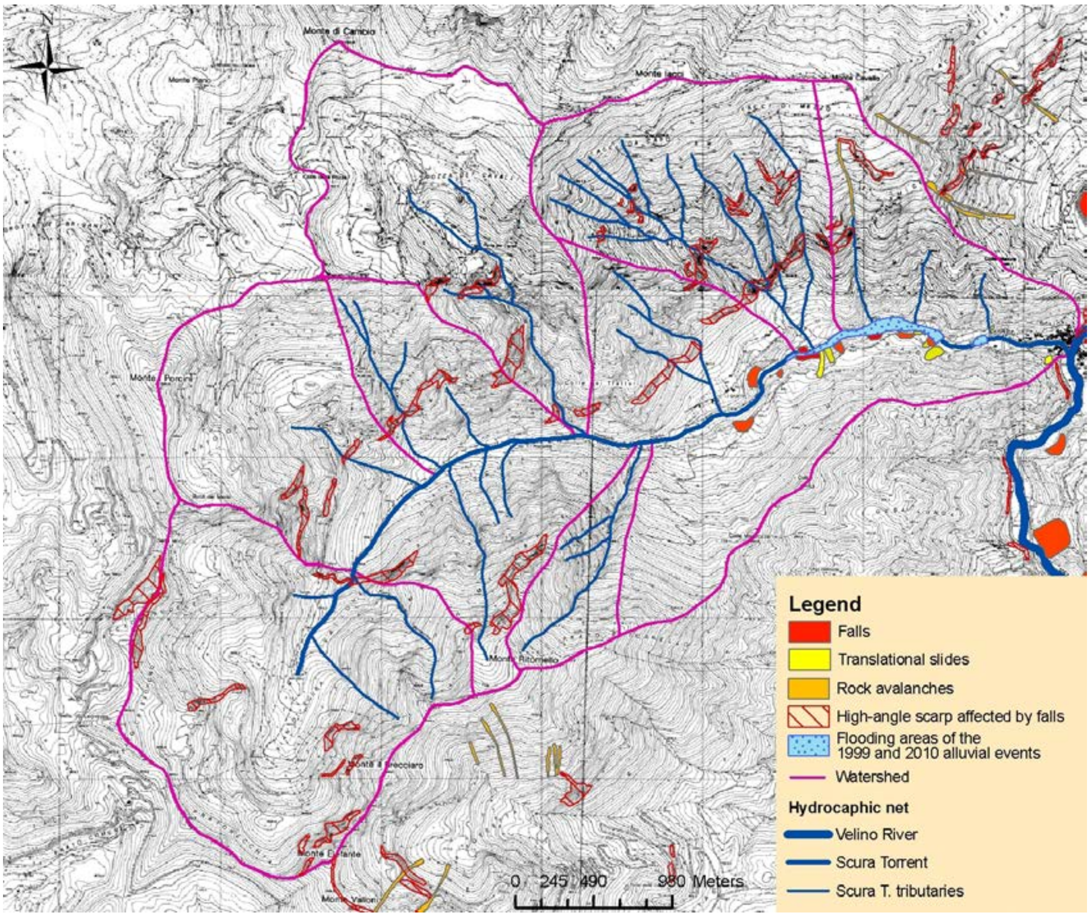

Figure 2 – Landslides map of the T. Scura Valley.

LANDSLIDES

The articulated morphologic setting and the very high relief energy of the slopes cause frequent slope instabilities, as reported in Fig. 2.

Landslides affect mostly the calcareous and calcareous-dolomitic succensions of platform and basin, where rockfalls prevail and the detachment of small volume rock fragments is very frequent along the high-angle scarps, as also happens in the surrounding areas (Amanti et al., 2009).

In addition, many falls become flow-like after moving a short distance and transform into rock avalanches.

To a lesser extent, rock falls and translational slides affect detritus and fans deposits hung along the sides of the valley.

Studies regarding landslide initiation and development are still in progress.

Furthermore, the Scura Valley has been frequently interested in the past by extreme alluvial phenomena (Guarino et al., 2011). Particularly, in December 1999 and 2010, intense rainfall events triggered numerous and widespread erosion processes at the foot of both slopes, debris-flows and the moving of enormous quantities of debris. In many places the torrent deviated its course, invading and destroying the route and the footpath that ascend from Sigillo towards the head of the valley.

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LANDSLIDE MAP OF TIRANA REGION AT SCALE 1:50,000

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KEY WORDS: Landslide map, lithological map, data base

INTRODUCTION

Landslides are a big problem in Tirana region due to the relief conditions, causing a negative impact in terms of cost and level of inhabitants' life. For this reason Albanian Geological Survey (AGS) compiled the Landslides map of Tirana Region at scale 1:50,000 and landslide data-base, as needed information for decision-makers to decrease risks in their communities and for land use planning

The Landslide map has been compiled, during this year,by the Engineering - Geology Department and GIS Department.

THE METODOLOGY

The Tirana region is located in western Albania. It covers about 1,640 km^2. The methodology applied to build up the Tirana landslide map is based on: Archive data and field surveys.

Archive data: Gathering all information **from Central Archive of AGS** (Geological map of Tirana 1:50,000, The studies in the geodynamic phenomena's),**from TA of the Ministry of Construction** (The map of administrative countries, geological-engineering studies) **and Road Directory** (technical report for landslides in infrastructure).

Archive of AGS contain 90 studies from 1994 until 2010. This studies were carry out for emergency, with the request of Municipality, in order to assessment the danger and to give up recommendations to decrease risks in their communities. TA of the Ministry of Construction had 33 studies from the years 1970-1990.

Field surveys: to evaluate the landslide evolution, present state and activity.

For each landslide, evaluated by field surveys is filled out data sheet. It is organized in five information levels of increasing detail:

- 1st level contains General information (region, municipality, topographic map and geographical coordinates X, Y.
- 2nd level contains data for the Geology of the body to move, the plan of slide and the basement without moving.
- 3rd level provide data on Morphology (lithology, land-use, erosion, cause of activation).
- 4th level contains Hydrogeology data (ground water, underground water level, and springs).
- 5th level contains Geological Engineering data (type of movement, state activity, humidity).

From Central Archive of AGS,TA of the Ministry of Construction, and Field surveys are identified 174 landslide in Tirana Region, The MS Access database built for this purpose, contains 174 landslide.

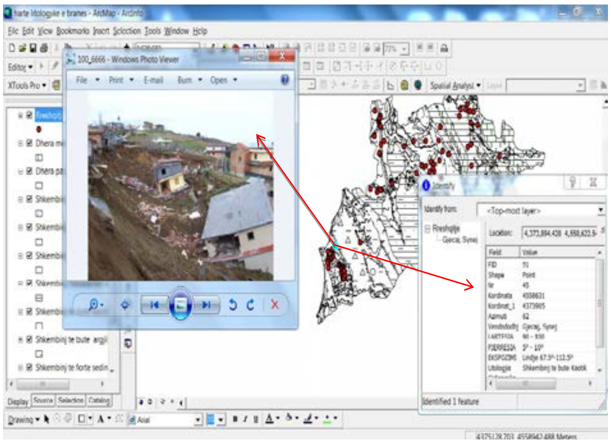

Figure 1 – Data base

CRITERIA FOR BUILD UP THE LANDSLIDE MAP

The criteria on which based to build up the landslide map was: lithological criteria and slope angle.

On the basis the Geological map of Tirana region at scale 1:50,000 and engineering geological field survey, carry out during this year, the lithological map was compiled. The classification of formation has been made on the basis the landslide susceptibility.

Ten groups of lithological/engineering geological unit were defined for the all region: 1-Hard limestone rock (11 %); 2-Average of stratified rocks (34%); 3-Sandy rocks (6%); 4-Average clay rock (17%); 5-Soft clay rock (6 %) ; 6-Conglomeratic rock (1%); 7-Chaotic rock (4%); 8-Soil with cohesion(3%); 9-Soil without cohesion(3%); 10-Soil stratification with and without cohesions.(17%)

In this map are marked 174 landslides, according to coordinates and azimuth of the direction of slides.

Landslide distribution according to lithological class are : Hard limestone rock - 7 ,Average of stratified rocks- 34, Sandy rocks -16, Average clay rock -35, Soft clay rock -41, Conglomeratic rock- 2,Chaotic rock -28, Soil with cohesion-5, Soil without cohesion-3,Soil stratification with and without cohesions- 1.

The slope angle is easily relatable to the slope movement, because it is strongly linked to the forces involved. High slope anglesites have more susceptibility to landslides.

Slope angle map is building in nine groups: Areas with slopes 0-5, 5-10, 10-15,15-20°,20-25 25-30°,30-40°,40-65 and areas with slopes > 65°.

From previous studies and surveys is emerged that the phenomenon of sliding occurs in most cases in slopes with inclination from 10° to 30° In slopes with an inclination greater than 30 ° occur phenomena of topples and falls. This is related mainly to the lithology and to physical – mechanical characteristics of rocks and grounds situated on the slopes

The data collected from archive and fields as well are entered as inputs in a database that serves to build the map of landslides in the GIS mapping.

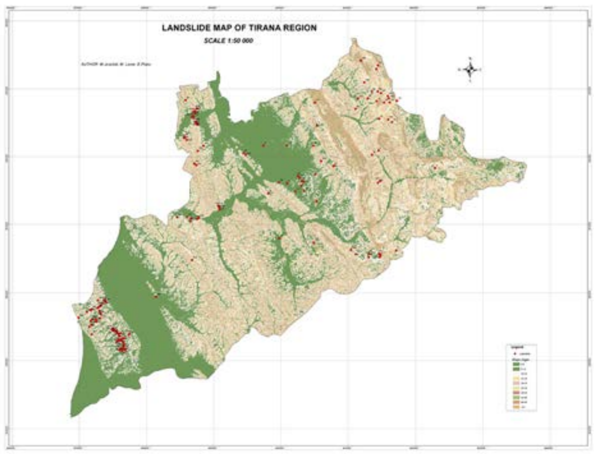

Figure 2 – Landslide map of Tirana Region at scale 1:50,000

CONCLUSION

the Tirana region covers about 1,640 km$^{2.}$ Through a field work and archive data are identified 174 landslide. Clay rock was found as the most susceptibly lithological complex

From previous studies and field surveys it is emerged that the phenomenon of sliding occurs in most cases in slopes with inclination from 10° to 30°. In slopes with an inclination greater than 30° phenomena of topple and falls occur.

A big role, during last years, in the activation of slides phenomena, has played the human factor, which with its interventions on slopes, often not well studied, has caused the acceleration of these phenomena and made them appearing more dangerous, due to the fact they affect engineering works also.

Based in this map and analyses of landslide spatial occurrence, coming year will be proceeded in derivation of the Landslides Susceptibility map of Tirana at scale 1:50,000

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USE OF GEOGRID FOR SLOPE STABILIZATION AND LANDSLIDE MITIGATION

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KEY WORDS???

INTRODUCTION

The objective was to study the efficiency of geogrid materials in technical and economical aspects for high slope stabilization and decrease of soil erosion. Geogrids provide stability to the top soil layer through confinement: once extended to their full open size and filled with lightly compacted top soil, a stable and inextensible planting medium is achieved. Slopes with different length, inclination, soil characteristics, can be properly protected against erosion by the choice of the most suitable kind of geogrid. Geogrids have junctions that allow the passage of water between adjacent cells [1] and [2]. Some cases in soil stability are pointed in following:

At Iserlohn a 19 m high, 215 m long, geosynthetic reinforced earth structure was built for Lobbe Holding GmbH & Co. The construction is located adjacent to the A46 motorway and has a maximum free height of 16.70 m with a width of 11.20 m at the base. Both planning and the design calculations were carried out by Geokunststoff GbR [3], located in Weimar, Germany. The design is strictly in accordance with the Empfehlungen für Bewehrungen aus Geokunststoffen –EBGEO. The completed wall has a slope angle of 80° without berms whilst the slope face has been completely vegetated. This paper describes both the design approach and the construction details including construction time, installation sequence and details of the face vegetation. The results of deformation measurements over a period of 2 years are also included [3]. The soil or aggregate infilled by providing lateral confinement: in this situation the infiltration of the water is facilitated and the runoff is decreased both in volume and in speed, with a consequent reduction of the water erosivity. Rills and gullies are therefore prevented.

MATERIALS AND METHODS

The Chandab basin is situated in the 60 km south eastern of Tehran province in the northern part of Iran, in the latitude 35º 24′ 31″ N and Longitude 51º 55′ E situation (Fig. 1).

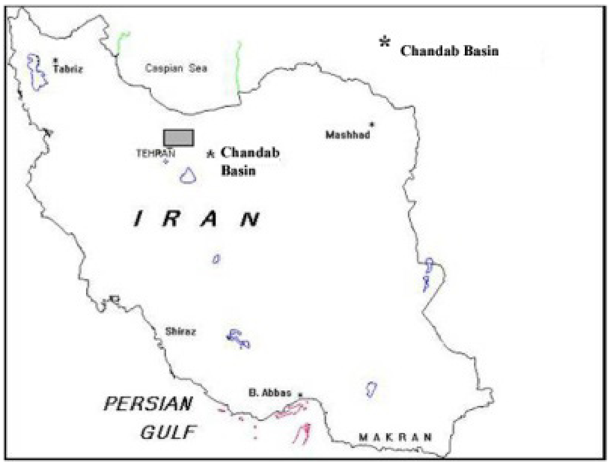

Fig. 1 Location of the study area.

The topography of the study area varies from plain to mountainous and includes old to young geological formations. The climate of the Chandab catchments is arid to semi arid, although locally the climate varies due to the altitude. There are four kinds of meteorological stations; rain gauge and evaporation station. The all of stations record the amount of precipitation, air temperature, relative humidity and amount of evaporation from class A pans. The mean of annual precipitation rate is 185.7. Mean maximum temperatures during 1990-1997 range from 29.9 to 39.9 Cº and mean minimum ranges from -1 to 6.6 Cº January is the coldest month while August is the warmest month in the study area. The mean of annual temperature rate is 16.1 Cº. Temperature regime of area is thermic.

The geogrid soil reinforced structure has to be designed taking into consideration the characteristics of the backfill, subgrade and reinforced soil. The maximum particle dimensions of the aggregate shall be 125 mm and it shall be avoid the use of swelling plastic clays, due to their low compactability.

It shows that they can present soil degradation and soil erosion plots of 12×2 meters were chosen in the research. At the end of plots, runoff is caught and measured and sediment amount in the runoff was measured. Different treatments along with replications were chosen (Table 1).

Along the slope the geogrid shall be anchored with pins. The spacing between the pins shall be determined by the design engineer.

	Table 1: Different chosen treatments
A	Geogrid with natural grassland covering
B	Geogrid with seeding aboriginal grassland species
C	Without geogrid and with natural grassland covering
D	Without geogrid with seeding aboriginal grassland species

Pins have shape and length depending on the soil characteristics. Pin diameter shall be 8 mm minimum. Each pin shall be placed at the junctions of the panel. The geogrids can accommodate infill and finishes such as soil/grass, gravel.

The most number of runoffs also related to ninth event which in the respect of other runoff events it has been the most in all of plots. Least runoff event belongs to second event. The table 3 also shows the quantity of measured sediment concentration in the each plot. The receipted data has been analyzed with Spss program. The effect of slope and soil covering of plots, also their reciprocal effects to amount sediment concentration has been evaluated with two way on variance analysis (Fig. 2). Regarding to obtain results, soil conservation in the steep slope soils with geogrid in comparison with other protective methods like to gabion, retaining wall, pitching and terracing decreased expenses respectively 450, 490 and 219 percent to hectare.

DISSCUSION AND RESULTS

Fig. 2: Sediments produced related to plots with and without geogrid

CONCLUSION

A total of 9 events resulted runoff and sedimentation. The data were analyzed with the Spss program. The results showed in both slope types: a) in the 110% slope the erosion was much more than the 85% slope b) the treatment plots which were stabilized with geogrids indicated a lesser to no erosion. Geogrids are made of polypropylene resistant materials. Because of low price and not necessity to complicated installation equipments, these materials are more economical and reliable them the other less than stabilization methods. Also under the ecological point of view, as e.g. CO2 reduction, further positive impulses for this type of application can be expected in future [4]. This investigation and other studies suggest that the use of geogrid to issue in soil conservation and soil stability in the steep slopes (road trench and railway lines) and prevent erosion of rivers and dam borders.

The polymer products are completely recyclable. An effective and cheap way to preserve valuable soil is using up geogrid (geosynthetics). Results indicate geogrid is an effective means of upland slope stabilization on erosional slopes and shallow rapid landslides and is practical and economical.

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A STUDY ON DECISION OF SURVEY PRIORITY RANK FOR EFFECTIVE MANAGEMENT OF CUT SLOPE

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KEY WORDS: cut slope, Inventory data, Score of risk degree

INTRODUCTION

For systematic and efficient management for cut slopes at a national level for national roads, the Land and Maritime Affairs has been focused on the safety of the road users such as finding and investigating of dangerous slopes, application of measures for the construction, management of slopes, etc, developing and introducing CSMS (Cut Slope Management System). In this paper, we compared scores of the risk degree(SRD) estimated from the failed cut slopes with the inventory data of failed cut slopes that occurred in Gangwon-Do and Chungcheong-Do from 2006 to 2008 so as that we verified the confidence in the SRD estimates from the collected data.

INVENTORY SURVEY OF THE CUT SLOPES

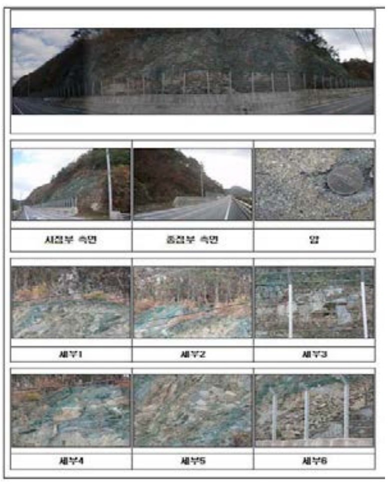
Materials obtained from the inventory survey of the cut slopes are classified into data and images. The data includes general status, characteristics of the cut slopes, and inspector's opinions and the images are constituted with the front view, detailed pictures of the cut slopes and so on. The data was recorded by directly surveying with the naked eye of inspectors and the images were acquired using a digital camera. The survey for the general status of the cut slopes was compiled with inspectors, survey date, location information (GPS coordinates), etc. The characteristics of cut slopes included specifications, attributes of risk factors, history of cut slope failures, etc and inspector's opinions contained the subjective risk degree and damage of the cut slopes, necessary process, etc. A Manual of Survey Method was written about each survey item for the sake of consistency and objectivity of the data during the survey.

The inventory data in an Excel file was then converted into an Oracle DB structure so that the server of the database was built up. They were edited in a report form in the Hangeul word program and then the data, of which the survey was completed, was distributed to the national road management offices so as to assist the staff working in the field in managing the cut slopes. Table 1 show the survey item lists and in figure 1 an example appears of a report form distributed in each national road management office.

Table 1 – Survey item lists of the cut slopes

Classification	Item lists
General status	distance mark, latitude and longitude, lane, survey date, inspector
characteristics of cut slope	Length, height, inclination, distance, berm distribution, type, surrounding terrain, ground water, leak location, weathering grade, discontinuity orientation, slope shape, side shape, valley, history of collapse, distribution of floating rock and rockfall, rock types, subsoil depth, bedrock type, types of discontinuity, construction status
Surveyors' opinions	Risk degree, damage degree, types of collapses, risk grade, danger zone, necessary main construction, more details

Figure 1 – Reports and pictures for inventory survey of the cut slopes



ASSESSMENT OF RISK DEGREE FOR THE CUT SLOPES IN GANGWONDO AND CHUNGCHEONGDO

In that the workforce and budgets are limited, the relative risk degree should be estimated so as to effectively manage the 20,000 or more cut slopes around nationwide national roads. It then may be effectual that the cut slopes with the higher risk degree get priority in managing the cut slopes and for doing this, first of all, the risk degree of the cut slopes should be assessed.

An assessment method of the risk degree for the cut slopes was as the following: points were given for each section regarding each survey item and then given points for each item. These points were then summed up so that a total was calculated. The score of the risk degree (SRD) was then defined by the total of the points. It was assumed that the cut slopes with higher SRD were relatively more dangerous than ones with lower SRD.

Table 2. Items for the inventory survey of the cut slope and score distribution table of the risk degree

No.	Items	Range			
1	length	Less than 0~100m	Less than 100~200m	Less than 200~300 m	300m or more
2	height	Less than 10m	Less than 10~20 m	Less than 20~30 m	30m or more
3	slope	Less than 45°	Less than	Less than 55°~65°	65° or more
4	Upper slope	Less than 10°	Less than	Less than 20°~30°	30° or more
5	distance	5m or more	Less than 3~5m	Less than 1~3m	Less than 1m
6	Types of slopes	nature	Rock bed	soil	mixture
7	Surrounding area	plain	hill	Semi-mountain	mountain
8	ground water	dryness	humidity	Dropping, wetting	flowing
9	degree of weathering	fresh	a little, normal	Severe, perfect	remaining
10	Discontinuity orientation	unknown	rear	parallel	coincidence
11	Slope shape	straight	concave	convex	wave
12	Side shape	straight	uneven	protrusive	hollowed
13	valley	0	1~2	3~4	More than 4
14	Types of collapse	none	surface	Deep layer	-
15	Distribution of floating stones	none	Small(1 ▯ or less than)	Medium (1~5▯)	Large (5 ▯ or more than)
16	Distribution of falling rocks	none	Small(1 ▯ or less than)	Medium (1~5▯)	Large (5 ▯ or more than)
17	Depth of soil layer	Less than 0.5 m	Less than 0.5~1m	Less than 1~2m	More than 2m
	score	5	10	15	20

Although each SRD did not present the absolute risk of the cut slopes, the higher-score cut slopes can contain the possibilities of high risk compared with lower-score ones. The score range was divided into total 5 sections: 85 ~ 135, 135 ~ 185, 185 ~ 235, 235 ~ 285 and 285 ~ 335.

As with the SRD calculated by the inventory data acquired from the cut slopes, we also calculated the SRD using the inventory data obtained from the failed cut slopes.

The failed cut slopes were distributed in the high score range compared with common cut slopes and figures 3 and 4 presented the distribution of the overall cut slopes and failures over each score section. As shown on Figure 3 and 4, the failed cut slopes were mainly spread through the high score range of risk degree and this result implies that the higher SRD could have a higher possibility of collapse.

Figure 3. Distribution of cut slopes over score sections of the risk degree(%)

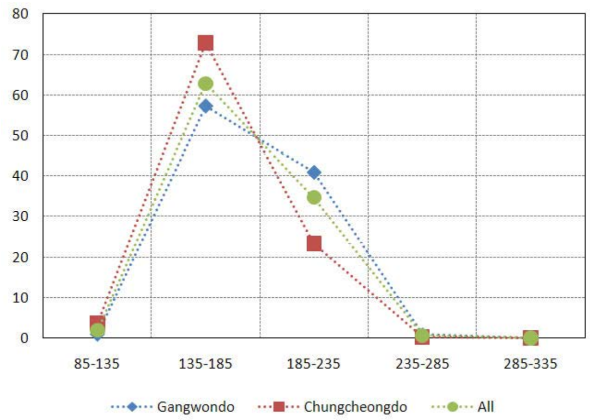
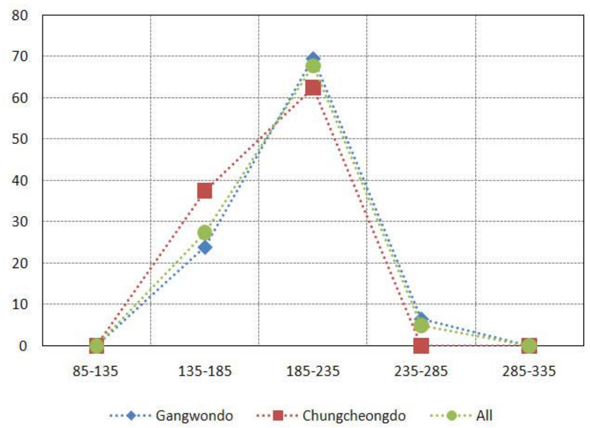


Figure 4. Distribution of failed cut slopes over score sections of the risk degree(%)



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STUDY OF RISK FLOODING IN EL HARRACH WADI (ALGIERS - ALGÉRIA).

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KEY WORDS: El Harrach wadi, floods, risk, hydraulic management, mapping, vulnerability zones, prevention systems.

ABSTRACT

The great urban development in Algiers province, more particularly the catchment area of the El Harrach wadi, does nothing but increase the floods risk to which it is exposed. To study this risk the hydraulic management of Algiers Province (DHWA) launched a study entitled « integrated study outside Bouzareah massif " which will target the mapping of vulnerability zones to natural hazards. The lower part of El Harrach wadi is classified priority zone N°2 (ZP2) and must be taken into account since it cumulates at the same time flood and morphology problematic, accompanied by a pollution problem linked to nearby industrial units. The aim of this work is to draw an overview on flooding problems, resume the most recent El Harrach wadi studies and try to propose some alarm and prevention systems .

HISTORY

El Harrach wadi always caused serious flooding problems and starting from 1906, records of days with numerous victims were kept. We recall the years 1911, 1923, 1931 (Fig.1), 1935, 1936, 1939, 1946, and 1954 where overflowing occur, properties were damaged and people hurt. Finally, in march 2007, a 1800 m^3/s important flooding caused a water return through waste water canalizations, which increased the risk of infectious diseases, with a water level over 1.5 meter.

GEOGRAPHICAL SITUATION

The site of study is located at the extreme part of the wadi El Harrach while emerging towards the sea, and this, in the zone of Hussein Dey to some 8km in the east of Algiers.

The El Harrach wadi catchment area, covering a surface of 1200 km2 belongs to the Algiers coastal catchment area. The wadi El-Harrach, major wadi in the Mitidja plain, has an overall length of 67 km, takes its source in the north of the blidean Atlas.

Figure1–Floodings in El Harrach City hall place.

FACTORS OF FLOODING

The analysis of the preceding data shows that the flood with El Harrach results from the interaction of several factors.

METEOROLOGICAL FACTORS

A remarkable weather situations resulting in a strong rainfall (important rains, violent storms) characterize the climate of northern Algeria. It happens that all the effluents of the river grow bigger at the same time because of strong rains, the river overflows of its minor bed to flood its major bed. These risings are exceptional: ten to fifty years. The flows calculated from the precipitations values of the downstream part of the El Harrach wadi catchment, indicate the existence of a centennial flow HQ=2010m3/s, which overflows in all the built-up area (Smar, El Harrach, Baraki) to the embouchure (Fig.3).

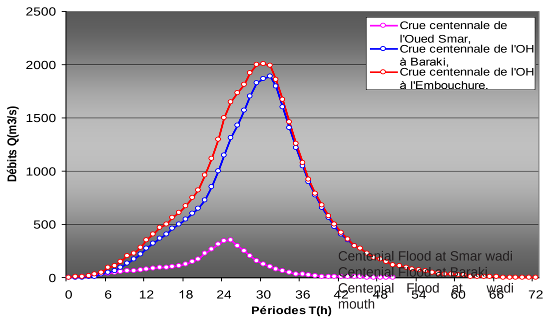

Figure 3 – centenial floodings of El Harrach and Smar wadi

TOPOGRAPHIC FACTORS

The importance of the topographic factor lies in the fact that the slope is undoubtedly one of the most perceptible parameter because it influences the flooding power, as well as the speed of the rainy flows. The plain of flood or alluvial plain is vast expanding from sandy grounds, with gravels and clays which cover the valley bottom. In the downstream basin part of El Harrach three classes of slopes were highlighted:
0 to 3%, 3 to 12,5%, and over 12,5% .

ENTROPIC FACTORS

Urbanization constitutes one of the principal factors of aggravation; the estimates show that the surface urbanized on a catchment area scale tripled. Adding to that the destruction of the cleansing network, the swelling of the downstream by wastes, mud and embankments.

Also for a more rigorous cartography of these risk zones, and on the basis of precise measurement heights of risings (Fig.4) collected at the direction of hydraulics of the wilaya of Algiers (ANRH), we established transverse profiles to follow the evolution of flooding compared to topography with its evolution from downstream to upstream of the area of study and to show the relation between the overflows of the wadi at the time of the risings and the increased risk due to numerous recent constructions.

A map of the grounds of the downstream cat chment area part of the El Harrach wadi shows that these grounds are low permeable to impermeable, which increases the risk of flood at this place.

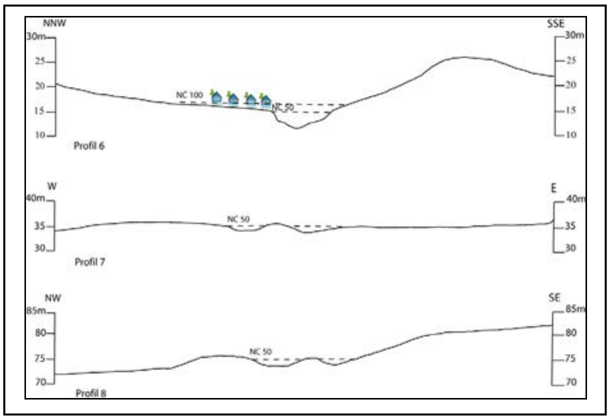

Figure4–Cross-section of flood level with topography.

CARTOGRAPHY OF FLOODED ZONES

The cartography of El Harrach zone enables us to know and account for the risk, but also to show the vulnerability of the various zones with their degree, which will be useful for the developers and decision makers to integrate in their step of global management and regional planning the decisive information. The realization of the combined study of the various factors influencing the risk of flood, namely, the climatic, topographic and morphological factors, enabled us to produce a map of flooding zones according to their hazard (Fig.5).

REHABILITATION OF EL HARRACH WADI

Alteration work was recently undertaken in the wadi in order to decrease the risk of flooding in the area. This work finalized in July 2009, consists of an extension and earthwork of the banks at the level of the two bridges of the El Harrach wadi, within the downstream and urbanized areas. In addition, what was carried out then, in 1976 by a German company (CKI), in urgency and 3 sections is summarized in three batches:

Batch N°1: Installation of the mouth of the wadi, i.e. the banks on 400 ml up to the bridge of the motorway. (recent extension of the banks July 2009) Realization of 2 riprap arms on 220m inside the sea. Dredging of the bed of the wadi (depth reduction of the wadi level in contact with the sea.)

Batch N°2: Construction of a protection and retaining wall of 320 m length and 9 m in height to replace the worn out and old one.

Batch N°3: Re-calibrating and reshaping the El-Harrach wadi near the big market. Adjustment of the junctions of the wadi Smar and Adda on 100m.

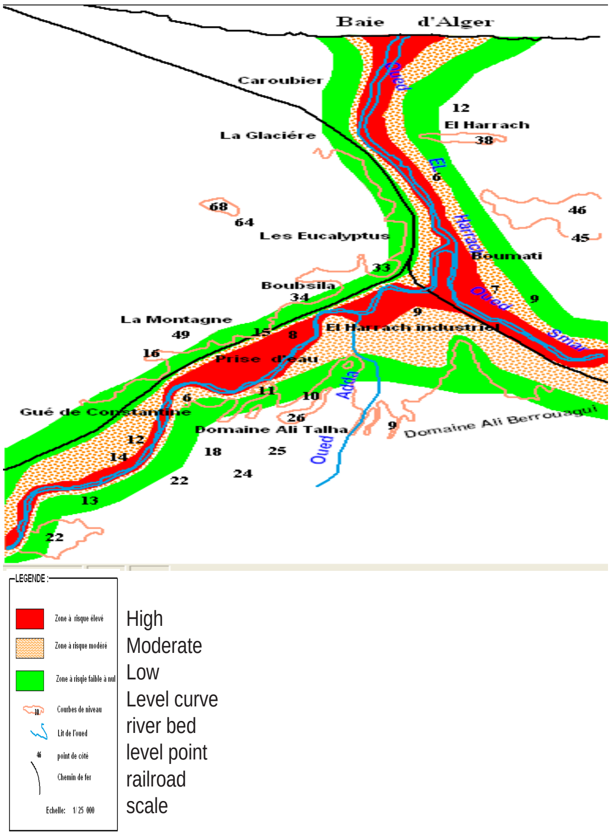

Figure5–Map of flood hazard in El Harrach

CONCLUSIONS AND RECOMMENDATIONS

The study of the risk of flood on the level of the wadi El Harrach shows that four dominating factors must be taken into account for its development: the history of the risings, morphometric factors, hydroclimatic factors and finally the geotechnical factors. The adjustment of the wadi proves to be essential to reduce this risk, which was carried out in three batches.The recommendations suggested relate to more one follow-up for better apprehending the risings and would be:

- Programming for second phase of installation.
- A control of the correct operation of the works carried out in order to ensure a better protection against the floods.
- A follow-up of installations by the regular clearing out of the bed and the banks.
- A determination of the hydraulic characteristics of the rain water works.
- The taking into account of the problem of the natural risks during the city planning.

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rapport sur l'état et l'avenir de l'environnement.

LANDSLIDE HAZARD IN PROVINCE OF CASERTA (CAMPANIA, SOUTHERN ITALY): A PRELIMINARY STUDY.

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KEY WORDS: landslides, GIS, susceptigility, hazard, IFF, landuse, thematic maps, statistic.

INTRUDUCTION

The hydrogeological instability is an issue of considerable importance for Italy, because there are many catastrophic events that have affected the area and which have caused the loss of lives and substantial damage for property. As a result of exceptional hydrogeological instability events, in fact, Italy is the first Country in Europe by number of victims and missing persons and the second among the world's most industrialized Countries.

In Campania Region the landslide risk areas are numerous and the geological-hydraulic risk exposure is a problem of great social importance, both for the number of victims, and for damages caused to houses, industries and infrastructures. Campania is a region geologically "young", subject to intense morphogenetic processes which shape the landscape substantially. Besides this natural inclination, for which the instability manifests itself in many different combinations and modality spoilage, other spoilage factors of the natural balances are related to mining activities, the presence of landfills, illegal building, and the widespread ignorance of geological problems.

From surveys conducted between 2004 and 2006, the Report on Landslides in Italy shows that the province of Naples, because of its essentially flat morphology, is the one with the lowest number of landslides (809), while Salerno with 6,730, followed with Benevento and Avellino (6,122 and 6,049) are the provinces with the highest number of landslides (APAT, 2007).

In connection with matters concerning land use planning is being paid increasing attention to the problems arising from the hydrological instability. In facing the issue, even in this case, it is now customary use of GIS (Geographic Information System). This work presents a methodological application for the integrated management of information on landslide events through the use of function analysis, typical of GIS, in order to create a Map of Landslides based essentially on areas already affected by landslides in operation or occurred in the past, counted with the IFFI Project (Inventory of Landslide Phenomena in Italy).

STUDY AREA

The Province of Caserta covers an area of approximately 2,639 km^2, or 19.4% of the Campania Region. From a morphological point of view, is rather complex: on the whole mountainous areas cover the 8.7% of the territory, the hills to 56.3% and 35% are flat. The altimetry varies from sea level to about 2,050 meters above sea level (Mt. Miletto, in Matese Mountains). The main geological features that characterize it are: the limestone-dolomitic relieves, of mesozoic age, of the Southern Apennines; the plain of the mean Volturno and the coastal plain of the Garigliano, morpho-structural depressions filled by argillaceous-arenaceous-marly miocene sequences and quaternary, alluvial and pyroclastic deposits; the Roccamonfina volcano, whose products, lavas, tuffs and melted pyroclastics, characterize the subsoil of the tectonic depressions surrounding. Volcanic fall deposits, produced by Phlegrean and Vesuvian activity during the late Quaternary-Holocene, cover the area non uniformly (Vallario, 2001).

In this context, the most disastrous landslides are concentrated in areas where the slopes are covered by pyroclastic deposits (APAT, 2007).

METODOLODY

Areas affected by landslides events according to the IFFI project have been used as input data for analysis: the attributes of each landslide have been usedprocessed to obtain a preliminary classification of landslides with extension less than 1 hectare, linear slides, linear slides evolving in areal and areal landslides. For each identified landslide area was extrapolated the information for the type of prevalent landslide.

Other tematic maps were after used to verify the spatial correlation with landslides:_ a) Lithological Map of the Province of Caserta, obtained from the Geological Map of Italy grouping the rocky bodies with similar lithologic characteristics; b) Soil Regions Map of Italy (ESBSC, 2003REF!). Finally, even if a clear difference in terms of both accuracy and resolution existed, the Agricultural Land Use of Campania region (CUAS) (SESIRCA, 2004) have been used as input data too.

A GIS project using Geomedia Professional 6.1 GIS software was carried out to better process and analyse both numerical and cartographical data such as vector, raster, and alphanumeric database. Spatial intersection of the IFFI Project elements with other tematic maps have been carried out and the results have been analysed using simple statistics.

RESULTS AND DISCUSSION

IFFI Project data analysis evidenced that: for punctual landslides with extension less than 1 hectare, the landslide prevalent movements were crashes/rollovers; landslides with a linear development set on watersheds more or less incised were mainly related to the phenomena of rapid dripping of lithoid material or more rarely melted; in their evolution at the foot these tend to occupy wider spaces when the morphological conditions permit; the areal landslides are mainly related to rotational/ translational landslides, rapid and slow dripping.

The spatial intersection with the Lithological Map of the Province of Caserta has determined that the failures occur mainly on calcareous substrates (mainly as rapid dripping) and sandstones (generally as a type of landslide with rotational/translational slip and slow dripping).

The intersection of the Map of Soil Regions of Italy with the database IFFI shows that the soils most affected by disorders are: Epileptic Phaeozems of 59.7, fine; Eutric Regosols of 59.7, fine-loamy; Haplic Calcisols of 59.7, fine-loamy, and Calcaric Cambisols of 59.7, sandy. The first two types of soil, characterized by limited thicknesses, are predominantly affected by landslides for rapid dripping while the other two by landslides for rotational/translational sliding and slow dripping.

The intersection with CUAS evidenced some problems in interpretation of results due to the different resolution and time-span of the original data, suggesting that a more accurate analysis should be carried out in order to better correlate, at a finest scale, land use, vegetation and landslides. Previous results anyway evidenced a clear spatial correlation between landslides and, in order of decreasing frequency, deciduous woods, olive groves, the arable land and grazing areas. Moreover fast dripping landslides occur predominantly in the “broadleaves dominated forests” and “natural pasture areas and grasslands of high altitude” while sliding rotational/translational landslides are frequent in “deciduous forests”, “olive” and “arable autumn winter crops - cereals for grain” classes.

The intersection of all considered layers has determined that the rapid dripping on carbonate bedrock (rock or soil) and slow dripping in sandstone deposits are the most common types of landslides in hilly and mountainous areas. The rapid dripping on carbonate deposits could be related to rocky landslides or mud slides, where there is vulcanoclastic coverage also thin thickness. The sandstone-clayey, instead, are affected by roto-translational slippage.

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STREAM RESPONSES TO SLOPE FAILURES IN LOW-TO-MEDIUM RELIEF RANGES: EXAMPLES FROM CENTRAL ITALY

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KEY WORDS: Landslide-dams; Knickpoints; Epigenetic gorges; Marche Apennines; Italy.

INTRODUCTION AND PURPOSE

In situ controlling factors, as local bedrock lithology and dip-topography relationships, play a crucial role in susceptibility to failure of mountain slopes, which are also highly sensitive to triggering factors as earthquakes and heavy rainfall/snowmelt. Besides shaping hillsides and ruling sediment supply to streams, failures on steep-sided valleys of mountain regions can produce stream blockages and/or diversions. Major controls by slope failures on hydrography of mountain regions thus results (Korup et al., 2010). Pronounced knickpoints can be formed, thus influencing long-profile shape and trends; stream impoundments can be established, which often result in formation of both lakes and intra-mountain alluvial plains; marginal spillways, epigenetic gorges and terraces can be also produced.

Although so far almost completely neglected, many examples of damming and diversion of streams due to slope failures can be observed throughout the north Marche Apennines, in central Italy. Imposing failures occurring in high-relief areas as Alpine or Himalayan mountain ranges often result in damming of trunk valleys (Korup, 2005; Ouimet et al., 2007). Conversely, the study area, which is a low-to-medium relief mountain chain, only brings about landslides the magnitude of which -if compared with the valley width- is insufficient to produce stream blockage of the large, often terrace-stepped, trunk valleys. Hence, such phenomena are usually abundant only throughout the secondary network (i.e., along the tributary streams). Here, hydrography is effectively influenced by landslides of different type and size, from a few tens of metres up to several hundreds of metres of front/runout extension. Nonetheless, a requisite for damming and/or stream diversion is the presence of wider pre-existing slope movements, including deep-seated slope deformations, the partial reactivation of which is the cause of the very most part of the observed phenomena. Some valley-blockages produced small lakes, which in some cases survived even for several millennia. Other landslides caused blockages that, although short-lived, were able to produce substantial modifications on stream profiles, triggering either stream downcutting or local aggradational episodes.

In this regard, this work presents three examples, which can be taken as representative of the major interactions between streams and slope failures along tributary valleys within a low-to-medium relief mountain chain. We take as examples the Montelago, Secchiano, and Corticelli sites. Meso-Cenozoic marly-calcareous and calcareous formations belonging to the Umbria-Marche Succession compose the bedrock of the three study areas. In each of the reported sites, during the Holocene, slope failures produced major stream modifications, as landslide-dam lakes, stream diversion, epigenetic gorges, knickzones and individual knickpoints.

CASE-STUDIES

Montelago. The Montelago site lies at the heights from 600 to 1200 meters a.s.l. in the upstream sector of the Sentino River basin, along one of its main tributary valleys (i.e., the Fosso del Lago stream). The downslope-dip of the strata here favoured the failure of the marly, marly-limestone and limestone bedrock, as well as the dislocation of the overlying thick, partially cemented talus. The slope failure produced a large "first time" block-/rockslide, which remained perched high on the valley bottom without any significant interference with the stream. Later on, large sectors of such landslide failed further downslope, damming the Fosso del Lago stream. Large amounts of calcareous breccia boulders incorporated into the runout produced an effective stream blockage, with the formation of a small lake that survived over seven millennia (Savelli et al., in press). The stream blockage produced important changes throughout the catchment. Beside the production of a lacustrine trough, key adjustments included a marked convexity of the stream profile, an associated epigenetic gorge, and distinctive knickpoints on residual landslide boulders.

Secchiano. The study-site is placed at the heights ranging from 300 to 600 meters a.s.l. within a tributary catchment of the Bosso River valley (Metauro River basin). The marly and marly-calcareous formations belonging to the Scaglia Group compose the bedrock of this area.

A partial rejuvenation of a gravitational slope deformation affecting the whole right (NE-facing) valley side forced the stream to undermine the opposite (SW-facing) hillside that, in turn, also favoured by the downslope-dipping of the bedrock strata, failed producing a large “first time” rockslide. Such initial failure stages only caused slight stream deflections. Nonetheless, the subsequent partial reactivation of the rockslide on the left valley-side produced a runout that effectively dammed the stream. Although no lake was apparently produced, several distinctive landforms resulted from the stream blockage. Among the principal landforms we found a small alluvial plain just upstream the landslide runout and a marked downvalley steepening of the stream profile with formation of an epigenetic gorge.

Corticelli. The site lies at the heights ranging from 130 up to 500 meters a.s.l. on the left side of the mid Metauro River valley, where marly and marly-calcareous Cenozoic formations crop out. The sample area encompasses part of a NW-SE oriented hogback ridge shaped on the relatively more resistant lithologies belonging to the Bisciaro formation and segmented by tributary streams in a rim of single rocky flatirons. One of these flatirons (i.e., the “Corticelli flatiron”), which is enclosed by the Fosso di Monte S. Angelo stream and the Fosso dei Brotoni stream, is displaced by a deep-seated gravitational slope movement. The slope failure caused the sagging of the rocky ridge, producing drainage perturbations and diffuse shallow landsliding. Two distinctive stream blockages can be recognized on the streams bounding the displaced flatiron. First, the runout of a shallow landslide atop the displaced flatiron dammed the Fosso di Monte S. Angelo stream producing a small alluvial plain that downvalley joins an epigenetic gorge. Second, the Fosso dei Brotoni stream was dammed by a landslide failed from the adjacent, relatively stable portion of the rocky ridge. Such phenomenon is probably related to the unloading of the stable rocky ridge following the sagging of the Corticelli flatiron. As a consequence, a small lake, at present transformed in a wetland, formed upstream the runout. At the same time, the blockage increased an already existing downvalley knickzone where inner gorges and a series of small waterfalls can be also recognized.

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SLOPE VULNERABILITY, LANDSLIDES AND GEOHAZARDS: INVESTIGATION AND MAPPING IN WESTERN HIMALAYA.

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The present study is an attempt to analyse and predict the land use changes and to investigate the impact of micro climate change on slope instability, geohazards and livelihood sustainability at local scale covering a range of time of Fifty Years between 1956 to 2005. In the Upper Beas valley of the Western Himalaya, Fieldwork, current data and historical prognostication have improved the understanding of causes of increased frequency of Geohazards. Study is based on both the Primary as well Secondary Sources of data. To collect the primary data for the transition of land uses, Spatial and temporal distribution of Hazards all the four revenue villages and twenty two hamlets of the Valley were surveyed on the basis of Stratified Random Sampling (SRS). For demarcation of critically and hazard zone mapping, the direct method as well as Standard Score Methods were used with the help of Geographical Information System (Arc /View software and 3D analyst). To find out Standard Score, different types of factors were rated according to their spatial distribution and severity to people. Different types of land uses and topographic features were rated out to calculate the Standard Scores. Finally the scores were crosschecked through community perceptions and experts from various institutions working in this field. Two hundred questionnaires were fulfilled along with the physical investigations of the landslides, Rock fall, debris flow, and mud flow for direct mapping.

In the Himalayan geosystem, changing relationship between man and environment have brought about irreversible changes in the ecosystem those of change in temperature and rainfall regime which have affected slopes prone to dip slip. Changing glacial behaviour and increasing numbers of avalanches, and over flowing rivers and streams have also increased the frequency and magnitude of landslides.

Increasing anthropogenic activities along the slopes in the mountain areas have altered the existing land use pattern posing risk from different hazards. The hazards are risk to people encountered in the physical environment. However, for all practical purposes natural hazards are perceived as events having abrupt modifying capabilities such as, earthquakes, landslides, etc. Hazards are also caused by human factors and exceed the tolerable magnitude, makes imbalance and leads in catastrophic losses of property, resources and lives. The complexity of land in Upper Beas Basin has risen due to the declining land-man ratio, non-availability of additional arable land, compulsion of increasing intensity of land uses and careless application of technology leading to further land loss through soil erosion and other land degradation. Frequent occurrences of hazards are becoming common feature in Upper Beas Basin. These hazards and the changing biophysical setup have a great impact on mountain geo-system.

When considering landslides, a number of hazard components are not operationally accessible. For this reason, a number of research programs have been developed around several themes, in particular the introduction of error calculations when defining potentially unstable areas. The inclusion of triggers in mapping, the differentiation of landslides propagation zones, and the uses of 2D and 3D investigational methods. Beyond scientific and technical programs, methods for structuring data at different scales should be proposed, in order to provide operational responses to problems of land management, crisis preparation and management and information. It is also important to utilize modern technologies and tools for making data available (i.e. GIS and Remote Sensing).

SLOPE INSTABILITIES TRIGGERED BY HEAVY RAINFALL: GEOMORPHOLOGICAL STUDIES OF COASTAL SLOPES IN THE ABRUZZI REGION (CENTRAL ITALY)

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KEY WORDS: heavy rainfalls, floods, soil erosion, Abruzzi region, Central Italy.

INTRODUCTION

Heavy rainfall is one of the most important triggering causes of landslides - particularly in Mediterranean areas, that are characterised by moderate to low annual precipitation and, occasionally, by high precipitation intensity. In agricultural or poorly vegetated hilly landscapes - particularly when characterised by clayey lithologies - heavy rainfall triggers very rapid geomorphological processes, such as floods, soil erosion (rill, gullies) and landslides (rapid earthflows) inducing strong erosion rates on the hilly landscape, sediment transport and sedimentation along the alluvial plains and at the mouths of rivers.

Over the last ten years, the Abruzzi region was affected by several heavy rainfall events. Three of them have had daily rainfall > 100 mm or >200 mm over few days: 1) on 23-25 January 2003 (in the whole region), 2) on 6-7 October 2007 (in a small part of the hilly and coastal Teramo area), and 3) on 1-2 March 2011 (in the hilly and coastal Teramo and Pescara area). These events have triggered different types of geomorphological instabilities: landslides, soil erosion and flooding. The distribution and types of instabilities and landforms is different in the three cases.

The 2003, 2007 and 2011, heavy rainfalls were analysed with regard to their meteorological aspects, and geological and geomorphological features, highlighting both common and distinct geomorphological effects on the landscape.

The meteorological data processing enabled the analysis and comparison of hourly rainfall intensity, cumulative rainfall, daily rainfall, monthly rainfall and previous monthly rainfall.

Geomorphological effects of heavy rainfall were analysed through a field surveys, aerial photo analysis and inventories and technical reports, mapping the distribution of the landslides, soil erosion and flooding.

The comparison of the heavy rainfall events (2003, 2007 and 2011) outlined that all had different features (Tab. 1), concerning:

- geographical extent (2003 regional; 2007 local; 2011 intermediate);
- lithological setting;
- duration (2003 ~3 days; 2007 <1 day; 2011 ~1 day);
- season of occurrence (2003 winter; 2007 autumn; 2011 winter end);
- previous humidity conditions (2003 very humid; 2007 very dry; 2011 moderately humid).

This variable conditions, taking into account also the general geomorphological setting and landslide distribution of the Abruzzo region, induced the trigger of different geomorphological instabilities (landslides, flooding, gullies, rills and sheet erosion, Crevasse splays), concerning type and areal distribution, as summarised by Table 2.

GEOMORPHOLOGICAL STUDY

In this work, a geomorphological study focused on slope instabilities and flooding occurred on the hilly area and coastal slopes of the northern Abruzzi area. The study is based on a multidisciplinary approach incorporating; orography and hydrography, hydrology of basins and channels, multitemporal photogeology, detail geological and geomorphological survey, river channel survey, boreholes, pluviometry, soil erosion survey and extimation. The whole project is developed within a GIS.

Event	Date	Extent	Season	Durat. (hours)	Ih_{max} (mm/h)	Pd_{max} (mm)	Pc_{tot} (mm)	Pm_{tot} (mm)	P previous
2003	23-25 gen	regional	winter	~72	10-17	40-130	80-230	120-380	elevate
2007	6-7 ott	local	autumn	14-16	10-40	60-205	60-220	200-300	scarce
2011	1-2 mar	intermediate	winter end	22-26	15-35	60-180	120-211	150-300	moderate

Table 1 – Main meteorological characteristics of the heavy rainfall events studied in this work. Legend: Ih_{max} - max hourly rainfall intensity during the event; Pd_{max}- max daily rainfall during the event; Pc_{tot}- cumulative rainfall during the event; Pm_{tot} - total rainfall during the event's month; P previous - rainfall in the month before the event.

Event	Landslides	Flooding	Gullies	Rills and sheet erosion	Crevasse splays
2003	>1300 landslides	Alento, Foro, Sangro, Sinello, Trigno	n.d.	n.d.	n.d.
2007	~ 0,6 km^2(6%) flows	~ 3,8 km^2 (29%)	~ 4,0 km^2 (31%)	~ 4,5 km^2 (35%)	-
2011	~ 0,5 km^2 (6%) flows	~ 6,5 km^2 (75%)	~ 0,8 km^2 (9%)	~ 0,4 km^2 (5%)	~ 0,5 km^2 (6%)

Table 2 – Geomorphological instability and landforms triggered by the three heavy rainfall events studied in this work.

Figure 1 – Landforms triggered by 2011 event: F. Salinello, flooding and crevasse splays on the main alluvial plain.

Figure 2 – Landform triggered by the 2011 heavy rainfall event: Pineto, gullies on the coastal slope.

The field mapping allowed for the realization of geological maps (1:5000) including bedrock lithology and superficial deposits. Integrating field mapping with borehole analysis, the thickness of superficial deposits (i.e. colluvial cover, slope deposits) has been also mapped. This is basic in the work because superficial deposits are the ones that are eroded and incised during heavy rainfall.

Field mapping, joined with multitemporal photogeology, allowed for the definition of the recent geomorphological processes and the progressive grow of urban areas in the last 60 years. A detail study on aerial photos, taken right after the 2007 heavy rainfall event, and a detail geomorphological survey, after the 2011 event, were specifically focused on the mapping of the triggered slope instabilities and flood landforms.

Particular attention was devoted to the estimation of sediment volumes eroded during the events within minor drainage basins that underwent the most slope instabilities in the studied events. These were compared to the esti-mation of sediment volumes potentially removable defining erosion rates during heavy rainfall with recurrence time ~100-200 year and more.

CONCLUSION

This work allowed us to highlight that these types of methods, investigations and data are basic to applied geomorphological studies for the stabilisation and management of slopes and minor or major drainage basins as well as for general land management. Only a high level of knowledge of geomorphological instabilities - connected to drainage - geological-geomorphological and morphostructural features and meteorological events - particularly when joined to geotechnical data - allows for effective stabilisation and management plans.

Finally, these types of studies are basic and complementary to recent methods for the investigation and mapping of land sensitivity to geomorphological processes, such as landslides, soil erosion and desertification, etc., and they allow us to define future scenarios - which sustainable land planning and management should be based on - taking into account the specific destination of different areas and contributing to the identification of proper sites for quarrying, dumping and purification plant, etc., or else the proper areas for industries, urban expansion or supporting in general the process of creating an urban plan.

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QUALITATIVE APPROACH TO ASSESSING RISK LANDSLIDE IN THE NORTHEAST ALGERIA (THE MAPPING OF COMMON ZAAROURIA AS A MODEL)

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KEY WORDS: Keywords: Risk, landslide hazard, GIS, Spatial modelling, qualitative approach, Zaarouria.

Climate change could increase the intensity or frequency of natural events such as landslides.

Several Algerian regions suffer from this problem. For example the torrential rains of 2003. More than 200 landslides have occurred in less than 15 days.

In northern Algeria, landslides occur everywhere. The most vulnerable areas are located in mountain areas, where slopes are steep and heavy rainfall. This is the case in the region of Zaarouria near Tunisian border.

From 1981 to 2011, 82 landslides were recorded. These landslides have caused dozens of injuries, and damage estimated at several million dollars, and the relocation of hundreds of families.

The majority of these landslides occur on slopes of Triassic marlclay. Coupled to the increase of snow and rain seeped into the ground, because of the shrinkage phenomenon of swelling clays.A substantial increase in the number of landslides and roadfailures is recorded.

This paper follow a regional scale method based on the exploitation of Multi-source information: earth observation data, and their derivation from hybrid data sets, to study landslide hazard zonation relative weighting-rating technique.

For the study area (Zaarouria area, northeast of Algeria) this Zonation is conducted through superposition and interpretation of multiple factor layers including morphological, lithological, structural, land use, map of slope classes calculated from the digital elevation model, rainfall map, and drainage network derived from the satellite scene, a multi-temporal inventory of the spatial distribution of past landslides sets from aerial photographs (about 30 years), confirmed by measuring terrains....

For each mapping unit, we obtain the landslide recurrence by dividing the total number of landslide events inventoried in the unit by the time span of the investigated period. Assuming that landslide recurrence will remain the same in the future, and adopting a Poisson probability model, we determine the exceedance probability of having one or more landslides in each mapping unit, for different periods.

Once the GIS database completed, the index of risk of landslides is calculated and zoning risk of landslides is determined by slicing histogram.

The results displayed distribute the field study area in the area of high slope stability, a stable slope zone, the zone of quasi-stable slope, and slope area relatively unstable area ofunstable slopes. a series checkpoints GPS (Garmin) on identified landslide in the preliminary campaign Referring to the active, inactive and occasionally reactivated are used to validate the accuracy of the technique used in our study.

This paper proposes a probabilistic model to determine landslide hazard at the departmental scale. The model predicts where landslides will occur, how frequently they will occur, and also stress the importance of a correct characterization of the processes leading to landsliding to produce reliable susceptibility and hazard-zoning maps.

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THE ACCURACY ASSESSMENT OF GEOMATICS DATA USED IN ROCK SLOPE STABILITY ANALYSIS

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KEY WORDS: accuracy assessment, engineering-geological data, terrestrial laser scanning, digital terrestrial photogrammetry.

The knowledge of a rock slope structural setting is necessary for the analysis of instability phenomena. Frequently, the inaccessibility of either natural or artificial fronts does not allow direct measurement of discontinuity surfaces by traditional geological methods; often, versants are very high, sub-vertical or even protruding while the structural setting resulted from traditional engineering-geological surveys is only representative of a restricted part at the bottom of the slope.

Geometrical characteristics of joint systems that extend in the whole versant can be studied using geomatics technologies such as digital terrestrial photogrammetry (DTP) and terrestrial laser scanning (TLS). Given a correct planning of data acquisition, these techniques guarantee the possibility to model the whole slope under study. The “point cloud” obtainable from TLS is automatically registered and it corresponds to the exact morphology of the slope; TLS (Fig. 1) allows to investigate fronts of various morphological complexity, size and in a short time. DTP, for its part, utilises images to be processed and oriented in respect to the ground in order to produce the stereoscopic model of the front from which detailed digital elevation models (DEM) and orthophotos can be also created. The reliability of the photogrammetric technique is linked to the photographs acquisition process, to the quality of both images, in terms of spatial resolution and contrast, and reference points on the ground. Facing with several slopes morphologies and different operating conditions, such as the accessibility of the study area, authors of the present paper have decided to create three different aluminium bars for the acquisition of digital stereo-images. Basing on site peculiarities, the proper equipment can be chosen among a topographic tripod (Fig. 2A), an aerostatic balloon, helium inflated, which can lift the rig up to three hundred metres from the ground (Fig. 2B) and a helicopter (Fig. 2C) supporting the photogrammetric bar below or hooked up to its lateral hump.

Both from TLS and DTP, following different processing procedures, information about the slope morphology, the volume and the shape of unstable blocks and metric characteristics of discontinuity systems, such as joints attitude, persistence and spacing, can be obtained. Recent experiences by several authors (Haneberg, 2005; Lim et al., 2005; Tonon and Kottenstette, 2006; Sturzenegger and Stead, 2009) have demonstrated that TLS and close-range DTP together represent a new and effective technology for rock mass characterization. For this reason, data accuracy must be carefully assessed because every inaccuracy in measurements could determine an erroneous evaluation of stability conditions. Therefore, these techniques have to be accompanied with detailed studies on boundary conditions and with a complete model’s calibration in respect to the real slope configuration.

Figure 1 – Terrestrial laser scanner operating at the Apuan Alps Marble District (Carrara, Italy).

In this study, a validation procedure has been followed in order to assess the accuracy of dip direction and dip measured on joints and slope’s surfaces present both in a quarry wall and in a natural front sited in the Apuan Alps Marble District (Carrara, Italy). Measurements from the two proposed geospatial methodologies have been also validated in respect of data coming from traditional direct engineering-geological surveys. Analysis results have enabled to highlight the strong points of the proposed methods related to the great number of measured facets, their quality and spatial distribution all over the slope.

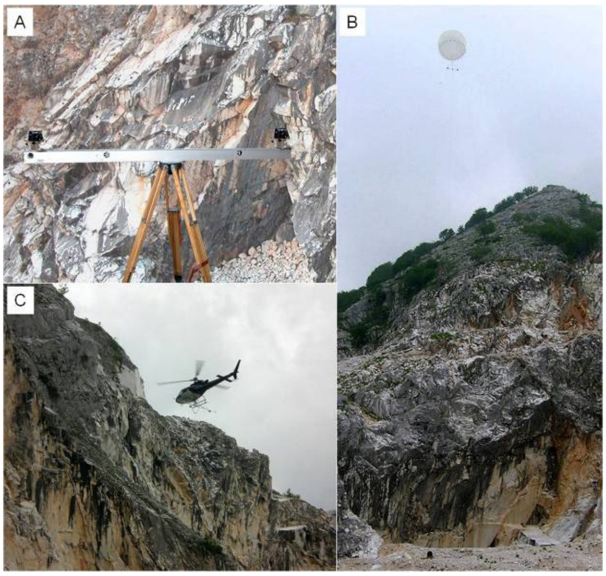

Figure 2 – Acquisition of photogrammetric data by different equipments: terrestrial reamed bar (A), aerostatic balloon (B), helicopter (C).

Since TLS points cloud must be not biased and it is not prone to manual errors, the measurements comparison has demonstrated the high accuracy of DTP with mean values similar to that of TLS and differences always lower than 10 degrees (Tab. 1). Standard deviation of attitudes derived from DTP, less than 10 degrees, indicate the precision attainable with this technique and, in respect to TLS and fieldwork data, the confidence that deriving measures can be compared with. In addition to the described advantages, this study has faced with some critical issues related to the correct planning and execution of the surveys as well as to the data processing complexity.

The final step of the study has been the identification of terrestrial laser scanning and photogrammetry distinctiveness in a way to make possible the definition of modalities and contexts where they could be used as alternative rather than as supplementary.

Rock Surface	DipDir (diff.μ)	Dip (diff.μ)	TLS DipDir (σ)	TLS Dip (σ)	DTP DipDir (σ)	DTP Dip (σ)
A	-3.6°	-0.5°	0.9	1.7	4.9	4.6
B	-0.2°	-2.3°	0.7	0.2	4.1	4.6
C	-3.4°	-7.2°	1.1	2.2	3.4	1.5
D	1.8°	9.2°	0.4	1.6	9.4	7.1
E	1.9°	4.7°	0.9	0.6	4.9	2.8
F	-1.2°	1.3°	1.1	1.9	1.6	3.1

Table 1 – Examples of comparison between dip and dip direction values of rock surfaces measured on the stereoscopic model (DTP) and on TLS points cloud. The table states the mean (μ) and standard deviation (σ) of surfaces attitude.

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ARTIFICIAL NEURAL NETWORKS AND WEIGHT OF EVIDENCE METHOD TO LANDSLIDE SUSCEPTIBILITY ASSESSMENT

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KEY WORDS: Slope instabilities, geostatistics, artificial neural network, soil and planning.

INTRODUCTION

The problem of identifying areas having a higher propensity for the triggering of shallow landslides during extreme weather events is crucial in land use planning. The hazard is defined as the probability that a particular landslide occurs in a given area and in a given period of time, is calculated and then visualized (using maps of slope stability), by using different methodologies. In the last decade, the continuous growth of the available calculation power allowed to apply methods for evaluating hazards for increasingly complex landslides. Nevertheless, a correct implementation depends on the deep knowledge of their limits of validity as well as on the appropriate choice of the factors which are presumed to affect the slope instability.

The possibility to implement a realistic and accurate representation of the depth and geomechanical properties of incoherent deposits would greatly improve the calibration of models for landslide hazard assessment.

Various studies dealing with the landslide susceptibility assessment have been carried out by several authors [2,3]. In this work, the Artificial Neural Networks (ANNs) have been used to define an ANNs-based methodology for the identification of the depth of the detrital layer on the basis of hydrogeological efficiency index, slope, geology features and classification detrital layer type.

GRADING AREA

This study aims to develop a statistical model of the spatial distribution as well as of the geomechanical characteristics of the sloping deposits and layers of granite alteration on a fairly large area near the village of Capoterra (Province of Cagliari, in South Sardinia, Italy); which is often subject to flooding and debris flow phenomena of great magnitude. These models have been developed through analysis of correlations between the depth of the detrital layers, their geotechnical, geo-mechanical, hydraulic parameters, and several other variables (morphological, geological, structural, physiographic, vegetation, etc.). The characteristics of stability and strength of the identified areas have been analyzed by building a geo-database full of over 500 sample points.

LANDSLIDE SUSCEPTIBILITY ANALYSIS USING WEIGHT OF EVIDENCE METHOD

Using the location of the landslides, GIS data and topographic factors, such as soil and land use, the Weight of Evidence method [1] has been used to calculate each factor's rating and to evaluate landslide susceptibility. To assess the reliability of results obtained the method of ROC curves (Receiver Operating Characteristic) has been used. The result of the statistical analysis in the case of prediction of the value of a bimodal variable, such as the presence or absence of the detritus deposits, is constituted by a map that represents the probability that the variable assumes one of two values. To measure the degree of reliability, given a probability threshold, the map is reclassified assuming that all areas that assume a probability value exceeding that threshold are covered with debris.

ARTIFICIAL NEURAL NETWORKS

Multi Layer Perceptron Artificial Neural Networks (MLP-ANNs) [4] have been used in this work to create a model of the studied system. The ANNs have been trained on the basis of a set of 504 input/output pairs of examples divided into a training and a test set. The best subdivision between said two sets have been determined through a incremental trial procedure.

The best structure of the MLP, namely the number of hidden neurons, has been determined by means of a trial and error procedure, so that several trainings have been performed assuming a growing number hidden neurons [4]. The described procedure leaded to have 265 and 239 examples in the training and test sets respectively and a number of hidden neurons equal to 7.

The Levenberg-Marquardt algorithm and has been used to train the network. The network was composed of one input layer, one hidden layer and one output layer. The input layer is composed by 4 neurons corresponding to the hydrogeological efficiency index (HEI), the slope (S), the geology features (G), and the classification detrital layer type (CD). The output layer is composed by 1 neuron corresponding to the depth of the detrital layer (D) (Figure 1). The hyperbolic tangent has been chosen as activation function of the hidden layer and the linear activation function for the output layer. The goal of the training process is to find the set of weight values that reconstruct the input-output relationship. On the basis of the input parameters above mentioned the depth of the detrital layers has been determined.

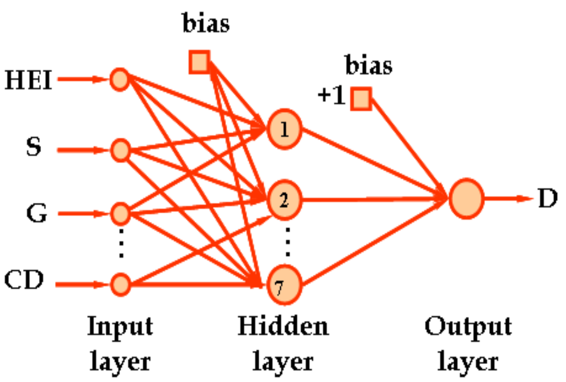

Figure 1 – 4-7-1 Multi-Layer Perceptron ANN

RESULTS

Weight of Evidence Method has been applied in a first analysis, so as to identify the position of the blanket without fixing the exact thickness. From the graphs of the obtained ROC curves, for both the train and the test areas, a success rate of over 70% has been obtained.

The ANNs-based method performance has been evaluated on the area of Capoterra, aiming to determine the depth of the detrital layer of the area. A 4-7-1 MLP- ANN has been trained with a training set of 265 examples. On the basis of preliminary trials, the number of training epochs as been set to 500, and the mean squared error on the test set was equal to 5% of the range of target values.

CONCLUSIONS

The possibility to implement a realistic and accurate representation of the thickness and geomechanical properties of incoherent deposits will greatly enhance the calibration of deterministic models for landslide hazard assessment. Through a better stratigraphic, pedological, hydraulic and mechanical characterization of the studied basin, the location and timing of initiation of the phenomena of sliding surface of the detrital layers are determined, in the context of a meteoric event of a certain intensity and duration.

ANNs represent a suitable methodology for modeling landslide susceptibility assessment. In general, the results showed very good performances in approximating the depth of the detrital layers

The advanced knowledge and study of the area can provide preventive knowledge, to prefigure scenarios and simulate events that help make decisions, to manage disasters, to monitor the area, to develop plans and actions. The constant use of this techniques and a policy of greater sharing of data between local authorities would allow planning can not only prevent the emergency but also its real-time management.

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V.I.S.O. – GIS-BASED INFORMATION SYSTEM FOR ROCK FALL HAZARD/RISK PREVENTION ON ROAD INFRASTRUCTURES MANAGED BY THE PROVINCE OF BOLZANO/BOZEN

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KEY WORDS: prevention, hazard/risk assessment, road network, rock fall management.

INTRODUCTION

The need of prevention acts against rock fall on road infrastructures in the Province of Bolzano/ induced the Road Service together with the Geological Service and the Department of Informatics to develop a system in order to investigate and catalogue rock fall protection measures and to evaluate the hazard on a stretch of a road. So the so called V.I.S.O. project (Viability Information System) was developed.

V.I.S.O. consists of two main parts: an alphanumerical (VISO application) and a geometric database (SDE strata). VISO offers a module with a standardized interface and provides at the same time not only a connection to the GIS-system but also to the databases Oracle and the Microsoft Access archives.

The V.I.S.O. tool offers the surveyor a way to quickly detect the hazard due to landslide or toppling phenomena that characterizes a slope adjacent to the stretch of a road. It also allows creating a priority list of intervention (new investments) and maintenance based on fundamental parameters like the hazard (in future the risk) level of the slope.

The development of a tool to link an index of vulnerability and exposition to every segment of the road network and finally to calculate the risk is still ongoing in collaboration with the University of Bologna DICAM (Department of infrastructure engineering) in the frame of the Interreg Project PARAmount (imProved Accessibility: Reliability and security of Alpine transport infrastructures related to mountainous hazards in a changing climate).

SLOPE HAZARD LEVEL

The procedure to define the specific hazard level is based on the detection of 7 fundamental parameters:

- Intensity of the landslide phenomenon;
- Probability for the phenomenon to occur at the same point again;
- Hazard level of the slope without protection systems;
- General situation of protection systems;
- Hazard level of the slope supplied with protection systems;
- Vulnerability of the road segment;
- Specific risk of the road segment.

These parameters need field work to define three major points:

- Survey of the position (GPS or classical topographic methods) and of the characteristics of the protection system(s); this implies the identification of the type of protection measure and the determination of their geometrical features.
- Detection of the intensity of the rock fall events that may occur on the slope and by assessing specific damping factors. The intensity of the event (G.E.I. - geological event intensity) is given by the sum of the following parameters: single block volume, greatest volume to be mobilized, state of decompression of the slope and structural situation of the rock face (orientation and spacing of discontinuities). The damping factors (S.C. - Slope Coefficient) are assigned through the definition of the slope angle, the morphology and the rebound of the slope, as well as the type and density of vegetation.
- Survey of functional characteristics of the protection system; this includes its conservation state, its efficacy and its proper positioning related to the intensity and the geometry of the phenomena that may develop on the slope as defined in the previous step.

The assessment of the hazard level to a slope segment without protection systems is fundamentally based on the intensity of the phenomenon (S.E.I. slope event intensity), given by the sum of G.E.I. and S.C. parameters, and the probability of occurrence.

The calculation of the probability of occurrence for the V.I.S.O. method is based on the counting of every rock fall event (records of surveys, and/or technical reports archived at the Office for Geology and building materials testing of the Autonomous Province of Bolzano/Bozen) within the maximum time span of monitoring available (from 1998 onwards). The error bars depend clearly on the quality of event detection and the period of monitoring.

The assessment of the hazard level to a slope segment with protection systems is given by crossing the hazard value for the slope without protection systems and the evaluation of the examined protection system.

THE ATTRIBUTION OF A HAZARD LEVEL TO A ROAD SEGMENT

A road at the base of a slope is affected by the hazards above which depend on the slope event intensity and the state of the protection systems as shown above. To calculate the hazard for a specific road sector, the arterial roads are subdivided into segments of homogeneous hazard level in this way: first the slope is divided into areas with the same slope event intensity (S.E.I). In the next step these portions of slope are intersected with the present protection system. Where there are no protections, the slope hazard is attributed directly to the road segment. Where protections are present, the remaining hazard below all protection system lines is attributed to the road segment below.

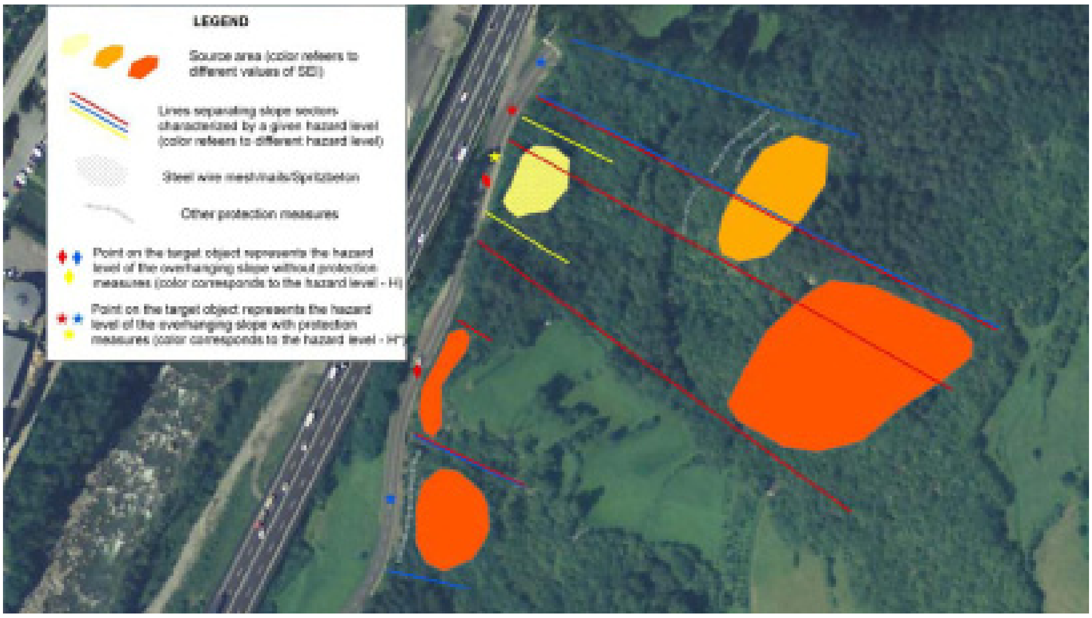

Figure 1 – Hazard level referred to a road segment

To simplify the different GIS operations and statistical calculations every road segment is represented by its median point which gets all information of the entire segment.

DRAFTING OF INTERVENTION PRIORITY LIST

To attribute to every median point a priority of intervention, it is necessary to assign a numeric value at every point in the matrix slope event intensity *(S.E.I.)*, vs. the probability of occurrence (*Tr)*. This is made by the formula,

$$h^* = \left(50 - Tr\right) \cdot \frac{5}{9} + \frac{S.E.I.}{3} + \alpha$$

where α is a value that defines the functional characteristics of the protection systems. It varies from -33.33 in the case, where the protection is best, to 0 where the structures are not present or have no effect to + 11.11, where the protection does even aggravate the situation.

After that every specific segment of an arterial road has an index of intervention priority. This index allows to elaborate a maintenance plan of the protections, to schedule extraordinary repairs of protection systems and to target new mitigation measures.

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FAILURE MECHANISM AND FACTORS CONTROLLING EARTHQUAKE TRIGGERED LANDSLIDES IN EL SALVADOR.

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KEY WORDS: El Salvador, landslides triggered by earthquakes, Jiboa landslide, Failure mechanism

On 13 February, a M-6.6 earthquake occurred ~40 km east-southeast of San Salvador and triggered thousands of landslides. The landslides were concentrated in a 2500 km^2 area. The most common landslides were shallow, disrupted soil-slides on steep slopes and were particularly dense in the central part of the country. In addition to these, numerous large landslides occurred (Ej. El Desague and El Jiboa), which blocked river channels and rod cuts. Analysis of size, failure mechanism, characteristics and controlling factors of landslides showed that, occurring and distribution of landslides is influenced by several causative factors. The shallow landslides are mainly controlled by the geotechnical properties, slope geometry and lithological and topographic seismic amplification. Most of them are cited in the recent deposits of, late Pleistocene and Holocene Tierra Blanca rhyolitic tephra deposits known as “Tierra Blanca” and “Tierra Color Café” which are prone to a large seismic amplification and steep slips deep river valley.

Nevertheless the distribution of large landslides which have a complex failure mechanism seems independent of superficial effects (superficial deposits and topographic effects).

Field and laboratory data were collected from one of the largest landslide; JIboa landslide. This study demonstrates that the Jiboa River landslide occurred in a three stage failure mechanism, collapse/tension cracking/shearing. There is also a large near field contribution in landslide distribution (Tsige, 2010). specially in the collapse stage, where it has occurred as a combination of high frequency ground shaking and a local seismic wave guidance of fault zone which modify the seismic waves

EARTHQUKE TRIGGERD LANDSLIDES EN EL SALVADOR

El Salvador, due to its geodynamic context close to the Cocos-Caribbean segment of the Middle American subduction zone, where the plates converge-, is located at one of the most seismically active areas in Central America. For this reason, it has suffered 11 destructive earthquakes during the past 100 yr, which have caused severe damage and great loss of life, mainly due to the earthquake triggered landslides.

Recently in 2001, El Salvador experienced two devastating earthquakes. On 13 January, MW7.7 earthquake centered ∼40 km off the southern coast associated to the seduction zone, caused widespread damage and fatalities throughout much of the country. The earthquake triggered thousands of landslides that were broadly scattered across the southern half of the country though, there was a large concentration to the central part of the country. One month later, on 13 February, a M-6.6 earthquake occurred east-southeast of San Salvador produced by the E-W trend El Salvador Fault Zone. This earthquake triggered additional thousands of landslides east of Lake Ilopango. The landslides were concentrated in a 2500 km2 area and occurred mostly on step slips. Most of them were shallow disrupted soil-slides, and rockfalls cited in the recent mechanically weak volcanic pyroclastic deposits, known locally as “Tierra Blanca” These highly pours and unconsolidated deposits are prone to seismic wave amplification and are supposed to have contributed to the triggering of some of the hundreds of landslides related to the historical and recent earthquakes (Tsige, et la, 2010, Boomer, 2002,).Therefore, a combined effect of topographic and lithological seismic amplification is considered as the most important casual factors which contributes to the occurrence and distribution of these shallow landslides. The two earthquakes also triggered numerous deep large scale landslides responsible for the enormous devastation of villages and towns Many of these landslides are located at distances more than 50 and 100 km from the focal distance, although some of them occurred at near field. Even if, the shallow small landslides produce some important damages, the greatest damage including fatalities was produced by these large scale landslide, being Interesting there study for a high seismic hazard analysis and mitigation measure. Other important aspect of these large landslides is the large amount (most of them more than 250000), and the post-rupture behavior of the slide mass.

Geotechnical, geological and geophysical investigation was undertaken on one of the largest landslide occurred during the 13 February Mw 6.6 2001 earthquake (Jiboa landslides), to determine the factors responsible for its occurrence and failure mechanism and post-rapture behavior.

JIBOA RIVER LANDSLIDE FAILURE MECHANISM

Jiboa landslide, occurred. near the confluence of the Río El Desagüe and Río Jiboa. The volume of the landslide material is estimated at about 12 million cubic meters with vertical drop about 170 m The landslide blocked about 700 m of the valley of Rio Jiboa with debris and the upstream lake could potentially have been as deep as 60 m and about 2 km long causing a serious hazard in the area (Braun et al, 2001). The result of the Geotechnical and Geophysical study at the Río Jiboa landslide show that the slope consists primarily of a blocks of indurated andesitic breccias and pyroclastic deposits interbeded by rhyolitic, tephra belonging to the Cuscatlán Formation. The failure at the slope occurred along a combined failure plane within a complex sliding deformation mechanism; Collapse / cracking-settlement / shearing.

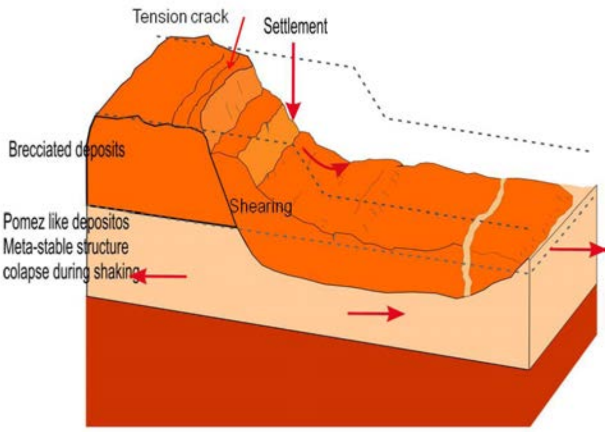

Fig.1. Three stage rapture mechanism of Jiboa Landslide; Colapse/tension cracking and settlement/ shearing,

In the collapse/tension cracking-settlment/shearing mechanism, there are three deformation stages (fig 1) Collapse in the low inclined highly porous tephra like materials which are interbedad in the brittle andesitic brecciate deposits, cracking in the near surface and settlement and at last shearing failure of the block. The sliding plane dips more steeply >60º than the slope surface <25º)

The underlining tephra like deposits are crucial for the formation of the landslide due to their collapse. The microstructure study under scanning electron microscope (SEM) of these deposits revels, that they have an open meta-stable “skeletal” microstructure, consisting in a direct grain-grain contact or bonding, weak cementation and large pores (including important intra-crystalline pores, (fig 2).

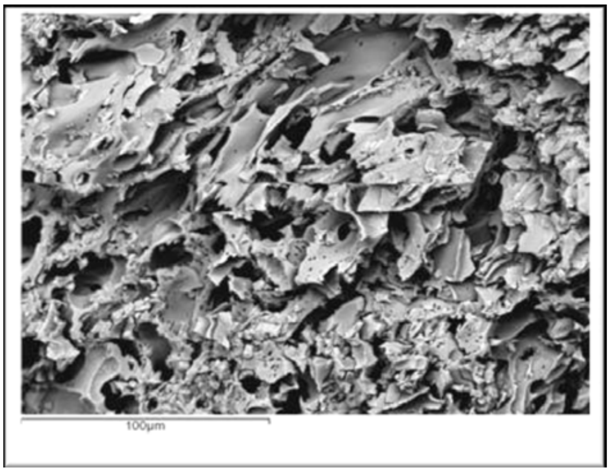

Fig. 2. Microfotograph of the tephra like deposits.

During the earthquake they suffer a large internal permanent deformation and strength reduction as a consequence of the grain-grain bonding collapse. and the lose of cementation due to seismic shaking The insitu strength with high peak strength and brittle behavior supplied by these bonding, can be mobilized by small strains Soil/rock interface in these soils during seismic shaking, creating an impermeable barrier that allows air-trapped during seismic shaking and consequently collapse and reduction on strength.

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LANDSLIDE HAZARD IN THE SANT'AGATA DE' GOTI MUNICIPAL TERRITORY (CAMPANIA, SOUTHERN APENNINES)

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KEY WORDS: landslide, hazard, GIS, thematic maps, spatial analysis.

ABSTRACT

The landslide susceptibility points out the tendency to the instability of the slopes calculated on the basis of qualitative judgment, without a temporal reference. The use of tools GIS and of statistic processing of data, has allowed to develop suitable methodologies to determine the landslide susceptibility of a territory. Aim of this research is to determine the landslide susceptibility of territory of Sant'Agata dé Goti (Southern Italy) using a dataset normally available.

GEOLOGICAL SETTING

The municipal territory of Sant'Agata dé Goti covers a 63 km^2 area extending at the feet of the Taburno-Camposauro Meso-Cenozoic carbonate mountains, in the Southern Apennines. It is characterized by a steep gradient, ranging from 42 m a.s.l. (Ponte Biferchia locality) to 1,323 m a.s.l. (Colle dei Paperi, SW side of the Mt. Taburno massif). At the mountains base Mio-Pliocene mainly terrigenous deposits outcropping, often covered by Pleistocene talus fans. Pyroclastic flow deposits (mainly ascribed to the "Ignimbrite Campana") are widely present.

Volcanic fall deposits, produced by Phlegrean and Vesuvian activity during the late Quaternary-Holocene, cover the area non uniformly (Carannante *et al*., 2011).

METHODOLOGY

From the Digital Elevation Model, made using as input the basic topographic data of the Regional Technical Map (at the scale 1:5.000), we drew the Slope Map, whose classes were chosen on the basis of the van Zuidan classification (1985) that links any steepness degree to the movement types and their characteristic processes.

The Lithological map was drawn starting to the Geological Map of Italy at the scale 1:50.000 (Sheet 431 "Caserta Est") grouping the rocky bodies with similar lithologic characteristics.

The acquired informations form the dataset of a Geographic Information System (GIS), managed by the Intergraph Geomedia PRO 6.1 software; it was been linked to the database and the maps of the Schedule of Landslides in Italy (IFFI Project) and also to the Map of the Agricultural Utilization of Soils (CUAS 2000).

Through the features of the topological overlay, peculiar of GIS, the cartographic documents intersection, only in vector format, allowed to determine the individual attributes for each landslide area.

ANALYSIS

Within the municipal territory of Sant'Agata dé Goti 144 landslides have been recorded; the prevailing types are:

- rotational/translational slides and complex and compound landslides: mainly occur in moderately steep (inclination of the slope between 8° and 16°) and steep (16° to 35°) areas, on clays and arenaceous complex covered by olive groves and orchards.
- slow flows landslides: mainly occur in moderately steep areas, on clays covered by orchards and olive groves.
- fast flows landslides: mainly occur in steep areas, on limestones and debris deposits covered by loose pyroclastic deposits and, above, deciduous.

Through the collected information we analyzed for landslide hazard areas within the whole municipal territory.

The procedure followed for the identification of different hazard areas is based on the statistical processing of the IFFI database landslides features as number, type, state of activity, lithology of the slide phenomena and steepness of the slope affected by the failures. The methodological approach is referred to the principle that higher is the concentration of landslides higher is the possibility that new ones occur or that those present are subject to reactivation.

Each landslides category, distinguished for state of activity, lithology and steepness, was attributed to different levels of hazard, according to the predisposing causes of instability:

- P3 – very high hazard (areas characterized by the presence of one or more categories of Active/Reactivated/Suspended landslides);
- P2 – high hazard (areas characterized by the presence of one or more categories of Dormant landslides with high probability of reactivation),
- P1 – moderate hazard (areas characterized by the presence of one or more categories of Dormant landslides with low probability of reactivation).

The same landslides categories were also attributed to intrinsic hazard levels related to the involved lithologies.

The reactivation probability of P1 and P2 levels and the intrinsic hazard were determined through the topological overlay of lithology and steepness and after statistically analyzed. Finally, the Landslide Hazard Map of the Sant'Agata de' Goti town at scale 1:25.000 has been drawn.

Analysis of the data showed that only 9.24% of the Sant'Agata de' Goti territory is affected by the P1, P2 and P3 hazard classes, despite the town is one of the 2,839 Italian municipalities having a very high risk from landslides (APAT, 2007). In fact, only 5.7 km^2 of the whole municipal area are affected by instability phenomena related to landslides. However a large section of the territory (39.3%) has lithological and steepness characteristics of the typical areas where the majority of landslides occur. So these sectors are prepared to collapse because, in these areas, the probability of landslides occurring is quite high. In the produced maps these zones were well-defined as areas potentially affected by landslides.

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HYDROGEOLOGICAL STUDY OF CORNIOLO LANDSLIDE (HIGH BIDENTE VALLEY, ITALY)

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KEY WORDS: Corniolo, landslide, Bidente Valley, Northern Apennines, Emilia-Romagna Region, hydrogeological monitoring, tracer test

INTRODUCTION AND STUDY SITE

Corniolo town (Santa Sofia, Forlì-Cesena, Italy, Fig. 1) lies on an isocline slope, on the marls and sandstones of a flysch formation, precisely a sandstone lens (original survey data) in the Corniolo Member of Marnoso Arenacea Formation (Langhian).

In the past, the slope was interested by large landslides, testified by extensive debris deposits (colluvium) above and among the town, while the village lies mostly on a sandstone layer that forms a wise structural surface. These gravity movements can be classified as translational rock slides (on structural surface) with local small rock falls that evolve in translational debris slide (Varnes 1978); they let recognize the whole displacement as a complex and combined slide. Thanks to borehole logs, the stratigraphy of the body has been precisely identified: an upper thick colluvium (maximum thickness of about 21 m) overlays a highly fractured bedrock 5-10 m thick stratum and this last one lays on the normally fractured bedrock.

At the beginning of the last century, the slope was interested by a large gravity movement, in its lower part, from the town to Bidente River, immediately below the main road. In the ’20s the Civil Engineering Office of Florence made the first slope seattlement works, mainly represented by river arrangements to protect the lower part of the slope by fluvial erosion. In the ’60s, in order to prepare building squares, the thick sandstone layer below the village was cutted leaving footwall without a substain ridgeward. After the cuts, the rock slope showed instability indications, mostly represented by fractures on civil buildings. Since it, the Technical Basin Service of Romagna (ex Civil Engineering Office) made a lot of set ups and consolidation works in order to make the village free from hydrogeological risk and avoid the replay of the phenomenon; it also installed a first monitoring net on the landslide (piezometers, inclinometers and extensimeters). The triggenning causes (the most are foot erosion and subdigging by Bidente River) were solved by the works on the river bed, while in the area upgradient to Corniolo town, uncontrolled and widespread infiltrations and underground water occurences, triggened slow land movements identified by the inclinometer monitoring net.

In the last years (mainly in 2008) intense and long duration rain events caused an abrupt movement along the landslide moving surface, measured by all the inclinometers located up-gradient of Corniolo village.

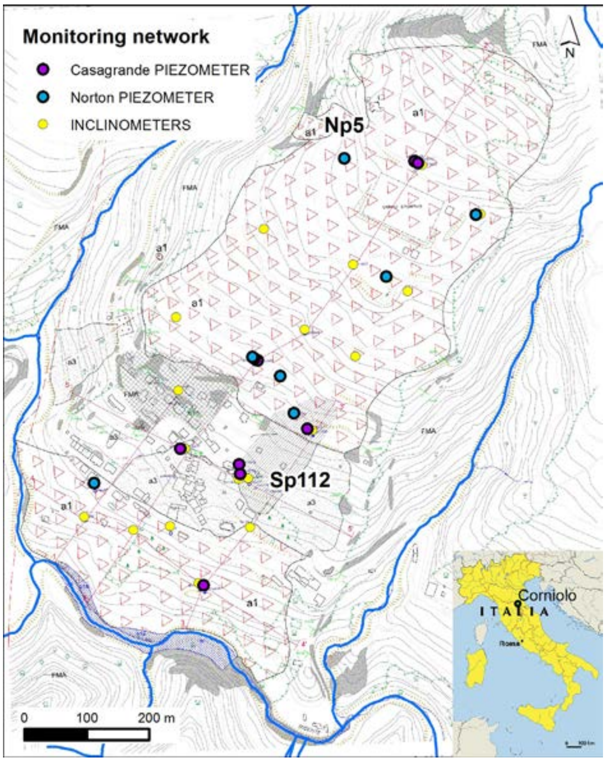

Figure 1 – Geographic location of Corniolo landslide; monitoring network points above the detailed geological map of the area (by Andrea Benini): FMA = Marnoso Arenacea Formation, Corniolo Member; a1 = active landslide; a3 slope debris; Np5 and Sp112 are the two monitoring points presented in Fig. 2.

This movement re-activation induced Regione Emilia Romagna with S. Sofia Municipality to plan new monitoring and restoration activities on the landslide, between them: implementation of the monitoring net and investigations surveys, drainage works and arrangement of subsurface and/or ground hydric regulation systems. In this context, the hydro geologic study here presented was propaedeutic to future restoration works on the landslide body. The main goals were: the definition of the hydrogeological conceptual model of the landslide, the identification and localization of groundwater flows and the planning of a slope tracer test with fluorescent tracer, aimed to definitely prove groundwater velocities inside the debris and the highly fractured bedrock.

MATERIALS AND METHODS

The existent monitoring network (made during years 1997 and 2002) has been implemented in 2010 with the perforation of 4 Norton piezometers and 6 inclinometers.

A continuous monitoring network of hydraulic heads has been set up by installing pressure transducers inside 7 piezometers (4 Norton type, 3 Casagrande type). The monitoring activities started in November 2010 and are still going on: the instruments measure the groundwater level every hour. Manual piezometric surveys are regularly performed in order to check the status of the instruments and the reliability of recorded data.

A census of spilling water points has been performed with the help of local people indications: the surveys allowed to identify natural water spilling points, springs and fountains (active or abandoned) and existent drainage works.

Hydraulic conductivity tests have been made inside the Norton piezometers, testing two different methods: 1) bail tests with water injections and measurement of the dynamic level until its stabilization to static level; single borehole dilution tests made by injecting a sodium chloride solution and monitoring the electrical conductivities in order to assess the groundwater flow velocity (Käss, 1998).

In order to get a 3D visualization of the subsurface structure, a detailed geological map of Corniolo landslide and several geological sections have been made, starting from the stratigraphic data collected at a large number of boreholes and all the data available from geological surveys; minimum and maximum groundwater levels have been plotted on the geological sections, in order to understand which parts of the landslide body are saturated during different conditions (high flow and low flow).

MAIN RESULTS

The main results obtained from the here presented hydrogeological study are:

- a census of spilling water points;
- the hydrogeological behaviour of the different portion of the landslide and of the bedrock;
- the hydrogeological parameterization of the translated bedrock stratum: it presents K values ranging from 10^{-6} to 10^{-7} m/s;
- the relationship between damages and lesions of man-made structures and the position of groundwater table and/or water circulation above the surface.
- the groundwater distribution (in space) and regime (during time, as a function of rainfall events).

Particularly, the piezometric monitoring (Fig. 2) allowed to define the water table position during the high flow (maximum in winter-spring season) and low flow conditions (minimum at the end of the summer) for the different part of the bedrock (highly and normally fractured). The comparison of piezometric heads with rainfall data allowed to define the time-lag (from rain event to piezometric peak) and to compare this information with piezometer depth and position, filtered lithology and with K values derived from field experimental tests.

Finally, the here presented study allowed to plan a big tracer test (spring 2012) along the slope located up-gradient to Corniolo town. Some first results of the tracer test will be probably available for the congress date.

ACKNOWLEDGEMENTS

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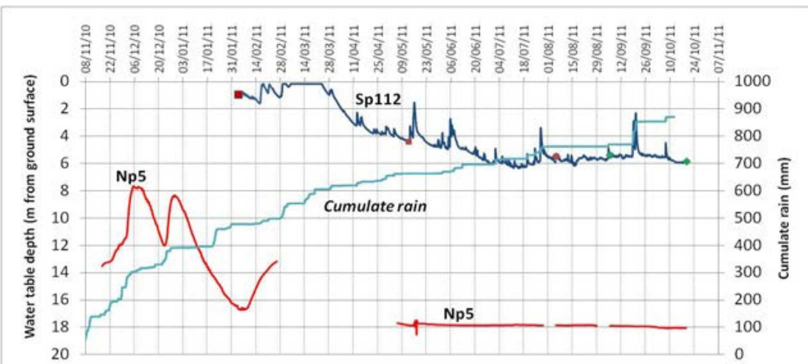

Figure 2 – An example of hydrogeological monitoring data: Np5 is a Norton piezometer at the head of the landslide body and Sp112 a Casagrande piezometer in Corniolo town; for their locations see map of Fig.1.

GOVERNANCE OF SOIL CONSUMPTION IN CATALONIA

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KEY WORDS: Soil consumption, land use, Catalonia.

INTRODUCTION

Soil is a natural resource, non-renewable in the short and medium term, that supports most of human activities. Soil use, therefore, leads strong competition.

Rational land use requires responsible management of the resources and its functions. This management can only be done through active conservation policies integrating the apparent contradiction between development and conservation, involving all stakeholders (conservationists, economists, planners...), differentiating between local visions and the overall interests of higher realms, and balancing the permanent struggle between public and private interests.

GOVERNANCE OF SOIL CONSUMPTION IN CATALONIA

In Spain there is no specific legislation relating to soil protection. Land planning is regulated by the "Ley del suelo" (land act), based on the European Regional/Spatial Chart adopted, in 1983, by the European Ministers responsible for Regional Planning. The law states different plans adapted to the several organizational levels (national, regional and local) that presents the Spanish Administration has:

- Plan Nacional de Ordenación (National Management Plan), not implemented yet.
- Planes Directores Territoriales de Coordinación (Territorial Master Plans of Coordination), developed by the different regions.
- Planes de Ordenación Urbanística (Urban Management Plans), with a local scope.
- Moreover, specific legislation, ruling important economical sectors (water, mines, forests, waste…) and special areas (mountain, national parks…), completes land planning governance.

With regards to Catalonia, a region situated in the north-east of Spain with an extension of 32.107 km^2 and a population of more than seven and a half million inhabitants, the main objectives of the Territorial Master Plan for Catalonia are related to the promotion of a balanced distribution of economical growth and the obtainability of better standards of life by the orderly implementation of the economical activities.

The Territorial Master Plan establishes:

- Territories (7) with similar characteristics from socio-economical and development potentials points of view (Fig 1),
- Cities that, according to their characteristics, must exert driving forces for development,
- Spaces to preserve for general interest of the territory.
- Land classification (urban vs. rural),
- Emplacement of large infrastructures (highways, railways, dams…) and
- Areas where specific uses must be promoted.

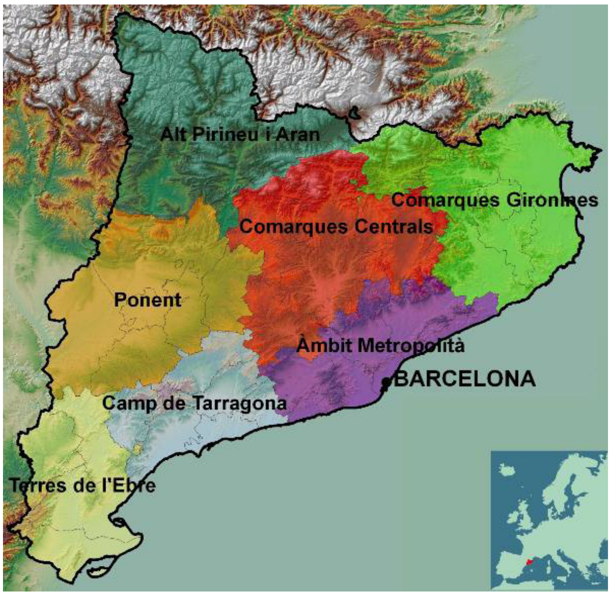

Figure 1 –Territories established into the Partial Territorial Plan for Catalonia.

Partial Territorial Plans have been developed for each established territory. They divide the territory in two main categories: Building and Non-building lands. In turn, non-building lands are classified in three groups:

- Non-building lands with special protection
- The special protection category is granted

- to areas where different values, justifying a high degree of protection, concur. They are mainly related to inventoried areas of interest (national and natural parks, nature reserves and shelters…), where any change or transformation would inevitably affect it.
- Non-building lands with territorial protection.
- The territorial protection category is given to areas that, although not achieving the category of special protection, are advisable to preserve from transformation because of natural hazards, landscape value or strategic reserve (location, connectivity, characteristics…).
- Non-building lands with preventive protection.

The preventive protection category is given to the rest of the areas that are always subjected to the limitations of Urban Management Plans.

In any case, areas with similar properties (soil type, rock outcrops, natural hazards, accessibility, location...), can be classified in different groups depending on the special characteristics of the territory where they are located (mountainous, industrial, metropolitan...).

The government of Catalonia has some agencies related with the governance of soil consumption.

In this way, the Institut Català del Sòl (Land Institute of Catalonia) is primarily involved with the promotion of land, trying to adapt offer and demand of both residential and economical activities, and contributing to improve the competitiveness and the economical balance of the region.

Meanwhile, the Institut Geològic de Catalunya (Geological Institute of Catalonia) is entrusted, through the “Geoworks” programme, with the study, research and advisement to the government and to society in general on soil and subsoil, which constitute an indispensable tool to promote policies and actions focused on the land and to establish preventive or corrective measures in situations of geological risk.

SOIL CONSUMPTION IN CATALONIA

From a physiographic point of view, Catalonia can be divided in three areas (Fig 2):

- The Pyrenees, made up of a series of mountain chains ranging, in parallel way, from west to east. They are characterized by high elevations, wild landscapes and relative dryness.
- The Mediterranean System, consisting of two complex mountain chains ranging, in parallel way, from north-east to south-west. They present a long and narrow valley, in between, that is densely populated and very rich from an agricultural point of view.
- The Central Depression, formed by flat or almost flat areas in between the Pyrenees and the Mediterranean System. It presents young and soft parent materials where rivers have excavated large valleys and erosion basins.

Catalonia has a very complex orography, with extensive mountain ranges, inland depressions, mountain peaks reaching 3.000 meters high in the Pyrenees and, a mere 240 km to the south, a delta that collects the sediments from one of the most abundant river of the Iberian Peninsula: the Ebro river. This makes from Catalonia one of the most steeped regions in Europe, with 70% of the territory arising more than 10% slope,

This characteristic is directly connected to land use; in this way only 29% of the territory is dedicated to agriculture, 60% to forestry, 6% is occupied by urban activities, mainly along the coast, and 5% are considered miscellaneous, including roads, rails, rivers and other water bodies (Fig 2).

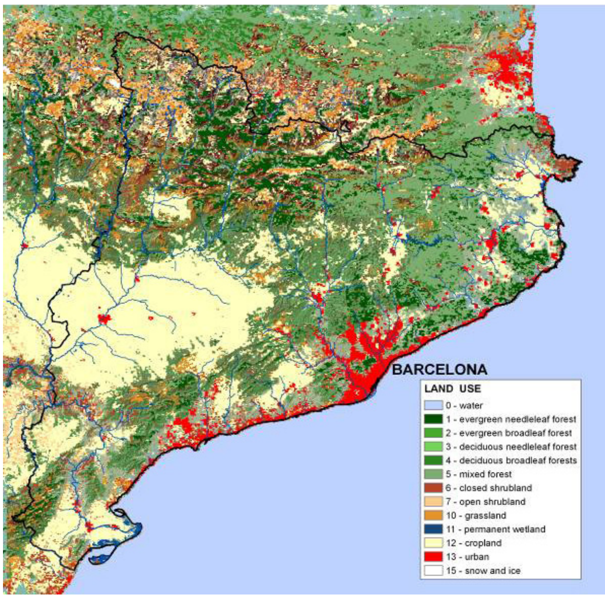

Figure 2 – Land use in Catalonia.

Since 1995, the Centre for Ecological Research and Forestry Applications (CREAF) is responsible for conducting the Land Cover Map of Catalonia. The process is carried out by means of photointerpretation and digitization (with a minimum cartographic unit of 500 m^2 and 61 categories legend) of colour ortophotographs from different flights conducted by the Institut Cartogràfic de Catalunya.

Interim results of the comparison of the ortophotographs from 1993 and 2005 show a reduction of 12% for crop areas, This reduction was offset by the increase in forest and urbanized area (related, respectively, to agricultural abandonment and to the real state explosion that happened in Catalonia during the last decade).

SOIL SURVEY - POTENTIALS FOR THE FUTURE

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KEY WORDS: soil maps, evaluation, soil functions, soil hazards, prognosis maps, soil protection, planning, Bavaria.

INTRODUCTION

Soil survey in Bavaria is divided in two category groups (Fig. 3): The “Soil Basis Inventory” deals with punctiform locations while the “Soil Area Inventory” records the spatial distribution of soils and their properties (soil mapping). At present the compilation of the “Outline Soil map 1:25000” takes centre stage (Fig. 3).

For some applications it could be possible to deduce necessary information directly from the map legend by support of the mapping soil expert.

This approach is not purposeful in the respect of the growing number of protection and planning related requirements (TRAIDL 2005). Thus a map referring data set is necessary to change a soil map into a derivative map understandable and applicable to all (Fig. 1).

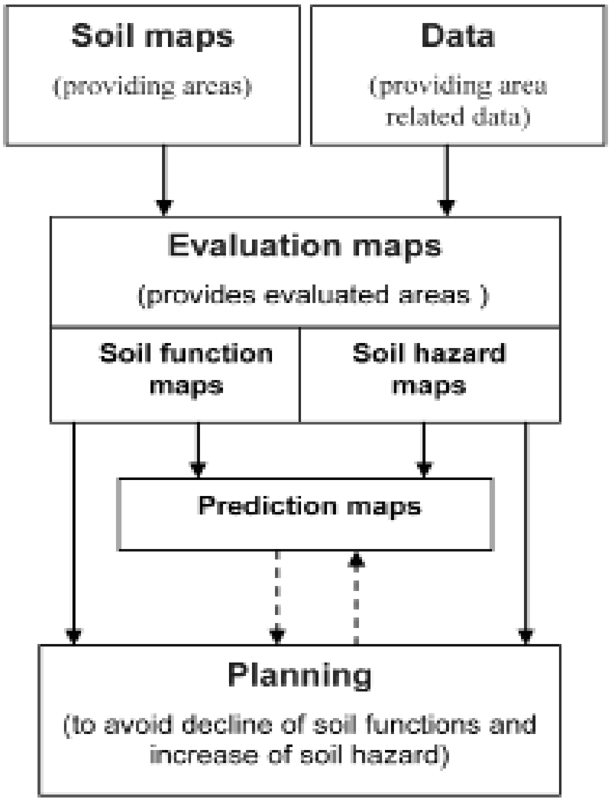

Figure 1 – Soil maps and attached apllications.

POTENTIALS OF SOIL SURVEY

The soil map provides various applications (Fig. 1). In summary, there are different levels of approaches to offer an informative basis for planning. These are

- Maps of soil functions
- Maps of soil hazards
- Prediction in case of changing environmental conditions (natural and anthropogenic)

Soil function and soil hazard maps demonstrate evaluation of the current state of soil and are the basis for planning and prediction at the same time. Planning as a tool of anthropogenic environ-mental change can be a parameter of prediction maps.

Soil function maps

Soils are of extreme importance for ecosystems as well as to human society. As soils are easily irreversibly destroyed and industrializa-tion and population density is increasing, planning plays a crucial role in preserving soil functions in an optimal way.

The German Soil Protection Act (BBdSchG) defines the following base soil functions:

- Natural soil function
- Functions as an archive of natural and cultural history
- Use functions

These three topics are intended to include all potential functions and are divided in subfunctions. So every subfunction must be defined as precisely as possible to achieve an evaluation by accordant data.

Many use functions can be considered as soil suitability. A current example in this respect is the suitability for ground heat exchange for geothermal heating.

Currently, one third of the area of Bavaria is covered by soil function maps (Fig. 2). The mapped soil functions include: retention capacity of precipitation, filter and buffer for nitrate, buffer for acidification, bond strength for heavy metals (Cadmium) and habitat potential for natural vegetation (BAYERISCHES GEOLOGISCHES LANDESAMT & BAYERISCHES LANDESAMT FÜR UMWELTSCHUTZ 2003).

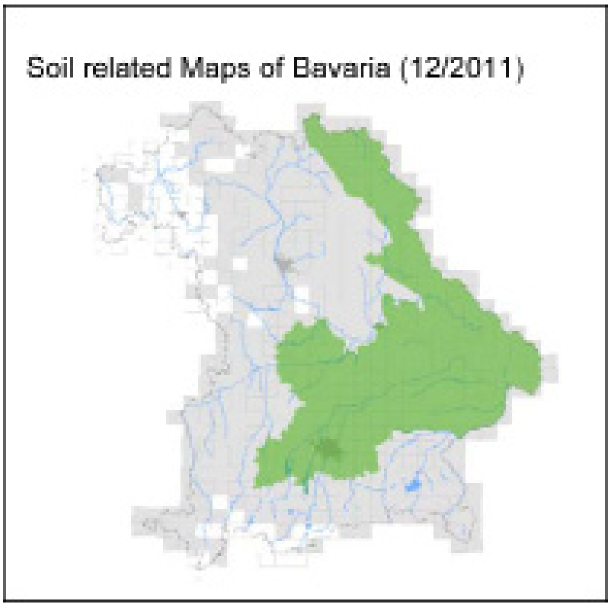

Figure 2 – Soil functions maps of Bavaria (green); grey: outline soil map; white: no map available.

SOIL HAZARD MAPS

Soil hazard information deduced from soil maps also shows a wide spectrum. Beside global hazards like soil erosion and contamination there are different threats and hazards that can be defined: Flooding, storm loss of forests, mass movements, salinization, acidification, drought stress, and organic matter decline are examples for possible evaluations of the soil map.

PREDICTION MAPS

Prediction refers to declined soil functions as well as to hazards resulting from changes in environmental conditions like climate and land use. The latter indicates the significance of prediction maps for planning. Very important are soil properties that react quickly to changes. Hence the water balance of soils and the soil organic matter is in the focus of interest.

PROBLEMS

Major problems at national and international level are the lack of applicable soil data as well as. insufficiently harmonized data, approaches and methods.

In the end, the conflict of interests between economy and ecology has to be faced and solved.

Soil Basis Inventory	***Soil Area Inventory***
Soil Profiles[1]) Individual sites with detailed description and samples, mostly pits.	*BÜK 500 With explanatory report (1953); out of stock.*
Soil Sequences[1]) Records according to the Catena principle, with abbreviated description, mostly hand drilled, some with samples.	*BÜK 200 Conceived for the total area of Germany; published sheets: Munich; Augsburg Passau, Regensburg, Bad Reichenhall.*
Articles "Soils" for GK 25 Text with soil description and analysis tables for the respective sheet.	*SBK 50 14 sheets as a block "München-Augsburg and its surroundings" with explanatory report (1986, 1987).*
The Soils of Bavaria Data Manual, for example: "Tertiary hill land..." (1992); data hand-book "Keuper, Lias land ..." (2002).	*SBK 25 8 sheets as a block "Hallertau" with explanatory report (1981).*
Soil estimation archive [2]) Profiles of the soil estimation.	*BK 25 23 sheets from different soil areas; with explanatory reports (1957 to 1978).*
	Outline soil map 25 Outline soil map; a conceptual map, verified in the field; nationwide coverage in 2015.
[1]) Release by data protection legislation *[2])Archives, unpublished*	*Thematic maps City Soil Map of Allach (1992)[2]; Vineyard soil maps (1957 to 1962)[2] at different scales. Outskirt soil maps 1:10000, three sheets (2010-2011): Kümmersbruck, Hof, Moosinning, currently implemented by the Unit for Soil Protection; Peat land map (2011).*
<u>Abbreviations</u>	*BSÜK 25 only agricultural land represented; nationwide coverage.*
BÜK Overview soil map *SBK Site soil map* *BK Soil map* *BSÜK Soil estimation map* *GK Geological map*	*BSÜK 100 11 sheets for the districts of Upper Bavaria (northern part), Lower Bavaria, Upper Palatinate and Swabia (1944 to 1978).*

Figure 3 – Products of the Soil Survey (LfU) in Bavaria.

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MONITORING SOIL CONSUMPTION: STRENGTHS, WEAKNESSES, AND EFFECTIVENESS OF DIFFERENT MONITORING APPROACHES IN ITALY

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KEYWORDS: monitoring, land use planning, soil consumption, land consumption, land use, land cover, land take, SEA, Italy

ABSTRACT

The oral contribution aims to review some of the monitoring approaches in soil/land consumption available in Italy.

The first part introduces the judicial framework, the theoretical and practical approach to the definitions of soil protection and soil/land consumption.

The second part focuses on indicators and monitoring soil/land consumption, briefly presenting some experiences ongoing in Italy, and critically highlighting their potential and their limits in the pursuit of limiting soil/land consumption.

The last part provides suggestions about exploring the potential of using specific indicators in Strategic Environmental Assessment of urban and territorial planning, such as evaluating the baseline scenario, assessing alternatives and monitoring.

SOIL PROTECTION AND LAND CONSUMPTION LIMITATION

Soil has a generally underestimated value in land use planning, and it should be considered as important as other resources in the pursuit of sustainable development.

Studies from the last 50 years have provided lots of references to the soil/land value as a "common", and its intrinsic fragility (Hardin, 1968, Diamond, 2005), bringing up the issue of a consequent need for governing and protection (Ostrom, 2006). Recent Italian judicial cases (i.e. TAR Brescia 16/11/2011) have confirmed the interpretation of soil as a common, as a non-renewable resource.

Besides the strong social and cultural value, from an environmental point of view, soil has demonstrated a fundamental contribution to several functions in the fields of climate change/ CO_2 sequestration, ecology system and biodiversity, groundwater recharge, food and agriculture, landscape.

Considering official and draft European documents (i.e. Report on best practice for limiting soil sealing, 2011), soil consumption refers to the concept of "land take", also known as "urbanization", "increase of artificial surfaces" and represents an increase of settlement areas (or artificial surfaces) over time, usually at the expense of rural areas.

Given the evidence of the need for governing land consumption while preserving soil value, soil protection has consequently become an increasingly important objective.

From this perspective, the European Commission adopted a "Soil Thematic Strategy" (COM 231, 2006) and a proposal for a "Soil Framework Directive" with the objective to protect soil across the EU, acknowledging its socio-economic as well as environmental importance for the community (COM 232, 2006).

INDICATORS AND MONITORING SOIL/LAND CONSUMPTION IN ITALY

In the last few decades in Italy, there has been massive urbanization disproportionate to the demographic increase, and mostly in the Po Valley, where each day 200.000 m2 are urbanized, "about 30 soccer fields" (CRCS Report, 2011)

Italy, unlike most European countries, does not have a national spatial development plan, nor a definition of soil sealing limits and targets (like in Germany, UK, Austria).

The availability of data on soil/land consumption is the starting point for any further consideration and assessment on land use policy.

While land consumption is on the agenda of various European governments and integrated data is available, in Italy there is neither a national framework nor a database on land use despite the high number of territorial IT systems (Pileri, 2009).

Different approaches coexist in monitoring soil/land use and consumption in Italy, each with different aims and tools.

Among the most relevant approaches for the purpose of this presentation there are:

- European Corine Land Cover (data created in 1990, 2000, 2006);
- Eurpoean LUCAS (Land Use/Cover Area frame Statistical Survey done in 2001, 2003, 2006,

- 2007, 2009);
- Eurpoean ETC-LUSI-Eionet HR Built-Up Areas (project ended in 2008);
- European and Italian statistical approach (Eurostat, Istat), i.e. ISPRA and Consiglio per la ricerca e la sperimentazione in agricoltura (a statistical approach, report about soil sealing published in 2011);
- Sistema Informativo Nazionale per lo sviluppo dell'Agricoltura (SIN project, promoted by the Italian Minister of Agriculture);
- Tavolo interregionale per lo sviluppo territoriale sostenibile dell'area padana-alpino-marittima (an interregional agreement on analysis, tools and policies for limiting land consumption, 2011,);
- Regional experiences, such as the monitoring system of Regione Lombardia (DUSAF, a database with a detailed characterization of land use and land cover for 1999, 2005, 2006, 2007), Emilia Romagna (vectorial maps 2003, 2008), Friuli Venezia Giulia (maps 1980, 2000), Sardegna (2003, 2008);
- Osservatorio Nazionale sui Consumi di Suolo, ONCS (report done in 2009) and Centro di Ricerca sui Consumi di Suolo, CRCS (reports done for 2009 and 2010);
- local experiences at Province level (Provincia di Trento) and at Municipal level (such as monitoring in Masterplan);
- ONG experiences, such as Fondazione Cogeme Onlus (monitoring land consumption in Pianura Sostenibile project);
- Universities (Geostatistical approach at university of Bologna) and other contributes (Società Geografica Italiana, etc.)

The presentation will explore strengths and weaknesses of these different approaches, and will critically highlight their potential and their limits for the pursuit of limiting soil/land consumption.

They are extremely different in their main purpose (economic, environmental) and especially in their methodology and choice of indicator.

For instance, some of them consider a methodological approach based on "the transition matrix" (Pontius et al., 2004), bearing in mind the "triangle of transformation" (Pileri, 2009). Besides the "flow model", also the "difference model" is currently used; it evaluates only the cumulative difference of land cover change in two different years. The interpretation of the results may significantly differ, on the basis of the different aggregation of data.

The selection of indicators is also fundamental; among the others, the evaluation of land use/cover transition can be represented by indicators that measure: land use at different times (i.e. every year), change of land use (different timeframe), land take per capita, rapidity of the transformation, incidence of the transformation compared to the original land cover stock.

A thoughtful analysis of the different approaches might be useful to have a comprehensive idea of the available status quo and to understand their validity and their effectiveness towards the aim of monitoring land consumption limitation, as defined at European level for all the members.

MONITORING SOIL CONSUMPTION IN S.E.A. FOR LAND USE PLANNING

According to SEA Directive, competent planning authorities are obliged to accomplish a systematic assessment of all significant environmental impacts of regional land use plans (Art. 3 para. 2). Using appropriate indicators, SEA:

- evaluates the likely significant effects on the environment, including issues such as soil, water, air, landscape;
- includes monitoring (i.e. on land consumption): the SEA Environmental Report, part of the Plan official documents, must include the "monitoring plan" (Article 10, SEA Directive).

SEA has the potential of including specific indicators in land use planning for monitoring land consumption (useful also in evaluating the baseline scenario, assessing alternatives and monitoring effectiveness).

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LAND TAKE AND SOIL ECOSYSTEM SERVICE LOSSES: SOME DATA FROM EMILIA-ROMAGNA

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Keywords: Land take, Soil sealing, Soil Ecosystem Services, Food Security

ABSTRACT

Soil is a limited, non renewable and multi-functional resource that provides a range of ecosystem goods and services. The range of services provided by soils is much broader than the support to biomass production or the physical support to human activities.

Current and future demand of land for delivery of goods and services, for example food, biofuels and fibres, expansion of urban areas, is greater than the amount of soil surface available. In addition some of these processes, such as the land taken for the construction of residential, industrial or commercial districts, are increasingly competing with agricultural areas for production of food but also with land areas for nature conservation. The land take and the soil sealing processes have a deep impact on the capability of soil to deliver ecosystem services. In this paper we are describing the impact of land take on soil ecosystem service delivery in Emilia-Romagna. The research has been based on the comparison of land use at different dates (1976, 2003, and 2008), and on the assessment of the soil ecosystem services potential associate to different soil types.

INTRODUCTION

Soil is a multifunctional non-renewable resource. These concepts have been pointed out in the Thematic Strategy for Soil Protection (COM (2006) 231 final) (EC, 2006) through which the European Union has defined an action plan for soil conservation in Europe. The Communication of the Commission to the European Parliament and the Council "Towards a Thematic Strategy for Soil Protection" (COM (2002) 179 final) (EC, 2002) identifies the main eight soil degradation processes to which soils in the EU are confronted. These are erosion, organic matter decline, contamination, salinisation, compaction, soil biodiversity loss, sealing, landslides and flooding. As a result of urban sprawl and increasing land demand from many sectors of the economy, land take and more specifically soil sealing are becoming significantly more intense in the EU. The Soil Thematic Strategy lists a series of soil functions, or ecosystem services, such as food production, biodiversity pool, carbon pool, biomass production, source of raw material, storing filtering and transforming nutrients, substances and water, physical and cultural environment for humans, archive of geological and archeological heritage. From a human perspective, biomass and food production can be considered among the most important soil ecosystem services. Agricultural zones and, to a lesser extent, forests and semi-natural and natural areas, are disappearing in favour of the development of artificial surfaces (EEA, 2011). The objective of this research is to assess the impact of Land Take pocessesses between 1976, 2003 and 2008 in Emilia-Romagna, on the food production capability, considered as Provisioning Ecosystem Service. In this paper however, we will present the results deriving from the analysis of the 2003-2008 period.

MATERIALS AND METHODS

The estimate of land take between 1976, 2003, 2008 was realized on the base of the Land Use maps produced by Regione Emilia-Romagna. The land use changes considered in this research, causing land take on agricultural land, have been all the conversion from agricultural areas to artificial areas, sensu Corine nomenclature. The estimate of the loss of Potential Agricultural Production Capability (PAPC), was calculated using the average winter wheat yields (2001-2010) data for the main physiographic areas of Emilia-Romgana Region. The calculations were performed on the base of the equation [1]:

Phys_PAPClosses = ALT_Phys * WWAY_Phys
[1]

where:

Phys _PAPClosses = Losses of Potential Agricultural Production Capability (in tonnes of winter wheat)
ALT_Phys = Land Take of agricultural area for Physiographic Unit (ha)

WWAY_Phys = Winter Wheat Average Yields area for Physiographic Unit (t ha-1)

RESULTS AND DISCUSSION

Data on Land Use change in Emilia-Romagna, between 2003 and 2008 are shown in figure 1. During this period the rate of agricultural area losses was higher than 9 ha d-1, comparable to the rate of the previous period (1976-2003).

The impact of this process on the production capability of the agricultural sector has been calculated using winter wheat as model crop. The syntesis of the data produced in this analysis are reported in table 1.

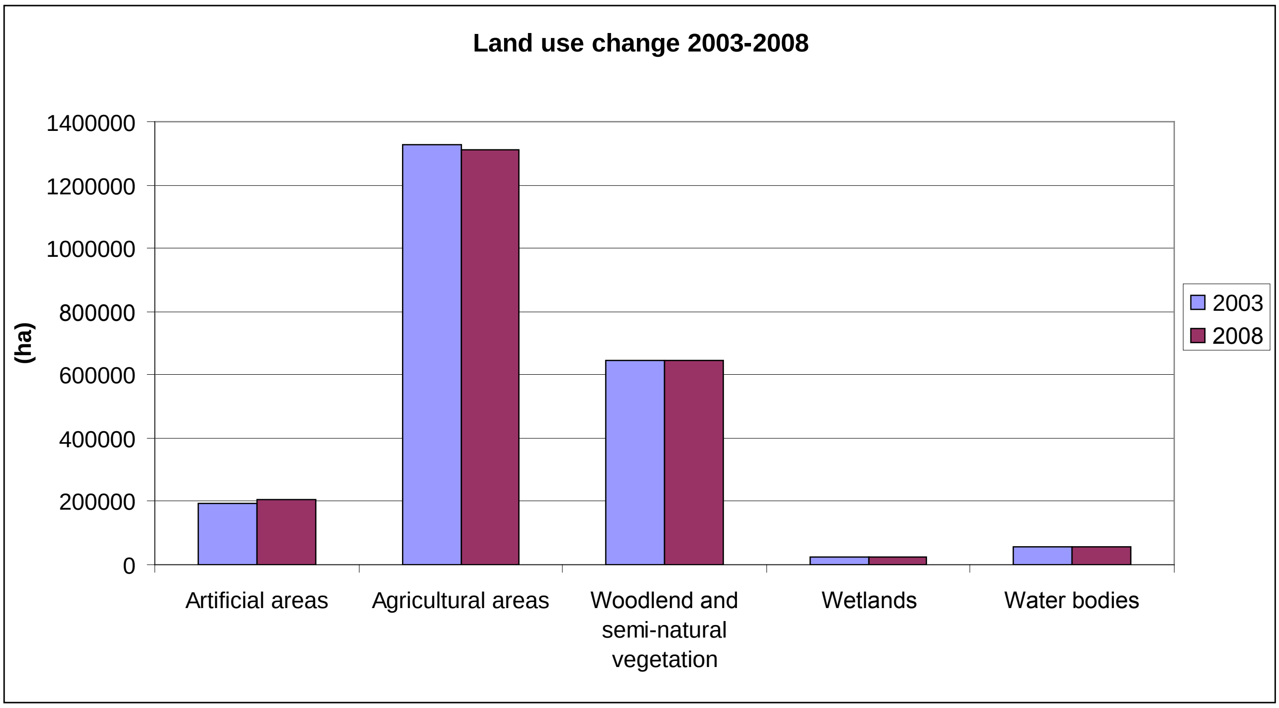

Figure 1 – Land Use Change in Emilia-Romagna betwwen 2003 and 2008.

The consequences of 5 years land take on one of the most important ecosystem service, the provision of food, has been estimated in 100,000 tonnes of wheat, equivalent to more than 1% of the total PAPC of the region. Soil sealing and land take are having impacts also on other soil ecosystem services, such as the capacity of storing and regulating water flow, supporting biodiversity, etc. The more comprehensive evaluation of impacts of land take on these other ecosysem services will be further developped in the prosecution of this research.

Table 1: Land take and losses of PAPC in Emilia-Romagna between 2003-2008.

	Plain	Hills and Mountains
Land take (ha)	13357	1799
Average yield (t ha-1)	68,5	44,9
Yield loss (t)	91547	8070

ACKNOWLEDGEMENTS

We are grateful to Stefano Corticelli for the data provided.

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THE RULES GOVERNING THE PROTECTION OF AGRICULTURAL LAND IN POLAND

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The primary regulation which extends legal protection over agricultural land in Poland is Act of 3 February 1995 on Protection of Agricultural and Forest Land. According to this Act protection of agricultural land shall consist in:

- limiting its use for non-agricultural and non-silvicultural purposes;
- preventing deterioration and devastation of agricultural land as well as damages to agricultural production caused by non-agricultural operation and the movements of earth masses;
- reclaiming and managing the land intended to be used for agricultural purposes;
- preserving peatmoors and small ponds as natural water reservoirs;
- limiting changes in the natural layout of the surface of earth.

The special protection are covered by the most fertile soil, categorized as class I-III. Allocation for non-agricultural of agricultural land being arable land categorized as class I–III, if its consolidated projected area intended for such purposes exceede 0.5 ha – shall require a consent of the *Minister of Agriculture and Food Economy.* Such consent is issued to the local spatial management plan. Thus, protection of agricultural land in Poland is closely linked to spatial planning. In the planning processe considering soil quality in order to preserve the most productive soil in agricultural use.

An effective method of limiting exclusion from the production of the most productive soil are payments. The level of the fee is releted to soil fertility class. The principle of is that the higher class the higher a fee. The fee is required from all types of organic soils.

Moreover, the Act implemented the possibility to compensate for soil losses and soil function losses by imposing an obligation to remove the humus layer of the soil from the land categorized as class I, II, IIIa, IIIb, III, IVa and IV as well as from peatmoors, and to use it to increase the land use value.

Despite these restrictive methods of limiting exclusion from the production, the statistics indicate that the significant areas of fertile regions are excluded from the production of agricultural land (tab.)

TAB. **Agricultural land designated for non-agricultural purposes** *according to the existing legal regulations on protection of agricultural land*

SPECIFICATION	2000	2002	2005	2007	2008	2009
	in hectares					
	Total					
TOTAL ……………………………..	**2176**	**2860**	**4048**	**5514**	**5397**	**3276**
of which:						
Agricultural land …………………….	1501	1767	2782	3918	3441	2060
soil valuation classes:						
I-III ………………………………..	1053	906	1783	2091	1830	982
IV …………………………………..	393	816	858	1608	1486	871
V i VI ……………....................	55	45	141	219	125	207
Other agricultural land	675	1093	1266	1596	1956	1216

Of which by direction of designation
(excluding agricultural land designated fot planting with trees and bushes)

TOTAL ……………………………..	**2176**	**2860**	**4048**	**5514**	**5397**	**3276**
designated for:						
Residential areas ……………………..	1083	1037	1637	3208	3159	1909
Industrial areas ………....................	349	342	759	647	815	400
Roads and communication trails …….	156	315	210	232	167	83
Minerals ……………………………..	195	296	243	438	264	358
Water reservoirs ……………………..	12	24	586	59	33	32
Other purposes ………………………	381	846	613	930	959	494

Source: *Statistical Yearbook of Agriculture 2010*.

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THE CASE STUDY OF THE INDUSTRIAL CERAMICS DISTRICT: INTEGRATED ANALYSIS OF LAND USE CHANGES

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KEY WORDS: ceramic district, land use, change of use

SOIL AND PLANNING

The study area includes the municipalities of Casalgrande, Castellarano, Castelnuovo Rangone Castelvetro of Modena, Fiorano Modenese, Formigine Maranello, Rubiera, Sassuolo, Scandiano, Serramazzoni and Prignano sulla Secchia: except for the last two, these Municipalities are all part of the Sassuolo-Scandiano ceramic district.

This paper is intended to analyze changes in land use of an area characterized by a deeply-rooted industrial production vocation, which has remained unchanged over several years despite cyclical economic downturns. This analysis pursues two objectives: first, to acquire and disseminate a deeper knowledge of the area and its history; secondly, to provide useful tools to assess the effects of that history on environmental, landscape and socio-economic components of the study area.

MATERIALS AND METHOD

The analysis consisted in comparing the "1954", "1976", "2003" and "2008" land use maps produced by the Emilia-Romagna Regional Authority. Since they are characterized by captions and different minimum areas, a common caption has first of all been defined related to all maps (fig.2); then, maps with smaller areas have been generalized to make them comparable with the less detailed ones.

Land use changes have been analyzed with a specific focus on the caption "items" related to manufacturing activities and built urban areas. Furthermore, since the phenomena that characterize land use evolution often significantly differ in lowland areas than those in hills or mountains, these two areas were separately studied.

A further analysis focused, instead, on so-called SIN areas (Sites of National Interest), according to the definition provided by the Ministerial Decree DM 26/02/03 under the project "Feasibility study for the remediation of surface aquifer in the ceramic district of Modena and Reggio Emilia" (Resolution 1838/2007).

As far as the latter are concerned, a specific land use caption was used, including 5 items (building, storage area or square, parking area, area for agricultural use, area devoted to other uses) and an interpretation of images related to 1974-78, 1998, 2003 and 2008 periods was provided.

RESULTS AND DISCUSSION

Observing the trends in land use changes in the ceramic district from 1954 (taken as the "year zero" of the analysis) to 2008, the phenomenon that emerges most clearly is the increase in production and residential areas to the expense of farmland (557 only between 2003 and 2008).

The new residential areas are located both in the territories in the foothills, concerned by the sprawling of the old urban centers especially during the 70s, and on lower hill slopes and lowlands, where the urban sprawl phenomenon is more evident.

Instead, since 1976, business and manufacturing areas are mainly concentrated in lowlands and vallies.

In the period between 1976 and 2003 (Figures 1 and 3), the farmland decrease is also attributable to the abandonment of arable land in hilly areas, followed by a re-naturalization and reforestation phase, which has substantially declined in the subsequent period.

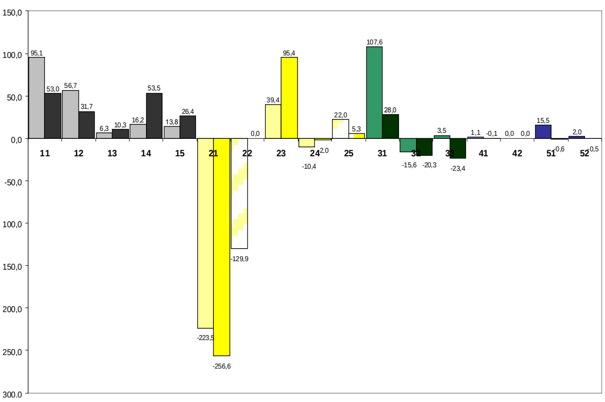

Figure 1 – land use change in ha / year in the Ceramics District between 1976 and 2008

Land use classification		
Artificialized land	urbanized areas	11
	Industrial and business sites	12
	Networks and infrastructure areas, port and airport areas	13
	Mining areas, landfills, construction sites and built areas	14
	Artificial non-agricultural green areas	15
Farmland	Arable land	21
	Wooded arable land	22
	permanent crops	23
	Meadows	24
	Heterogeneous agricultural areas	25
Wooded lands and semi-natural environments	Wooded areas	31
	Grassland and/or shrubs	32
	Open spaces with little or no vegetation	33
wetlands	Inland wetlands	41
	Marine wetlands	42
Water Environment	Watercourses	51
	water bodies	52

Figure 2 – Land use caption

1976-2003	% on the District area	Causes
Perdita seminativi	from 59% to 48%	urbanizzazione e rimboschimento
Rimboschimento	from 8% to 14%	abbandono seminativi ed evoluzione arbusteti
Urbanization	from 4% to 8,9%	Arable land consumption
Growth of industrial and business sites	from 3% to 5%	Arable land consumption

Figure 3 – Main phenomena

Dal focus sui SIN risulta che le variazioni d'uso delle aree interessate dalla contaminazione si sono verificate prevalentemente nell'ambito delle aree più contigue alle attività produttive vere e proprie (parcheggi e depositi).

La percentuale di riqualificazione urbana, consistente nel riuso a scopo produttivo o residenziale, è piuttosto bassa (< 20%) e si concentra soprattutto tra il '76 e il 2003 per poi subire una battuta d'arresto nel periodo successivo.

The focus on SIN points out that land use changes in areas affected by contamination mainly occurred in areas adjacent to actual production activities (parking & storage). The urban regeneration percentage, i.e. land re-use for manufacturing or residential purposes, is rather low (<20%) and it is mainly concentrated in the period between '76 and 2003, whereas it actually suffered a setback in the following period.

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VALORISATION OF THE FLATLAND-HILL PASSAGES IN THE PERIURBAN OF THE INDUSTRIAL CERAMICS DISTRICT

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KEY WORDS: landscape, green infrastructure, open spaces system, territorial planning

PROJECT

The project is localization in the territory in-between higher flatland and hills, among the urban agglomerates of Sassuolo, Fiorano Modenese, Formigine, Maranello e Castelnuovo Rangone.

The central area in-between the municipalities of Fiorano and Formigine, because of its conformation, represents the green 'hart' of the city of ceramics, taking the connotation of periurban Agricultural Park with within the urban areas and functioning as a 'showcase' for the production activities. The Eastern area from Castelnuovo distinguishes itself for a territorial project made up with routes and networks of identity, fruitive and ecological interest, able to give value and to preserve the rural space.

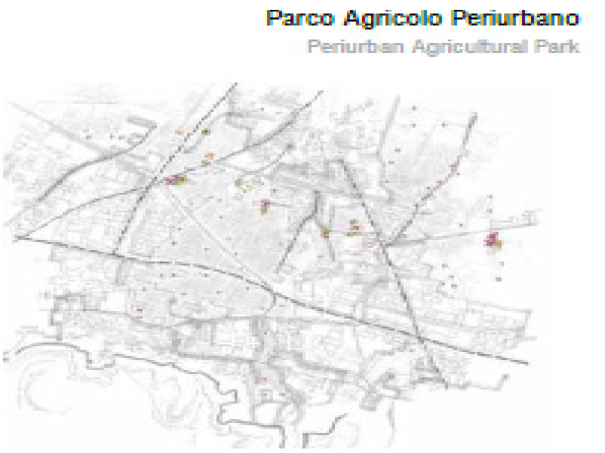
PROJECT AIMS AND RESULTS

The project expectations want to rapresent the consequences of the PTCP – Territorial Planning of Provincial Coordination – of the Province of Modena on the urban planning instruments referring to the landscape politics and to define good practises for the improvement of the flatland-hill passages system.

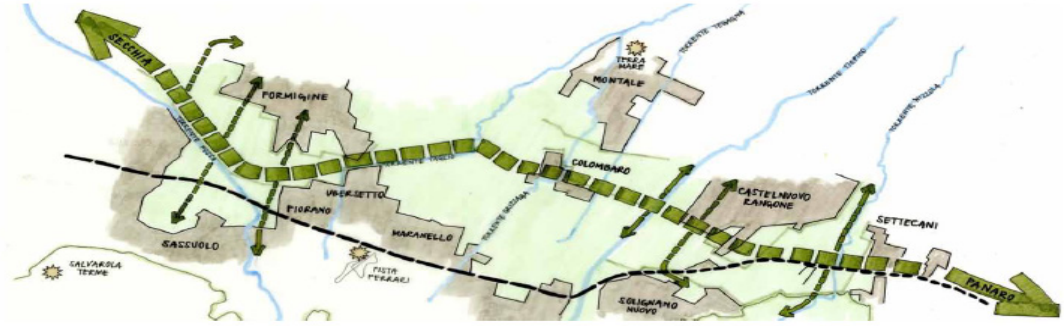
Among those, the intention is to limit the further erosion of rural surfaces, to safeguard the periurban open spaces, to give value to the remaining environmental resources and the communities identity aspects and to improve the urban settlements.

STRATEGY

The chosen strategy is to operate in order to build up in time a vast green infrastructure, an arboreal-shrubby vegetation area with features of continuity together with a pedestrian and bike network that goes through the piedmont flatland, placing itself in-between the biggest urban systems and the strip of hills; a green corridor between the rivers Secchia e Panaro, a piedmont green line that also allows relations between the inhabitated centres on the via Emilia and the hill stripe.



La linea verde / The green line



Spunti progettuali: percorsi tra paesaggi agrari di pregio, storia e natura / Design suggestions: networks among high-quality agricultural, historical and natural landscapes

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Promoters /Lending Bodies
Regione Emilia-Romagna, Provincia di Modena, Comune di Castelnuovo Rangone, Comune di Fiorano Modenese
Partner : Comune di Formigine
Designers : Studio Politecnica Ingegneria ed Architettura /Arch. Fatima Alagna –designer responsible
Overall project cost: 40.000 euro
Realization : 2009-2010
Sito-web: http://www.territorio.provincia.modena.it/

ANALYSIS OF THE RELATIONS BETWEEN CONTAMINATED SITES AND URBAN PLANNING

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KEY WORDS: Remediation, polluted areas, risk assessment, urban planning.

SOIL AND PLANNING

In our normative system, private citizens, not only the responsible of contaminations which have direct burdens, but also the investors interested in regeneration of areas hardly exhausted by their industrial history, are the ones that mainly take care of the environmental rehabilitation.

The reclamation process, completed or not, provides information about designation and use restrictions of an area or about the interventions necessary to comply with a certain use designation.

Dealing with the parallelism between norms concerning urban planning/building on one side and contaminated areas on the other, and because of a lack of a legislation able to link these two fields, the operative strategies and the different areas of expertise during the various steps require formal protocols with procedures involving local authorities.

There are three main fields requiring these formal administrative ad hoc-protocols:

- Inclusion of polluted areas into the urban planning tools;
- Relation among urban planning regulations, building permissions and reclamation procedures;
- Relation between environmental authorizations and reclamation procedures.

The first area is correlated to the data collection and registration issue. This is one of the main questions which should be solved not only towards the administration of polluted areas, but also with regard to procedures of reclamation and redevelopment of the country. One of the today's most important obstacles to redevelopment plans is the lack of information at the starting point, which provides financial uncertainty and a temporal coefficient, both resulting lethal for the development of the plans and deterrents for investors.

The application of environmental information results completely unrelated with the urban planning and building phase which should on the contrary take advantage from these information. Urban projects often start without being aware of what they will face, bringing along an uncertainty coefficient significantly bigger than a normal enterprise risk. It would be then crucial the formalization of a dynamic system able to move information from reclamation to urban planning and building, a registry process of environmental reclamations which could be quickly and fully acknowledged by the urban planning tools, so that it would be possible to have valid information and right warranties. How is then possible to create a link between environmental reclamations and urban planning tools? Without national guidelines the issue should be solved with the procedures and protocols, mentioned above, among the involved local authorities.

Two general procedures are likely to be identified:

1. Offices responsible for environmental reclamation produce deeds to formalize the register of the polluted areas and afterwards data are acknowledged by the urban planning offices which produce the essential updating of the tools.
2. Offices that control polluted areas convey acts and deeds to the urban planning offices, which consequently produce adaptations and adjustments.

The third issue mentioned in the introduction refers to the environmental authorizations system, which actually causes competence uncertainties involving many fields from the jurisdiction question to doubts on the predominance of one or another procedure.

One of the most recurring examples is the one about the Environmental Assessments, which should highlight the general subsistence of environmental questions on the plan taken into consideration. Actually it does not seem clear whether they should consider only the 'effects' of the plan on the environment or also the 'effects' of the environment on the plan. It is also controversial if these assessments should say over the urban compliance of the plan, if we consider that the reclamation is incumbent on the use designation, giving criticality environmentally speaking. The same occurs, for instance, in the case of IPPC.

Hence it is necessary that the local authorities perform their duty of operations' management and control as well; in addition, private citizens must be given the possibility to intervene. It is undeniable that the local governments should stop demanding the unachievable as well as entrepreneurs should stop considering the environment as a mere obstacle to financial activities.

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IMPACTS OF LAND AND SOIL RESOURCES ON FUTURE DEVELOPMENT OF THE MEDITERRANEAN REGION

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KEY WORDS: soil degradation, sustainable soil management, population pressure, food security, climate change

INTRODUCTION

The Mediterranean is placed at the crossroads of three continents and yet continues to have an important role in European and global issues ranging from peace, security, and migration to environmental quality and livelihoods of millions of people. The region shows distinct political, social, economic, and environmental differences between its northern and southern shores. One thing is in common: shortages of land and water that are particularly relevant in the southern and eastern countries of the basin where especially water lie at the centre of many problems they are facing.

The region covers about 854 million ha, but only 118 million of them (or 14 per cent) are suitable for agricultural production. In North Africa and the Middle East (MENA) agricultural land covers about 5 per cent; in Egypt and Algeria it occupies less than 4 per cent and in Libya less than 2 per cent of the total national land area respectively. Region wide land use/land cover divides between natural pastures/ rangelands (15 per cent), forests and woodlands (8 per cent), with the remaining 63 per cent comprising desert sands, shallow, rocky, saline, sodic soils and areas sealed by urbanisation (Fig. 1). Land degradation is a severe problem in most countries. Estimates for the period 1961 to 2020 show for a rapid increase of population and extensive losses of agricultural land due to continued urbanisation and land degradation. If these estimates are correct, agricultural land per capita would more than halve from 0,48 ha (1961) to 0,21 ha in 2020 (Fig. 2). Food security is likely to become increasingly severe, especially in the MENA countries, which would require a major reassessment of the agricultural development policy for the whole region.

LAND AND SOIL RESOURCES

Land encompass all attributes of the biosphere immediately above or below the surface, including those near the surface, the climate, the *soil* and the terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the surface sedimentary layers and associated groundwater reserves, the animal populations, the human settlement pattern and the physical results of past and present human activity (FAO 1998).

The World Reference Base for Soil Resources (FAO/ISRIC/ISSS, 2006) describes the soil as: "… *any material within 2 m from the Earth's surface that is in contact with the atmosphere, with the exclusion of living organisms, areas with continuous ice not covered by other material, and water bodies deeper than 2 m*".

Soil is the interface between earth, air and water and hosts most of the biosphere. It is essentially a non-renewable resource in that the degradation rates can be rapid whereas the formation and regeneration processes are extremely slow.

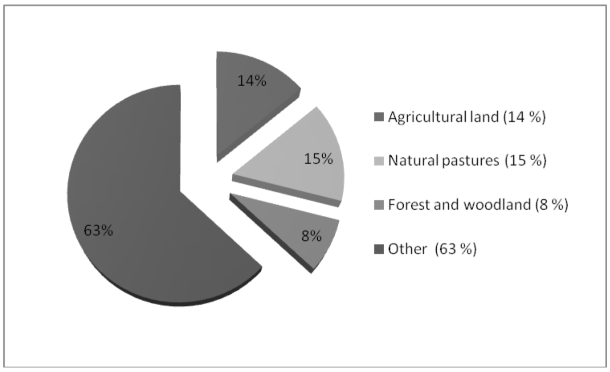

Figure 1 – Land cover distribution in the Mediterranean

MEDITERRANEAN SOIL CHARACTERISTICS

Mediterranean soils show great diversity that reflects the impact of climate, landscape, vegetation, time and especially, the long-term influence of the human activities. Erosion has been a dominant factor in carving landscapes and influencing soil distribution in a region that is also tectonically active. Some of the best-known examples of Mediterranean soils are the famous "*terra rossa*", defined as Rhodic and Chromic Luvisols (FAO/ ISRIC/ISSS, 2006) or Rhodoxeralfs by the USDA

Soil Taxonomy (Soil Survey Staff, 2010).

The following Reference Soil Groups of WRB are recognised in the Mediterranean region (Zdruli *et al.,* 2010):

Histosols (organic soils including peat);

Anthrosols and Technosols (soils strongly modified by human activities);

Leptosols (shallow soils reaching the lithic contact with the bedrock in less than 25 cm);

Vertisols (soils rich in swelling clays);

Fluvisols (formed on alluvium deposits, floodplains and tidal marshes);

Gleysols (characterised by poor drainage);

Solonchaks (high salinity);

Solonetz (alkaline soils due to high sodium content);

Andosols (formed on volcanic ashes characterised by allophanes or Al-humus complexes);

Kastanozems, Phaeozems and Umbrisols (fertile soils rich in organic matter content);

Gypsisols, Durisols and Calcisols (soils of dry climate characterised by the presence of indurated subsurface horizons);

Luvisols (clay enrichment by illuviation in subsurface horizons),

Arenosols (sandy soils including coastal sand dunes);

Cambisols (moderately developed soils);

Regosols (soils with no significant evidence of pedogenesis).

Cambisols cover the largest area in the region, followed by Leptosols and Regosols. The most fertile soils are Kastanozems, Phaeozems, and Umbrisols that are rich in nutrients and posses good physical properties; however their extension is limited. Saline soils (natural and human-induced) cover about 10 million hectares throughout the region. Spain has 3.4 million ha, followed by Turkey (2 million), Libya (1.5 million), Egypt (1 million), Italy (1 million), Greece (600,000), Morocco (350,000), Tunisia (150,000), Syria (125,000) and Albania with 15,000 hectares. Soil salinisation and alkalisation (Solonetz soils) are regarded as major causes of desertification and are serious forms of soil degradation in the Mediterranean. Human-induced salinisation has expanded because of poor quality irrigation water, especially along the coasts by sea water intrusion into the fresh water aquifers.

Productive soils such as Cambisols, Luvisols, Vertisols, Fluvisols and Gleysols are extensive in the Northern Mediterranean (i.e. Po river valley and Tavogliere delle Puglie in Italy) as well as in the South, especially in the Nile Delta in Egypt. They are crucially important for crop production and should be protected by all kinds of soil sealing, including solar pannel establishments, as found in many parts of Mediterranean Europe. Histosols are very limited in extent and their impact on crop production is minimal, they should be protected however for the large amount of organic carbon they are able to sequester. Anthrosols are most widely spread in Sicily and in Apulia in southern Italy and used mostly for growing grapes, olives and orchards. Instead Technosols cover large areas, especially along the coast and are a direct indicator of urbanisation that often has expanded onto some of the most fertile soils of the region. Urbanisation is a big problem throughout the Mediterranean with hundreds of ha agricultural land lost also due high tourism pressure. The situation is very critical in Malta, followed by Slovenia, Portugal, Spain, Cyprus, Italy, and Greece and in the coast of Morocco, Tunisia, Egypt and Lebanon. In fact, 40 per cent of all the Mediterranean coast is already urbanised. Gypsisols and Durisols are widespread in the MENA region and Calcisols occupy large areas in Spain. In Turkey and Cyprus, Calcisols are the second most extensive soil type after Leptosols. Arenosols are typically found in the MENA countries, and along the coast associated with sand dunes in Italy, Spain and throughout North Africa.

LAND RESOURCES AND POPULATION PRESSURE

Total agricultural land covers 34.4 per cent of the total land area in the Mediterranean EU countries but only 9.1 per cent for the countries located in the southern and eastern shores (Albania, Algeria, Croatia, Egypt, Jordan, Israel, Lebanon, Libya, Morocco, Palestinian Authority, Syria, Tunisia and Turkey). Excluding Albania, Croatia and Turkey, the percentage of agricultural land for the remaining countries compared with their total land area shrinks to 5 per cent (Zdruli, 2012). Annual crops occupy about 100 million ha of the total of 118 million ha of agricultural land and fruit trees include over 1 million ha of citrus and approximately 8 million ha of grapes, peaches, apples, cherries, pistachio, and almonds. Olive groves cover about 9 million ha, most commonly in Spain (2,4 million ha), followed by Tunisia (1,4 million), Italy (1,1 million), Greece (800,000 ha) and Turkey (600,000 ha). Other countries have the remaining 2,7 million ha of olive groves.

The Mediterranean population of 428 million in 2005, of which more than 286 million lived in MENA (Plan Blue 2005), had increased by 50 per cent over the last 30 years and this trend remains high especially in the South Eastern part of the basin (2.35 per cent per year or 3.9 million additional people per year). Furthermore, the annual population increase in the urban areas of MENA is five times greater than rates of population increase in the Northern Mediterranean. By 2020, Egypt will have 95 million people and Turkey 87 million, collectively about 35 per cent of the total population in the region. By contrast in 1990, Egypt, France, Italy and Turkey had more or less the same number of inhabitants (55-57 million). In coastal Mediterranean regions, the population increased from 90 million in 1970 to 143 million in 2000 (NUTS3 level), primarily in the Southern and Eastern countries. The population in coastal areas is estimated to be 186 million by 2025, with the major increases again in the South and East. On average, between 50 to 70 per cent of total population of the Mediterranean riparian countries (excluding France and Turkey) live within 60 km of the coast. Population in the Southern and Eastern Mediterranean is estimated to be 300 million by 2020 (Plan Blue, 2005) and conservative estimates for total Mediterranean population range from 522 – 543 million people by 2020 (MEDITERRA, 2008).

SOIL DEGRADATION AND SUSTAINABLE LAND MANAGEMENT

Drylands cover 33.8 per cent of the Mediterranean EU member states and 61.3 per cent of the territory of the MENA countries. Studies suggest that 30 per cent of semi-arid Mediterranean drylands are affected by desertification (Rubio and Recatala, 2006) and 31 per cent of the region's population suffer from severe degradation (Safriel, 2009). The largest areas vulnerable to high erosion in Northern Mediterranean are located in southern and western Spain (covering 44 per cent nationally), and with local erosion hotspots on the southern coast. In Portugal, one-third of the country is at a high risk of erosion and in Italy and Greece, the areas with a high erosion risk cover almost 20 per cent of the total land area (Montanarella, 2007). Saline soils (natural and human-induced) cover about 10 million hectares throughout the region. Spain has 3.4 million ha, followed by Turkey (2 million), Libya (1.5 million), Egypt (1 million), Italy (1 million), Greece (600,000), Morocco (350,000), Tunisia (150,000), Syria (125,000) and Albania with 15,000 hectares. Soil salinisation and alkalisation (Solonetz soils) are regarded as major causes of desertification and are serious forms of soil degradation in the Mediterranean. Human-induced salinisation has expanded because of poor quality irrigation water, especially along the coasts by sea water intrusion into the fresh water aquifers

Figure 2 shows very disturbing scenarios for the region. The Mediterranean population is likely to more than double but the agricultural land area may shrink with the loss of 8.3 M ha (or 7 per cent) if the present rates of urbanisation and land degradation remain unchanged. The evidence is that even in the near future agricultural land and water resources that only partly fulfil food needs of the MENA population will come under increased and severe pressure as populations increase, land degradation remains unabated, and climate change impacts become more pronounced.

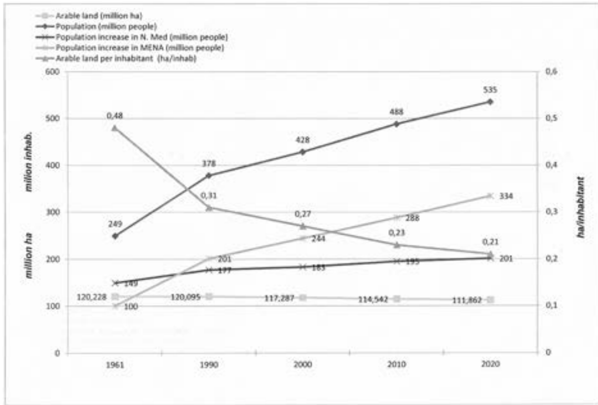

Figure 2 – Population increase, land losses and prediction of reduction of agriculture land per capita in the Mediterranean.

CONCLUSIONS

These data show that there are no "easy" options for expanding the cultivated land area, especially in the Southern and Eastern Mediterranean region compared to the Tropics where 83 per cent of the new cropland for the period 1980 – 2000 came at the expense of natural forests. However, there are options for much improved land management and for reclamation of some degraded lands. Most common interventions include terracing (i.e. Syria, Morocco) and expansion of cultivation onto desert areas (Egypt, Israel). These interventions would require increasing water use efficiency since agriculture use more than 80 per cent of the available water.

Implementation of *sustainable land management* (SLM) technologies is the best approach for mitigation and remediation (Zdruli 2010). Studies show that SLM has the potential to increase yields by 30-170 per cent, increase soil organic carbon sequestration up to 3 per cent (thus mitigating climate change) and increase water use efficiency by up to 100 per cent (WOCAT 2007). Technologies such as conservation agriculture, organic farming, no till or reduced tillage, reforestation, afforestation and agro forestry, halophyte cultivation in saline areas and development of new varieties of drought-resistant crops, water harvesting, increased water use efficiency, mulching, cover crops, controlled grazing, integrating crop and livestock production, and well designed terracing need to be implemented.

Resolution of these problems would illustrate how regional cooperation can provide sustainable benefits to the least favoured people of the Mediterranean who strive daily to make their living and at the same time protect the environment. If no action is taken, continued inefficient and inequitable use of land and water resources in the absence of implementation of sustainable development strategies will only worsen current conditions in the region, increase hardships and foment political instability.

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SOIL-LANDSCAPE MAP OF ARNO BASIN: SOIL-LANDSCAPE SAMPLING AND ANALYSIS.

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KEY WORDS: spatialization, pedology, Arno River.

AIM OF THE STUDY

This project has as its purpose the creation of the Map of soil-landscape Arno river basin (1:10,000 scale) through a soil survey carried out in some sample areas of the basin (Fig.1). Simultaneously seeks the creation of an information layer of detail on regional soils, their physical and chemical characteristics and their functional behavior, the content information of the geological map at 1:10,000 scale and other databases of detail found in regional Sit .

The project, also based on innovative methods of spatial analysis, is a recurrence to increasing transaction accuracy of identification of soil types present in the region, their geographical location to an appropriate scale, their distribution in the landscape and the variability their characteristics in space (Fig.2). The project follows some priority criteria dictated by necessity and urgency of solving regional problems in certain geographical contexts. Survey of soils, from analytical data collected from processing was made possible result after multiple themes for different applications and information deepen knowledge on specific topics.

Fig.1: Arno Basin and test area identified through remote sensing interpretation.

SAMPLING METHODOLOGY

The detection of the sample areas within Arno basin and its subdivision into landscape units was based on photointerpretation. The database of soil analysis has only one punctual feature class and the coordinate system reference geographic is the Gauss-Boaga (Roma40). Each point collects the data of each soil observation. The database has been compiled directly on netbook during relief activities and each point was placed directly with GPS USB on a topographic map.

The structure and fields of the table follow those contained in a standard paper form of soil sampling. Some fields in the table provide precise values encoded as defined in the “Guida alla descrizione dei suoli in campagna e alla definizione delle loro qualità” of the Tuscany Region, other areas, however, provide for the insertion of text or numeric fields unencrypted. Surveys activities started in October and ended in June: 44 sample areas were detected within about 1200 drilleds and 120 pedology profiles.

Several analysis were also carried out on soil sample in laboratory: individuation of USDA class of soil, sand and clay percentage, amount of carbonate, soil framework, organic matter, pH, csc, EC, Ca, Mg, K, Na and soil umidity.

Fig.2: Fland use, slope, exposition identify different lanscapes

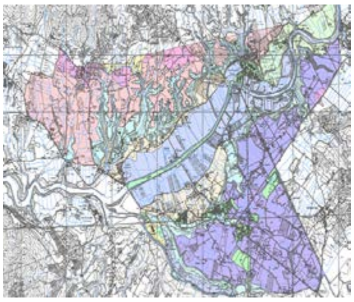

Fig3: UDP map.

RESULT

All chemical and physical analysis of soil samples collected during drilling and during the profiles are collected in a database (Fig.4).

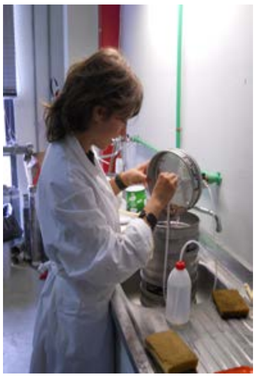

Fig. 4:Ground analysis in a core soil and Laboratory analysis in a sample of soil.

It is possible spatialised information collected and obtain the Soil-Landscape Map Of Arno basin; increasing the density of the observations and profiles can also obtain the semi-detail Soil Map that represents the third level of the entire project.

Moreover geostatistical analysis can be performed on data collected in order to get map on the trend of values analyzed.

The soil data can be used in the study of all phenomena involving soil as a factor: hydrogeological characterization of soils, soil erosion, solifluction and much more.

The catalog information is a key resource for regional assessments, it is important that its continuous updating and increasing the analytical and descriptive data.

The "Map of the Tuscany Region Soils", is implemented with the Geological Survey of the region by a working group composed of various professionals LaMMA Sesto Fiorentino and the CRES-LaMMA of Grosseto, the "Centro di Geotecnologie" and professionals.

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LANDSCAPE SENSITIVITY ANALYSIS FOR THE SOIL EROSION RISK ASSESSMENT OF HARVESTED COPPICE FORESTS IN THE ITALIAN CENTRAL APENNINE REGION

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KEY WORDS: Forest management, coppicing.

INTRODUCTION

Climate change, globalization and the growing demand for energy and raw materials have resulted in an increasing demand for forest resources at a worldwide scale. In Italy, forestland is the second most common type of land use covering about 87,592 km² (29% of the land surface), out of which 42% is currently managed as coppice forest (INFC, 2007). As a result, a vast area of the country, mostly located in mountainous areas characterized by heavy bursts of intensive and erosive rainfalls that hit the steep slopes (van der Knijff et al., 1999), is subject to operations of wood extraction. For some of these forest landscapes this practice of land resource exploitation may result in irremediable damages. The aim of this study is to contribute to research on accelerated soil erosion risks in Italian forests that are involved in the wood supply chain.

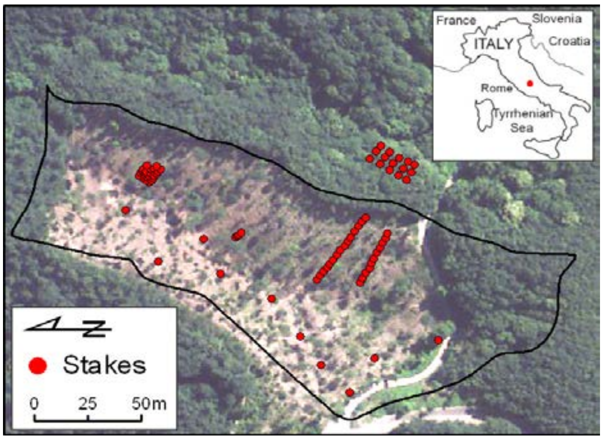
STUDY AREA

Two first-order watersheds (EX-01 and EX-02) have been selected to carry out direct observations and quantifications of the topsoil morphological evolution under two different forest management approaches.

The experimental watersheds are located in a rather remote mountain location inside the Regional Nature Reserve of Monti Cervia and Navegna (Latium - UTM coordinates 4674045N and 338150E). Both watersheds are incised into middle Miocene flysch in pelitic-arenaceous facies. The predominant soil is a not very well-developed yellow-brown (7.5YR 3/2 - 10YR 4/4) Endoleptic Cambisol formed by alteration of the parent material. Table 1 provides further information about the morphology of the two watersheds. The average annual rainfall is 1270 mm, while the average annual temperature is around 11.3 °C.

Between May 2008 and December 2009, the coppice vegetation (*Acerus*, *Quercus pubescens* and oak) of the study site EX-01 was harvested entirely using the shelterwood technique (about 150 trees ha⁻¹ standing after the clear-cut). Study site EX-02 in contrast remained undisturbed. Here, the tree density is approximately 2400 trees ha⁻¹ and the tree heights range from 7 to 15 m.

Figure 1 – EX01 site and the metallic stakes distribution.



Name	Area	Altitude	Mean Slope	Stream length	Stream slope
	[-]	[m a.s.l]	[degree]	[m]	[degree]
EX-01	1.97	989	23.8	196	11°
EX-02	2.24	1002	27.5	211	24°

Table 1 – Characteristics of the study sites.

METHODOLOGY

The work activities followed two main lines of study: a) landscape sensitivity analysis to assess the soil erosion susceptibility and b) direct field measurements of the change in soil surface level.

For the analysis of the landscape's susceptibility to water soil erosion an analysis of the potential soil erosion risk was carried out (van der Knijff et al., 1999). For this purpose, a RUSLE mode has been run considering the RUSLE basic risk factors (i.e., K-factor, LS-factor, R-factor). All parameters were computed following the methodology reported in the USDA Handbook 703 (Renard et al., 1997). The LS-factor was computed using a 2.5 m resolution DEM while the R-factor was calculated based on 15-min interval rainfall data of the Collalto Sabino station. The soil erodibility calculation (K-factor) rest on 35 soil samples collected through DGPS-guided systematic sampling. The samples were analyzed for grain size (LDS), total organic/inorganic carbon

(Woesthoff Carmhograph) and bulk density in the Physical Geography Laboratory of the FU Berlin.

To ensure a continuous observation of the soil surface changes caused by water erosion, 85 metallic stakes were driven into the soil. In the EX-01 watershed 70 metallic stakes with a diameter of 10 mm and a length of around 500 mm were placed across the watershed surface in July 2008. Beyond this, 15 iron stakes were placed into the EX-02 watershed. For both watersheds, the stakes were distributed in different patterns across the surface and geo-referenced with a Leica tachymeter (Fig 1). The changes of soil surface measured by the iron stakes were regularly checked every four months in accordance with the annual variations of the rainfall patterns in January, May and September. In doing so, between September 2008 and May 2010 six metallic stake records were taken.

RESULTS

The grain size analysis (LDS method) revealed similar distribution patterns of the soil particles in the area (σ= clay: 1.6, silt: 4.8, sand: 6.1). According to the 35 topsoil samples analyzed for their grain sizes, silt loam (60.6%), and to a lesser extent sandy loam (30.3%) texture classes dominate the EX-01 watershed. All soil samples were characterized by their low clay fraction contents (4-10%). The TOC values in the watershed range from 0.7 to 14.8%, while the averages values are 4.1, 5.6, and 4.5, for low, medium and high watershed positions, respectively. The K-factor, calculated according to the characteristics of the sampled soils data, ranges from 0.016 to 0.09 t h MJ^{-1} mm^{-1} with a mean value of 0.056 (σ= 0.0177). The LS-factor shows a moderately high average value of 5.9 (σ= 4.6) with local maximum values (from 20 to 25) on the hillslopes. The temporal variability across the year shows high values of rainfall erosivity during the autumn period and during the second half of spring (Table 2). In contrast, the rainfall erosivity is lower in summer and winter. Based on these analyses and specifically the multiplication of the three considered parameters, a map with the assessment of the potential soil erosion risk has been created (see Fig. 2).

The analysis of the changes in the surface level obtained from the metallic stake records revealed a dominant soil mobilization in the harvested watershed EX-01. In 18.8%, 26.1% and 55.1% of the stakes placed in the EX-01 watershed variations (erosion or accumulation of sediment) equal or greater than 0-5 mm, 5-10 mm and >10 mm, respectively, were recorded. In contrast, in EX-02 none of the stakes measured values of a soil surface change in excess of 0.5 mm. The cumulative surface level variation of the observation points in the EX-01 watershed is 98 times the one of EX-02 during the study period (Table 2). There is a strong correlation between the sediment movement regime and the precipitation pattern.

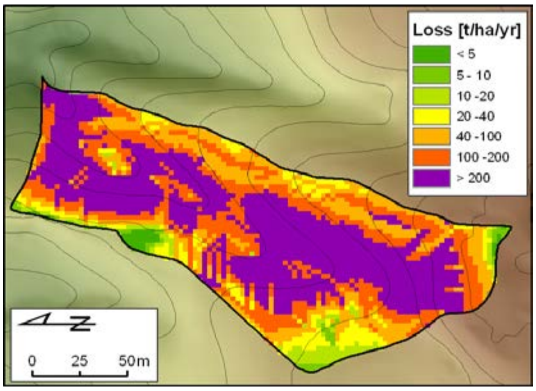


Figure 3 – Potential soil erosion risk map.

Date	Day	Raifall	Rainfall erosiviy	Average change	
				Ex-01	Ex-01
	[-]	[mm]	MJ mm h^{-1} ha^{-1}	[cm]	[cm]
4/1/09	116	717.4	1571	0.025	-0.52
6/5/09	238	430	158	0.02	-0.47
8/9/09	361	144.2	138	0.01	-0.42
8/1/10	480	687.8	963	-0.025	-0.57

Table 2 – Cumulative surface change in the 1st year.

DISCUSSIONS AND CONCLUSIONS

The high potential soil erosion risk estimated for the area was quantitatively confirmed by the field measurements of the field work. There is a prevalence of soils categorized as soils with an erodible texture. These soils have a low percentage of clay which, in turn, determines their low soil cohesion (Torri et al., 1997). This situation is only partially compensated by the quite rich content of organic matter. As a result, the soil was mainly classified as highly erodible. The removal of the vegetation left the soil covering the steep slopes under aggressive rain events. 25 out of 70 stakes (36.2%) placed in the harvested watershed indicated a negative change in the surface level greater than 1 cm. Finally, during the period from August 2008 to January 2010 rates of net soil loss of 49 t ha^{-1} yr^{-1} for the harvested and 2.3 t ha^{-1} yr^{-1} for the undisturbed forested areas were estimated.

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DIGITAL SOIL MAPPING USING ARTIFICIAL NEURAL NETWORKS – SAMPLING ISSUES

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KEY WORDS: Soil Digital Modelling, Neural Networks, Multi-Layer Perceptron Model, Sampling, Spatial Autocorrelation.

INTRODUCTION

Digital Soil Mapping (DSM) is an advanced technique for mapping soil classes (Dobos et al., 2006) which has been developed to bridge the gap between existing soil maps based on traditional soil survey and the increasing demand for soil information. Indeed, at the European level, DSM has been driven by the urgent need to address the strategic importance of soils and the growing concern about environmental disasters, the impact of human activities on soils and the role that this thin layer has on global change.

Artificial Neural Networks (ANNs) are sophisticated computer programs which are able to model complex functional relationships. As such, ANNs provide the means to predict soil types at locations without soil spatial data by combing existing soil maps with factors known to be responsible for the spatial variation of soils (McBratney et al., 2003). Thus, a set of variables related to soil forming factors and the respective soil type is used as training data for the ANN, which constructs rules (Tso & Mather, 2001) that can be extended to the unmapped areas.

Whilst the literature provides a number of examples where DSM is presented as an efficient surveying technique and soil spatial variation is shown to be induced by a limited number of soil forming factors (Mora-Vallejo et al., 2008), still little is known about the impact that the training sites have on the predictive accuracy of the models.

Indeed, sampling method and location of training sites is particularly important for ANNs because their rate of learning, convergion to a solution, network performance and ability to generalise depend on the efficiency of the layout of the sampling pattern which, in turn, depends on the presence of spatial periodicity of the phenomena. Although all environmental variables exhibit spatial autocorrelation at some scale (Englund, 1988), high values found in the spatial distribution of the variables used to train an ANN is likely to affect is performance. Thus, the main objective of this work is to assess the impact that sampling methods used to select training areas for an ANN have on their predictive accuracy.

MATERIAL AND METHODS

The study area is a catchment in Mondim de Basto (Figure 1), north-western Portugal, with approximately 900km^2 in area. The catchment was chosen because it presents a varied geomorphological and ecological setting and a number of soils that are well representative of the soil types found in the region between the Douro and Minho rivers.

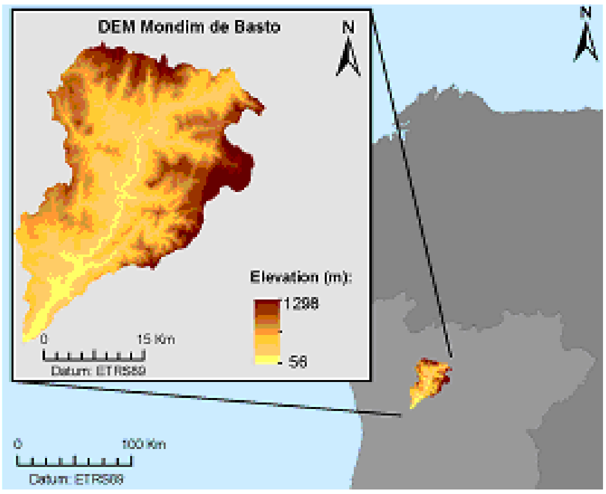

Figure 1 – Digital Elevation Model of Mondim de Basto catchment, in NW Portugal.

The terrain surrogate data used to train the ANN were derived from SRTM digital elevation data with a 90m resolution and selected after multicollinearity tests showed little data redundancy. Thus, in addition to altitude, land use (Corine Land Cover 2006) and geological data were combined with seven morphometric variables which are frequently used in DSM: slope steepness, plan and profile curvatures, upslope catchment area, dispersal area, wetness index and potential solar radiation. Digital soil data at 1:100000 were provided by DRAEM, the regional agriculture department of the North West Portugal. In order to account for the possible effect of autocorrelation, the coordinates (latitude and longitude) were also included in the input vector to indicate location.

Two different sampling strategies were implemented for training a multi-layer perceptron (MLP) neural network model in IDRISI Taiga (Clark Labs), using a highly popular supervised method known as error back-propagating algorithm (Haykin, 1999). Thus, the ANN was trained by presenting it a number of different examples of the same soil type drawn either (i) randomly (RS), or (ii) in a stratified fashion (SS). For the latter, training pixel vectors were located by choosing (a) random coordinates within soil types strata (SRS), (b) random coordinates within soil types and chosen evenly in the frequency space (SRPS) and, (c) nearest coordinates within soil types and chosen evenly in the frequency space (SNPS).

The experimental setup for each training set used fixed input specifications (200 pixels per class for training and testing), two network topology settings (1 hidden layer, no layer two nodes and either 7 or 8 layer one nodes), with a variety of training parameters changes which included using automatic training and a dynamic learning rate which, if used, could vary between 0.01 and 0.2. The stopping criteria were achieving either a RMSE ≤ 0.01, an accuracy of 100% or a maximum number of iterations ranging from 1,000 to 100,000.

RESULTS AND DISCUSSION

Spatial autocorrelation assessment, measured through Moran´s I, indicates that autocorrelation is significantly high for wetness index (0.65) and slope steepness (0.76) and very high for potential solar radiation (0.88) and altitude (0.99).

Analysis of all the results obtained with the different model parameterisations shows that the predictive accuracy of the ANN models is highly dependent on the sampling method and highly correlated with RMSE but not so dependent on the number of iterations (Figure 2).

Sampling Method	Iterations	Testing		Accuracy (%)	RMSE
		Min RMSE	Max RMSE		
SRPS	50000	0.37	0.39	57.8	0.36
RS	40000	0.36	0.46	65.4	0.35
SNPS	5000	0.31	0.43	71.1	0.31
SRS	30000	0.30	0.37	74.7	0.31

Figure 2 – Impact of sampling method on the performance of ANN models and no. of iterations required to achieve the best results obtained with each method, assessed through predictive accuracy level and minimum and maximum RMSE values in the testing set.

Whilst random sampling did not achieve as good predictive accuracy results as the one possible to obtain with stratified sampling (65% *vs*. 75%), it is clear that spatial autocorrelation causes an oustanding drop-off in the number of iterations required to achieve similar levels of accuracy (71% and 75%) and RMSE (0.31). Thus, accounting for spatial autocorrelation by choosing pixels that are as close as possible to each other (SNPS) resulted in only 5,000 iterations being required (as opposed to 30,000) to achieve similar accuracy levels.

CONCLUSIONS

The main conclusions of this work are: (1) sampling strategy has a very important impact on the accuracy of soil predictive maps developed using ANNs and different strategies should be tested, and (2) sampling strategy benefits from reflecting high autocorrelation of factors of soil formation because the ANN learns faster that close neighbouring positions are more likely to have similar soil types, allowing the ANN to converge faster to a better solution.

ACKNOWLEDGEMENTS

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DESERTIFICATION VULNERABILITY MAP OF SICILY - SCALE 1:250.000 – (ENVIRONMENTALLY SENSITIVE AREAS TO DESERTIFICATION, ESAS)

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KEY WORDS: Desertification, Climate Change, Soil use.

INTRODUCTION

This is a project realized by a coordination through administrative regional departments (Dipartimento Regionale Ambiente, l'ARPA, il Dipartimento Regionale Interventi Infrastrutturali per l'Agricoltura, il Comando del Corpo Forestale ed il Dipartimento Regionale dell'Acqua e dei Rifiuti) and belongs to the need of a regional data base organized for the evaluation of environmental sensitive area to desertification. The output is an actualized Desertification Vulnerability map of Sicily applying the MEDALUS-ESAs (Environmentally Sensitive Areas) methodology.

The MEDALUS-ESAs appears as the most used methodology at international level and recently has been utilized in three test areas of Mediterranean Basin (Italia, Portogallo e Spagna).

The methodology has the scope to identify sensitive areas through the use of biophysics and socioeconomics indicators and classify the areas in: Critical ESAs, Fragile ESAs and Potential ESAs.

. After an evaluation of individual data base realized by each department, all the useful information has been centralized and participated.

According to the original methodology proposed by Kosmas et al. (1999), in Sicily has been necessary make appropriate changes in the application, especially for the pedological, climatic and land use characteristics.

MEDALUS METHODOLOGY

MEDALUS methodology is based on the identification of "Environmental Sensitive Areas to Desertification (ESAs)" and consists of a multifaceted approach of environmental processes in place, both on general and local one. The methodology in question defines 4 classes of desertification indicators relating to the following categories:

- Soil (6 indicators);
- Climate (3 indicators);
- Vegetation (4 indicators);
- Land Management (3 indicators).

Through the first three categories will get an overview of the state of environmental conditions, while the last index expresses an evaluation of the pressure exerted by human activities, from the average of the four indices ESA determines the index of environmental sensitivity.

The methodology is based on the classification of each quality index calculated as the geometric mean of the environmental and anthropogenic available. These indicators are quantified by assigning each a score in relation to its influence on the processes of desertification.

The methodology involves the development of 4 Quality Indices starting from the variables which are assigned a numerical value based on the greater or lesser influence on the process of desertification.

At the end of this process there will be 4 general indices:

- 1. Soil quality index - SQI
- 2. Climate quality index - CQI
- 3. Vegetation quality index - VQI
- 4. Management quality index - MQI

The final step comprises the matching of the physical environment qualities (soil quality, climate quality, vegetation quality) and the management quality for the definition of the various types of ESAs to desertification. The four derived indices are multiplied for the assessment of the ESAs index (ESAI) as following:

ESAI = (SQI*CQI*VQI*MQI)1/4.

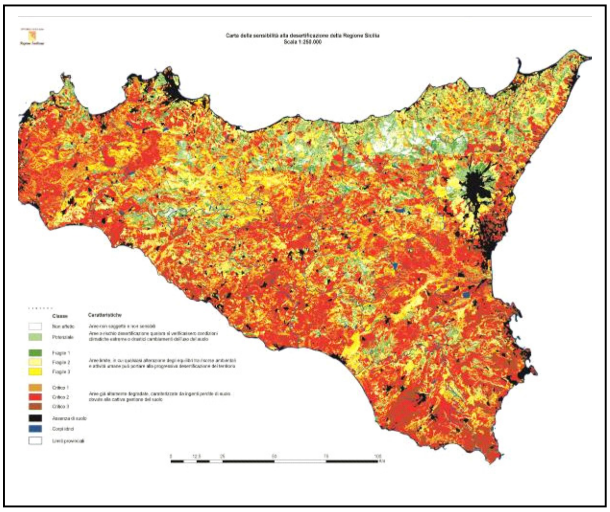

Figure 1 – . Desertification Vulnerability ma p of Sicily - Scale 1:250.00

RESULTS AND CONCLUSIONS

The cartographic application of the MEDALUS methodology in Sicily has revealed a general sensitivity to land degradation as specifically set forth below.

Critical areas account for 56.7% of the whole island; these can be divided into three criticality levels: low, areas C1, 17.7%; mean, critical areas C2, 35.0%, and high critical C3, the most critical, amounted to 4.0% of the entire island.

Fragile areas, those where any alteration of the delicate balance between natural factors and human activities can lead to desertification, representing an amount equal to 35.8% of the total, it can also distinguish between areas that are less fragile (F1), 7.0%, and those most fragile, vulnerable areas (F2), 12.8%. Areas with a fragility (F3), those next to the class C3 reach 16.0% of the entire surface. Only 5.8% and 1,8% of the areas of Sicily presents a potential or no sensitivity to desertification.

The Data Base to support cartographic analysis was implemented by numerous detailed and updated data, especially for the soil and vegetation component.

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SOIL EXCAVATION AS THE MAIN MORPHOGENETIC AGENT IN THE TORRENT CORLO VALLEY (NORTHERN APENNINES, ITALY)

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KEY WORDS: Soil excavation, morphogenesis, GIS, geomorphological mapping, Modena Apennines

INTRODUCTION

This work deals with morphological changes in the landscape of the valley of the Torrent Corlo from the mid-20th century to date and provides their relationships with soil excavations.

The valley of the T. Corlo is located in the western sector of the Modena Apennine margin, with elevations ranging from 123 to 298 m a.s.l. The valley is located in the Municipality of Fiorano Modenese, in the district of Sassuolo-Fiorano-Maranello-Formigine where hundreds of factories were built after World War 2 for the production of ceramic tiles (Fig. 1). The T. Corlo is a small watercourse which runs through the Modena Apennines for about 3 km; it reaches the Po Plain at Fiorano and, some 3 km downstream, flows into the Fossa di Spezzano stream, which belongs to the River Secchia catchment.

As regards climate, the T. Corlo valley is comprised within the sub-continental temperate climate with average precipitation of about 700-800 mm/year and average temperatures of 12-13 °C (Fazzini, 2007).

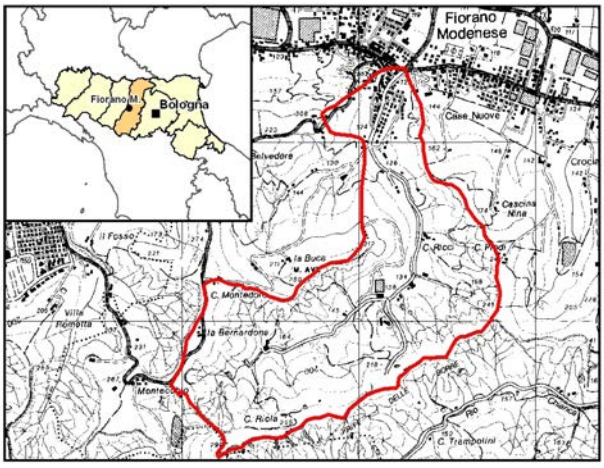

Figure 1 – Geographic setting of the Torrent Corlo valley.

The area studied stretches over 175 ha and, from a lithological standpoint, only marine silt-clay soil types (Plio-Pleistocene in age) are exposed (Gasperi et al., 2005). The most evident natural morphological features to be observed on the slopes of the valley, as well as in the surrounding valleys, are badland landforms locally named “calanchi”. These badlands are one of the most spectacular erosion landforms of the Apennine margin. Typically, they are composed of clayey-silty soils and are characterised by a very fine drainage network and short, steep slopes with narrow interfluves. Various small to average-sized earth slides and earth flows are found in the area.

The deposits are mostly made up of very fine materials deposited by the T. Corlo on the valley floor and by rill-wash at the foot of the slopes.

The main anthropogenic landforms are represented by abandoned soil pits on the slopes of the mid-sector of the valley. The materials used in the ceramic tile industry are, in fact, the clayey soils which crop out in the low and medium sectors of the Northern Apennines.

STUDY METHODOLOGY AND RESULTS

This study was carried out according to the traditional methods used in geomorphology (bibliographic research; research on historical maps, morphological analysis by means of interpretation of aerial photographs taken in various periods, geomorphological field-survey) as well as digital processing methods on maps and aerial photographs. The available digital data have been overlaid and compared using GIS software also by means of 3D elaborations in order to better appreciate the morphological features. The documents considered in this study are shown in Table 1.

The research led to the elaboration of four schematic geomorphological maps related to morphological features as surveyed in different periods in a time range of 73 years.

The morphological features of 1954, 1973, 1994 and 2011 were mapped. The main landscape changes occurring in these years are described as follows.

Type of document	Date	Scale/ Resolution	Note
IGM map	1935	1:25,000	B/W
GAI aerial photos	1954	1:33,000	B/W
RER aerial photos	1973	1:15,000	B/W
CTR map	1977	1:10,000	B/W
Volo Italia aerial photos	1994	1:70,000	B/W
CTR map	2005	1:10,000	B/W
AGEA orthophotos	2008	0.5 m	C

Table 1 – Documents considered in this study. IGM: Italian Military Geographic Institute; GAI: Aerial Italian Group; CTR: Regional Technical Maps (CTR) of Emilia-Romagna Region; RER: Emilia-Romagna Region; AGEA (Agenzia per le Erogazioni in Agricoltura); B/W: black & white; C: colour.

In 1954 the landscape of the study area still looks quite "natural", showing just three small soil excavation zones in the medium sector of the valley. Soil pits are concentrated in the slope's lower portion on the left hydrographic side of the T. Corlo. In 1973 soil excavation activity is much more extended, affecting also the right hydrographic side of the valley as well as upstream and downstream areas. Various artificial ponds and large levelled-out areas are present. These were constructed in order to mitigate rill-wash erosion and safeguard dirt service roads leading to the soil pits. In addition, at its lowest extremity, the valley is now developed, following the intense urban expansion of the village of Fiorano Modenese. In 1994 the soil exploitation areas on the left slope are abandoned whereas on the right slope soil exploitation activities are further expanded uphill with new excavation fronts which in some cases have removed stretches of the watershed with the conterminous T. Chianca valley. To date, man-made changes are clearly visible all over the T. Corlo valley, which appears to be characterised by levelled-out surfaces and slopes with artificial morphological profiles typical of excavation areas (Fig. 2). Nevertheless, at present the remodelling of excavation fronts resulting from concentrated rill wash processes can be observed in various points. In some cases, the action of water running freely along slopes previously affected by artificial shaping tends to give them a more natural aspect. Some of the artificial ponds are now filled by sediments. Furthermore, in the upper portion of the slopes natural badlands can still be observed. In these areas rill wash water tends to thin the slopes' crests, owing also to the fundamental contribution of superficial earth slides and earth flows. Indeed, present-day evolution of badlands takes place in many areas also because of small slope movements, which cause the rapid withdrawal of the badlands' heads and the filling of their valley floors with clayey deposits.

CONCLUSIONS

According to ASQ-ConsultinGroup (2008), soil excavation began in an improvised, makeshift way in the 1930s. By the 1960s, though, excavation was carried out in a more organized, industrial way. Extraction of soil for the ceramic tile industry ceased completely in 2008. Soon after the whole area previously affected by the presence of several soil pits was the object of a project of landscape and environmental reclamation and upgrading, with the implementation of a horse riding centre and some small ponds for recreational purposes. The study describes and maps some stages of the evolutional trend determined by soil excavation. Finally, a detailed assessment is made of the fundamental role played by excavation activity as a morphogenetic agent of the T. Corlo valley as well as its impact on the natural evolution of the landscape.

Figure 2 – The medium sector of T. Corlo valley in which abandoned soil pits are visible.

ACKNOWLEDGEMENTS

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SOIL MAPS – TURNING OLD INTO NEW

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KEY WORDS: Soil digital mapping, Artificial Intelligence, Soil Survey.

INTRODUCTION

Soils have long been recognized to be an important non-renewable resource crucial for human activities (Potocnik & Dimas, 2005) and for modulating global change. Yet little account is taken of soil properties and their spatial variation in planning, hindering the assessment of soils and their ability to support a range of services, from food production, to biodiversity and pollution buffering.

Whilst soil surveys have been carried out in many countries, the area coverage and scale of resulting soil maps are far from being ideal for planning applications at national level (Dobos *et al.*, 2006). Additionally, the lack of consistency between soil classifications and legends across countries contributes towards a slow progression in integrating soil datasets, even in Europe (ESBN, 2005).

Geographical Information Systems (GIS) together with artificial intelligence (AI) maximize the information content of existing soil maps by learning the rules that have, more or less explicitly, led to the mapping of soil classes across the landscape, and then use that knowledge to predict the spatial distribution of soil classes or properties at similar resolutions.

Thus, one of the main objectives of AutoMAPticS (Automatic Mapping of Soils), a portuguese project carried out at national level and based on the development of artificial neural network (ANN) models, is to predict soil classes in (i) currently unmapped areas of Portugal, and (ii) harmonise soil legends across regions with distinct soil mapping classifications, using Portuguese and Spanish soil spatial datasets to a) improve the level of transnational data integration and b) assess existing data.

SOIL MAPPING

Portugal, like most EU member states, only has a fraction of its territory covered with soil maps at semi-detailed or reconnaissance scales (McBratney *et al.*, 2003). Whilst 55% of continental Portugal has soil maps at 1:50 000 produced by traditional methods of soil survey before the 1970s, only about 40% of the territory has more recent soil map coverage at 1:100 000 with some degree of overlap (Figure 1). Thus, not only the published coverage remains incomplete, but there are also significant problems with the existing cartography. There is a lack of cartographic uniformity between the different regions: (1) scales are different, (2) four different taxonomic systems were used, and (3) the framework behind the mapping of soil units at the two scales is different: the 1:100 000 maps have a physiographic basis whereas the 1:50 000 maps have a taxonomic basis. Moreover, using taxonomy as the basis of map design often results in high intra-unit variability of soil properties (Mulla & McBratney, 2000) and limited correlation between soil type and soil hydrologic parameters (Western & Grayson, 2000). Therefore, only 43% of the area of Portugal has high standards of soil cartography.

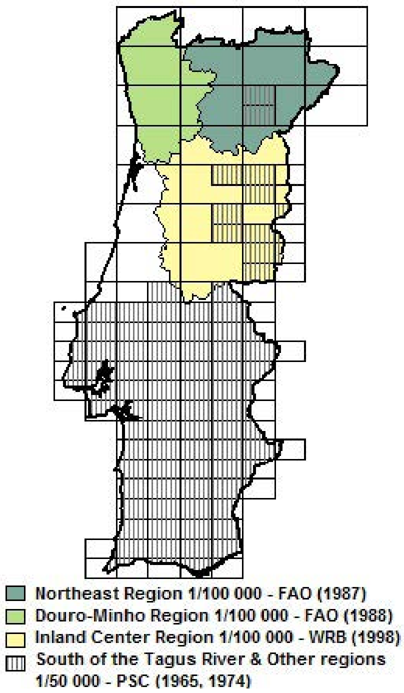

Figure 1 – Scale and legends of regional soil maps of continental Portugal.

The Portuguese soil map coverage provides an outstanding opportunity for advancing Digital Soil Mapping (DSM) because (1) half the country has high quality soil-map coverage for which a very large number of geo-referenced soil samples were collected, (2) there are geo-referenced soil profile data at a number of sites throughout the unmapped area, and (3) there are also soil maps at different scales. Additionally, as soil units are not coterminous with political soil maps, Spanish soil spatial datasets were collated to allow a better integration of the Portuguese soil cartography at an international level.

SPATIAL MODELLING OF SOILS USING GIS & ARTIFICIAL INTELLIGENCE

With the technologies available today, such as GIS, which allow storage and retrieval of large amounts of spatial data, including of those which are considered to be the main factors of soil formation and development (Irvin *et al.*, 1997; MacMillan *et al.*, 2000), combined with advances in Artificial Neural Networks (ANN) and Fuzzy Logic (FL), it has become possible to map the spatial distribution of soils in a cheaper, more consistent and flexible way, using surrogate landscape data. Thus, ANN models are used to translate knowledge of soil-survey, which is encapsulated in existing soil maps, into relationships between soils and landscape features in order to predict soil types in unmapped areas for which the landscape characteristics are known. In this way, first-order digital soil maps are used to generate third-order ones (Behrens & Scholten, 2006).

During the training phase, the ANN learns about regularities present in the datasets (soil classes and landscape features, i.e. digital terrain data, land cover, lithology) and, based on these regularities constructs rules (Tso & Mather, 2001) that can be extended to the unmapped areas.

The ANN is trained by presenting it a number of different examples of the same object (i.e. different landscape-feature vectors for a certain soil type) and this methodology is applied to each pilot region in Portugal and Spain and at different resolutions.

FUTURE PERSPECTIVES AND NEEDS

Processes involved in soil development do not usually operate on a discrete level but produce a continuum of change (McBratney & Odeh, 1997). Also, according to the same authors, imprecision and uncertainty are inherent parts of natural systems. Fuzzy Logic is an approach that can address the continuous nature of soil in DSM. There is a natural synergy between ANNs and FL that makes their hybridization powerful for DSM, which will be later developed in this project.

Results obtained using both methodologies will be compared and validated using existing maps and soil profile data, and the best model will be used to map soil classes across areas which are currently lacking spatial soil data. Thus, the main aim of AutoMAPticS is to complete the Portuguese soil map coverage at 1:100 000.

ACKNOWLEDGEMENTS

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USE OF MULTISOURCE GEOGRAPHIC DATA FOR THE ASSESSMENT OF LAND TAKE PROCESSES AT LOCAL SCALE

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Keywords: Land take, Soil sealing, Multisource geographic data

Soil sealing and land take processes are becoming processes with high priority in the political agenda, at both local and global scale. Recent reports and guidelines, published by the European Commission, show the implication that land take processes have, not only on the agricultural sector, but more in general, on the delivery of a series of fundamental ecosystem functions. In order to monitor, with very high temporal and spatial accuracy, the processes of land take and soil sealing at local scale, the use of geographic data from multiple sources can provide an important contribution. In this paper we describe the improvement in the accuracy of artificial area mapping, thanks to the use of geographic data that are currently produced in the local scale land planning process, and by the utility company managing the distribution of gas, water and electricity.

MULTITEMPORAL SATELLITE REMOTE SENSING AND GIS FOR THE MONITORING OF ERODED AREAS: THE CASE-STUDY OF SACCIONE RIVER BASIN

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KEY WORDS: Remote sensing, GIS, monitoring, Soil erosion, Geomorphology, Southern Italy.

INTRODUCTION

In the Southern Italy the relief geologically active, the Mediterranean climate, the abundances of recent clays and clastic sediments and the bad agricultural practices make heavy the problem of soil erosion by washing waters. This problem makes difficult the life and the development of local economy. This is well exemplified in the Saccione River Basin sited at the border of Puglia and Molise regions (Southern Italy) (Fig. 1).

Often, the soil erosion is quite difficult to detect in the field, especially when it is shallow and very extended such that the agricultural practices can easily masked it. In that case the field-survey reveals useless and expensive, so that is necessary resort to remote sensing techniques (Vrieling, 2006) like quail-quantitative multispectral data analysis (Lo Curzio, 2009; Lo Curzio and Magliulo, 2010). Such techniques allow to identify the areas affected by surface water erosion trough the characteristic differences in spectral response (De Jong et al., 1999).

The aim of this study is the assessment at the basin scale of the eroded areas in the Saccione River Basin from multitemporal satellite data analysis. That analysis come from the recognition and monitoring of the geomorphological evidences of soil erosion derived by Landsat ETM 7+ data integrated with the results of field-survey and photo-interpreted data.

The results obtained allow both the mapping and the monitoring of the eroded surfaces in the studied area, they are comparable with the same data coming from field-survey at the same scale.

MATERIALS AND METHODS

The study area, the Saccione River Basin, is a portion of a 228.6 Km^2 wide Landsat scene located in Southern Italy.

A collection of pre-existing lithological, pedological and land-use data and the creation of thematic maps have been used in this study.

Several image enhancement techniques (contrast stretching, Principal Component Analysis, decorrelation stretching, RGB false colour compositing) have been used by software RSI ENVI 4.5.

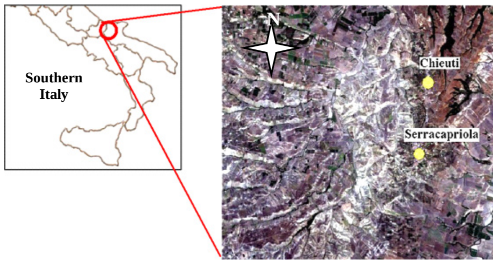

Figure 1 – Ubication of study area and its rapresentation in the Landsat image.

A classification of the Landsat imagery was then performed, consisting of the following steps: 1) definition of the training sites (or Regions of Interest, ROI); 2) extraction of spectral signatures; 3) final image classification.

The field geomorphological observations played a fundamental role in discriminating and interpreting the spectral response of areas subjected to soil erosion by washing water. It aimed to collect "ground truth" for ROI definition in the Landsat imagery. A GPS survey served for positioning of ROI. A simple statistical analysis was performed on Digital Numbers values of the pixels enclosed in the ROI.

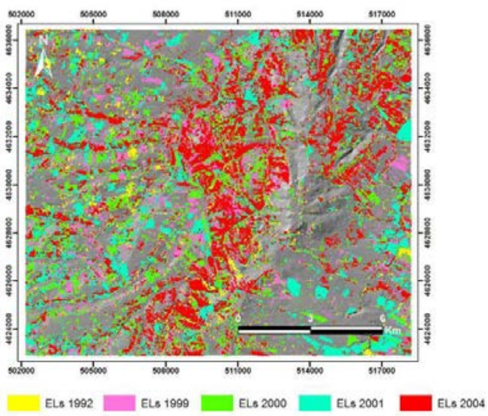

Figure 2 – Cumulative map of Eroded Landsurfaces (ELs) detected for each year of satellite observation (1992, 1999, 2000, 2001, 2004).

A classification with Maximum Likelihood algorithm of the whole image was used and from it were estracted only the information about the eroded polygons (Bocco, Valenzuela, 1988). This allowed to create several maps of eroded areas (fig. 2) for each year of satellite observation (1992, 1999, 2000, 2001, 2004).

RESULTS AND CONCLUSIONS

The spatial analysis in GIS software (Burrough, 1996) carried out only on extracted data showed the correlation between eroded areas detected and some geomorphological characteristics (lithology, slope, slope orientation, land cover) (Beguerìa, 2006) of the hillslopes in the studied area. Particularly, it was interesting to note the results of the histograms analysis showing the relationships between lithological and slope factors and the percentage distribution of the Eroded Landsurfaces (ELs) (fig. 3) for each year.

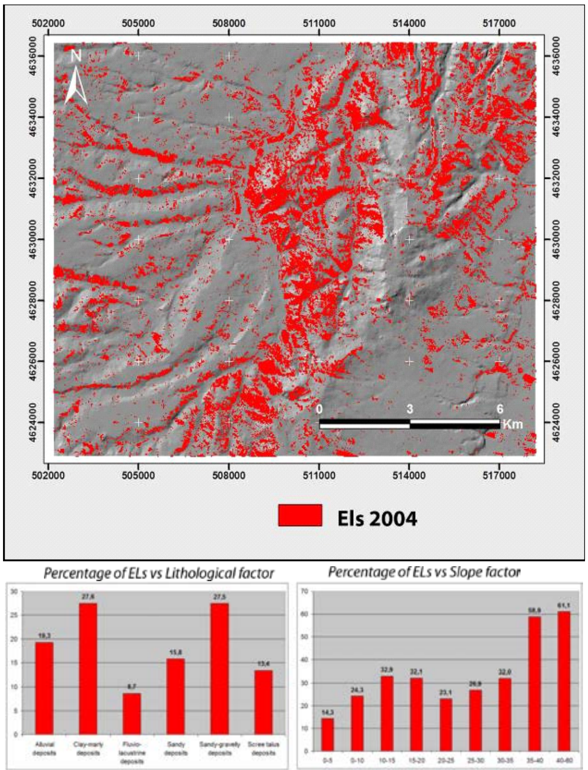

Figure 3 – Map and histograms showing the relationships between lithological and slope factors and the distribution percentage of the Eroded Landsurfaces (ELs) for the year 2004.

The maps of ELs detected have been intersected in GIS environment, allowing us to generate a new map showing the portions of the studied area always eroded relatively to examined years (1992, 1999, 2000, 2001, 2004) (fig. 4).

In conclusion, with this paper we demonstrate that is possible, in a relatively short time and at low cost, to realize the mapping and monitoring of such wide soil eroded areas.

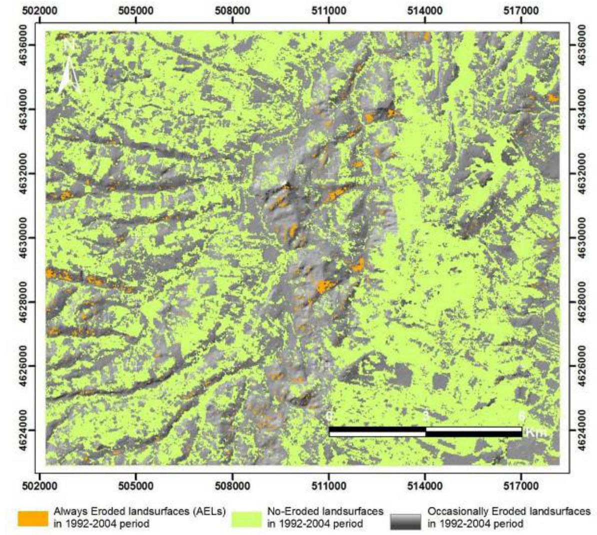

Figure 4 – Map showing the portions of the studied area always eroded relatively to examined years (1992, 1999, 2000, 2001, 2004).

The digital mapping produced represent a fundamental updating tool in the territorial management, monitoring and assessing policy.

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MORPHOMETRIC ANALYSIS OF THE DTM AND THE DEFINITION OF LANDSCAPE UNITS AIMED AT CREATING THE TYPES OF SOIL MAPPING UNITS AND THE BASIN OF THE RIVER OMBRONE (TUSCANY).

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KEY WORDS: spatialization, pedology, Ombrone River.

INTRODUCTION

“Landscape” it means the set of features that distinguish a certain land area of Earth’s surface from another, and these characteristics are the results of both natural processes and of human activities. Is widely accepted that there is a close correspondence among landscapes and soils.

The Ombrone River is the second largest (3494 Km^2) and longest (161 Km) river of the Tuscany Region, comprising the provinces of Siena and Grosseto (Fig.1).

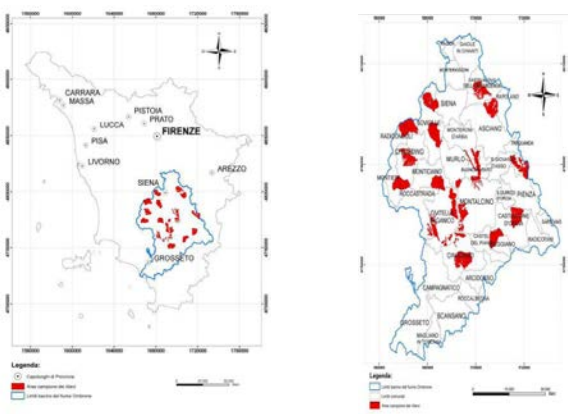

Fig.1: River Basin Ombrone and Sample areas of the project

METHODS

The methodology used to achieve a continuous coverage of the landscape unit (ie areas with soils that had the same formation and have similar morphological characteristics) for the whole basin of the river Ombrone, was based on modern techniques based on processing and GIS geo-referenced databases. Georeferenced spatial data base used are: the regional geological map at scale 1:10.000, georeferenced both in vector and raster format also contain values, such as outcrops, that are not shown in vector data, the land use map from recent detailed achievements, the potential vegetation map derived from the forestry regional database, elaboration of regional scale climate data created by Lamma Consortium in the DesertNet project, recent orthophotos (2006), the 10 meters DEM and its derived indices; for the soil we have used the catalogs relating to the Soil Map Project of Tuscany at scale 1:250,000, we had also consulted the soil detail analysis achieved for the Ombrone Basin in recent years. As it is impossible to achieve a continuosly spatial data analysis of the whole basin, for reasons of cost and time, we decided to proceed to sample the representative areas of the basin.

For the realization of the Landscape Units (UDP) close related with those identified in the sample areas, were developed technique of “automatic classification” and “semi-automatic classification” of the territory, which are based on the analysis of morphometric indices derived from the DEM, such as the slope, exposure, the longitudinal and the horizontal (concavity and convexity) curvature, the length of the slopes, the size, the density and the pattern of drainage. These techniques have been inspired by methodologies developed by several authors (Hengl, T. and Rossiter, DG, 2003, MacMillan et al., 1997).

The automatic extraction of the landforms was performed on some sample areas chosen to reflect both the morphometric variability and the soil information within the Ombrone basin, in order to test the reliability of the most possible classification techniques used in both automatic and semiautomatic processes (Fig.2).

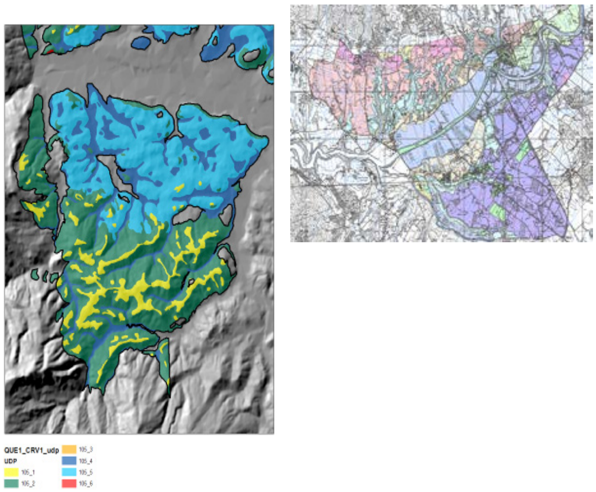

Fig.2: Particular of semiautomatic spatialization.

The selection of these areas has provided a very accurate analysis high level of land systems, in order to select land portions with the greater lithological and soil variability. Land systems may be considered as environments characterized by a peculiar combination of physical factors (lithology, climate, morphogenetic processes, vegetation, land use and anthropic), which affected both the formation and properties of soils, and the appearance of the landscape. For this reason the Land System has been used as a container of synthetic information on soils and landscape, and as a tool for the transfer of soil information.

CONCLUSIONS

The spatialization for large units, heterogeneously scattered on Ombrone basin, provides less reliable results since it moves away gradually from the interpretated sample area; this because of the variability of the areas

Also, when the criteria of division of the various landscape units are made from photo-interpreter based on factors such as the intensity of erosion, drainage patterns, land use, rock outcrops, etc., that are clearly identifiable aerial photo, but not characterizable by any morphometric index, it becomes very difficult the spatialization with techniques that, instead, these indices have their operational strength. It was very functional the use of various intermediate products, derived from processing of morphometric indices (slope, plan curvature, profile curvature, flow accumulation, topographic wetness index) together with more convincing results obtained by automatic and semiautomatic processing. These products provide the photo-interpreter of useful elements to trace the boundaries of landscape units.

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MAP OF BOGS AND HALF BOGS IN BAVARIA

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KEY WORDS: bog, half-bog, distribution, overview, map

ECOLOGICAL IMPORTANCE OF BOGS

The knowledge of distribution of bogs and half-bogs, their ecological state and their occurrence within the landscape is essential for nature conservancy. The new map is the first general map of bogs and half-bogs in Bavaria. It is a solid base for planning, nature conservancy, protection programs or recultivation.

Bogs and half-bogs are defined due to the guidelines for organic soils of the International Panel on Climate Change (IPCC) [2006], with more than 30% peat or 15% by volume respectively.

Bogs are important parts of the ecosystem due to water storage and their biodiversity. But bogs are also the most important terrestrial C-deposits and therefore important with respect to climate change. In the average of bogs in the Federal Republic of Germany 700 t C are fixed per ha of bog-land. Therefore, it is very important to maintain or to restore the peat in a steady wet state.

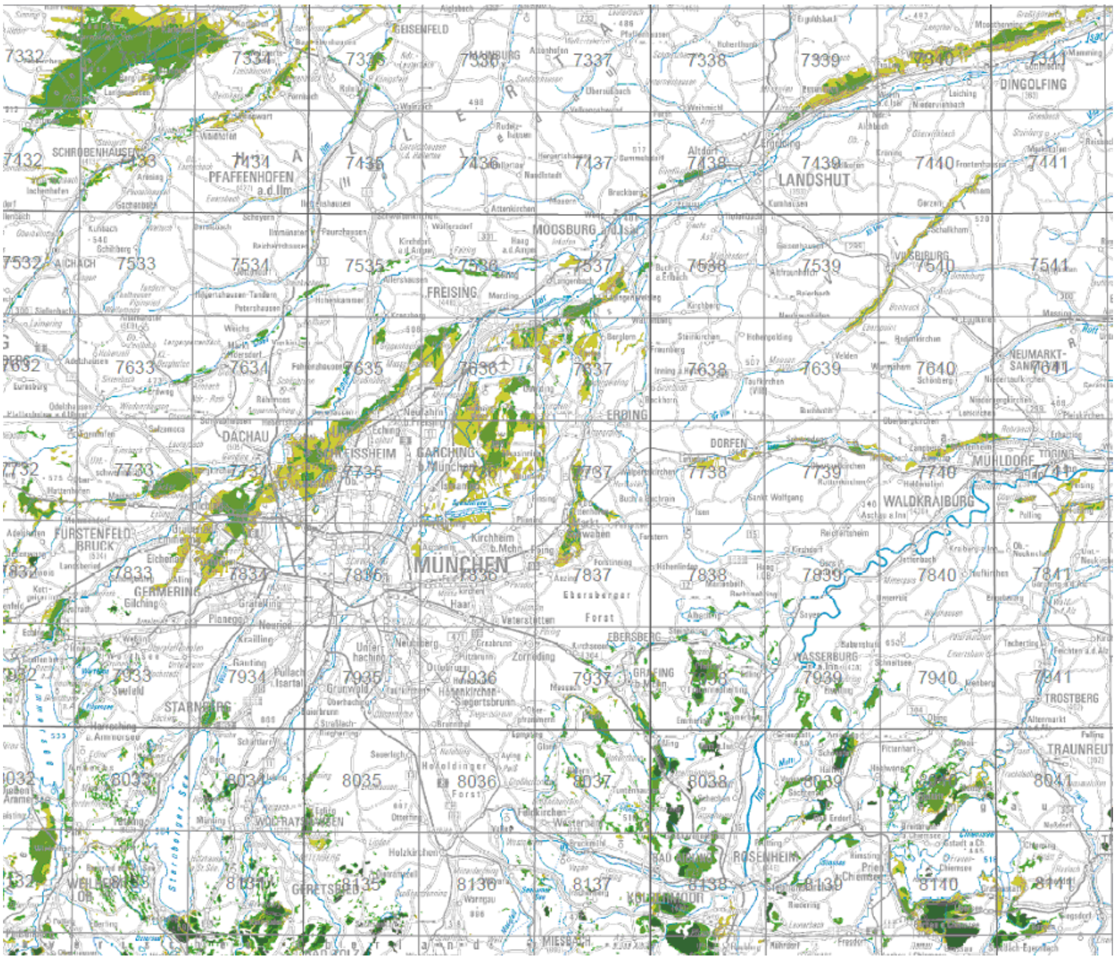

Figure 1 – Part of the map of bogs and half bogs of Bavaria showing the region of Munich and the south-east of Bavaria, where dark green are rainwater bogs, green groundwater bogs and yellowish green half bogs, respectively. The inscribed four-digit numbers point to bog maps in the scale of 1:25 000.

Drained bogs, especially under intense agricultural use, mineralize and large amounts of carbondioxide or dinitrogenoxide (> 300 times more effective greenhouse effect) are produced. With respect to the different types of bogs, intensity of usage and drainage more than 40 t CO_2-equivalent/ha*a may be released.

The protection of bogs is therefore an important task concerning climate and environmental protection. The map of bogs and half bogs will support these policies by showing the distribution of rainwater bogs, groundwater bogs and half-bogs.

BASIC SOIL MAP AND AVAILABILITY OF MAPS IN GREATER SCALE

The map of bogs and half-bogs of Bavaria was derived from soil maps in the scale of 1:25 000 (ÜBK25), available as a geodata base for almost the complete area of Bavaria.

Different soils representing bogs and half-bogs were selected with respect to the IPCC guidelines for organic soils [2006] and cover about 3% of the area of Bavaria.

Fig. 2 shows the different soil classifications of the ÜBK25 aggregated to the map of bogs and half bogs in Bavaria.

Legend Colour	Legend of the map of bogs and half bogs of Bavaria	Used legend numbers of the ÜBK25
	Mostly half bogs, partly degraded, with minor areas of gley.	61a, 62c, 64c, 65c, 66b, 67, 72c, 72f, 73c, 73f, 75 and 75c
	Mostly groundwater bogs, partly degraded	77, 78 and 78a
	Mostly rainwater bogs, partly degraded	79

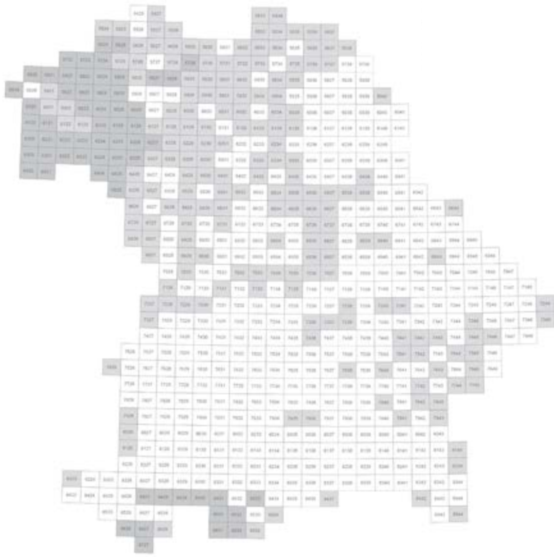

Figure 2 – Legend of the map of bogs and half bogs in Bavaria with respect to original legend numbers of the overview map of soil in the scale of 1:25 000 (ÜBK25)
Figure 2 – Advance in soil mapping and availability of maps of bogs and half bogs of Bavaria in the scale of 1:25 000.

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MEASUREMENT AND REGIONALIZATION OF THERMAL CONDUCTIVITY OF SOILS IN BAVARIA

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KEY WORDS: soil thermal conductivity, measurement, modelling, regionalization

INTRODUCTION

Soil thermal conductivity is a primary factor determining the heat extraction potential of ground heat exchangers. In the context of the EU co-financed project “Information Offensive Geothermal Energy”, the Bavarian Environment Agency (LfU) – Geological Survey creates regionalization of the thermal conductivity of soils in Bavaria in the scale of 1:25 000, with the aim of providing an overview of the suitability of regions for horizontal ground source heat pumps. To execute the project, we use a modelling approach to determine the soil thermal conductivity.

Over the last 60 years, many soil scientists have proposed models for predicting the thermal conductivity of soils. The model commonly used in Germany is that proposed by Kersten (1949), because of a recommendation from the Ad-hoc Working Group Soil of the Geological Surveys of Germany. However, the Kersten model was developed based on the laboratory experiments using Alaskan soils, originated from the unique climate and vegetation that were different from those of Bavaria. For example Alaskan soils typically exhibit lower quartz and higher basaltic contents due to the high volcanic activity.

The first step of the project is to examine the reliability of Kersten model for Bavarian soils: How accurately does it predict the thermal conductivity of the soils? For this purpose, we measure the thermal conductivity of a variety of soils, taken from representative geological areas in Bavaria, and we compare the measurements to the values estimated from Kersten model.

The apparatus for measuring the thermal conductivity and Kersten model is being explained. Also, a comparison of results of the measurements and the estimates is being presented.

MATERIALS AND METHODS

(1) Soil samples

On the basis of geology, Bavarian region falls into four characteristic areas: South German escarpment and fault block region, Southeast German crystalline basement, Alpine lowland, Alps. For soil sampling, we select 10 locations in each area, randomly. At each location, we choose two or three soil layers from the soil profile (from the surface to around 1m depth), and we collect a soil of 3-4 kg from each soil layer. Therefore, about 120 soils are used for the experiments.

The soils are air-dried and sieved through a 2mm mesh. Following the methods reported by Hiraiwa & Kasubuchi (2000), we prepare the samples over the full range of degree of saturation (S_r). The samples are packed into acrylic containers (6cm in diameter and 5.5cm tall). Table 1 shows physical properties of the soils: bulk density, ρ_d; volumetric solid content, V_s; mass fraction of sand, m_{sand}; mass fraction of silt, m_{silt}; mass fraction of clay, m_{clay}.

Table 1 – Physical properties of the soils

Location	Soil layer	ρ_d (g cm^{-3})	V_s (cm^3 cm^{-3})	m_{sand} (%)	m_{silt} (%)	m_{clay} (%)
6727/90/17	Ap	1.37	0.53	37	46	17
	Sd	1.39	0.53	35	30	35
6728/90/22	Ap	1.50	0.57	73	19	8
	Sw	1.60	0.60	77	15	8

(2) Measurements of the thermal conductivity

Figure 1 shows the container and a heat probe for measuring the thermal conductivity. The container is capped with an acrylic plate. At the centre of the top cap, a small hole (9mm in diameter) is bored to accommodate the heat probe. The heat probe is made of a stainless-steel tube with the following dimensions: 1mm outer diameter, 0.6mm inner diameter and 40mm long. The heater wire (enamelled constantan wire, 0.1mm in diameter) and a T-type thermocouple (enamelled cupper and constantan wires) are placed into the tube, and the remaining space is filled with epoxy resin. As a temperature reference, the cold junction of the thermocouple is placed into dry sand.

Figure 2 shows a schematic diagram of the apparatus to measure the thermal conductivity. The soil container and the temperature reference are placed in a thermal insulation box. During a measurement, a constant electrical current is applied to the heater wire for 120 seconds; at the same time, the temperature changes in the heat probe are measured every 5 seconds with a data acquisition system (CR1000, Campbell Scientific Inc.). Twenty-four data pairs of time (t) – temperature changes of the heat probe (ΔT) are collected for each heating and cooling process.

To determine the thermal conductivity, we apply the t – ΔT data pairs to the twin heat probe method based on the line heat source theory (e.g. Hiraiwa & Kasubuchi, 2000).

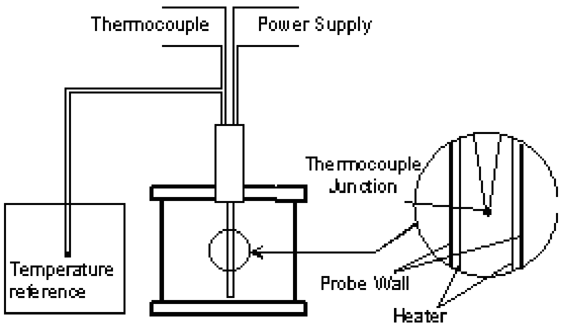

Figure 1 – A soil container and a heat probe for measuring the thermal conductivity.

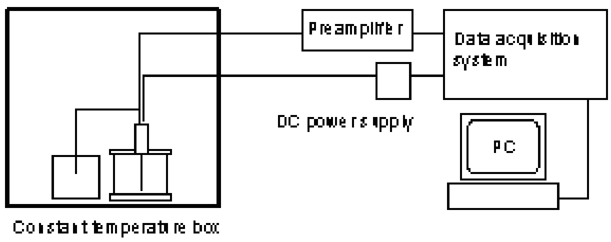

Figure 2 – A schematic diagram of the apparatus to measure the thermal conductivity.

KERSTEN MODEL

Kersten (1949) measured the thermal conductivity of Alaskan soils as a function of water content, and he published two empirical models for coarse and fine textured soils, which are respectively expressed as,

$$\lambda = 0.14 \cdot 0.9 \cdot \left(\log\left[S_r\left(1-V_s\right)/\rho_d\right] - 0.2\right) \cdot 10^{0.62\rho_d}$$

$$\lambda = 0.14 \cdot 0.7 \cdot \left(\log\left[S_r\left(1-V_s\right)/\rho_d\right] + 0.4\right) \cdot 10^{0.62\rho_d}$$

We deal with the soils containing m_{sand} of more than 50% as coarse textured soils (two from 6728/90/22), and the soils with m_{sand} of less than 50% as fine textured soils (two from 6727/90/17).

RESULTS AND DISCUSSION

Figure 3 shows the relationship between the measurements and the degree of saturation, and also shows the solid line indicating the estimates from Kersten model. The Kersten model seems to slightly underestimate the thermal conductivity near saturation, the tendency of which was also observed for the other two soils.

The soil water content around ground heat exchangers can be near saturation; therefore, focusing on the thermal conductivity at S_r of 0.7 and 1, we evaluate the performance of Kersten model by the relative mean squared error (RMSE):

$$RMSE = \sqrt{\frac{1}{n}\sum\left(\lambda_{measured} - \lambda_{estimated}\right)^2}$$

where n is 2 (the number of the measurements). The RMSE values are shown in Table 2. Kersten model can predict the thermal conductivity within the RMSE of 0.37 W m^{-1} K^{-1}, which may be acceptable for the project. Further measurements are necessary to evaluate, if this result is of general validity.

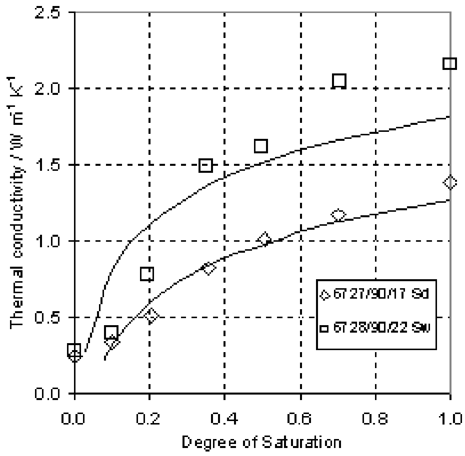

Figure 3 – Relationship between the thermal conductivity and the degree of saturation.

Table 2 – RMSE values

Location	Soil layer	RMSE (W m^{-1} K^{-1})
6727/90/17	Ap	0.25
	Sd	0.09
6728/90/22	Ap	0.22
	Sw	0.37

CONCLUSION

The measurements show, that Kersten model gives acceptable predictions of the thermal conductivity of the four soils investigated. Further experiments on a larger number of soils will reveal the applicability of the Kersten model for Bavarian soils. Additionally, other well known pedotransfer functions for the prediction of soil thermal conductivity will be tested.

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THE PEDOLOGICAL CONTRIBUTION TO ASSESSMENT OF GEOMORPHOLOGICAL SLOPE STABILITY

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KEY WORDS: Geomorphological stability, landslide hazard, morphogenesis, pedogenesis.

SOIL, AN INDICATOR OF GEOMORPHOLOGICAL STABILITY

Soil is a natural body on the uppermost layer of the Earth's crust with specific properties that derive from the physical, chemical and biological transformation of the original rock.

Its characteristics are the result of combined factors such as climate, morphological processes and mineral composition of rock. Soils can therefore provide a great deal of information on the geomorphology of an area, particularly on the environmental conditions existing at the time of its formation.

The degree of soil evolution is closely linked to the opportunity for pedogenetic processes to be active more or less continuously over time, and to the intensity of processes that shape the environment (morphogenetic processes): consequently it is possible to identify the moment of interruption in a morphogenetic process (depositional, hydro or gravitational), in a morphological element: slope, alluvial terrace, landslide.

In the hilly-mountain areas of Emilia-Romagna (Apennines) erosive, hydro or gravitational processes tend to abrade soils and, depending on their intensity, may lead to a truncation of the soil up to its complete removal.

During prolonged periods of morphological stability there is a reverse tendency of soil accretion: soil tends to develop and over time forms distinctive, increasingly well-defined characteristics as part of a balance with environmental conditions.

Consequently soil evolution is closely related to the interaction, intensity and duration of phases dominated by antithetical processes: morphogenesis and pedogenesis, and in particular it reflects the result of their interaction (morpho-pedogenetic balance).

SOIL AS AN ELEMENT OF DATING

The first experimentation using soil as an element of dating was conducted during the survey for the map of soils of the Modena plain, "Carta dei Suoli della Pianura Modenese," published in 1993 by the Geological, Seismic and Soil Service of the Emilia-Romagna Region.

Such experimentation was later refined, taking into account the indications of the "North American Stratigraphic Code - Version 1983" for the classification of "Pedostratigraphic Unities" developed in the extent of the Po Plain Geological Map at scale 1: 50000 for dating the continental Quaternary deposits ".

The analysis of the degree of evolution of soil profiles collected over more than two decades by the Geological, Seismic and Soil Service throughout Emilia-Romagna region, has enabled us to build up a "scale of the degree of evolution" across regional soils; "*types*" based on the degree of expression of genetic features have been created according to the degree of leaching of carbonates, organization of carbonatic nodules and presence-absence of one or more B horizon. Each "*type*" identifies the time or historical period in which the deactivation of geomorphological processes occurred and pedogenesis began.

Now we are able to establish the minimum time necessary for the development of a certain type of soil: e.g. the discovery in the profile of archaeological finds from the Bronze Age (800-2600 BC) is proof that pedogenesis began between 2600 and 800 BC.

Since the steady morphogenetic state has not subsequently undergone any significant disruptions, we can conclude that the "minimum pedogenetic time" (*mpt*) necessary for the development of the profile containing artifacts from the Bronze Age varies from between 2800 and 4600 years, while for finds from the 2nd century BC *mpt* can be estimated at about 2200 years and so on.

DATING OF LANDSLIDES ON A PEDOLOGICAL BASIS

Deposits with a gravitational origin can lead to the development of soils, similar to what occurs with alluvial deposits, and are indeed similarly related to the alteration processes. The start of soil evolution can be traced back to the time after the deactivation of geomorphological processes; it is believed that the method used in surveying Quaternary deposits can be useful in evaluating the geomorphic stability of slopes and landslide hazard.

Through assessment of the degree of soil evolution we can determine when the gravitational phenomena ended or, in polycyclic landslides, we can ascertain whether the deactivation was simultaneous or not on the entire body of the landslide.

In order to verify the method proposed in areas dominated by erosion processes and calibrate the "*types*" identified and the allocation of *mpt* given to them, we surveyed the soil profiles on the slopes and landslides whose status of geomorphological activity and duration of the period of stability were known.

The soil survey was performed by auger hole, as described by the Soil Survey Manual of the Geological, Seismic and Soil Service of the Emilia-Romagna Region, 2002 edition.

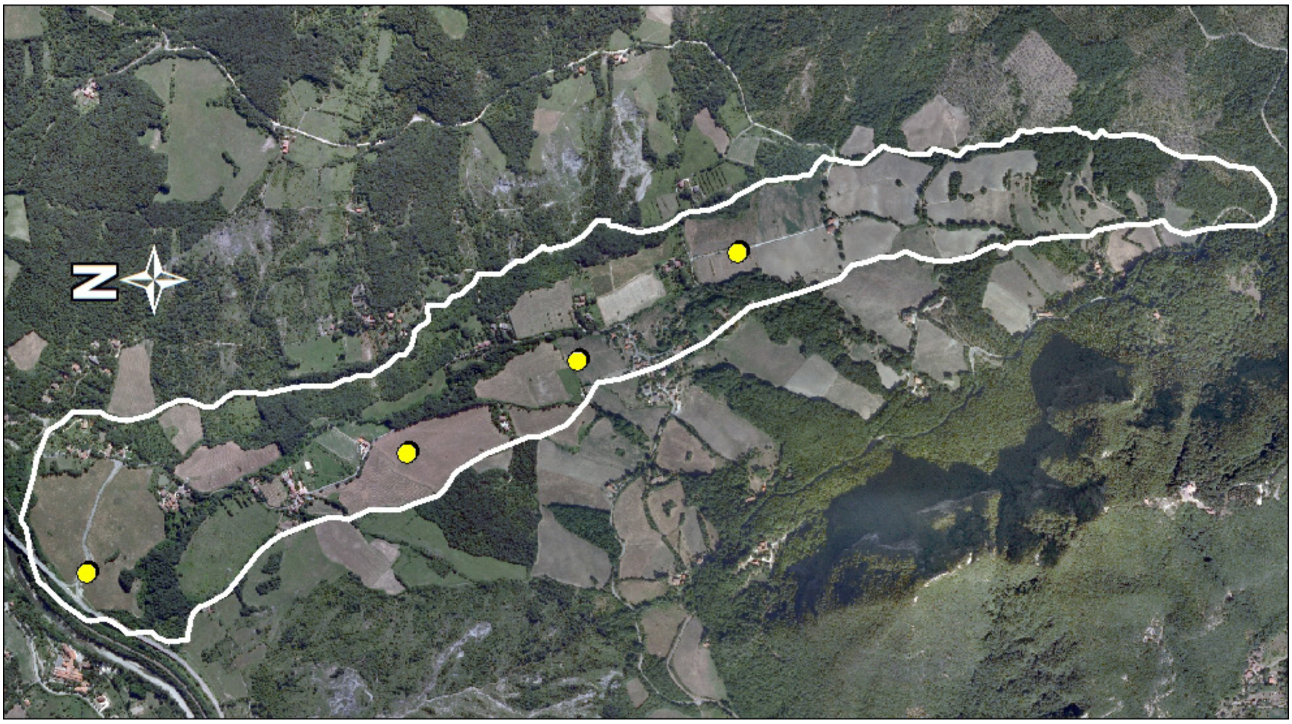

Fig. 1 - Soil survey of Oreglia landslide (Grizzana M. – BO). All the detected profiles have been assigned to the Profile type IV (Base map Orthophoto AGEA 2008).

The results of the survey, which confirmed the methodological assumptions, enabled the drawing up of the following "types" profile timescale:

Period of geomorphological stability: a few tens of years (<100) (Entisoils)

Profile "type" I: A or Ap - C; very calcareous (CaCO3> 10%);

Period of geomorphological stability: a few hundred years (100-500) (Inceptisoils)

Profile "type" II: A or Ap – Bw - C; very calcareous (CaCO3> 10%);

Period of geomorphological stability: hundreds of years (500-2000) (Inceptisoils)

Profile "type" III: A or Ap - Bw-Bk; moderately or very calcareous (5% <CaCO3> 10%) – C; very calcareous, concentration of carbonate (CaCO3> 10%);

Period of geomorphological stability: a few thousand years (2000-8000) (Inceptisoils)

Profile "type" IV: A or Ap – Bw; not calcareous or slightly calcareous (0,5 > CaCo3 < 1%) – Bk; very calcareous, concentration of carbonate (CaCO3> 10%) –C; very calcareous (CaCO3> 10%);

Profile *"type"* V: A or Ap – Bw; not calcareous (CaCO 3 <0.5%) – Bk; very calcareous, concentration of carbonates (calcic horizon);

Period of geomorphological stability: thousands of years (> 8000) (Inceptisoils-Alfisoils)

Profile *"type"* VI: A or Ap - Bw or Bt; not calcareous (CaCo3 <0.5%) –Bk; very calcareous, concentration of carbonates (calcic horizon) within 1-2m of depth;

Profile *"type"* VII: A or Ap – Bt; not calcareous (CaCo3 <0.5%) – Bk; very calcareous, concentration of carbonates (calcic horizons) over 2m deep.

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PHYSICAL PROPERTIES OF THE DASHTYARY GULLY AND METHODS TO PREVENT ITS EROSION

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KEY WORDS: Agriculture lands, subsidence, calcimetry, permeability, internal friction angle.

ABSTRACT

Most of the Dashtyary soil is devoid of vegetation and the existence of subsidence are signs of sub surface erosion. Flood flows are created drainage lines and gaps in the region. With increasing the gap development in the soil, agriculture lands are rapidly destroyed. The sampling depth of the soil sampled from the central region of the gully is 15 cm. The grain size distributions, hydrometry, Aterberg limits, calcimetry, specific weight, permeability (hydraulic conductivity) of the 27 gathered samples were measured and saturated and unsaturated shear tests were performed. Employing the Arc View GIS software and the digitalized topographic maps, the gully progress was characterized during the30 years. The results indicate that the investigated soils have a permeability coefficient of 4-10 m/sec, a liquid limit of less than %15, calcium carbonate of %15, internal friction angle of 29-32 degrees, and are silt with low plasticity. These results indicate a weak and erodible soil type. Based on the studies, the slope of the Dashtyary area is 0.2°-0.5° to the south and its height is between 14-64mvariable. From 1971 to 2001, the longitudinal gully profile has increased 3.2 times.

INTRODUCTION

One of the most dangerous forms of water erosion is a very length, width and depth gully created by running water (Ireland et al. 1939, Boucher 1980, Coleman et al. 200). Due to heavy floods and saturation, walls and beds of gullies lose their shear strength and stability and abrupt movements of sandy silt and clay masses occur by free-fall, slumping and rolling. The events cause degradation and destruction of Dashtyary farms and villages adjacent watercourse (Bacellar et al.2005, Dotterweich 2011, Schmitt et al. 2006, 9). The Dashtyary region has an area of approximately 645 sq km, located in Makran zone, at the northeast corner of the Chabahar city. About the gully erosion, so far, valuable articles have been published worldwide (Rahnama-Rad et al. 2011, Bacellar et al. 2005, Zeedyk & Jansens 2009, Perroy et al. 2010, Di Stefano & Ferro 2011). In this study the grain size distribution, hydrometry, Aterberg limits, calcimetry, specific weight, permeability (hydraulic conductivity) of the 27 gathered samples were measured and saturated and unsaturated shear tests were performed. The results show that the soil is silt and fine sandy silt (ML). The silty soils are non cohesive, have low permeability and low shear resistance against seasonal flooding. Upon wetting it loses strength and because of its open structure can experience large rapid deformations that can result in slope failures.

GULLY DEVELOPMENT AND ITS EFFECT ON LOCAL ECOLOGY

In some areas of Dashtyary region there is dominantly sub-surface erosion (Fig.1). Water can be the most common factor that causes slope instability, from surface runoff on the bluff itself (Bull & Kirkby, 1997). Due to the empty of the following level the Upper layers are falling. They started with the initiation of narrow channels which rapidly widened by erosion into major gullies. The effective strength reduces of the unconsolidated coarse sands in the walls of the gullies lead to intense erosion. The Grooves are created in the plains. Erosional grooves facing each other as they cut and they spread on the ground surface.The gully cross section are formed U-shape and the sidewalls are vertical. Factors leading to gullies, such as surface runoff, soil type, human intervention, vegetation and subsurface faults, demonstrated that the Longitudinal progression of gullies have strong relationship to the maximum daily rainfall. From 1966 to 2006, several villages were destroyed and now six villages have been emptied from population. The total destruction will be added with erosion progression. So far, about 50 percent of agricultural land and grassland have been destroyed, it lead to imbalances in nature, to the loss of fauna and flora species and followed by people unemployed and rural migration.

CONCLUSION

This development trend is very dangerous for agricultural lands and pastures. The soil is silt and fine sandy silt (ML). The silty soils are non cohesive, have low permeability and low shear resistance against seasonal flooding. Upon wetting it loses strength and because of its open structure can experience large rapid deformations that can result in slope failures. The development of the gullies has caused extensive damage to the environment and has driven many people away from their homes and farmlands.

Dams constructed with respect to engineering principles, an increase of vegetation in areas where gully progress has still not develop; have a high rate of prevention to gully progression.

Figure 1- The subsurface erosion, which led to sloughing and bank failures.

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GEOCHEMICAL AND MINERALOGICAL CHARACTERIZATION OF COAL COMBUSTION WASTES OF ANGREN THERMAL POWER STATION FOR ASSESSING THEIR FUTURE ECOLOGICAL THREATS AND INDUSTRIAL BENEFITS.

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KEY WORDS: Fly ashes, toxic, trace, extraction.

INTRODUCTION

The problem of safe waste management currently has a global and intractable nature. The generation of electricity by thermal conversion of coal results in significant volumes of solid wastes. Most of these materials are disposed of in surface impoundments near coal-fired power plants. The Angren thermal power station in Uzbekistan was founded in 1958 and is working based on the nearby Angren lignite mine. The coal ash wastes (about 11 million tons since 1958) occupy an area of about 82 hectares. This study determines their geochemical and mineralogical characteristics and content of rare and trace elements. The data obtained show high concentrations of trace elements in the coal ash wastes. Elevated concentrations of As, Cd and other metals pose a potential ecological threat.

In a result of research in soils and plants found that the content of the ore minerals and wastes in the form of spheres, and various globular segregations increases when approaching the sources of pollution. The study of thin sections by microprobe, made from heavy fractions, provided an opportunity to submit the form in which heavy metals found in emissions. Heavy oils Angren soil consists mainly of different balls, consisting of iron oxides, in the same grains of hematite, and titan- magnetite. The internal structure and elemental composition of the most spheric is almost the same. Above they are covered with glandular shell, but inside they are composed of many small balls and mineral particles (figure 1). All this makes it possible to determine the predominant role of waste of Angren TPP in the origin of geochemical anomalies and the high dispersion halos of heavy metals in the area.

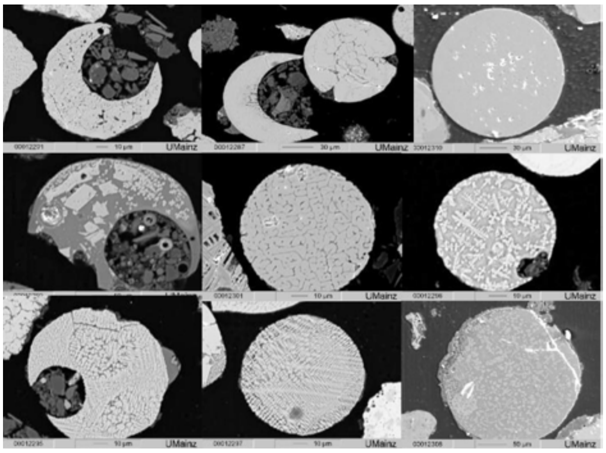

Figure 1 The morphology and structure of spheres in the heavy fractions of soil samples.

The properties of fly ash vary from one sample to the next depending on the source of the coal; degree of coal preparation, cleaning and pulverization: design, type and operation of the power plant boiler unit; conditions during combustion; additives used to assist combustion or improve precipitation performance; efficiency of emission control devices; storage and handling of the by products; and the prevailing climate.

Concentration of trace elements in the fly ashes is quite high (Table 1). In fly ash, zinc and lead displays the highest concentrations while cobalt the lowest.

Concentration of the some elements in fly ash of Angren TPP.

Element	values [ppm]
As	*93*
Cu	*108*
Cr	*65*
Cd	*11*
Co	*8*
Y	*28*
Mo	*57*
W	*82,3*
Ni	*14,2*
Pb	*307*
Sc	*11*
V	*62*
Zn	*1141*
Nb	*20,3*

Internationally, approximately 45% of the produced bottom ashes are used and applied in many sectors, as a secondary source of high quantities of valuable metals. By applying mineral processing technologies and hydro-metallurgical and biohydrometallurgical processes, it is possible to recover metals such as Al, Ga, Ge, Ca, Cd, Fe, Hg, Mg, Na, Ni, Pb, Ra, Th, V, Zn, etc., from bottom ashes. Recovery of metals from such wastes and their use are important not only for saving metal resources, but also for protecting the environment.

MATERIALS AND METHODS

Sampling program: The coal, fly ash, bottom ash and soil samples for this study were provided by the laboratory Environmental geochemistry and geotechnology of Institute of Geology and geophysics, Academy of science of Uzbekistan. The samples originated from Angren Thermal Power Plant (TPP). More than 100 fly ash and bottom samples with 3 triplicates from each site were provided for a total of three ash wastes. The samples were collected vertical and horizontal direction. The soil samples were collected from surface and below 20 cm from different locations around of coal combustion wastes. The pooled samples of fly ash and slag wastes, soils have been ventilated and sifted through a sieve of 2 mm and packed in plastic bags. The collected samples were dried at room temperature.

Methods: Chemical speciation, flotation, gravity, magnetic and electromagnetic separation techniques as well as XRF, XRD, SEM. Last analyses of major and trace elements concentration were determined in the fly ash, bottom ash and soil samples by ICP MS in Environmental Geochemistry University of Bayreuth 2011-2012. A six sequential extraction procedure was also applied.

ACKNOWLEDGEMENTS

We are grateful to proff. Britta Planer Friedrich to provide sequential extraction procedure in the laboratory of Environmental geochemistry, University of Bayreuth.

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SEDIMENTS AND SOILS OF RECENT AGE IN KISH ISLAND, PERSIAN GULF : ORIGIN AND CHARACTERS.

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Key words: Sediments, Soils, Recent ago, Kish island. Mining and natural aggregates resources

ABSTRACT:

Kish island with 90.4 km^2 area, is in the south of Iran and in the Persian gulf. It has many tourism potentials. To better know and evaluate the sediments and soils of Recent age of this island. Field studies are done, 100 samples are taken and subjected to geology and pedology tests. The whole surface of the studied area, are covered with Quaternary deposits. The rock units of these deposits are formed with reef limestone and little gypsum marl. Sediments and soils of Recent age of Kish island with very little thickness, are under factors such as: marine currents, waves, tides, winds and temporary runoffs on reef lime stones, which are formed approximately 11000 years ago. After lime, few amount of clay minerals, gypsum and halite are present in the combination of fine grains to coarse grains. The soils of this island, are categorized in 23 series and 4 classes. These soils have low fertility.

INTRODUCTION:

Since 1960, Kish island due to it's huge capabilities in tourism field, has attracted attention. In the past 4 decades, along with civil and servical activities, many comprehensive studies are done on diverse characters of this island. With regard to new developmental programs, the necessity of previous and editing of last studies are felt. One of these, is about sediments and soils of the surface of Kish island and also their origin and character which are discussed in the present article.

Kish island with 90.4 km^2 area, is located in 53° 53' to 54° 40' eastern longitudes and 26° 26' to 26° 35' southern latitudes in the Persian gulf. This island is in about 90 km south of Bandar Lengeh in mainland of Iran. **3-2- Geological characters:**

From geological point of view, Kish island is located in the south structural-sedimentary folded Zagros unit [1]. Folded Zagros is one of seismity areas of Iran and has tens of salt domes and folds with up to 70 km length and 20km width. Kish island is on an anticline with the same name and east-west strike with 40 km length and 15 km with and there is an underground salt dome near to area of study. They drillings of oil and gas wells have revealed sedimentary sequences from Permian to Quaternary exist with 4500m approximate thickness around this island [2]. No important fault has been reported with 150 km around Kish island. The area of study is located on a region with medium-high risk relative average of earthquake and plan base acceleration a = 0.35 g [2].

The surface of Kish island is covered with Quaternary deposits, completely. After tectonic movements of the tertiary end and Quaternary beginning, the Kish anticline is formed. The setting of the head of this anticline in a shallow marine waters, the existence of proper biological and climatic conditions are led to formation of reefs during of Quaternary. The main parts of Kish island reefs according to their importance are : coral, molluscan, bivalve and echinoderm. The especial geological position, the continuation tectonic movements and climatic Quaternary changes (glacial and interglacial periods) intensities the sea water surface changes effect on formed reef of this island in this period. The uplift rate of Kish island is estimated 0.18-0.22 mm in each year [6], and terraces on height of 0,10,30 m of this island, are signs of this phenomena.

Around 11000 years ago, with beginning of the last interglacial period, Kish island was forming its present situation. Marine currents, waves and tides in the area of coast, moisture, wind and temporary runoffs in the surface of Kish island are causing weathering, erosion of rock units of Quaternary and formation of Recent age's sediments. These rock units are : 1-Reef limestone, so called Coquina, which is comprised of the large area of the island surface and its thickness changes between 20-58 m. This rock are Composited from small clasts of coral, molluscan, bivalve and echinoderm, and jointed tohether with lime cement [7]. Its weathering depth is 1-1.5 m. The reef limestone of Kish island has medium – good strength and stability [5]. 2 – Gypsum marl which has about 1.5m thickness and with a gradual boundary is located below reef limestone. This rock with high water absorption, expansibility and erodibility in the north and east of Kish island, has limited outcrops.

The sediments of Recent age of Kish island with several centimeters to maximum 1.5 m thickness are placed on reef limestone. The mineralogical and geochemicals surveys which are done on 100 samples, show that lime form more than %90 of their composition and the rest are clay minerals, gypsum and halite. The total of this lime and fossil remains in discussed sediments, are originated from Quaternary reef limestone.

The insignificant present amount of clay minerals and gypsum, resulting from weathering and erosion of gypsum marls. Halite present is the result of penetration and evaporation of saline water of Persian gulf. Granulometry tests on taken somples, indicated that the sediments of this island from the point of grain size, are classed on fine to coarse grain. Coarse grain particles in the size of gravel and very coarse sand have the largest expansion in the eastern coastal strip, and resulting from waves, tides and marine currents. They are in scattered and limited forms which are under eolian erosion and are seen in the central region of this island. The medium grains (sand) are in the form of eolian and coastal sands. The coastal sands are mostly present in north and eastern north of this island. Eolian sands are subjected under prevailing process west, and are expanded from west toward east of kish island [4]. The fine grain sediments (silt and clay) with scattered form and very low thickness are present especially in center part of Kish island.

With the formation of Kish island anticline under tectonical movements in the end of Cenozoic period, particulary Pasadonian, and with the regard to its tectonic setting and Quaternary climatic changes, the required conditions reefs mainly coral with gypsum marl in the discussed area is provided. These deposits in Pleistocene are under sea level changes (resulting from tectonic setting and climatic changes). With the end of the last glacial periods around 11000 years ago, this island came out of water for the last time, and its Quaternary rocks are in the weathering process, eolian and water erosion. The results of these processes are: fine to coarse grain limic sediments, 23 series and 4 classes of residual soils, and it is a place with white to light grey color, little thickness, and under erosion forces covered the surface of Kish island.

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EXPERIMENTATION ABOUT A MAP ON "MARGINAL TERRITORIES" WITHIN THE EMILIA-ROMAGNA REGION (ITALY).

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KEY WORDS: "marginal terrains", renewable energy sources

FOREWORD

ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) is leader of the European M2RES Project, whose activities include the drafting of a knowledge base of "marginal terrains" in the Emilia-Romagna Region, deemed to be fit for the setting up of power plants for the generation of energy from renewable sources (Renewable Energy Sources, RES) including wind, solar photovoltaic, biogas and biomass. Geothermal energy is excluded, given the features of this source in the region (low enthalpy). To achieve this goal, a collaboration agreement was signed between ENEA and the Geological, Seismic and Soil Survey of the Emilia-Romagna Region, given its competences in the development of environmental thematic maps

"MARGINAL TERRAINS"

This term indicates areas affected by environmental degradation, where no recovery is possible (or economically sustainable) either for manufacturing or residential purposes. This state of affairs is the result of unfavorable natural features or, more often, of high-impact use change, related to human activities. Conversely, these areas may be of great interest for the installation of renewable electric power generation systems, as set out by the National Guidelines for the identification of areas suitable for this purpose (2010), also taken into account by the measures recently approved by the Emilia-Romagna Regional Authority. ENEA has classified marginal terrains into four categories:

- quarries (and strip mines)
- landfills
- abandoned military bases
- brownfields in general and / or subject to contamination of various kinds.

METHODOLOGY

The cartographic information on the four categories of marginal terrains identified by ENEA is first derived from the Land Use Map (edition 2011), produced by the Regional Service responsible for it. In a second stage, validation of data related to quarries and landfills is carried out by regional and provincial services, dealing with the census and planning of these sectors. Aerial photographs and computerized cadastral maps are used to identify abandoned military sites, i.e. not easily available information. The four categories of areas have also been integrated with data available in the Geological Survey databases, to obtain as much information as possible. They include, for example, areas with unfavorable soil characteristics for agriculture, areas unsuitable for arable land, forestry or grazing (Class VIII Land capability classification). This information is then processed by means of GIS programs to map potentially suitable marginal terrains, which are compared with:

- planning and legislative constraints related to the power generation from renewable sources• urban fabric and land characterized by the presence of water bodies
- lithology of the substrate, presence and characteristics of debris cover on slope (fitness for deep foundations, wind turbine blades)
- land use capability

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- land use capability

These layers act as filters that limit the potential exploitation of marginal terrains for the production of power from renewable sources.

Subsequently, areas will be further characterized according to other parameters, in order to obtain the optimal surfaces for power generation.

The following stage parameters are:

- steepness of the slopes and exposure to solar radiation / prevailing winds
- accessibility
- Information available on the buffer zones of roads, cemeteries, sewage treatment plants, radio antennas.
- lithology of the substrate at a larger scale
- wind
- minimal surfaces
- age of facilities (landfills)

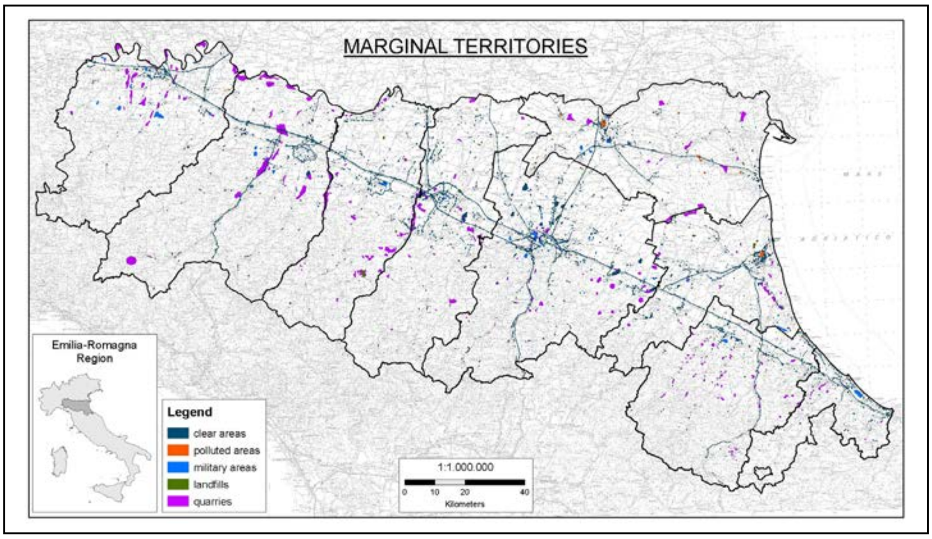

Figure 1 – Sketch-map of the "aree marginali" within the Emilia-Romagna Region.

CONCLUSIONS

The project is innovative in that for the first time "marginal terrains" within the region have been identified, at a detailed 1:25.000 scale. The map that has been drafted, as shown in figure 1, is not only the result of an accurate census, but also of the comparison with various types of spatial data, including geological ones, related to the characteristics of foundation soils and soil quality

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APPLIED FLUVIAL GEOMORPHOLOGY AND STREAMS RECOVERY: A CASE STUDY WHILE LANDSCAPE PRESERVATION IS THE HIGHEST VALUE

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KEY WORDS: bankfull, river stability, Natural Channel Design.

INTRODUCTION

San Lucano Valley (Taibon, Belluno, Italy) is situated in the heart of the Agordine Dolomites, included in the UNESCO System n.3: Pale of San Martino - San Lucano-Belluno Dolomites (Fig. 1).

The valley is a prototype study area for a research project issued from the collaboration among the Dynamics of Environmental Processes Institute (IDPA-CNR-Milano), the Technical Mining Industry Institute (ITIM, Agordo), and the Agordina Mountain Community (CMA), also involving other qualified subjects for environmental and land management (ARPAV; Civil Engineering Treviso).

The project aims to verify the applicability of the methodology referred as Watershed Assessment of River Stability and Sediment Supply (WARSSS - Rosgen, 2006) in the morphological and geological context of the Alps. The long-term perspective based on longer observations is three fold:

- monitoring trends in fluvial and geomorphic condition over time;
- expanding the investigation to the adjacent basins and define a " Dolomites physiographic region";
- introducing the geomorphologic "Natural Channel Design" (NCD) approach in restoring fluvial mountain environment, without disregarding the natural environment quality preservation.

METHODS

The basic principle for geomorphologic "Natural Channel Design (NCD) methodology, is that each natural undisturbed stream is shaped by both geomorphologic and climatic conditions into a physiographic region, then NCD requires surveys of several reference streams in order to understand their "stability" features: the measure of the proportion of a cross section of the bankfull stage (Fig. 2) is one of the key variables to quantify the morphology of the stream. Understanding the hydro-geometric correct ratios of a stable "reference reach", is the key to be able to design a new long-term stable channel, where you need to restore it.

This paper illustrates the results arising from detailed survey dataset collected in the valley bottom along the Tegnas River from year 2009 to 2011. A series of longitudinal profiles and cross sections, an extensive and diversified particle size analysis along the channel bed, can allow first to classify each reach type on the base of their hydraulics and geomorphologic parameters and then assign the real extent of the bankfull stage.

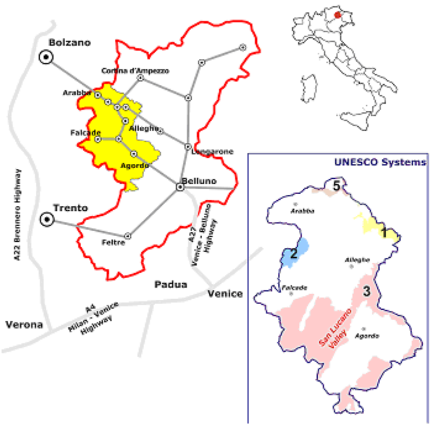

Figure 1 – San Lucano Valley location and UNESCO Dolomites System.

The bed particle size, the width/depth ratio, the entrenchment ratio and the slope were then calculated from field data in order to determine the stream classification as outlined by Rosgen (Rosgen, 1994). The bankfull profile, parallel to channel bed and terraces slope was determined as the average height of bankfull and then used to calculate width, depth and area for each cross section at the bankfull stage.

Figure 2 – Bankfull area in a B4-type natural channel X-section

Figure – 3. Tegnas Creek: A) B4-type (upstream disturbed reach), erosion check (red pins) at the X-section; B) B4-type point- bar, geomorphic evidence of bankfull (reference reach); C) D4-type downstream reach.

The flow velocity at the bankfull stage was determined by using Manning's equation where the coefficient *n* was calculated using the estimation method from survey analysis of particle size (D84), with the approximations of roughness associated to Rosgen classification (Leopold 1994, Rosgen, 1996), and tabular information for different types of bed and banks material. Stream classification itself ***does not attempt*** to predict the stability of the stream, the stability assessment procedure (in u se for over twenty years in USA), documented in the EPA web document *WARSSS* (Rosgen, 2006), was furthermore applied to this case study.

ACTUAL NCD IN S. LUCANO VALLEY

Along the valley bottom, along the upper Tegnas, three segments of the stream with gradient ranging from 2.6% to 1.9%, are easily delimited: a first upstream disturbed reach (B4-type as in Fig. 3A), a second stable (B4-type) reference reach (load transporting, as in Fig. 3B), and downwards, an aggraded reach (D4-type, Fig. 3C) flowing across a gravel deposit two hundred meters thick (Caielli et al. 2011) and two miles long, where surface water leaves their solid load. This area must periodically be quarried, in order to ensure the hydraulic protection of the sideway road, and a simple "V" shape, single channel, is mechanically rebuilt. Despite the good recovering ability shown by the riverside bush, the period elapsing between the removal activities is shorter than the natural process of re-naturalization. The recovered banks are quickly eroded, and the stream regress to a D4-type, becoming impracticable and completely unsuitable for spontaneous fish habitats and woods growth.

Some suggestions to control the erosion-transport-deposition process with long-lived, natural solutions, in order to stabilize the stream riverbed and their banks, are Illustrated here. Decreasing sediment supply, also coming from side headwaters, and resettle a more confined B4 instead of D4-type, may be a useful approach for restoring plans in order to improve riverbed re-naturalization and natural quality, in a next future.

RESULTS AND CONCLUSIONS

Comparing low-flow discharge data with local precipitations time series, and relating them with some surrounding watershed discharges, we can assume that the bankfull flow magnitude calculated for the stream is a realistic value. Then, without specific curves for alpine region, we can adopt the empirical Rosgen Colorado dataset and their relationships to evaluate several design solutions when you plan to restore natural channels (Rosgen, 2007) with a geomorphologic approach. In compliance with one of the highest environmental value areas of the Dolomite region, authors believe that an effort to make a stable and controlled balance between erosion and deposition is a good way to preserve the greatest heritage of the man/nature equilibrium.

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ESTIMATION OF SOIL LOSS IN BAVARIA

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KEY WORDS: soil loss, erosion, USLE, Bavaria

EROSION MAPPING IN BAVARIA

In summer 2012 a new version of the "Bavarian Atlas of Water Erosion Risk" will be published by the Bavarian State Research Center for Agriculture and its Institute for Agricultural Ecology, Organic Farming and Soil Protection. The motivation of updating was the availability of an area-wide Digital Elevation Model (DEM) generated from high-precision laserscanning data and the improvement of several other factors.

The estimation of soil erosion will be based on a variant of the well-established USLE (Universal Soil Loss Equation), developed in the USA by Wischmeier and Smith (W. Wischmeier & D. Smith, 1965 / 1978) in the 1950s/60s as an empiric model capable of predicting the long-term soil loss on arable land.

A first version of the USLE-based Bavarian-wide erosion atlas has been published in 1986 by Karl Auerswald. At this time a work accomplished completely without the use of modern geoinformation systems (GIS). Not before 2001 the atlas has been transformed into digital maps and has been recalculated based on now available digital geodata. Since then the maps of soil erosion prediction have been updated on a regular basis, last in 2008, as a regard to improvements in the field of geographic software and the increasing availability of digitized data.

A = R * K * S * L * C * P	
A =	potential long term average annual soil loss in tons per acre per year
R =	rainfall and runoff factor
K =	soil erodibility factor
S =	slope gradient factor
L =	slope length factor
C =	crop/vegetation and management factor
P =	support practice factor

Table 1 – Factors of the Universal Soil Loss Equation

The newest release will be calculated with ESRI ArcGIS 10.0, at first based on a grid of 25 meters with the perspective of using a resolution of up to 5 meters in succession. The calculation covers the whole of Bavaria, which is an area of about 70 500 square kilometers.

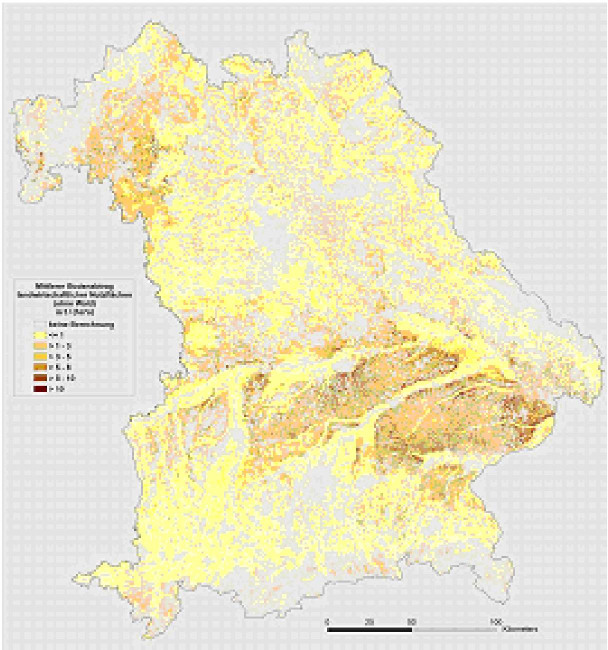

Figure 1 – Bavarian Atlas of Water Erosion Risk (LfL 2008): Soil Loss Estimation for agricultural landscapes

DATA SOURCES AND METHODS

One advantage of using the USLE for modelling soil loss is the bavarian-wide availability of all necessary data in consistent up-to-date quality.

The rainfall factor can be interpolated from nationwide precipitation maps with a resolution of approximately 1 km. The R-factor therefore is the dataset with the coarsest raster, but also with only marginal regional change, so that the cell size won't lead to undesired inaccuracy.

The soil erodibility can be deduced from digital soil survey maps, which depict soil types along with their characteristics for each parcel with agricultural use. Sandy soils or clay for example have a lower K-factor than loess soils, which are especially vulnerable for water erosion. Those detailed soil survey maps will be used the first time to calculate the K-factor and will be converted into rasterdata with a resolution of 5 m to meet the exact locations of the concerned parcels.

For computing slope and S-factor, the ready-to-use slope-tool provided with the ArcGIS Spatial Analyst will be applied to calculate the steepness of each raster cell considering the heights of each of the eight neighbour cells.

The slope length instead can not be calculated satisfactorily with any of the Spatial Analyst Tools. Therefore an IT company is entrusted to provide an extension, which can be executed from ArcGIS 10. This tool will use the “multiple flow direction algorithm” (Schäuble 1999) and the principle of the “contributing area” (Desmet & Groves, 1996) to determine the L-factor for each raster cell. Thereby the cell size of S- and L-raster depends on the resolution of the DEM in use.

In every earlier version of the erosion atlas the slope length was a constant value, representing a typical regional downslope dimension of cultivated fields, instead of a calculated variable, resulting in overestimating soil loss on small fields and underestimation on large acres. By determining the L-factor for each cell, heterogeneous topology with diverging and converging flows and its impact on the amount on water flowing over every part of a slope are taken into consideration.

Critical for the proper determination of flow accumulation is the clear delimitation of catchment areas and flow barriers, such as forests, larger meadow patches or hedge rows. Those data will be provided by a nationwide datamodel (ALKIS) containing the landuse in a reference scale of 1 : 5000 and an additional database (INVEKOS), managed by the Bavarian Ministry for Food, Agriculture and Forestry, which contains cropping statistics of 97% of the arable land in Bavaria at a reference scale of approximately 1: 1000.

This database is also used to average the C-factor for each of the over 7800 local subdistricts in Bavaria. The percentage of small crops, row crops, sod-forming crops and mulch tillage will be evaluated for each subdistrict and can be fed into an equation established by Auerswald (Auerswald, K. 2002) to calculate the C-factor for a larger region.

The P-factor, which considers further practices to prevent erosion, like contouring, will generally be set to 0,85 to acknowledge in a way the benefit of this practise, at least with less erosive rainfall events and less steep slopes (Schwertmann et al. 1987). Exact data of erosion protection techniques is not available.

FIELD OF APPLICATION

The erosion atlas is meant to help agricultural consultants and landscape planners in their decisions and also to provide a starting base for the detection of the effects on soil loss following changes in agricultural crop growing practice.

The regularly updating ensures a best possible result for all users and assists to better acceptance. Therefore the recalculation of the erosion atlas will not only result in new maps, but also in a detailed method description and advices for reasonable application possibilities.

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SOIL CLIMATE REGIMES OF CATALONIA

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KEY WORDS: Soil climate regimes, Soil temperature regimes, Soil moisture regimes, Catalonia.

INTRODUCTION

Soil climate regime reflects soil climate used in mapping, classifying and correlating of the soils by soil scientists according to the Soil Taxonomy System (SSS, 1999). It is composed of the soil temperature regime and the soil moisture regime.

The temperature of a soil is one of its important properties. Within limits, temperature controls the possibilities for plant growth, for soil fauna development and for soil formation. The mean annual soil temperature is related most closely to the mean annual air temperature, but this relationship is affected to some extent by the amount and distribution of rain, the amount of snow, the protection provided by shade and by O-horizons in forest, the slope, the aspect and irrigation. Other characteristics, such as soil colour, texture and organic matter content, seem to have important effects.

Each pedon has a characteristic temperature regime that can be measured and described. For most practical purposes, the temperature regime can be described by the mean annual soil temperature, the average seasonal fluctuations from that mean, and the mean warm or cold seasonal soil temperature gradient within the main root zone

On the other hand, water held at a tension of 1500 KPa or more is not available to keep most mesophytic plants alive. Consequently, a soil horizon is considered dry when the moisture tension is 1500 KPa or more and is considered moist if water is held at a tension of less than 1500 KPa but more than zero. The term “soil moisture regime” refers to the presence or absence of ground water or of water held at a tension of less than 1500 KPa in the soil or in specific horizons during periods of the year.

The soil moisture regime is only partially a function of climate. Soil characteristics (depth, texture, structure and porosity, rock fragments content...) and soil position (position on the landscape, aspect, slope...) are also very determining properties.

The moisture regime of a soil is an important property that determines the type of processes that can occur. Each of the moisture regimes in the history of a soil is a factor in the genesis of that soil and is the cause of many relict features in the soil. However, the most important characteristics for interpretations are associated with the present moisture regime, even if the present regime differs widely from those of the earlier regimes.

SOIL CLIMATE REGIMES OF CATALONIA

Catalonia is a region situated in the north-east of Spain with an extension of 32.107 km^2 and a population of more than seven and a half million inhabitants, mainly distributed along the coast.

Catalonia has a very complex orography, with extensive mountain ranges, inland depressions, mountain peaks reaching 3.000 meters high in the Pyrenees and, a mere 240 km to the south, a delta that collects the sediments from one of the most abundant river of the Iberian Peninsula: the Ebro river.

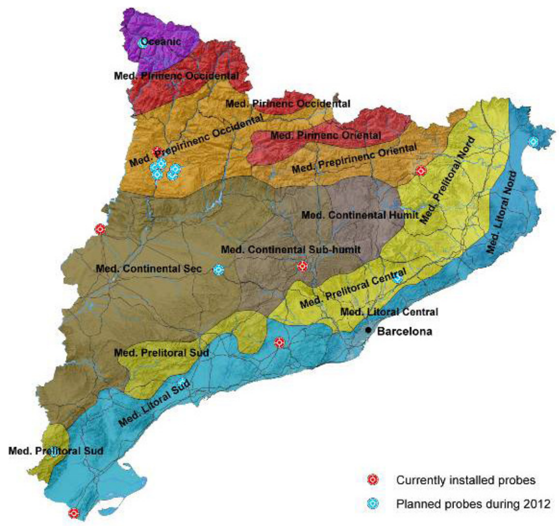

Figure 1 –Climate division of Catalonia.

The orography itself is notably responsible for the climate. While it can be said that the winters are mild and the summers are hot and dry, the temperatures themselves vary considerable between the coastline and the inland plains and the Pyrenees. Precipitation is also irregular, though peaks in the Pyrenees are generally covered in snow from December until spring (Fig. 1).

Digital climatic atlas of Catalonia is a set of digital climate maps of mean air temperatures (minimum, mean and maximum), precipitation and solar radiation. To generate these maps data were processed from more than 150 meteorological stations, selected according to a compromise between the length of the series (temporal stability) and density (spatial coverage). These values can be consulted, every 180 m over the whole of the territory, for the whole year or for any specific month or for particular periods of interest.

Maps have been generalised using statistical techniques (multiple regression with residual correction), geographic information systems (GIS) and spatial interpolation between the data from the meteorological stations of the Catalan Meteorological Service (Ninyerola et al., 2001).

A first approximation to the soil temperature regime of Catalonia has been estimated by adding 1ºC to the mean annual temperature (Fig. 2). Only four (Cryic, Frigic, Mesic and Thermic) of the nine possible classes described by the Soil Taxonomy System appear in Catalonia. Furthermore Cryic and Frigic classes cannot be separated at the work scale.

Figure 2 –Soil temperature regime of Catalonia.

The soil moisture regime has been estimated from water balances of the average year based on data sets for precipitation, reference evapotranspiration and soil moisture storage properties (Fig. 3). The computation of water balance has been carried out in a monthly time steps.

Four soil moisture classes (Udic, Ustic, Xeric and Aridic) described by the Soil Taxonomy System appear in Catalonia. Some areas stand out where it has been difficult to establish an accurate classification. Furthermore, the Aquic moisture regime only appears in scattered areas on river terraces, deltas and spots that present drainage problems.

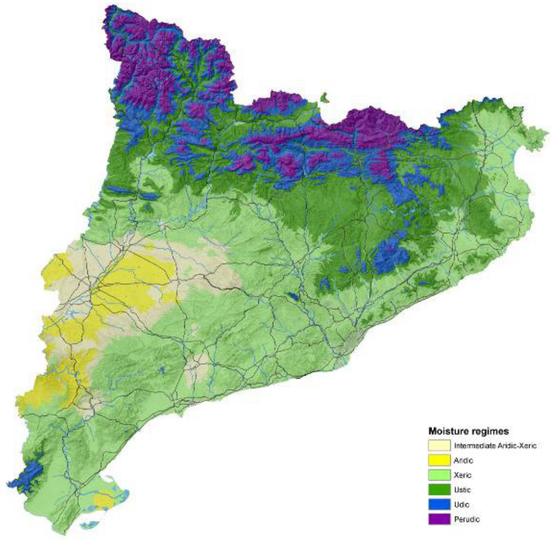

Figure 3 –Soil moisture regime of Catalonia.

In order to verify the preliminary results, the Geological Institute of Catalonia installed, in 2010, a set of soil temperature and soil moisture sensors at six different spots throughout Catalonia (Fig. 1). The sites reflect some of the soil climate regimes estimated from de digital climatic atlas. The sensors consist of three soil moisture probes placed along the soil moisture control section and a soil temperature probe installed to a depth of 50 cm. The logger records data every 6 hours.

Preliminary results have encouraged the Geological Institute of Catalonia to strengthen data collection by installing a second set of sensors to consider most of the soil climate regimes in Catalonia and to improve the precision and quality of the results (Fig. 1).

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HARMONIZATION OF REGIONAL SOIL INFORMATION: A TOOL FOR SUSTAINABLE SOIL MANAGEMENT

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KEY WORDS: soil mapping, soil indicators, soil erosion, soil organic matter

INTRODUCTION

In the European Communication "Towards a Thematic Strategy for Soil Protection"(2002/179), many soil degradation processes, called threats, are identified. In the following Thematic Strategy for Soil Protection and Proposal for a Framework Directive (COM 2006, 231 and 232), the need for an harmonised approach and methodology for identifying risk areas is stressed.

Since comparability of information on soils is limited, often based on few data, collected over a long time span using different methodologies, the Italian Institute for Environmental Protection and Research has financed and started the SIAS project (Sviluppo Indicatori Ambientali sul Suolo – Development of Environmental Indicators for Soil). The project aims to develop a new approach that exploits the most updated and detailed information on soil and the expertise available at local level to build reliable indicators on some soil threats at national level.

This pilot project has been focused on soil erosion and loss of organic matter, as these are two of the main threats identified by the European Commission.

The Regional Soil Survey Services are main partners of the project. They contribute defining methodology, elaborating soil data and assessing soil indicators for their own region, under the technical coordination of the Environmental Protection Agency of the Veneto Region. Technical partners of the project are CRA-ABP as a support to define the soil erosion methodology, and the Land Management and Natural Hazards Unit of JRC, for implementing upscaling data methodology, ensuring consistency with European standards and procedures. Many regional, national and international policies aim to protect, maintain and improve soil quality.

Some local plans (e.g. rural development plans) adopted by Italian regions look closely at the results of thematic maps worked out by each region. This way, the "bottom-up" approach followed by the project may assure a more homogeneous setup of national strategies for soil conservation in agreement with regional policies.

MATERIALS AND METHODS

SIAS Project has been developed using geographical reference grids (built following the recommendations of INSPIRE Directive) and a related database containing data and metadata (Fig. 1). The national grid is made of 1 km-size pixels, which seemed to be the best compromise between information quality, operability and goals of the project. The database stores information for each pixel concerning the two indicators, pixel coverage and information quality. Great effort has been set in the definition of shared data quality indicators, both as quantitative indexes of data availability in the pixel and specific confidence levels for each indicator in each pixel.

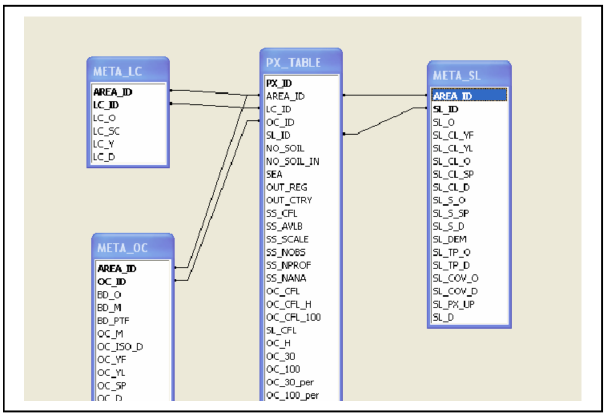

Figure 1 – Exchange format structure for storing data and metadata (database).

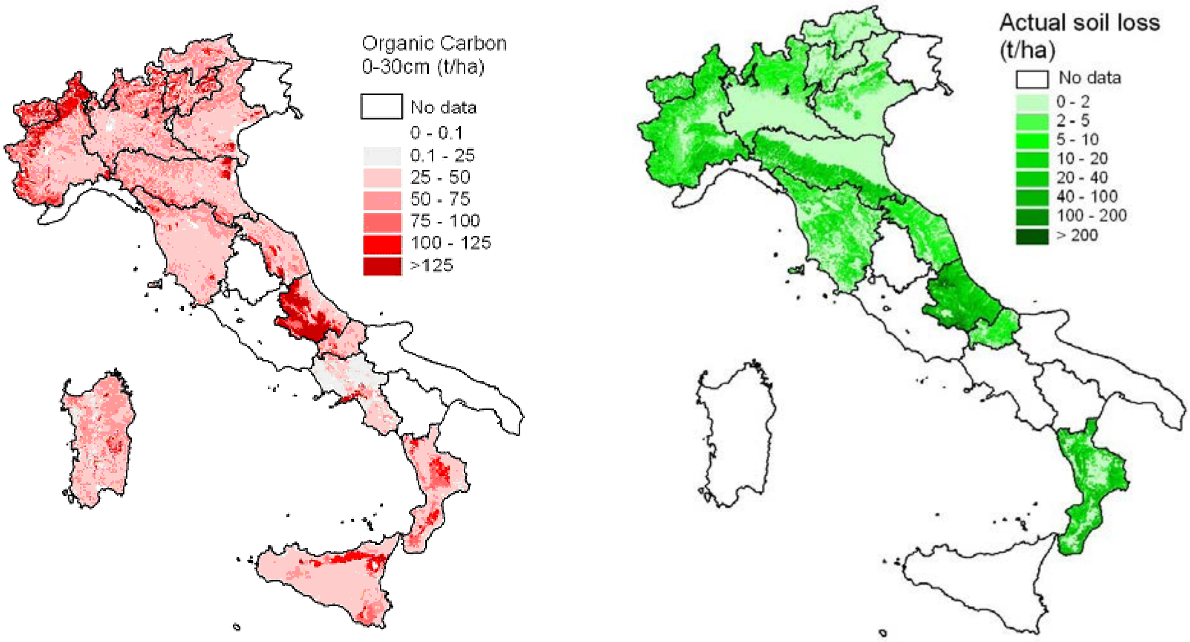

Figure 2 – Organic carbon content (0-30cm; on the left) and actual soil erosion (on the right) in Italy.

Organic carbon stock, expressed in t/ha, has been calculated for three different layers, 0-30 cm, 0-100 cm and holorganic layer, following the international recommendations (IPPC, 2003). Potential and actual soil loss have been assessed in most regions by means of USLE model.

RESULTS

So far SIAS Project has collected indicator data of 14 out of 20 Italian regions, most of them located in northern Italy and a minor part in central Italy. Some regions have only recently joined the project.

The approach to organic carbon stock has been different for each region or even for different areas of the same region, depending on data avaibility and observation density. Anyway, according to the first results average organic carbon content (Fig. 2) in plain areas ranged from 34 to 60 t/ha in the 0-30 cm section, with the lowest values in southern Italy and the highest ones in the north (Po plain). Average OC stock in the 0-100 cm section ranged from 78 to 154 t/ha in the plain, with the same geographical trend. In the Alps a higher variability has been found with OC ranging from 59 to 103 t/ha, on average, for the 0-30 cm section and from 87 to 160 t/ha for te 0-100 cm. Central and southern mountain areas (Appennines) had average contents of 50-58 t/ha within 30 cm and 95-114 t/ha within 100 cm

Differences in soil erosion assessment among regions are mainly related to rainfall erosivity (R) and land cover (C).

The first results highlight that only mountain and hill areas are interested by actual soil loss.

Alpine areas, mostly covered by forests and pastures, are characterized by the absence or very low values of erosion rates. Instead, hilly cultivated landscapes show high values of soil loss (expecially in central Italy). Concerning actual soil loss, average values ranged from 2 to 5 t/ha in the Alps, and from 6 to 23 t/ha in central Italy (Appennines).

The current stage of the project concerns harmonization among regions to gain a better comparability of results, smoothing out anomalies due to different assessment methologies. The technical and scientific coordination group is dealing with collecting, merging and harmonizing first regional results obtaining a national pattern of the two indicators, in order to provide an effective and validated national tool. SIAS project is the first Italian attempt to provide consistent information about soil.

Moreover project results can be used at European scale, to be part of a European database, managed by the European Soil Data Center (ESDAC at the EC DG JRC, Ispra) through EIONET.

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STORAGE CATALOGUE OF GERMANY

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KEY WORDS: Information system, reservoir rocks, barrier rocks, Storage Catalogue, Germany.

INTRODUCTION

In addition to the well-established technology of underground gas storage, the growing use of deep geothermal energy and the implementation of carbon dioxide storage are drawing increased attention to the deeper subsurface for storage and economic use. For a quantitative and safety-based assessment of the storage potential in Germany, at first reservoir and barrier rocks need to be investigated systematically and nation-wide. In particular, the CO_2-emitting industry needs quantitative and reliable information on the storage potential. For this purpose the “Storage Catalogue of Germany”, a geoscientific planning and assessment resource, has been developed by the Federal Institute for Geosciences and Natural Resources (BGR) and the state geological surveys.

OBJECTIVES AND METHODS

The main objective of the project was to identify regions with the occurrence of potential reservoir and barrier rocks in a first nation-wide harmonized approach, with a particular focus on the geological storage of carbon dioxide. An important aim of this project is to provide a qualified tool to politicians, the general public and industry. For this purpose, results of the project are published as report, publications, and also made available in a GIS-based map application.

The reservoir and barrier potential of 18 stratigraphic units have been assessed and categorized in thematic maps based on nation-wide uniform minimum criteria for reservoir and barrier rock units. Reservoir rock investigations focussed on porous sandstones (saline aquifers). The assessment includes the main potential reservoir rock units Rotliegend, Middle Buntsandstein, Lower Jurassic & Upper Keuper, Middle Jurassic, and Lower Cretaceous.

Rock salt and claystone are characterized by low permeability. Thus they can provide an adequate sealing for underlying reservoir formations. The assessment within this project includes the main potential barrier rock units Zechstein, Upper Buntsandstein, Lower Jurassic & Middle Jurassic, and Cretaceous.

The reservoir and barrier rock units have been categorized based on minimum criteria regarding depth and thickness, derived from CHADWICK et al. (2008). In order to be characterized as eligible for further investigations, the net thickness of reservoir rocks within the reservoir unit should be more than 10 m and the minimum depth of the top of the reservoir rock unit should be 800 m. The minimum thickness for barrier rocks within the barrier rock unit should be 20 m and the depth of the base of the barrier rock unit should be at least 800 m.

Under consideration of data availability and pre-existing geological knowledge, areas of investigation have been defined. These include the major sedimentary basins in Germany, i.e. North German Basin, Hessian Depression, Thuringian Basin, Saar-Nahe Basin, Upper Rhine Graben and Molasse Basin.

The work within this project was mainly based on the evaluation of already existing data, e.g. in well data bases and geological maps.

RESULTS

Thematic maps on the reservoir and barrier potential have been prepared by the geological surveys of the federal states and merged and harmonized nation-wide within this project. Figure 1 shows an example of a thematic map on the oldest reservoir rock unit Permo-Carboniferous. Within the green areas, the minimum net sandstone thickness and minimum depth requirements are satisfied. In areas with low data coverage the categorization is based on interpretation. Within the yellow areas only the net thickness criterion is satisfied but not the depth criterion. These areas do not apply for further investigation with respect to carbon dioxide storage, but may be suitable for different use, e.g. underground gas storage. Within the red areas the net thickness criterion is not satisfied so that these areas have little storage potential within porous saline aquifers. Additional information has been included in the thematic maps when available. E.g. the reservoir rocks in the unit Permo-Carboniferous in north Germany satisfy the criteria, but they are cemented in wide areas and thus poor reservoir properties are expected there.

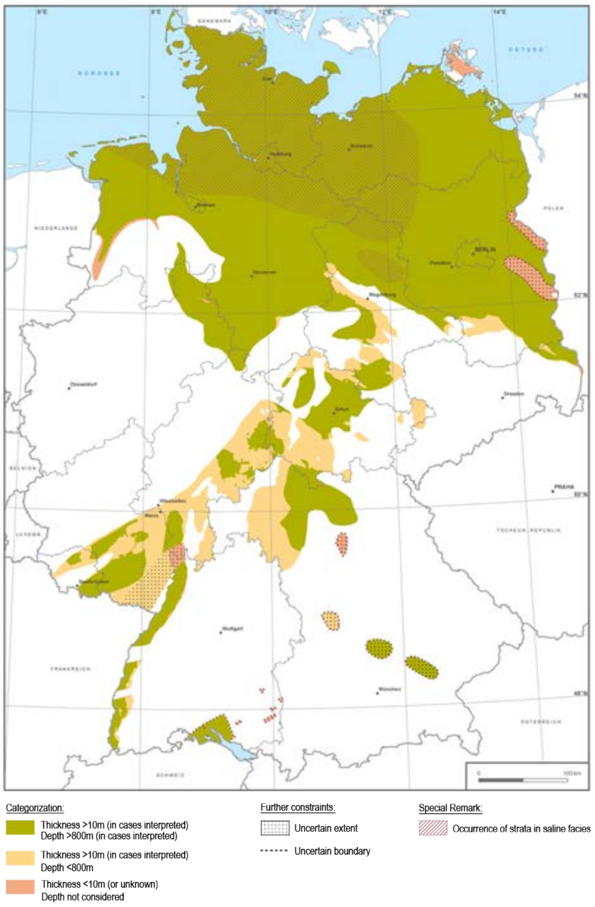

Figure 1 – Deposits of the Permo-Carboniferous as potential reservoir rock unit. Categorization based on depth and thickness.

The younger post-Zechstein reservoir units, e.g. Buntsandstein and Lower Jurassic & Upper Keuper satisfy the minimum criteria over large areas of the North German Basin, except those areas where salt tectonics resulted in uplift, formations have been eroded, or sediments were not deposited. These areas grow in number and extent towards younger units. The categorization and extent of the overlying barrier rock units generally follow the pattern of the reservoir rock units.

The thematic maps, supplemented by information on existing drillhole and seismic data have been compiled into an interactive map application that is publicly accessible via BGRs website www.bgr.bund.de/SpeicherKatasterwww.bgr.bund.de, in addition to selected reports.

DISCUSSION

Reservoir properties, primarily porosity and permeability, are needed for the further evaluation of reservoir rocks with respect to different options of use. These parameters have been documented on the federal state level as far as data have been available, but could generally not be mapped. Information on these parameters, together with maps on depth and thickness of the reservoir and barrier rock units, are included in the final reports and a special publication (e.g. BEBIOLKA et al., 2011; HUCKRIEDE & ZANDER 2011).

This project is the first step to create a nationwide database and to identify areas for further investigations on the basis of geological criteria. A large amount of additional data and information not considered within this project, such as borehole logs, is currently only available in analogue form and needs to be compiled and evaluated in the future as part of a subsequent and much more comprehensive analysis of the storage potential in deep saline aquifers.

In addition to geological factors influencing the suitability of reservoir and barrier rocks, economic aspects, potential conflicts of use, and especially the acceptance by the general public play an important role. Therefore, the suitability of a specific location can only be determined by detailed site-specific exploration and evaluation.

ACKNOWLEDGEMENTS

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LOW-ENTHALPHY GEOTHERMAL RESERVOIRS EXPLORATION IN THE APENNINES BURIED THRUST FRONT SOUTH OF PARMA (ITALY)

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KEY WORDS: Foreland Thrust Tectonics, Miocene Turbidites, Geothermal Reservoirs, Alluvial Plain Hydrostratigraphy.

INTRODUCTION

In the southern Po River basin there is no high-enthalpy geothermal source known at economically convenient depths. Yet, the growing green economy stimulates scientific research in the field of geothermal energy, which is becoming more and more competitive even at low-temperatures (>40°C). The screening of the Emilia-Romagna alluvial plain for potential geothermal resources completed by the Regional Geological Survey led to the recognition of several areas with positive thermic anomalies.

The geographic distribution of thermic anomalies coincides with the position of the main buried tectonic structures. In the southern margin of the Po River alluvial plain these structures are represented by a system of faulted folds named Emilian Folds by Pieri & Groppi (1981). The Emilian Folds represent thrust fronts whose crest may be encountered at a few tens of meters depth below ground surface, as in the case of the alluvial plain south of Parma which is the object of the authors ongoing studies. The positive thermic anomalies detected in the area encouraged this research aimed at finding potential geothermal reservoirs.

FIELD DATA

The southern margin of the Po River plain represents the perisutural zone of the Apennines orogenic belt in which Neogene and Quaternary sedimentation has been controlled by thrust tectonics (Fig. 1). The positive structure, extending south of Parma on the alignment of the towns of Monticelli Terme, Vigatto, Collecchio and Madregolo, consists of a thrust generated antiform deforming Miocene-Pleistocene beds.

At Monticelli Terme the alluvial deposits are directly superposed on the eroded Miocene substrate and are only 10 m thick. Westwards the thickness of the alluvium, modulated by the culminations and depressions of the positive structure, gradually increases and its erosive base overlies the marine *Costamezzana* synthem (Calda et al, 2007).

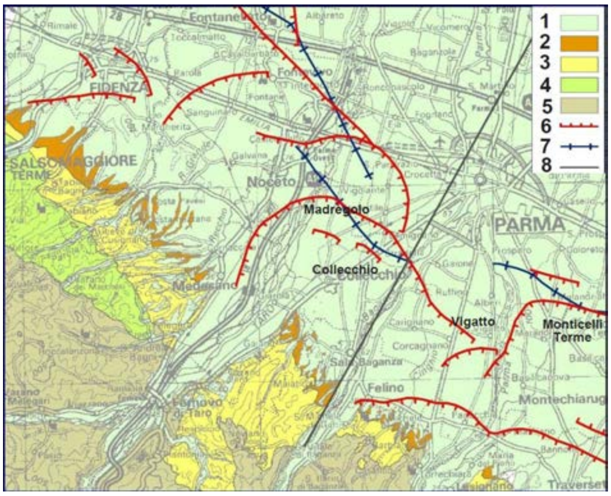

Figure 1 - The buried thrusts deforming Miocene-Pleistocene beds in the perisutural front of the Apennines south of Parma. 1.Quaternary continental deposits, 2. Quaternary marine deposits, 3. Pliocene, 4. Miocene, 5. Allochtonous, 6. Buried thrusts, 7. Fold axes of positive structures, 8. Trace of section in figure 2.

The Pliocene-Quaternary sedimentation, controlled by eustatic sea-level fluctuations, has been interpreted on the basis of regional unconformity surfaces (Rer & Eni-Agip, 1998) in: alluvial sedimentary synthems (Qc_2 and Qc_1 of Late-Middle Pleistocene age) and marine sedimentary synthems (*Costamezzana* and *Stirone* of Early Pleistocene - Late Pliocene age and *Lugagnano* and *Vernasca* of Middle - Lower Pliocene age).

The Emilian Folds have been extensively investigated as potential oil and gas reservoirs with the production of a rich wealth of data, in particular, seismic profiles, stratigraphic wells, and numerous well-log data. Additional information, with precise depth-temperature profiles, is provided by the so-called UNMIG collection and the ENEL-CNR studies on geothermal resources. The implementation of these data with the stratigraphic databases of the University of Parma and the Regional Geological Survey allowed the construction of key geologic cross-sections and their dressing with the temperature changes at depth (Fig. 2).

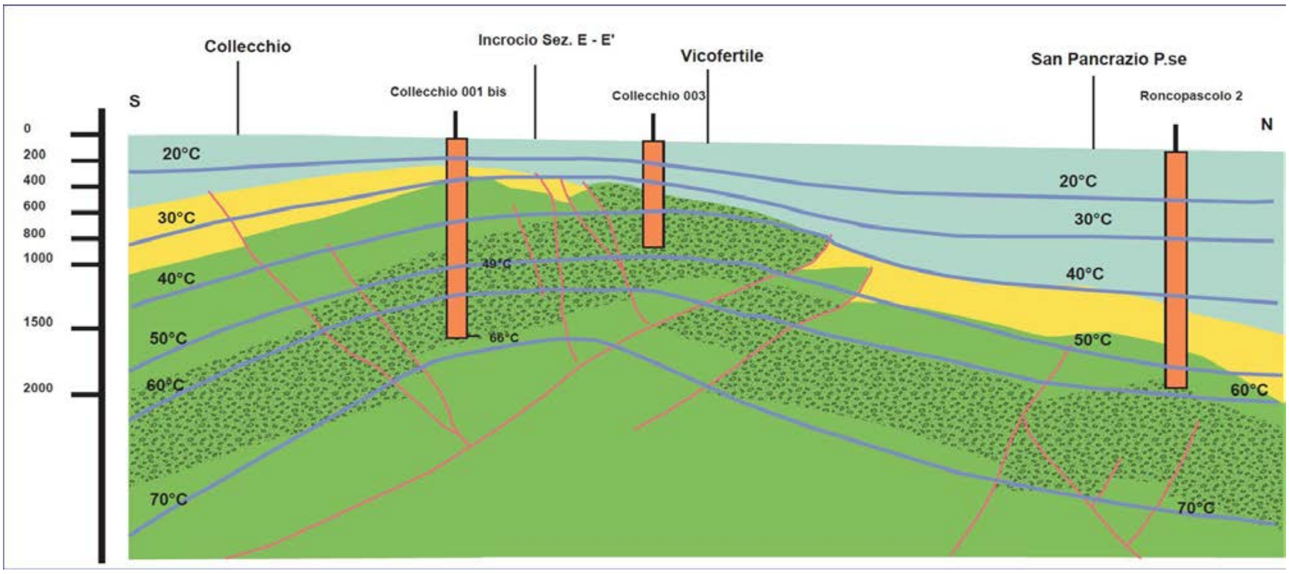

Figure 2 - Section of the Collecchio positive structure (trace in figure 1). Light blue: Quaternary marine and alluvial deposits, yellow: Pliocene, green: Miocene, shingled: saturated turbidite sandstone.The isotherms pattern and related thermal anomaly are controlled by the closely-spaced faults affecting the thrust crest zone down to 1500m of depth.

GEOTHERMAL RESERVOIRS

In the study area the geothermal reservoir has been recognized in the turbidite Miocene deposits covered by the Pliocene-Quaternary marine and alluvial deposits (Fig. 2). These turbidites, here considered the local substrate, are coarse-grained sandstones saturated by saline waters. The heat-flow from the Miocene substrate to the overlying fresh-water saturated sediments varies primarily as a function of the reservoir depth: from ten meters (Monticelli Terme) to a few hundred meters (Collecchio) and several hundred meters (Madregolo) below ground surface. In the culminations of the positive structure the temperatures detected in the Miocene reservoir vary from 40 to 50°C.

The temperatures measured in the overlying fresh-water aquifer are highly variable. At Monticelli Terme the alluvial Late Pleistocene aquifer has a temperature around 20°C.

Temperature estimates show that the geothermal gradient in the thrust crest zone (4.7°C/100m) is about twice the gradient in the areas south and north (2.2°C/100m). Accordingly, the heat-flow is higher in the saturated alluvial sediments covering the thrust crest and front (0.06-0.07 W/m²) than in the alluvial wedge to the north (0.04 W/m²).

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THE INTERREG PROJECT GEORG: 3D-MODELING OF COMPLEX TECTONIC STRUCTURES FOR ASSESSING GEOPOTENTIALS IN THE UPPER RHINE GRABEN

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KEY WORDS: 3D-modeling, seismic interpretation, geopotentials, Upper Rhine graben, Cenozoic wrench basin

INTRODUCTION

The EU project GeORG (Geopotentials of the deep Upper Rhine Graben) aims at the construction of a transnational database allowing statements about deep subsurface geopotentials, e.g. geothermal energy, thermal and mineral waters, possibilities of CO_2 sequestration and storage of compressed air.

The basis is a digital, three-dimensional geological model parameterized with hydrogeological and geothermal properties.

The Upper Rhine Graben is a complex rift and wrench system. Rifting started in the Eocene and led to a Cenozoic graben fill of up to 5 km thickness that consists of an alternating succession of terrigeneous and marine sediments. In the area of Mulhouse, Potassium salt deposits of Paleogene age have partially been mobilized by diapirism forming salt walls.Volcanic rocks occur only locally, with the Kaiserstuhl volcano as the largest complex. The Cenozoic graben fill is underlain by Mesozoic and late Paleozoic rocks. They also may form important geopotential sources due the occurrence of sandstones and limestones with varying permeability. Variscan metamorphics and igneous rocks form the basement in the model area.

The area is tectonically highly-deformed. Normal faults in places show vertical throw of > 1km and are partly overprinted by transtensive and transpressive strike-slip structures. The reproduction of the complex block tectonics combined with the development of a conclusive structural-genetic concept is one of the main challenges to the project.

INPUT DATA AND THEIR HARMONIZATION

Within the project the following input data are used:

- 2150 drillings (lithological description, geophysical logs)
- 5400 km reflection seismic data (2D profiles, velocity models)
- hydrogeological and geothermal data sets
- results of previous works (structural maps, cross sections, 3D models of sub-areas)

The data basis mainly comes from the archives of the project partners. Further information, especially seismic profiles, have been provided by various oil companies. The multi-source data with their various acquisiton dates have gone through several paradigm changes regarding their geological interpretation. Therefore, it was necessary to standardize the data with regards to technical parameters and content prior to further analysis. Seismic profiles show different datum planes and have been processed with varying correction methods. Reprocessing on a consistent basis leads to a better comparability of the data and improves their quality.

Master data of deep drillings (location of the well site, well path deviations etc.) have been revised and corrected, if required. The lithostratigraphical description of drilled units varies with the date of drilling and the status of knowledge at that time, but also with different regions and partially with workers in charge, especially in Tertiary stratigraphic units. Within the scope of the GeORG project representatives of the geological surveys of Baden-Wuerttemberg (LGRB), Rhineland-Palatinate (LGB) and France (BRGM) as well as of the University of Basle agreed on a consistent nomenclature for the stratigraphic Tertiary units of the Upper Rhine Graben within the project area.

SEISMIC INTERPRETATION AND 3D-MODELING

The seismic interpretation and 3D-modeling is performed with the software packages SeisVision and Gocad.

As the input data have been measured with different methods (drillings in meter below well location, seismics in travel time, older structural maps and models usually in m above sea level), building a velocity model is essential for combined display and analysis. The 3D model is first built in time domain and is subsequently converted into depth.

In the first part of the modeling surface objects are generated, including faults, bounding surfaces of geological units and hull surfaces for salt diapirs and volcanic rocks. Modeling of the structural inventory is especially complex and time-consuming. With regard to their strike direction, apparent dip and vertical offset, fault sticks detected on the seismic profiles are correlated to surfaces which are preferably free from twist effects. At the same time it is checked whether the fault surfaces constructed fit into the main structural concept. After that, focus is set on the modeling of a water-proof fault network. Horizons which are well detectable in seismic profiles are modeled in time domain. If the resolution of horizons is low because of poor impedance contrasts or great depth, they are added subsequently into the depth-converted model by means of well markers and thickness distributions. This is especially applied for Mesozoic units.

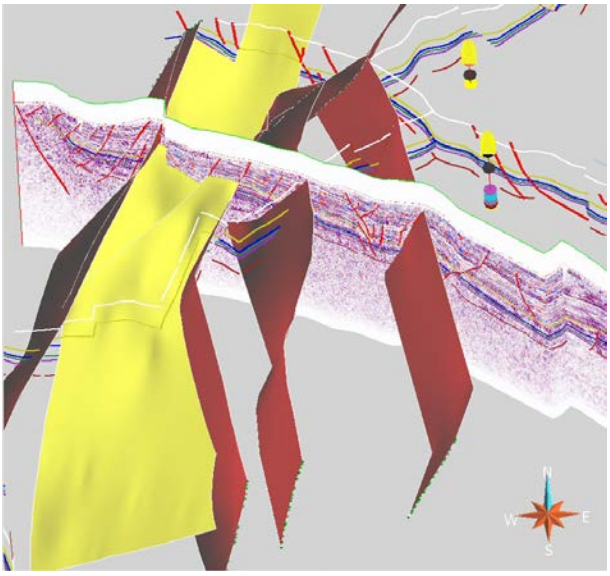

Figure 1 – Seismic information and wells are used to model faults (red objects) and horizons (yellow).

After the modeling of surfaces all objects are transformed into a volume model. Due to the resolution and size of the model block, a division into sub-models with consistent boundaries is inevitable. After that, volume bodies are parameterized with with hydrogeological and geothermal properties for the derivation of geopotentials.

PRODUCTS

The final products of GeORG will comprise reports, publications and geodata sets with the following issues:

- Structural maps and cross sections
- Thickness distributions
- Facies distributions of selected geological units
- Temperatures at certain depths
- Information about heat conductivities
- Distribution and depth of selected storage and barrier complexes for CO_2 sequestration and gas storage
- Parameter sets of heat in place, hydrochemical properties, permeability and porosity of selected units.
- Geopotential maps and cross sections
- GeORG geoportal and web services
- Current information in the internet at www.geopotenziale.org.

ACKNOWLEDGEMENTS

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GEO.POWER PROJECT: SWOT ANALYSIS AND TRANSFERABILITY ASSESSMENT OF GROUND-COUPLED HEAT PUMP (GCHP) SYSTEMS INTO THE PROVINCE OF FERRARA (ITALY)

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KEY WORDS: heat pump, low-enthalpy geothermal energy, SWOT analysis, transferability assessment.

INTRODUCTION

Determined to fight against climate change, the EU is committed to reducing its own greenhouse gas emissions by at least 20% by 2020 (compared to 1990 levels) mainly by improving the use of renewable energy and curbing energy consumption. Geothermal energy is one of the most environmental-friendly and cost-effective energy resources in use. The exploitation of geothermal energy, especially low-enthalpy power generation utilizing Ground-Coupled Heat Pump (GCHP) systems, is rapidly becoming an attractive and viable solution.

In this context, the Geo.Power project (“Geothermal energy to address energy performance strategies in residential and industrial buildings”) has been developed by grouping together Ministries, Regions, Local Authorities, and Universities of nine EU countries, coordinated by the Province of Ferrara, lead partner of the project.

The general objective of GEO.POWER project is to exchange Best Practices (BPs) related to low enthalpy geothermal energy supply and - after a technical and cost/benefit assessment to evaluate the potential of reproducibility - to prepare action plans for the large scale introduction of GCHP in each of the Project Partner (PP) regions.

The project is divided in three phases:

- **Phase 1** (Jan-May 2011) regarding the review and selection of the BPs realized within GCHP sector;
- **Phase 2** (Jul 2011–Jan 2012) based on SWOT analysis and transferability assessment of the selected BPs into each PP region;
- **Phase 3** (Feb-Jun 2012) consisting in the elaboration of an action plan for each involved PP in order to support policymakers’ commitment.

Here are reported the main results of the SWOT analysis and transferability assessment of five selected geothermal heat pump systems into the Province of Ferrara. The analysis aims at recognizing advantages and disadvantages of the technologies and their opportunities for future development and penetration in the target area.

SWOT ANALYSIS

In Phase II of the Geo.Power project, the Province of Ferrara went through a SWOT analysis to estimate the weaknesses and potentialities for the application/adaptation of GCHP technologies in its territory, based on the local technical, economic, and environmental situation. The SWOT analysis is based both on an internal analysis, which has the objective to carefully define Strengths (S) and Weaknesses (W) of the selected BPs (energy efficiency, reliability, economic efficiency, etc.), and on an external analysis, concerning Opportunities (O) and Threats (T) of the Ferrara target area where the selected BPs could be promoted for future replication.

Five BPs have been selected and examined under a variety of different combinations of parameters in regards to current market situation, environment, location, legislation, financial incentives, application and type of installation, energy and cost efficiency.

TRANSFERABILITY ASSESSMENT

Weighting factors are assigned to each component of the SWOT analysis. In order to assess the transferability of the selected BPs into the Province of Ferrara, each weighting factor value is multiplied by a score, according to its degree of transferability (from 2 for “very high transferability” to -2 for “very poor transferability”). Each BP is then given a rank and its transferability is assessed. Below the three most transferable applications are summarized.

- **Transferability of the University of Setùbal (Portugal) into the Province of Ferrara:** The Polytechnic Institute of Setúbal is an engineering school built in 1979. The ground floor is acclimatized by ground source heat pump providing 50% of energy saving in reduction of primary energy consumption. The system integrates three different geothermal uses (heating, cooling, and hot water) in order to cover a high fraction of thermal loads in the building. This BP has a good transferability score (248) into the Province of Ferrara, where most of the local schools were built in the 70’s and have similar characteristics. A system

- optimization and approved plans for daily monitoring, supervision and management of the system would further improve the efficiency of the system. Some special care must be taken about air distribution system. Ground floor of University of Setubal is heated and cooled by fan coils. Transferability would be easier if existing schools and universities in Ferrara had already this type of distribution system, so that energy renovation would not interest the whole buildings, but only thermal plants and closed loop geo – exchangers. Despite the lack of legislation and regulation in the geothermal energy, the political support for the realization of GCHP in public building is high and many energy renovation projects have already been done in this sector.
- **Transferability of the Greenhouse in Antwerp (Belgium) into the Province of Ferrara:** The semi-closed greenhouse has a net area of 13500 m^2. The air handling unit conditioning the greenhouse is coupled to an Aquifer Thermal Energy Storage (ATES). A GCHP (824 kW) produces heat for heating the greenhouse while extracting heat from subsurface by a groundwater system (ATES system with 2 wells, flow rate = 80 m^3/h, oil boiler, yearly groundwater displacement = 170.000 m^3). A heat pump is used, combined with a ground source open loop system. During winter, the heat pump tries to cover the heating demand of the greenhouse. The cold at the evaporator is stored into the cold well, which is used during summer to cool down the greenhouse. There is considerable reduction in energy costs due to energy saving by 30%, compared to a traditional greenhouse installation and an expansion of the season of cultivation. The reduction of CO_2 emission is about 34%. The presented solution could be clearly feasible in Ferrara (score 330). The land of Ferrara is largely suited to agriculture and there are many greenhouses, which this BP could be easily transferred to. It is a system that significantly reduces the use of gas and electricity for heating and cooling, leading to cost and gas emission reduction. A suitable portion of aquifer for construction of ATES technology would be needed, and environmental permits would be required for the open loop system. Considering the Italian situation, problems lie in the lack of government incentives or fiscal profit. Moreover, there is a sort of reluctance in abandoning the old production system and cultivation techniques. Unfortunately, there are very few references in Italy regarding this type of installation in agricultural sector; hence it is so important to spread out the experiences of Geo.Power project.
- **Transferability of the building in Hun Street (Hungary) into the Province of Ferrara:** This BP consists of a ten-story panel building with 256 flats that, before the investment, was disconnected from the local district heating system. The groundwater heat pumps system consists of four wells and six injection wells; three heat pumps are installed (434 kW nominal capacities for heating, 245 kW for domestic hot water supply). Because water is returned to the ground, the underground water supply is not depleted by the heat pump operation. The BP of Hun Street is technically transferable in the Province of Ferrara (score 268) but the economic and environmental convenience must be accurately evaluated: the intervention could be very expensive, decreasing the profit margin; the geothermal district heating system of Ferrara is more modern and efficient than the Hungarian system, consequentially the convenience of using independent heat source decreases, in both economic and environmental term. Moreover, realization of an open loop system with heat pump needs authorization and requires space around the block of flats for the well drilling and installation. This BP could be better applied to private buildings that are not connected to the geothermal district heating system yet.

CONCLUSION

SWOT analysis and transferability assessment has permitted to assess the selected BPs reproducibility in the Province of Ferrara.

Local market in Ferrara for GCHP is characterized by neutral to positive market opportunities where limited market segment, economic crisis, rising taxation and high price sensitivity are counterbalanced by high growth rates, increasing interest of customer and investor, and high possibility to attract cooperation and create new jobs.

The lack of government regulations and regional incentives has to be considered as a threat to the development and implementation of long-term investments for GCHP applications.

The strong competition from natural gas is balanced by the positive environmental impact of geothermal energy for heating/cooling, favourable climatic and hydrogeological conditions for the installation of GCHPs, and good capacity for promotion of new technologies.

The Geo.Power project has permitted to share knowledge and useful information so far. The next final phase (Phase III) will be focused on developing an action plan that paves the way towards the transferability of the BPs into the Mainstreaming Programmes and energy regulations plans. This strategic document has to provide an organized set of legislative, economical, technical and marketing initiatives to address long-term investments strategy for GCHP application at wide scale

ACKNOWLEDGEMENTS

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THERMOMAP – SPATIAL MAPPING OF SUPERFICIAL GEOTHERMAL ENERGY RESOURCES USING WEBGIS FOR INFORMATION DISTRIBUTION

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KEY WORDS: very shallow geothermal potential, renewable energy, GIS, modelling, WebGIS, Europe.

THERMOMAP PROJECT

Renewable energy resources are becoming more and more important in recent times. Besides the well-researched and already implemented solar, wind, and hydro power domain, less research has been done in the analysis of very shallow geothermal energy resources in Europe. However, industrial partners from the EU funded project ThermoMap argue for an efficient and inexpensive exploitation of this geothermal resource. Based on existing geodata the authors together with the ThermoMap consortium developed an approach to estimate very shallow geothermal potentials for the first ten meters below surface according to the Kersten formula (Kersten 1949). Pedological, climatological, topographical, geological, administrative, and groundwater data sets have been used to calculate both the pan-European geothermal energy potential on a small-scale (1:250.000) and selected case study areas on the local (site level) to medium (regional level) scale. In this talk we will demonstrate the methodological framework for the pan-European approach and its extension to the processing methods developed for the geoscientific data sets in different test areas across the twelve partner countries. Processing methods are unified across Europe and standards developed for the spatial analysis in order to allow a unified geovisualisation approach. For visualisation, a WebGIS prototype was developed to spatially explicit map the different very shallow geothermal energy potentials. The results show variations of air temperature and heat flow in depths which are predominantly controlled by soil parameters like grain size according to US soil classification (USDA 2012) and soil type according to WRB (WRB 2006), bulk density, pore size distribution and characteristic air- and water balance within the soil matrix. Thus, the modelling approach and the WebGIS toolbox provide target groups such as planners, governments and non-governmental organisations with a common interactive information tool for instance on heat conductivity in W/m*K and heat capacity in MJ/m3*K. This is running on a platform independent web browser (Figure 1). Private users may check the potential of their residential district, community planning and administration authorities may test the geothermal potential of their entire administrative unit. Thus, this tool is intended for multi-purpose use in a transdisciplinary working environment.

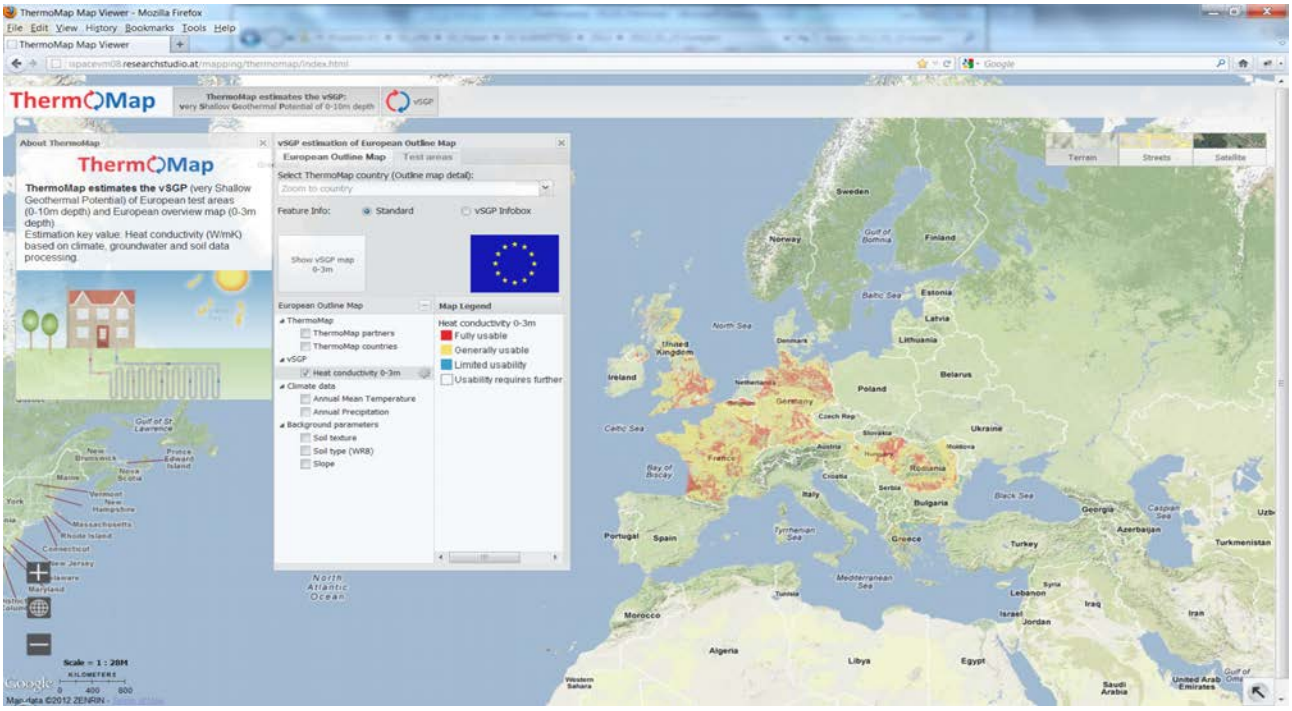

Figure 1 – WEBGIS application.

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ADVANCED INSAR TECHNIQUES TO SUPPORT RESERVOIR MODELLING

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KEY WORDS: InSAR, PSInSAR™, CCS, UGS, surface deformation monitoring, reservoir.

INTRODUCTION

Surface deformation monitoring can provide valuable constraints on the dynamic behavior of a reservoir by allowing the evaluation of volume/pressure changes with time, as well as an estimation of reservoir permeability. Levelling campaigns, tiltmeters, GPS and InSAR are all geodetic techniques used to detect and monitor surface deformation phenomena.

InSAR data from satellite radar sensors are gaining increasing attention for their unique technical features and cost-effectiveness.

In particular, SqueeSAR™ is an advanced InSAR technique (a second generation of the PSInSAR™ technique) capable of providing hundreds of measurement points for km^2 with millimetric precision over long period of time, without the need for installing equipment or otherwise accessing the study area (Ferretti et al., 2000; Ferretti et al. 2001, Ferretti et al., 2011).

PSInSAR™ data have been already used successfully for environmental assessments, reservoir monitoring in CO_2 sequestration experiments and monitoring gas storage areas. Significant advances have further increased the quality and effectiveness of satellite reservoir monitoring: (a) the development of new InSAR algorithms, SqueeSAR™, which provides a significant increase in the spatial density of measurement points, as well as an improved time series quality of the deformation; (b) the availability of an increased number of satellites characterized by higher sensitivity to surface deformation, higher spatial resolution (down to 1m), as well as better temporal frequency of acquisition (typically a few days rather than monthly updates) and (c) the possibility to combine two or more data stacks acquired along different satellite orbits to estimate 3D vectorial displacements rather than 1D measurements along the satellite LOS.

All three of the factors mentioned above have a positive impact on the application of satellite data for reservoir monitoring and CO_2 sequestration. Some specific examples are shown in this paper.

CARBON CAPTURE SEQUESTRATION (CCS)

SqueeSAR™ observations associated with CO_2 injection data have been widely used to model fluid flow in reservoirs and estimate flow properties such as permeability. In fact, the surface deformation measurements could be used to infer volume/pressure changes due to CO_2 injection, then, using the diffusive equation governing the fluid flow in a reservoir, the permeability is estimated.

Such methodology has been successfully adopted to monitor the CCS in the InSalah project (in Algeria): the largely unexpected results (Fig. 1) well correlate with local geological observations and reservoir characteristics (Mathieson et al. 2009). Displacement information were used to monitor faults reactivation induced by reservoir exploitation. The permeability estimated (Vasco et al. 2008, 2010; Rucci et al. 2010) exhibits a privileged flow direction which is the same of the regional fault system, in contrast with the model, available before the analysis, based on a homogenous isotropic permeability distribution.

This result suggests that the pre-existing faults guide the flow of the injected CO_2 trough the reservoir Such information is important especially for safety reason since it is mandatory to know precisely the spatial distribution of the injected CO_2.

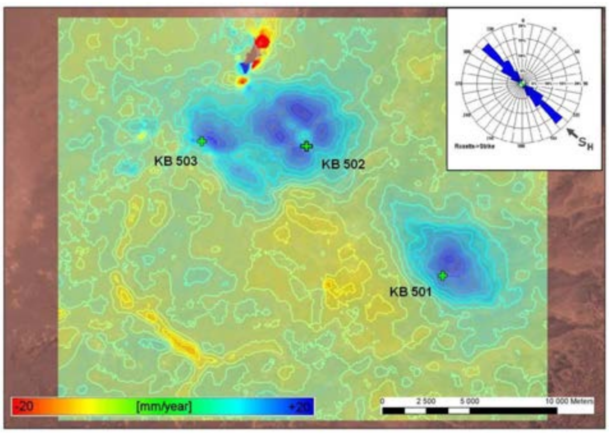

Figure 1 – Maximum displacements measured along the Line of Sight with squeeSAR™, compared to strike of the main conductive fracture system (right, from Iding & Ringrose, 2009). .

UNDERGROUND GAS STORAGE

Another succesfully application for SqueeSAR™ is the surface monitoring of gas storage areas. Surface deformation related to underground gas storage depends on a number of factors, including the reservoir depth and geometry, the geomechanical properties of the injected rock and the overburden and the the pore pressure changes induced by gas injection and/or extraction.

The displacement meaurements obtained with SqueeSAR™ on a gas storage area located in the Po Plain (Northern italy) are showed in Figure 1. Summer injection and winter withdrawal of gas in depleted hydrocarbon reservoir are responsable for seasonal surface displacement in this area.

The vertical displacements showed a very good correlation with the gas volume stored in the reservoir (Fig. 3), allowing the setup and calibration of 3D fluid-dynamic models (Teatini et al. 2011), aimed to evaluate a future enhanced UGS program. It's important to estimate the pressure changes induced by the injection/extraction activities especially to guarantee the integrity of the buildings present in the UGS area.

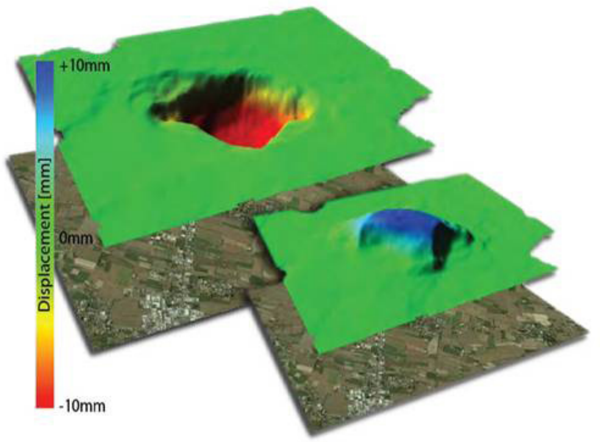

Figure 2 – Two images taken from a movie showing the evolution of vertical surface displacement as gas is injected and extracted throughout the life cycle of the gas storage reservoir.

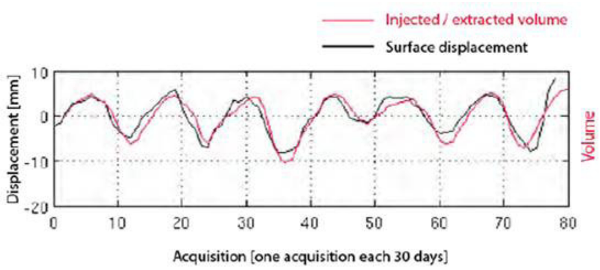

Figure 3 – Scheme of functionality operation.

CONCLUSION

Unlike traditional surveying techniques (optical levelling, GPS, tiltmeters, etc.) SqueeSAR™ provides a high spatial density of displacement measurements with high precision and low costs over long periods. For this reason satellite data represent an important tool for the calibration of reservoir models, which can be complementary to conventional approaches (geological, geophysical, geochemical investigations, core and log analysis, well testing, etc.).

It's important to underline how advances in processing algorithm have significantly increased measurement point density in non-urban areas. Furthermore, X-band satellites with faster repeat times and higher ground resolution have also improved both temporal and spatial resolution of results.

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EVALUATION OF THE GEOTHERMAL POTENTIAL OF THE COASTAL AQUIFER NEAR RAVENNA (ITALY).

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KEY WORDS: Geothermal energy, Salt-water intrusion, Coastal aquifer, Ravenna.

INTRODUCTION

The coastal aquifer near Ravenna (Italy) contains mostly brackish and saline water (Antonellini et al; this volume; Mollema et al., this volume) that is not suitable for drinking water but supports the ecosystems in the natural areas (Antonellini and Mollema, 2010). The current salinization trend will become worse in view of climate change (Mollema et al., 2012). The large volume of the aquifer (2,5x10^9 m^3) however, perhaps allows for the aquifer to be used for low enthalpy geothermal resources development.

The temperature of the groundwater in the top layer of the aquifer (*surficial* zone) is sensitive to the changes in atmospheric temperature throughout the year while the temperature of the deeper groundwater follows the geothermal gradient (Anderson, 2005).

One of the scopes of the project is to discover which part of the aquifer has a constant temperature throughout the year. A constant temperature is needed for storage of heat at low enthalpy.

Groundwater temperature was measured during December of 2010 and June of 2010 in 56 piezometers placed in the coastal dunes of Marina Romea and Ramazzotti, the Paleodunes with pine forests of *San Vitale* and *Classe*, and the farmland in between the dune belts.

RESULTS AND DISCUSSION

In summer the groundwater temperature at the top of the aquifer is mostly above 15°C whereas in winter it is below 14°C, as expected with the variation in air temperatures. The highest temperatures are found near the lagoons of the *Pialasse*, (Fig. 1) at the back of the coastal dunes and close to surface waters (rivers and quarries).

The piezometers in the pine forests of *San Vitale* and *Classe* show slightly lower temperatures than the surrounding area except for the openings in the forest where higher temperatures are observed (+1.5 °C higher). Also evident is the warming effect of the sea that with its large inertia keeps the temperature more constant and influences the groundwater close to the coast.

The depth-temperature profiles (Fig. 2) show that. 84% of the wells at a depth of 10 m or below have a constant temperature with depth of 13-15°C that reflects the yearly average temperature of the atmosphere near Ravenna (about 14°C). The overlap of winter and summer temperatures that is caused by the time-lag between the change in air temperature and the change in groundwater temperatures is evident in 62% of the wells. In many wells, however, this overlap is not distinguishable (see well P3S). In those wells, therefore, the *surficial* zone is deeper than expected from the theory (Anderson 2005, Vandebohede 2011).

Temperature anomalies like those observed are usually explained by the variation in land use, or vegetation cover, soil type, the nearby presence of rivers, and thickness of the unsaturated zone (Anderson 2005). Most of the wells with a deep *surficial* zone, in our study however, are in the vicinity of a drain and/or pumping station. As already noted the land reclamation system of drains and pumping stations strongly influences the hydraulic gradients and salinity (Antonellini et al. 2008) and the water budget (Mollema et al., 2012) of the aquifer; here, we show that also the temperature distribution of the groundwater is influenced by the drainage system. This study shows that the potential for geothermal energy must be pursued in places where the aquifer is thicker, where seasonal variations of temperature are less felt and where the drainage system influences the temperature of the groundwater the least. Following the paper of Anderson (2005) and the example of Vandenbohede and Lubbe (2011) the temperature distribution in the coastal aquifer will next be used to quantify better the amount of recharge, discharge and horizontal flow, using heat as a tracer.

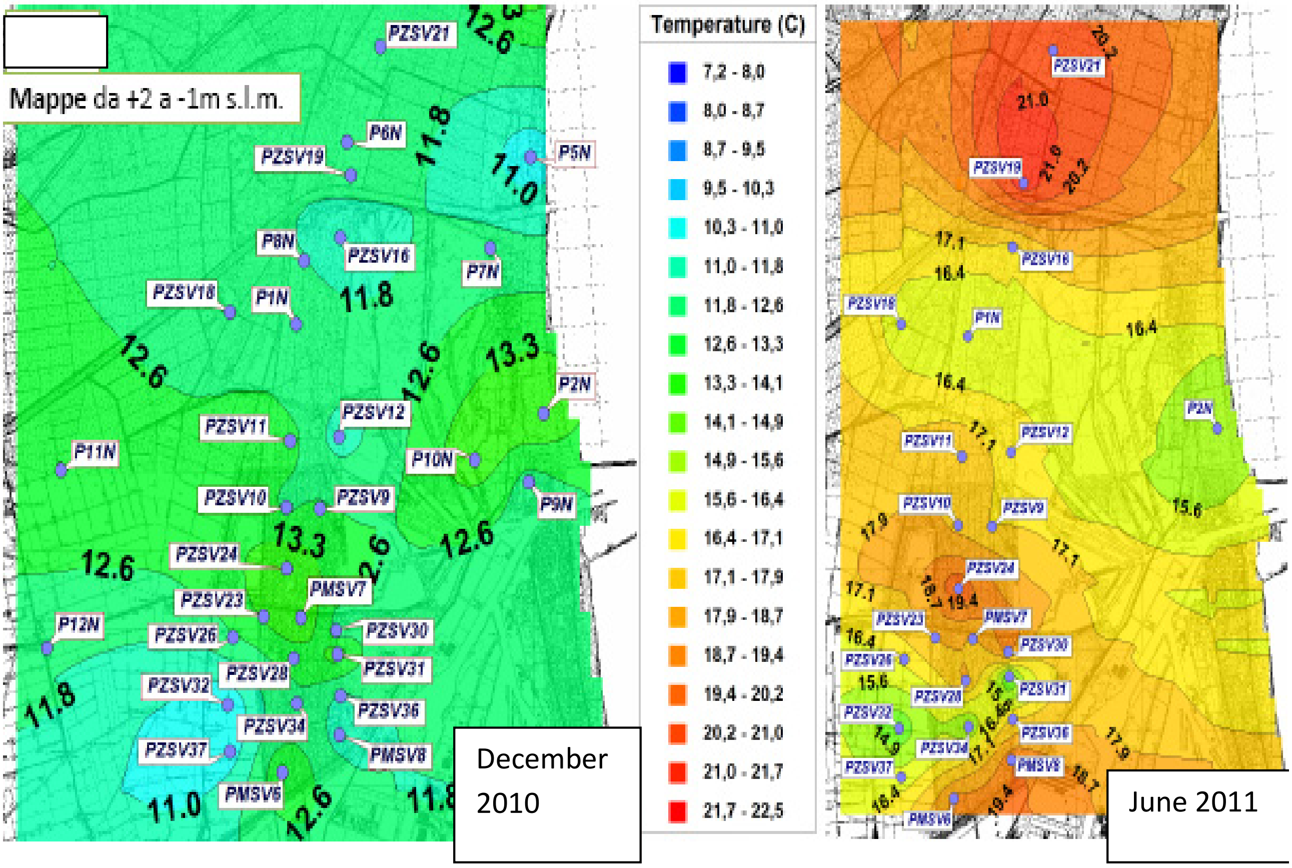

Figure 1 – Ground water temperature distribution at the top of the water table. In winter (left) and in summer (right).

ACKNOWLEDGEMENTS

The data used in this study was collected during the Coastal Salt Intrusion project funded by ENI Spa.

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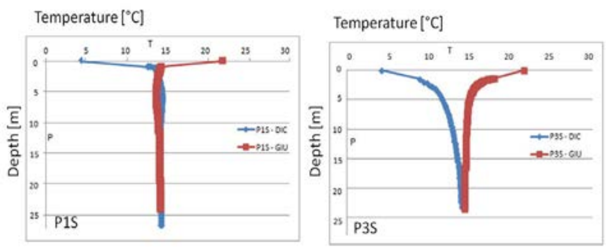

Figure 2 –Winter and summer depth-temperature profiles in two characteristic piezometers. In P1S there is a distinct ‘surficial zone’ while n P3S the “surfical zone” is not well defined within the aquifer.

EVALUATION OF POTENTIAL RESOURCES OF LOCAL STRUCTURES OF TIMAN-PECHORA OIL-GAS-BEARING BASIN FOR CARBON STORAGE WITH THE USE OF GEINFORMATION TECHNOLOGIES

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KEY WORDS: GIS, carbon, capture, storage, structures.

INTRODUCTION

The territory of the Timan-Pechora oil-gas-bearing basin contains significant resources of hydrocarbons, among which there are large oil and gas fields (Belonin et al, 2004). The complex development of the territory, where alongside with production of hydrocarbons the natural reservoirs can be used for hydrocarbon storage, allows solving economic and environmental problems, in particular the climate change problem.

Underground carbon storage is now the most developed and almost achievable task allowing resolving the problem of CO2 increase in atmosphere (IPCC, 2010). Sedimental rocks are the most convenient for this purpose, which can have either a high porosity and be reservoirs, or possess impermeable properties. The higher plasticity of sedimental rocks is also favorable for anticline structures and traps, which are ideal for long storage of carbonic gas. Significant porosity and permeability of the rocks is essential for maximal CO2 storage. The rocks with good inpermeable properties should overlap these beds to prevent gas leaking. The storage of CO2 should be located deep enough to prevent gas blowouts, though deep storage demands more expenses for pumping and use of more expensive technologies.

DATA ANALYSIS

The territory of the Timan-Pechora oil-gas bearing basin possesses many objects, which meet the requirements. There are various types of structures with numerous structural characteristics, porosity of enclosing rocks and various seals. They contain deposits of hydrocarbons (gas, oil, gas condensates) and there are also many empty structures.

The presence of anticlinal local structures and traps is necessary for oil and gas fields and for carbonic acid storage. The use of geoinformation technology gives the chance to capture all available data on structures and traps and to consider their spatial arrangement. GIS was used for the analysis of distribution of local structures, which was realized on the basis of ArcGIS 9.3 software, and it included the following maps: maps of local structures, seismic and drilling maps, maps of fields, structural maps. The map of structures contains digitized contours of structures with data about depth, reflecting horizon (suggested age), morphological characteristics, condition of structures (revealed, prepared for drilling, explored by drilling). GIS contains information on basic tectonic borders, oil-gas bearing regions and areas, data on deposits (Vakhnin, 2008).

As an initial factual material for definition of reservoir properties of local structures the structural maps from the seismic reports, results of drilling and remote sounding were used. The analysis of density of local structures, distributions of morphological characteristics by area, amplitude, elongation, intensity were carried out. The ratio of productive and empty structures was estimated for the assessment of potential resources for carbon dioxide storage. The given factual material is of great importance for the assessment of reservoir volumes for CO2 storage.

Seismic prospecting works revealed more than thousand local structures in the basin with average area 23 км2 and amplitude 74 m, many of them contain oil and gas (Vakhnin, 2011).

Storage of carbon dioxide is most efficient in worked-out deposits of hydrocarbons or developed deposits because, on the one hand, such reservoirs possess sufficient sealing, and on the other hand, there is appropriate infrastructure for CO2 pumping (known geological structure of reservoir, boreholes, etc.). The conducted researches defined necessary geological requirements for the reservoirs. The parameters of seal, consisting of impermeable rocks and located over reservoirs, were defined. The seal should have thickness from 2 m to 4-5 m depending on the depth of occurrence of the reservoir and to be persistent on the area. Within the future contour of the reservoir with CO2 storage there should not be permeable tectonic dislocations, which can invoke decrease in tightness and possible leakages of carbon dioxide.

Average areas and volumes of local structures in the Timan-Pechora oil-gas-bearing basin

Oil-gas-bearing area	Area, thousand sq km	Number of structures in thousand of sq km	Average area of structure sq km	Average volume cubic km
Timanskaya	10.3	1.64	23	0.99
Izhma-Pechorskaya	106.1	2.5	17.1	0.79
Malozemelsko-Kolguevsky	22.3	3.09	36.6	3.88
Pechora-Kolvinskaya	37.4	6.49	32.6	3.51
Khoreyverskaya	32.8	9.74	23.6	1.71
Varandey-Adzvinskaya	11.5	5.31	38.1	6.76
Severo-Preduralskaya	104.1	1.87	31.6	6.06
Total	324.5	4.5	31.1	3.4

Basic mechanisms of carbon dioxide leakage are gas migration through dislocated and permeable rocks, diffusion through sealing rocks, CO2 dissolution in water-bearing horizons and through boreholes lack of hermeticity.

CONCLUSION

Many deposits are in the stage of decreasing production. Therefore the use of technology with carbon dioxide pumping ca on the one hand help to solve ecological problems, and on the other hand increase oil production of deposits. Scientific researches and development of technologies are supported by many countries (Dan Charles, 2009). In the studied territory there are objects with considerable carbon dioxide production. For example, this is Pechorskaya hydropower station covering about half of demand of the Republic in electric power and it is located near a number of deposits, where CO2 could be pumped. There are also oil deposits with increased CO2 content in accompanying gas. Thus, in Yuzhno-Khylchuyuskoe deposit in the north of the Timan-Pechora province CO2 content reached 8% in accompanying gas. In such deposits it is efficient to use technologies of CO2 production from accompanyinig gas and pumping of CO2 into the bed.

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WHY TOGETHER ON SUBSURFACE GEOLOGY ?
THE BENEFITS OF COLLABORATION IN ASSESSING SUBSURFACE POTENTIALS

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KEY WORDS: Subsurface potentials, assessment concepts and methods, supra-regional collaboration, 3D modelling.

BACKGROUND

A comprehensive understanding of the physical make-up of the territory and its subsurface is vital for society, business and industry. This understanding is a basic prerequisite for any sustainable development.

Coping with the energy turnaround and climate change requires the upgrade of the share of renewable energies and promoting their efficiency. The deep subsurface, particularly in foreland basins, features a multitude of subsurface potentials pivotal to achieve this target. Coherent information on these subsurface potentials is an imperative requirement for integrated planning and sustainable resources management avoiding usage conflicts.

Geology is inherently 3-dimensional. Thus, balancing subsurface claims (e.g. integrating geothermal energy generation or storage of renewable energies with ground water rights) must be based on 3-dimensional spatial planning tools and strategic guidelines in line with national and EU requirements. However, only very few approved methods and good practice exits in this new field of cross-sectoral information exchange between geosciences, territorial planning, and approving authorities. Thus, new methods have to be entrenched and best practice has to be spread widely through multiplier-effect activities, in due consideration of general public interest and concerns. Moreover, due to the lack of common European regulations, all methods must regard the differing restrictions of the data access policy in the countries involved.

MISSION STATEMENT OF THE 3 REGIONS WORKING GROUP ON SUBSURFACE GEOLOGY

As Geological Survey Organisations (GSOs) it is our responsibility to provide quality-controlled data and information on the subsurface for policy makers and approving authorities and to make the best coherent geological information existing accessible to the clients. Lately, due to the ongoing discussion on options for the mitigation of climate change, such as geothermal energy, carbon capture and storage (CCS), deep repositories for nuclear waste, and buffer reservoirs for base-load incapable renewable energies, the scope of GSOs has been substantially expanded beyond the 'classical' focus on the subsurface, i.e. to produce inventories of subsurface resources on energy and primary industries supply issues.

These new demands may considerably constrain current utilizations. To allow a multi-purpose use of the subsurface, to avoid mutual interferences and to mediate competing interests requires an integrated and sustainable planning and resources management based on sound, coherent and unbiased 3-dimentional subsurface information on a regional (multi-claim wide) scale, provided by the competent GSO.

Due to their geological evolution foreland basins host a variety of subsurface potentials and are thus in principal focus of subsurface utilisations. As each of the 3 Regions features a significant share in a deep foreland basin (Ebro Basin, Molasse Basin, Po-Adriatic Basin) and is facing similar challenges to be tackled in the near future, a close cooperation on the subsurface issue is of mutual benefit.

THE BENEFITS OF COLLABORATION

Assessing subsurface potentials is largely based on restricted industrial data which may be employed only at the legally mandated GSO. Only derived, anonymised data (e.g. 3D geological framework models) may be used for dissemination and publication. However, the competent GSOs are often regional authorities or institutions with only little capacity to contribute to the conceptual advancements with respect to subsurface potentials. But, contributing to the further development of assessment and evaluation concepts is pivotal to ascertain that all geological situations are regarded in prospective workflows and recommendations. The coordinated collaboration of regional GSOs undoubtedly gives more importance and influence on the conceptual issues currently under development.

Furthermore, the reach of impact of many subsurface utilisations is much larger than the respective licence areas and, as geology in general, does not respect political boundaries. The sustainable management and impact assessment of exploiting subsurface potentials, thus, inevitably requires a supra-regional approach. To ensure the cross-border comparability of potential assessments an early agreement on methods and parameters to be considered is necessary. Participating actively in these proceedings on harmonisation and definition of best practice, eventually leading to standards, is pivotal to guarantee the adequate consideration of the 'homeland' situation, as these transnational agreements will impact the policy implementation. Pre-coordination amongst regional GSOs and 'speaking with one voice' (as far as the differing national regulations allow) strongly increases the influence on the decision-making process and the drafting of EU-regulations. Striking examples of such trans-regional collaboration for harmonisation and standardisation are Interreg projects such as GeORG (e.g. RUPF et al., 2012) or proposed GeoMol (cf. DIEPOLDER, 2011).

As discussed, assessing and prioritising subsurface potentials and the sustainable management of the subsurface as a finite resource must be based on 3-dimensional spatial planning tools. Applying modern 3D modelling techniques, thus, is imperative to provide the appropriate information for territorial planning. Visualisations of 3D geological models are extremely effective in communicating how subsurface potentials are distributed and to transform abstract geoscientific information into tangible products which allow to explain complex geological findings also to non-geoscientists and policy makers.

3D geological modelling as used in GSOs has strongly evolved over the last decade, and is now a wide-spread technology that many users can handle and that does not require a sophisticated cyberinfrastructure. However, a major obstacle at many regional GSOs are limited resources, which make it difficult to stay up-to-date in this complex and continuously evolving technology. Thus, a continuous exchange and cooperation with other GSOs is crucial (DIEPOLDER, 2011).

Due to highly diverse starting positions collaboration among the 3 Regions on this topic is at its very beginning. But even if a GSO is not actively involved in 3D modelling techniques (e.g. when outsourced to external experts) it can benefit from cooperation and knowledge exchange because model building is just one part of the entire procedure including a variety of pre- and post-processing steps where many different processes have to be understood and various software has to be handled. Interpretation of seismic data, e.g., as an essential input for 3D modelling and an example for restricted industrial data which may be treated at the legally mandated GSO only, can be implemented more efficiently through standardised, commonly applicable workflows. Concerted methodologies in seismic interpretation, e.g., may also feature useful side effects in new approaches and scenarios in assessing (induced) seismic hazards.

SUMMARY AND OUTLOOK

Cooperating in geoscientific and technical aspects of assessing subsurface potentials is a key issue of the 3 Regions' collaboration in order to tackle upcoming challenges. The cooperation, so far, was mainly focused on the problem how to assess and describe subsurface potentials of different settings in a comparable way. Results will be incorporated in supra-regional projects. Participation in transnational projects is an ideal platform to contribute to recent developments and to benefit from the achievements. Feedback and multiplier activities implemented in such projects will ensure the general applicability and the transferability of methods, procedures and guidelines for evaluating subsurface potentials. Technical workshops will help to spread 3D modelling techniques more widely.

The proposal of a '3 Regions working group on 3D modelling' serves the purpose to improve the collaboration in the field of practical 3D modelling and sharing best practice, eventually bringing knowledge and capability to a common high level.

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THE CONSTRUCTION OF A NATIONAL GEOLOGICAL MODEL FOR BRITAIN.

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KEY WORDS: 3D Modelling, Geological Survey Organisations, British geology.

BACKGROUND

Mankinds occupation of Planet Earth faces two major threats in terms of environment. The first is natural hazards that are part of our planets normal evolution over geological time, such as earthquakes, volcanic eruptions, and tsunami. The occurrence of such phenomena cannot be prevented by mankind and our response necessarily involves monitoring, predicting and mitigating the risks associated with these phenomena.

The second threat emanates from mans' use of the planet and its finite resources. This causes induced effects such as global warming, acid rain, polution and contamination. In addition, natural phenomena such as flooding or landslipage can also be exacerbated by mankinds modification of the landscape e.g. increased surface run-off and soil erosion resulting from deforestation.

As one of the planets leading economies and industrialised nations Britain must shoulder its fair share of the responsibility for the historic events and ongoing activities that affect this situation. So Britain's Natural Environment Research Council must respond and show leadership in the observation and management of the global environment. The Geosphere is one of the key spheres of that natural environment and within NERC is mainly the responsibility of the British Geological Survey.

In managing the Geopsphere we will need two principle things

- an understanding (model) of the subsurface arrangement of rock and sediment types
- realistic physical and chemical properties of the rock-sediment volumes in order to parameterise models and enable process modelling, prediction, mitigation and forecasting.

PRESENT CONTEXT

This year BGS will stop its' systematic surveying and litho-printed geological map production.

In future we will undertake integrated responsive mapping and 3D modelling in user defined target areas using all available geospatial data (map, boreholes, geophysics) assessed in a single workspace. The output will be 3D geological framework models that capture the understanding and interpretation of the survey geologist (Kessler & Mathers, 2004) These 3D geological maps (framework models) are used for both visualisation and analysis to enable management of the subsurface. Downstream the models can be populated with properties for process modelling.

We are now assembling our existing models (Figure 1) to produce a multi-scaled National Geological Model (NGM) of Britain. This will store both completed frozen models and objects such as surfaces, volumes and cross-sections deconstructed from these models. National and regional models exist (e.g. Figure 2) hence our emphasis is on incorpoarting detail into this overall framework. Our aspiration is to store our best interpretation at each point and so generate a multi-scaled dataset.

Until recently we have lacked an effective means to show geology in 3D. With modern 3D technology the benefits for professional geologists are considerable but may even be outweighed by those for the public and geoscience education. Geological maps will no longer be the iconic output from BGS, instead our framework models will take their place, continuously updated and manipulated to display the geology from the user's perspective whilst new data acquisition will drive iteration.

MODELLING SOFTWARE & OUTPUTS

Over the last 30 years BGS has developed a strong capability in 3D geological modelling using a variety of methodologies and modelling software to produce model outputs varying in resolution from national to site-specific. Currently BGS use s two main softwares GoCAD and GSI3D.

GoCAD is mainly deployed to produce models of structurally complex and heavily faulted bedrock geology drawing on datasets including geophysics, deep boreholes and surface geological surveying.

GSI3D is mainly deployed to model superficial, artificial and simple bedrock geology to shallow depths (c.500m) through the use of cross-sections (Kessler, Mathers & Sobisch, 2009).

Together these two packages enable the BGS to model almost all of Britain's geology at any resolution and evaluate all types of geoscience data in the production of these geological 3D framework models.

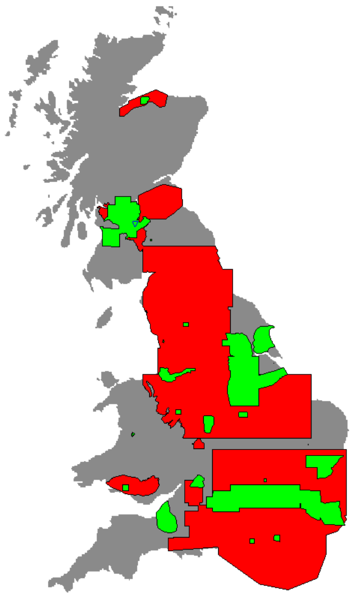

Figure 1 – Existing BGS models, grey national 1 Million scale surfaces red 250K scale regional models and green 50K-10K scale detailed models

Outputs from the modelling process are many and varied, they include screen grabs of models and 3D PDFs used to illustrate reports, derived maps highlighing particular geological situatons and answering particular user-defined questions, grids and tins for use in GIS systems. The models are also the delivered as fully attributed 3D block models using our bespoke Viewer-Browser, the LithoFrame Viewer. This Viewer enables the models to be queried, sliced and diced to generate synthetic borehole prognoses, lines of section and horizontal cuts at user-defined elevations. Using another BGS product, Geovisionary, 3D models and their components can be placed in a dynamic fly-through setting to demonstrate the interrelationship between terrain, surface geology and the sub-surface infrastructure.

THE NATIONAL GEOLOGICAL MODEL (NGM)

BGS is starting the systematic construction of the national geological framework model which will have the following properties.

- geospatially correct representation
- scalar independence and varied resolution
- national, seamless onshore and offshore

Existing datasets for incorporation include BGS's digital geological linework at all scales (the surface layer), sub-surface, offshore and survey memoirs and reports containing useful contour and isopach maps, existing models and surfaces and geophysical data. The assembly of the framework is also underpinned by key corporate databases and dictionaries and lexicons for boreholes, stratigraphic and rock and sediment terminology. A National GVS (Geological Vertical Sequence of lithostratigraphic units is also being developed. Framework construction will also use licenced national digital terrain and bathymetric models, air photography and remotely sensed imagery.

MODEL APPLICATIONS

Geological models have many uses just like their forerunner the geological map. In the case of linera-route planning for example several scenarios can be assessed to achieve an alignment most suitable from a geotechnical and engineering perspective. The model can be interrogated in real time to derive cross-sections along a series of potential routes or buffered to produce a ribbon of geology encompassing a specified or existing route. By switching the model attributes, factors such as ground strength, potential groundwater flow pathways and aggregate resource sterilisation can be assessed. Groundwater levels can also be incorporated for visualisation within the model.

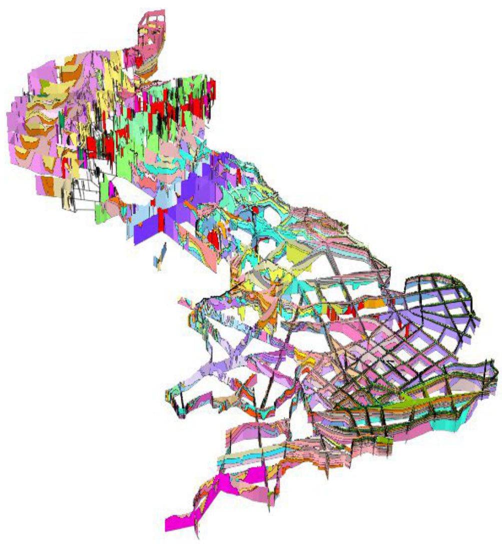

Figure 2 – The UK3D Bedrock fence diagram of Britain

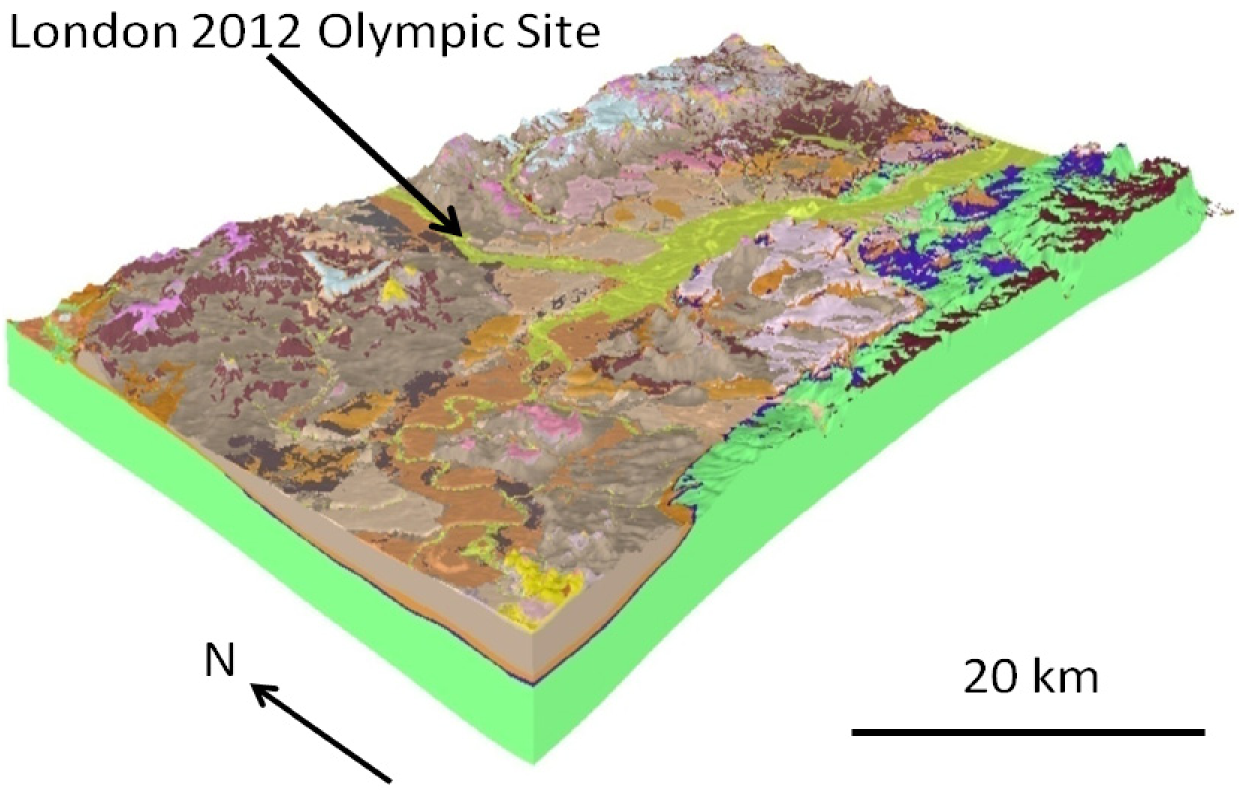

Figure 3 Model of London at 50K Resolution

In the field of hydrogeology extensive modelling has occurred in Britain's two main aquifers: the Cretaceous Chalk and the Triassic Sherwood Sandstone Group. Many of these models have been commissioned by the regional water companies or the regulatory Environment Agency of England and Wales. The models have been used to assess aquifer vulnerability, recharge potential, groundwater resources and abstraction impacts, and also to investigate groundwater flooding events and major industrial and agricultural aquifer contamination resulting from spills and leakages.

Other uses of block models include site-specific studies for new underground metro stations and other major infrastructure including bridges, the 2012 London Olympic site (Figure 3) and nuclear power stations, The models are also used by some local planning authorities to help evaluate future development proposals. Archaeological studies have also made use of the stratigraphic framework provided by BGS models in London. An increasing use of models in several cities is to provide automated borehole prognoses for ground source heatpumps especially into the Chalk aquifer beneath London. Bedrock models can provide the basis for improved understanding of concealed structure including fault and fold patterns.

MODELLING WORKFLOW

As described above the building of a framework model starts with the formatting of all the available geospatial data and its assembly into a single workspace or modelling environment (Figure 4). A single geologist or team then construct the model which is then signed off as checked and completed by the project manager. The model is then locked and submitted to a team of geologists and data mangers to provide QA and edit to ensure corporate standards and procedures are met. The output is stored in frozen form and also deconstructed into data objects such as individual cross-sections, fault planes or surfaces.

Products can be derived from this store and corporate datasets enhanced. The objects can also be reused in the construction of new models. 'Checking out' and editing of the objects would then result in newer improved versions being returned to the object store

MODELS FOR EDUCATION

As an additional spin-off from the construction of framework models we are also making available example models for free download from the 3D geology pages on the BGS website http://bgs.ac.uk .These include models for classic areas of British geology including the Isle of Wight and Ingleborough (Figure 5). These are served primarily through our LithoFrame Viewer technology but also as 3D PDF's, grids, tins and Flash animations.

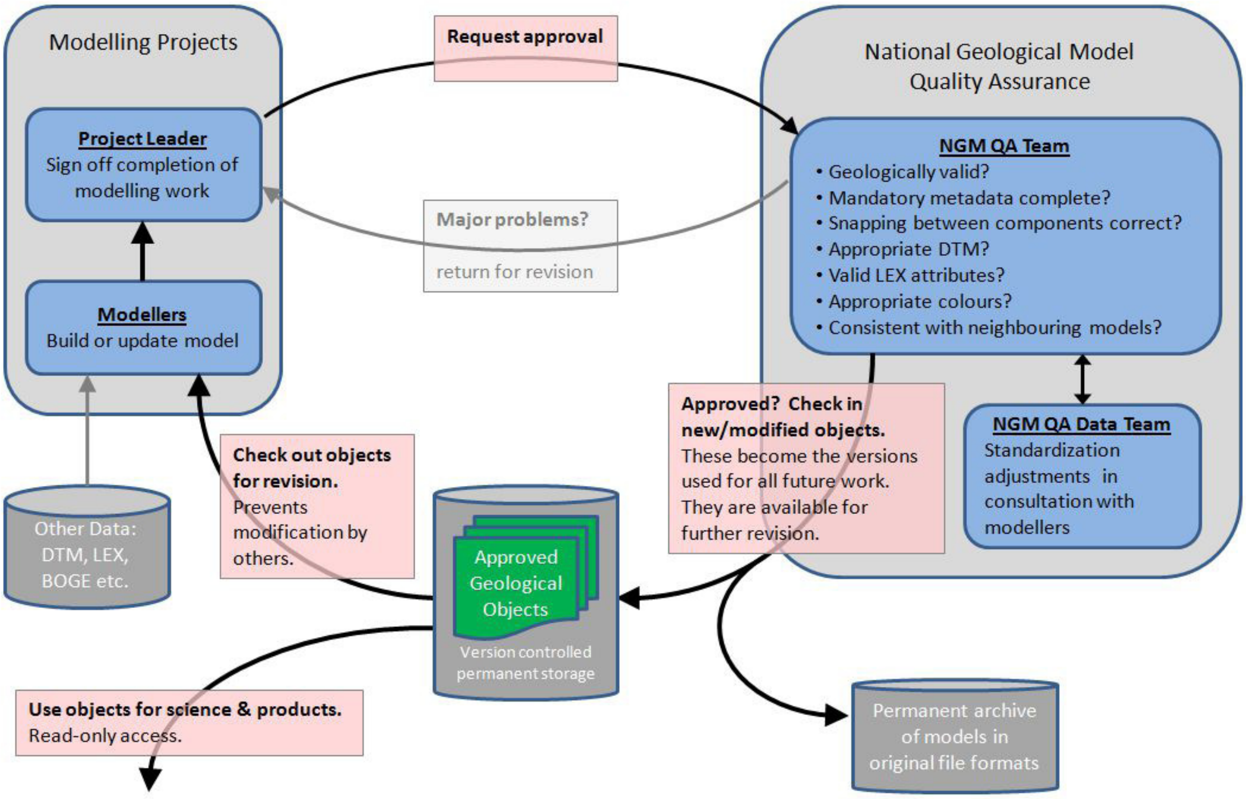

Figure 4 Data workflow for model building in the NGM

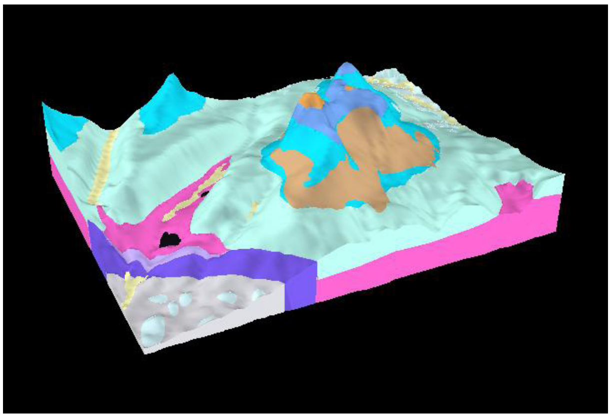

Figure 5 The Ingleborough educational model available as a free download from the BGS website

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ADVANCES IN THE MANAGEMENT AND DISSEMINATION OF GEOLOGICAL DATA: THE 3D GEOLOGICAL MODEL OF CATALUNYA AT 1:250.000, FIRST RESULTS.

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KEY WORDS: 3D geological model, structural analysis, data management.

INTRODUCTION

In the last years the geological community is engaged in developing new technologies for acquiring, processing, analysing and visualization of geological / geophysical data. This is closely linked to advances occurred in computers (both hardware and software), which have opened a new era with increasing possibilities to work with huge amount of data and different formats. A challange for researchers and mostly for Geological Survey Organisations (GSO) managing a significant amount of data sets is finding the way to properly handle the new available tools, but most importantly to integrate hard data with geological knowledge or constraints derived from the analysis of raw data. At present, most of the used workflows has not changed the methodology used to generate geological models. For example a 3-D reconstruction are mostly done using 2-D approaches, such as cross-sections (Susini and Donatis, 2009; Zanchi et al., 2009; Tonini et al., 2009) or cross-section mesh in different directions (Le Carlier de Veslud et al., 2009).

The Geomodels Research Institute and the Institut Geològic de Catalunya (IGC), has been working on generating a first version of the 3-D geological model of Catalunya (figure 1) at 1:250.000 in order to take an important step in the geology disclosure as well as the type and quality of the geological product generated

3-D RECONSTRUCTION

For a 3-D deterministic reconstruction, two aproximations are possible: an explicit method based on surfaces; or implicit method based on volumes (that represent the most current methodology under development).

The explicit reconstruction implies: stablishing 3-D geometric relationships between initial hard data; the use of initial data in its initial position in a 3-D space; avoid intermediate interpretations in 2-D cross-sections; and incorporating geological criteria in the data management (Groshong, 2006, Carrera et al., 2009).

The implicit reconstruction requires the definition of one or more mathematical functions that characterizes how the geological properties are distributed in the 3-D volume (orientation, stratigraphic position, etc) (Caumon et al., 2007). The surface can be obtained from an isovalue of the scalar field defined by these functions.

The implicit approximation requires a major effort in the equations definition, but the deterministic surface is obtained practically automatic (Caumon et al., 2007, 2009; Calcagno et al., 2008). In contrast, have difficulty in representing surfaces involving scalar field discontinuities or complex structures, limitations that currently are under development (Caumon et al., 2009).

Although the explicit reconstruction is more laborious, it provides a greater control and understanding over each reconstruction step and on the reconstruction of complex structures (multivalued, discontinuous, with nonuniform data distribution, etc).

THE CATALUNYA 3-D GEOLOGICAL MODEL. METHODOLOGY

Taking into account the assumptions made about 3-D reconstruction in the previous section, the methodology used to generate de 3-D geological model of Catalunya can summarized as follows:

- Adequacy of information. Collecting information from different sources involves different data formats. All this data must be transformed in a common digital format for its use in a common 3-D graphic environment.
- Database. At the same time, a database is generated including some properties (type, quality, format, authors, etc.)
- Adding information in a common 3-D graphic environment. Collect and visualize all available information in a single software (Gocad - Paradigm®).
- 3-D reconstruction. Deterministic geological surface 3-D reconstruction honoring all available data and incorporating geological constrains

- derived from structural analysis (cilindricity, dip domains, plunge lines, etc.)
- Adequacy of the 3-D geological model to a common format as universal as possible.

Initial data used to generate the 3-D geological model can be grouped into:

Surface data: digital geological map of Catalunya at 1:250:000 and all the available digital geological maps.; Digital terrain model of 200 x 200 m and 30 x 30 m.

Subsurface data: well data and seismic data (in SEG-Y; TIFF or JPG; and analogic format)

Derived data: combination of surface and subsurface data to obtain new geological data like cross-sections or contour maps (isopachs or isobaths).

Considering this intial data, the final model include the boundary surfaces of geological units with a geological significance in the studied area, as well as, the main faults that configure the geological structure of the area (figure 1).

DISCUSSION AND CONCLUSIONS

New computer technologies combined with a valid 3-D geological reconstruction methodology, can address the disclosure and understanding geology in a more efficient way.

The use of the described methodology allows to integrate a variety of information with different file format in a commom graphic environment. In turn it provides fast and effective acces to information and it is valuable to solve data base and geological inconsistences

The use of 3D geological model of Catalunya is mainly conceived by the IGC to serve as a warehouse of available geological information that would be permanently updated. Consequently, adding new data on the 3-D model will involve in an improvement of quality of the geological products generated.

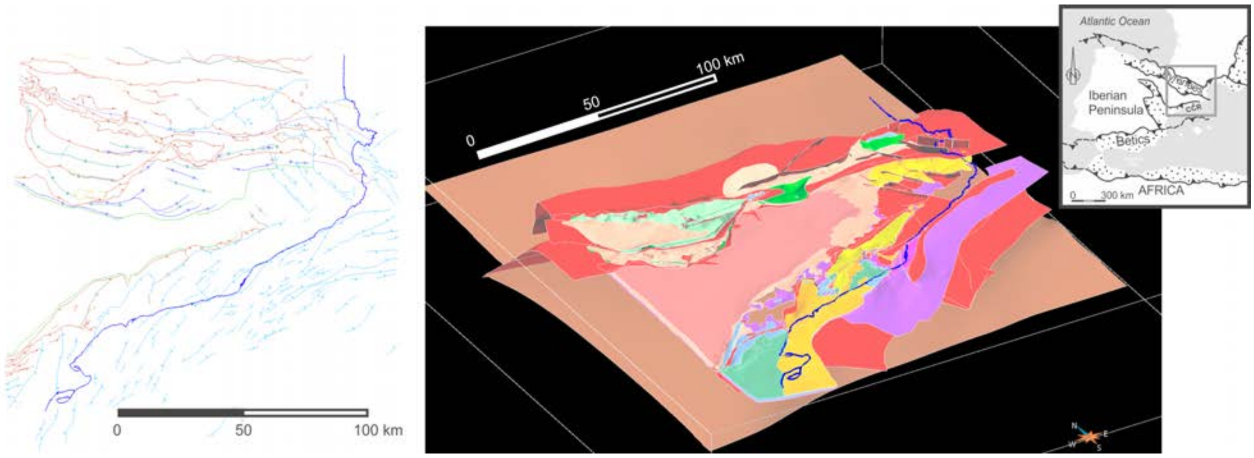

Figure 1 – Situation, structural map and 3-D model of Catalonia 1:250.000.

ACKNOWLEDGEMENTS

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SUBSURFACE GEOLOGY: DATA - KNOWLEDGE – 3D MODELING

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KEY WORDS: subsurface geology, database, 3d modeling, metadata, web dissemination.

In the last years the activities of national and regional Geological Surveys have been increasingly addressed by the growing demand of natural resources by our society.

New uses of subsurface such as geothermal energy, Carbon Capture and Storage, oil and gas production and storage couple the more traditional ground water exploitation.

To support this growing demand, the geologists invest greater efforts in understanding and disseminating the knowledge related to the geological structures representing potential sites.

Moreover in the digital era geologists can: i) benefit of the large amount of geological data stored in public databases, ii) easily integrate different type of data (geological and geophysical) using specific software (mainly for 3D modeling), iii) widely disseminate and share their knowledge through 3D representations and the Internet.

The complexity of subsurface structures can be finally addressed and overcome defining workflows, at the frontier of geology, geophysics and computer science, to build and update comprehensive 3D models.

For this reason subsurface geologic elaborations, both maps and models, become the most important and widely necessary documents that the Geological Surveys should produce to meet the needs of geologists, stakeholders and local communities.

In order to test our capability of building consistent 3D models we produced some elaborations integrating national-wide datasets owned by the Servizio Geologico d'Italia (deep and shallow borehole stratigraphies, surface geological data, gravity anomalies, isobath maps of key horizons) (CARTA et al., 2008).

Starting from these datasets we applied the three-dimensional modeling techniques to a variety of different geological domains (from fold and thrust belt to plain areas); we produced multi-scaled 3D geological models (from crustal- to subcrustal-scale, from local- to national-wide), to achieve different purposes (D'AMBROGI et al., 2010; D'AMBROGI & CONGI, 2010).

The 3D models, both detailed and regional-wide, have been the starting points for specific analyses and applications: i) structural history of sedimentary basins, ii) move on fault restoration and decompaction for calculation of long term slip rates (MAESANO et al., 2010), iii) thickness maps for key stratigraphic horizons (Fig. 1), iv) analysis of rock volumes for engineering purposes (Fig. 2), v) hydrogeological characterization.

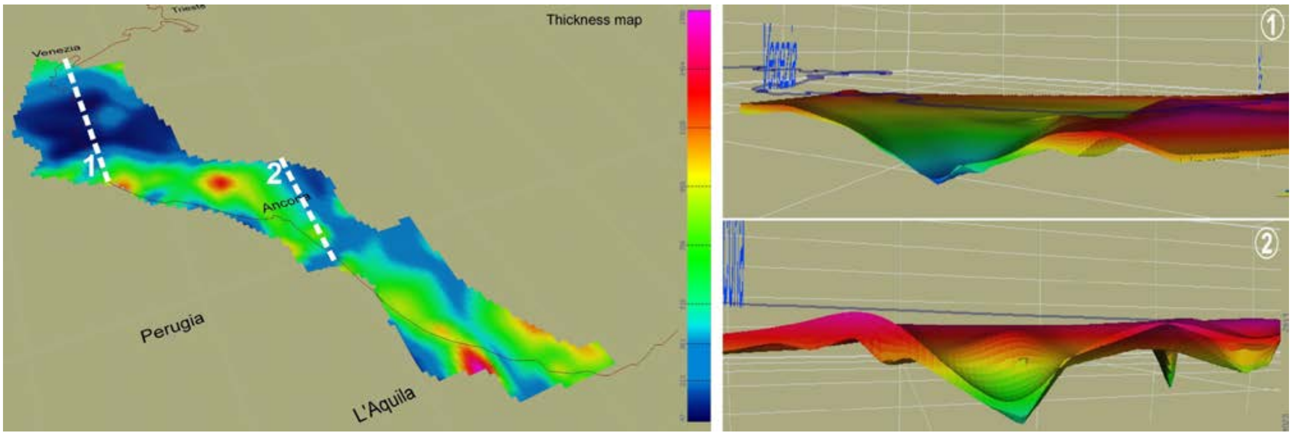

Figure 1 – Thickness map and volumes for the Argille Azzurre formation.

The tests carried out highlight that to fulfill this goal we have to deal with some aspects:

- the re-interpretation of existing data;
- the semantic and geometric harmonization of the datasets according to international standards and European directives (INSPIRE DIRECTIVE, 2007; 1G-E WP3, 2010);
- the definition and compilation of metadata both for the processed data, and elaborations;
- the definition and compilation of web standard services according to the European directives (INSPIRE DIRECTIVE, 2007);
- the standardization of the workflows, from data elaboration to web dissemination;
- the development of tools for web dissemination of the results.

The future goals will be: 1) to realize a comprehensive and consistent 3D geocellular model for the Italian territory, integrating all the available geophysical and geological parameters, with an increasing degree of detail from depth to the surface; 2) to share 3D data and models with end-users via the Internet.

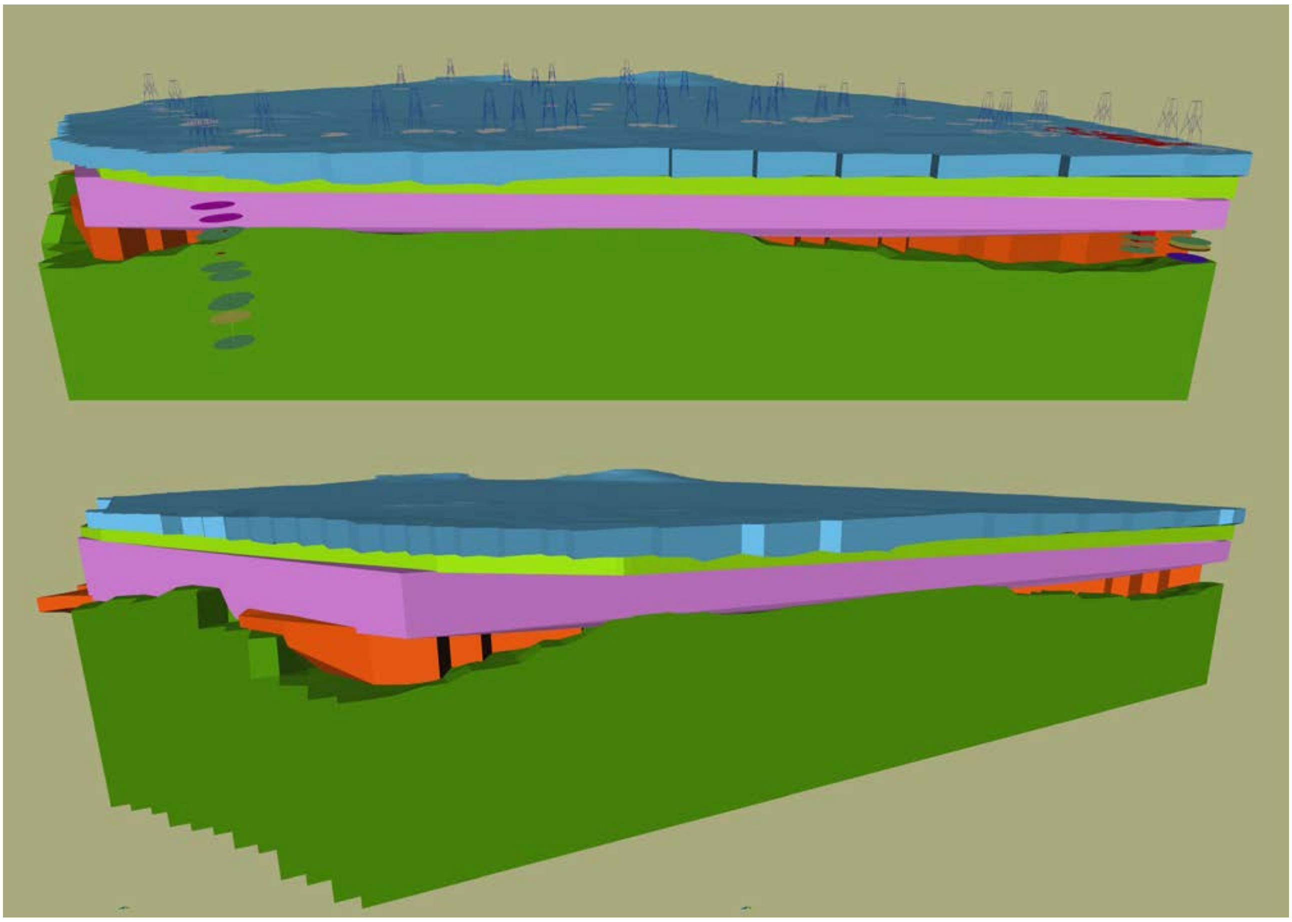

Figure 2 – 3D model of urban area of Florence.

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THE GEOLOGICAL 3D-MODEL FOR LOWER SAXONY AND THE GERMAN NORTH SEA SECTOR

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KEY WORDS: 3D-Geology, Gocad, 3D-Modeling, Geotectonic Atlas, North-Western Germany, Lower Saxony, North Sea.

THE DATABASE

The State Authority for Mining, Energy and Geology (LBEG) is currently building a Geological 3D-Model covering the area of Lower Saxony and the German North Sea Sector (Fig. 1).

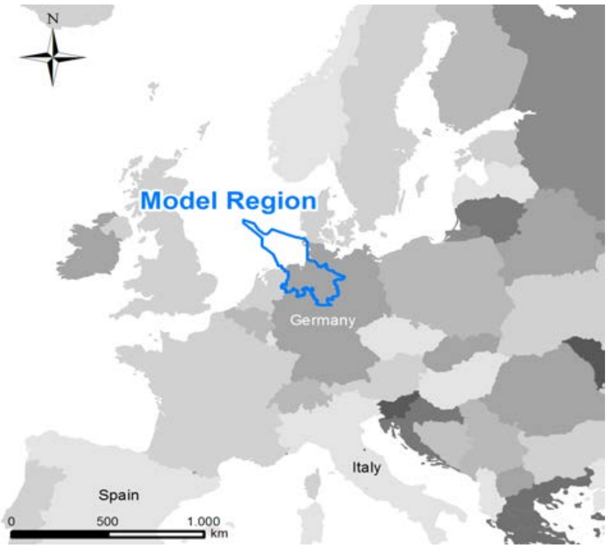

Figure 1 - Region of the Geological 3D-Model

The 3D-model is based on a data set provided by the Tectonic Atlas of Northwest Germany and the German North Sea Sector (BALDSCHUHN et al. 2001). This Atlas is the fundamental work on regional geology in that area. It is a uniform compilation and interpretation of the structural and paleogeographical development and shows the the subsurface geology on a regional scale down to depths of more than 9000 m. Mainly it contains structural maps showing the depth distribution and tectonics of 14 base horizons ranging from the Zechstein to upper Tertiary units (Fig. 2).

The Tectonic Atlas was developed at the Federal Institute for Geosciences and Natural Ressources (BGR) from the 1970's to the 1990's and is based on wells and digital seismic profiles acquired mostly for hydrocarbon exploration, and for the exploration of salt and mineral resources. The original mapping was done on a scale of 1:25.000, and was subsequently compiled for internal reports on the scale of 1:100.000. Furthermore, these reports were generalized and published on the scale of 1:300.000 (BALDSCHUHN et al., 1996; KOCKEL, 1995). In 2001 the maps where scanned, published on a CD (BALDSCHUHN et al. 2001) and afterwards digitized. This data set is the base for the construction of the 3D-Model (Fig. 3).

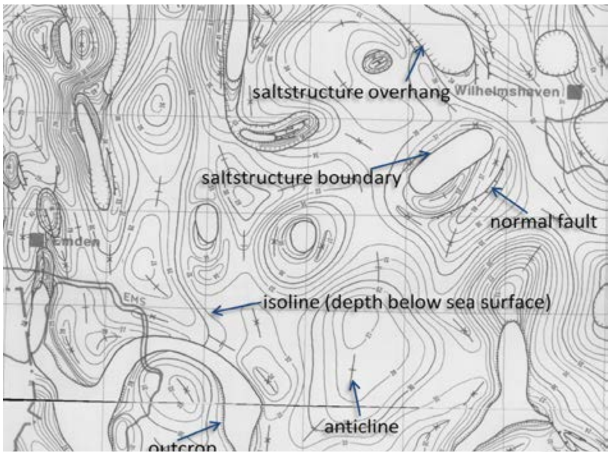

Figure 2 - Structure map base keuper

MODEL BUILDING

Model building is done in the framework of two different projects, one is the so called "GTA3D", which is the german acronym of "Geotectonic Atlas 3D". This project started in 2007 with the goal to model the area of Lower Saxony and it is still going

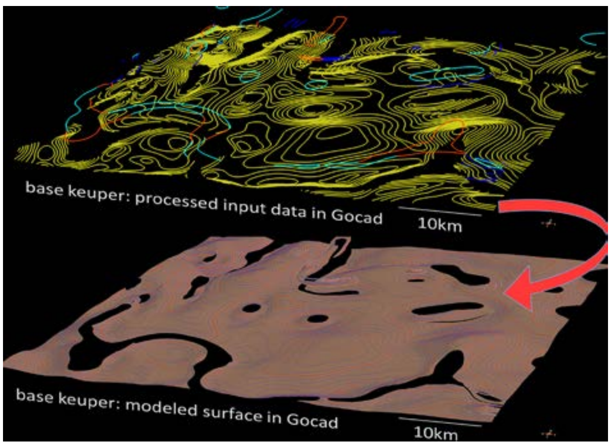

Figure 3 - processed data and finished base surface

on. The second project "Geopotential of the German North Sea" (GPDN) started in 2009 in collaboration with the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Maritime and Hydrographic Agency (BSH). One subtask of this huge project is the construction of a geological 3D-Model based on the Tectonic Atlas mentioned above. For the German North Sea Sector, this work is already finished except for the area of the so called "duck's beak", where no data is provided by the Tectonic Atlas. A new 3D-Model will be constructed in this area in cooperation with the BGR (Fig. 4).

The modelling tool is the software GOCAD® (PARADIGM™), which implements the DSI-algorithm (MALLET, 2002). This interpolation method is able to take into account many different types of data to constrain the geometry of very complex geologic interfaces.

With respect to the huge area of more than 87.000 km² which has to be modelled, it was necessary to minimize the amount of data that is used in the modelling procedure. Therefore, the whole area was spatially structured in small tiles of ca. 44 x 44 km according to the 1:100.000 topographic map (Fig. 4). Each tile was then modelled in a very structured way using newly developed workflows. To prevent misfits at the tile boundaries, the tiles were modelled with an overlap. After completion of one tile, the overlap is cut off and the surface nodes on the corresponding tile boundaries were used to model the new neighbouring tile.

Figure 4 shows the actual state of the modelling as of February 2012, the entire area will be covered soon.

EVALUATION OF THE MODEL VIA THE INTERNET

To make the model available for everybody, our group developed an application, allowing to generate geologic cross-sections and virtual boreholes directly from the 3D-model. It does not require any special knowledge or software and is accessible via the internet (Fig. 4).

For interested parties, the model data of Lower Saxony will be provided free of charge in GOCAD®-Tsurf format.

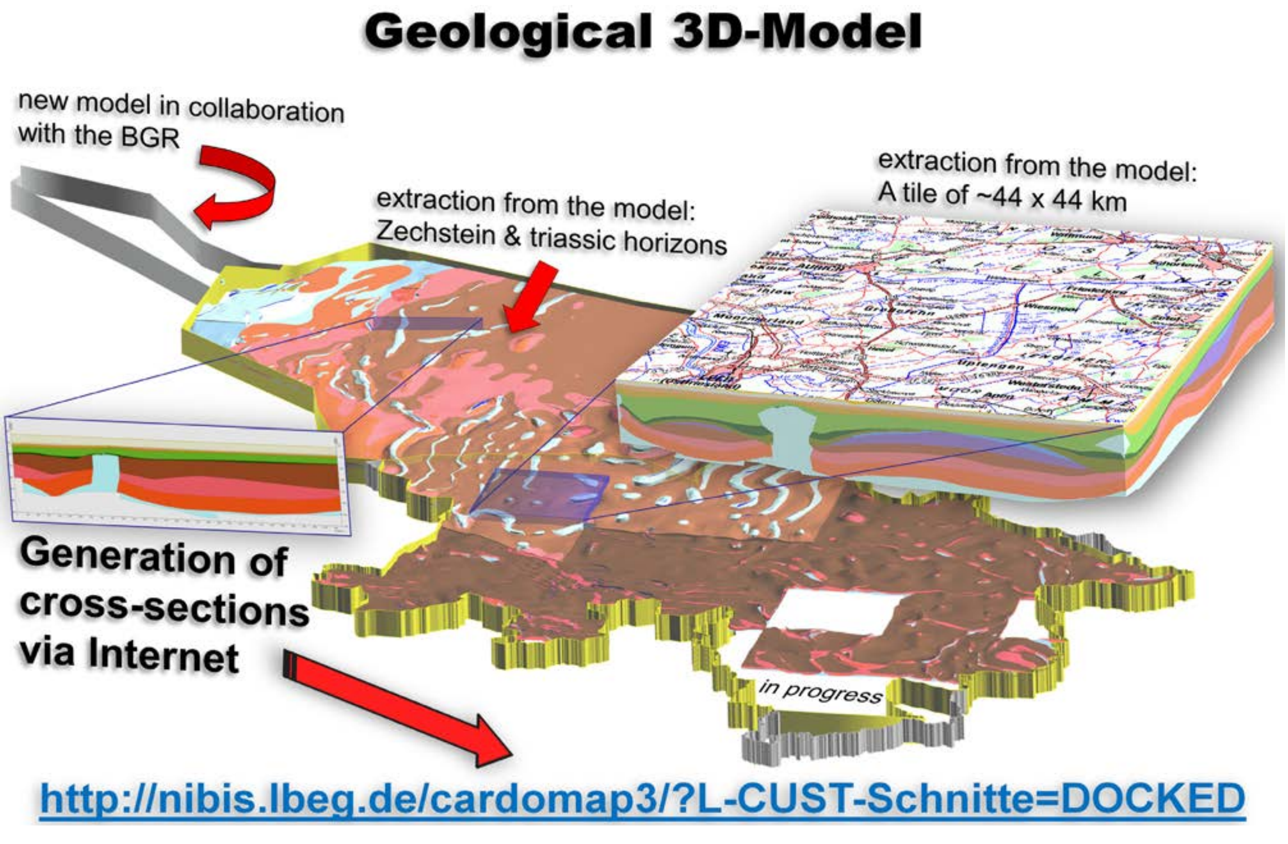

Figure 4 - The Geological 3D-Model of Lower Saxony and the German North Sea Sector

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GEOLOGICAL 3D MODEL OF THE CENOZOIC SUBSURFACE OF FLANDERS

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KEY WORDS: 3D model, Belgium, Cenozoic, Diest Formation.

INTRODUCTION

VITO has constructed a geological 3D model for the subsurface of Flanders (Northern Belgium) (figure 1). The Flemish Government will make it available through a free web application (available via http://dov.vlaanderen.be). During the last 6 years, VITO has modeled the main surfaces within the Flemish Paleozoic, Mesozoic and Quaternary substrate in 3D. Modeling of the Tertiary strata is still in progress and is planned to be finished at the end of 2012.

Figure 1 – Location of Belgium (dark gray area) within Europe.

CENOZOIC IN FLANDERS

During Cenozoic times, Flanders was situated in the southern part of the North Sea Basin. Continuous subsidence enabled the deposition of sediments during almost the entire Cenozoic era. The sediments were generally deposited in shallow water, resulting in cyclic stratigraphical patterns, with clays overlying sands and vice versa (Vandenberghe *et al.*, 1998). Sediments were not disturbed by folding nor by major lithification, but in the northeastern part of Flanders, fault activity was present during the whole Cenozoic. An overall tilting has also taken place, resulting in Tertiary units gently dipping towards the north. This also means that younger units are consecutively cropping out from the south to the north of Flanders. The overall geological constellation results in a series of north-dipping, mostly planar and locally faulted strata. Nevertheless, due to major erosional phases, some strata differ from this overall pattern and are characterized by large gully-shaped basal surfaces (figure 2).

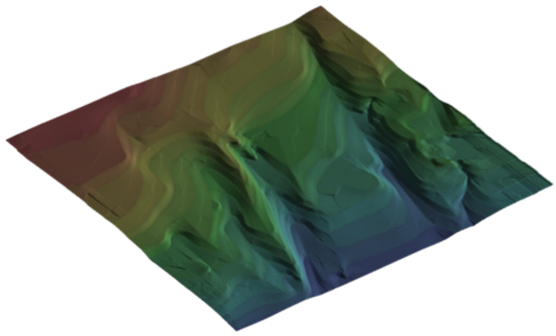

Figure 2 – The gully-shaped basal surface of the Brussels Sands in the vicinity of Leuven.

GEOLOGICAL 3D MODEL

During the modeling of the Tertiary strata, the basal surfaces of 25 regionally defined lithostratigraphical units were generated. The modeling mainly combines outcrop and borehole data, both stored in an ArcGIS-database. This facilitates the correlation of the data-points and the subsequent generation of basal isohypses. During this process, the geologist is taking into account the specific type of basal surface that fits this unit (e.g. a planar surface, a gully-shaped surface, a faulted surface), according to the data, the present geological knowledge and the new insights found during the modeling process. By doing so, he is introducing geological concepts into the modeling process which will have a major influence on the resulting model. The geologist makes the difference between a mathematically or statistically 'correct' model and a geologically realistic model. The resulting isohypses are imported into an AutoCAD-environment and transformed into 3D-lines.

Interpolation of those lines results in 3D-surfaces, stored as raster-files, that basically constitute the framework of the 3D model.

Due to a lack of borehole data, a different approach was used in the northeast of Flanders. Here seismic survey data were analyzed with WinPics software. Seismic reflectors were correlated to known geophysical contrasts. Subsequently, based on the few regionally available borehole data, a time-depth conversion was executed. This way, 3D-depth-surfaces were created and again stored as raster files. Joining of those rasters with the previous, borehole-based rasters, finished the construction of the 3D model.

DIEST FORMATION

One of the modeled Tertiary lithostratigraphic units is the Miocene Diest Formation (figure 3). Unlike the majority of the Tertiary strata, the Diest Formation is not gently dipping to the north, instead it has a gully-shaped base and an overall dip to the east-north-east. Hence, the Diest Formation is crosscutting many underlying Tertiary strata. Proceeding the deposition of this unit, a major erosional phase occurred in the North Sea Basin, possibly related to the Messinian Salinity Crisis in the Mediterranean. Large gullies were washed out, cutting through the underlying substrate, more than 100 meters deep in some areas. Even the Oligocene Boom clay was affected and locally completely eroded.

The Diest Formation was modeled by using a large number of outcrop and borehole observations (approximately 2 points per 10 km²). The geological concept of a gully-shaped basal surface, which was observed on the field and in the seismic cross-sections, was fitted onto these data points. The result is a 3D-surface which clearly crosscuts the basal surfaces of underlying Cenozoic units, like the Boom Clay. New subcrop areas for these older strata were generated through the numerical difference of their the basal 3D-surfaces and the 3D-model of the Diest Formation. Hence, new information was generated for studies concerning hydrology, nuclear waste storage, sand extraction, etc. Precise examination of the Diest Formation 3D model could also provide new insights about the way the Diest Formation was deposited.

AKNOWLEDGMENTS

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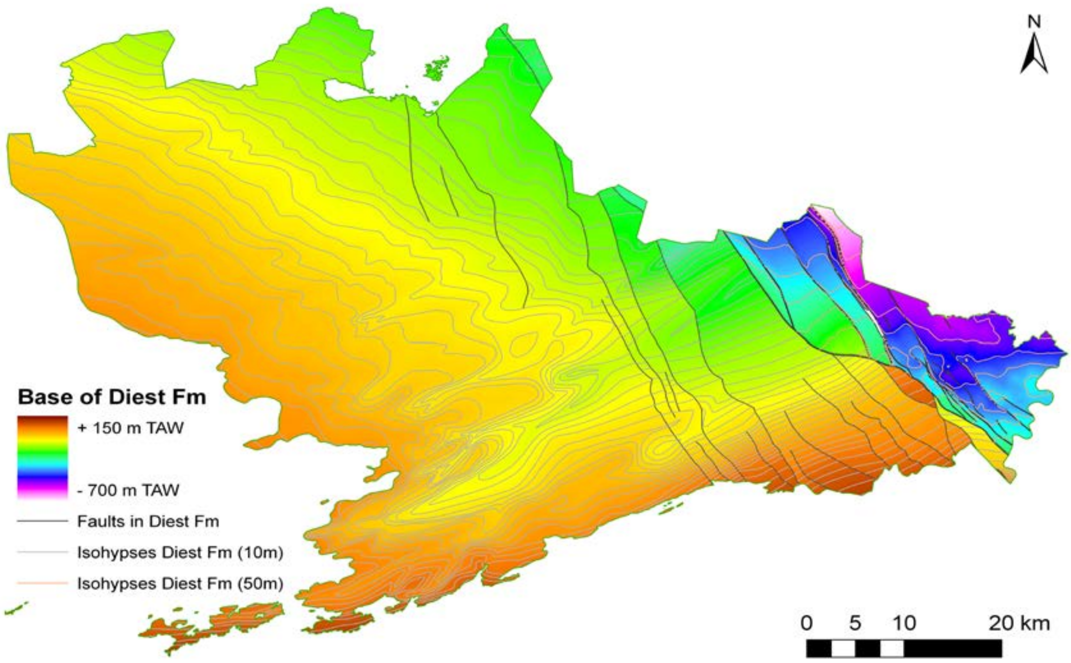

Figure 3 – Colour map of the base of the Diest Formation. Heights are presented relative to the Belgian reference sea level, TAW. The interval between the gray isohypses is 10m, while the interval between the orange isohypses is 50m.

THREE-DIMENSIONAL OF THE SHALLOW-LEVEL GROUND MODEL BASED ON BOREHOLE DATABASE: A CASE OF THE SOUTH KANTO PLAIN, CENTRAL JAPAN

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KEY WORDS: borehole data, 3-D model, surface model, grid model, N-value, lithofacies

INTRODUCTION

The Kanto plain, the biggest plain in Japan, includes the Tokyo metropolitan and adjoining prefectures, which consists of alluvial lowlands and Quaternary uplands. The alluvial lowlands are widely distributed along major rivers, which are underlain by the latest Pleistocene – Holocene incised-valley sequence, so-called Chuseki-so in Japan. The Chuseki-so consists mainly of fluvial sand and mud sediment overlying by marine mud and sand sediment deposited in the inner Bay. The total thickness is more than 70 m. The uplands consist by the Pliocene to Pleistocene shallow-marine to non-marine sediments reflecting the sea-level change.

The earthquake disasters have been closely related to the thickness and properties of the underground deposits. The damaged area is known to be concentrated in the region where thick Holocene marine clay or humid deposits are underlain. The detailed seismic-resistant evaluation needs the S-wave velocity structure model of the ground, and for the precision of which the construction of 3-D geologic model is essential. It is important that physical properties of shallow-level ground are a key in order to evaluate the earthquake motion of short period closely related to the earthquake damage of low layer residences.

Numerous borehole data for ground survey, most of which are standard penetration tests, are available in the highly developed urban area in Japan. These are very useful for modeling. We have constructed the borehole database including more than 20 thousands of digital borehole data in the south Kanto plain, in corporation with local government offices and national institutes.

The article is aimed (1) to introduce the methodology to construct a surface model for the basal plane of the Chuseki-so and the grid model including the geologic divisions between the Chuseki-so and other Quaternary deposits, based on borehole database, and (2) to demonstrate the examples of shallow-level ground of the Tokyo Lowland.

BOREHOLE DATA BASE AND STUDY AREA

The study area for 3D modeling, ranging from 35.91667 to 35.6667 degrees north and from 139.75 to 139.875 degrees east, is located in the northeastern part of the metropolitan area, and includes the alluvial lowlands and adjacent uplands (Fig. 1).

The borehole database used in this study includes six thousands of digital borehole data, and has been introduced from the Borehole Database for Urban Geology (Kimura, 2006), which has been developed as basic data of national land through the urban geology project of our institute. The borehole data are digitized based on the XML data format set up by the Ministry of Land, Infrastructure, Transport and Tourism, Japanese Government.

SURFACE MODEL OF THE INCISED VALLEY FILLS

Generally borehole data are not only sufficient number for modeling, but also have deviation in the distribution. The key subject for covering the sufficiency is to introduce the geomorphologic divisions of the buried incised-valley geomorphology to subdivide area for calculating the surface model based on point data. The divisions consist of four buried river terraces, wave platform, slope and flow channel incising the terraces.

The procedure of the method is the followings : (1) to determine the basal horizon of the Chuseki-so based on borehole data, (2) to build up 3-D boundary line between the Chuseki-so and the upland areas, (3) to build secondary point data to trace the buried incised-valley geomorphology, (4) to implement the 50m mesh elevation model of each buried geomorphic surface only based on primary point data, and finally, (5) to construct the surface model by space interpolation calculation using all data build up by the above procedure.

GRID MODEL

The basic method of the grid model is based on Eto et al (2008) and Kimura et al (2011). N-values and lithofacies of borehole logs due to a standard penetration test of ground survey are used for modeling. The models are to be constructed by horizontal interpolation of scattered data of the borehole logs and their vertical stacking. The inverse-distance weighting method is used for the interpolation. The borehole data for modeling are subdivided into the Chuseki-so and the basement based on the basal horizon of the Chuseki-so on each borehole log. The model calculation is performed for every subdivided geologic units.

The spacial distribution of the N-values and lithofacies in 3-D model demonstrates inner physical structure and sedimentary facies of ground such as basal gravel of the Chuseki-so, meandering-channel fills, transgressive sand shoal and marine mud of inner bay. In addition, the grid model of N-values and lithofacies offers a detailed renewable geologic model to calculate the S-wave velocity structure model for evaluating the seismic amplification properties.

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DEVELOPMENT OF A GEOLOGICAL DATABASE SCHEMA AND IMPLEMENTATION WITH POSTGRESQL/POSTGIS FOR 3D GEOLOGICAL MODELLING.

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KEY WORDS: database, GIS, PostgreSQL, PostGIS. 3D geology

INTRODUCTION

In the project of 3D geological modelling of the geological map of the Walloon Region (Southern Belgium), the University of Mons have been entrusted with a new geological database structure development. Database must allow to encode, to store and to manage geological data, some of them including geographical objects, in order to build 3D geological models of geological bodies based on the developed methodology (Kaufmann & al.) and to update geological maps.

This project consists of three phases:

- Database schema design and its implementation in a relational database taking into account geographic objects.
- Web interface development with several functionalities allowing to consult, to analyse, to encode, to modify and validate geological information.
- Integration of the validated data in a geomodeller to build 3D geological models.

For the database implementation, we selected PostgreSQL as the the relational database system with its spatial extension PostGIS. Geographic objects can be imported and managed (viewed, modified or deleted) in the geodatabase with the geographical information system QGIS.

At present, the third dimension (elevation), critical for 3D modelling, is managed separately. Elevation values are either encoded in the database as objects or are extracted from a DEM with the geomodeller as a property. Geographic layers associated with elevation values allow to represent the spatial position and shape of each geological object in a informal 3D spatial reference system.

GEOLOGICAL DATABASE RATIONALE

The database schema is built on an approach based on projects (Figure 1) and reuse of geological information (description of observation, interpretation) in various projects.

However, reusing former geological data in a new context is not straight forward. Relative and/or absolute locations in different coordinate systems may be associated with observations. These observations are often gathered within a site, on a geographical and practical basis. Moreover, several interpretations may be given to a geological description resulting from an observation depending on the interpreter knowledge and objectives as well as the adopted geological reference system (or canvas, see below).

In our approach, each project has a specific scope in terms of area of interest, project time frame and a geological description. Thus, a 2D coordinate reference system and a vertical reference system is defined. Every geological observation is linked with at least one project. The absolute locations of observations selected in a project are computed in its coordinate system. The most reliable location of each observation is then kept according to the positioning method and estimated precision. Descriptions and former interpretations are used to reinterpreted observations in terms of the current project geological reference system.

The major interests of the project approach are:

- Distinct validation of geological observation, localisation and interpretation within each project.
- Reuse of previously encoded observations with their localisation(s) and interpretation(s).

INTERPRETATION PROCESS

In a project, descriptions are interpreted according to a canvas and an interpretative scheme. Canvases specify which kind of geological bodies are considered and the relationships between them (i.e. facies variations or succession). Interpretative scheme try to clarify different criteria to associate observations to a geological unit s.l.

Geological observations previously interpreted according to at least one canvas can be reinterpreted in another canvas. This work is done by the interpreter working on a project and may be assisted by a pre-processing step consisting of translation queries based predefined rules.

Several steps of validation are performed to check geological data. The first step is to qualify the data in terms of fidelity to the original information and completeness of the records in the database. Then, for each project, there is a selection and validation process. Its aims are to keep accurate and reliable data and reject questionable or imprecise data in a dataset suitable for the current project. Firstly, the consistency of each piece of information is checked and validated separately. Next, data are checked to keep those useful to objective of this project.

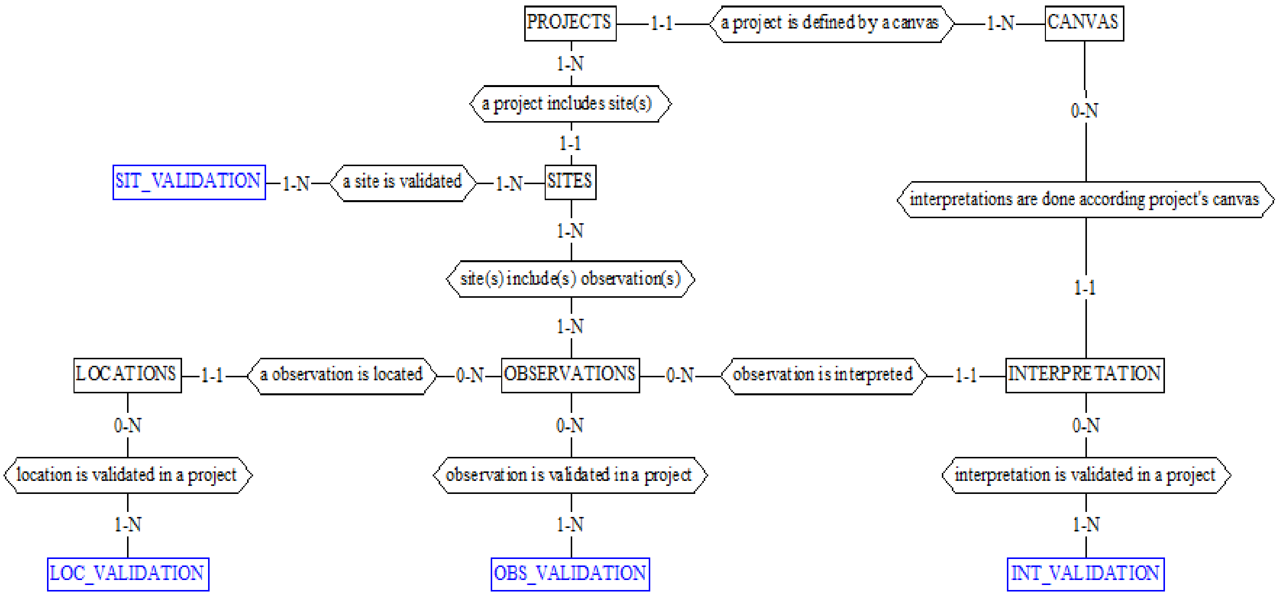

Figure 1 – Conceptual schema of the database.

WEB INTERFACE

Web interface has been created using the Django framework with its capabilities to manage geographic data. Several functionalities are offered according to user privileges (public or private). The interface allows to consult, to analyse, to encode, to modify and to validate geological information using interactive maps.

Similar interfaces with the equivalent scopes were already developed in the other study projects (e.g. Kaufmann & al. (2008), Masuto & al. (2010)).

CONFORMANCE WITH INSPIRE

Usually, the compliance of the national database with the INSPIRE directive needs a mapping between fields and classes. In case of an existing database, some mandatory requirements induce to adapt database structure and to collect and encode information.

The opportunity to develop a new geological database allows to taking into account such requirements and to fill in fields using controlled vocabularies from the predefined code lists and enumerations.

ACKNOWLEDGEMENTS

The authors wish to thank the Walloon Region (Belgium) for funding this study program “Programmme de Révision de la Carte géologique de la Wallonie – Modélisation 3D – Pilote pour la feuille Mons-Givry”. We also wish to thank M. Hennebert and S. Delaby, geologists working on the new geological map of Wallonia, for the information sharing and rich discussions on the new geological map of Mons-Givry.

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KINEMATIC ANALYSIS OF A TRANSTENSIONAL FAULT SYSTEM THROUGH 3D MODELLING: THE CASE OF THE MOLA PLAIN, ELBA ISLAND (ITALY)

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KEY WORDS: 3D modelling, brittle structure, Zuccale Low Angle Normal Fault

INTRODUCTION

Nowadays several research projects concern drinking water, which is a fundamental need in coastal areas and small islands, such as Elba Island (the biggest one of the Tuscan archipelago, in the northern part of the Tyrrhenian Sea), for studying possibilities of greater exploitation of existent aquifers. One of them is the fractured aquifer of Mola coastal plain ("Piana di Mola", Elba Island, Italy; Figure 1).

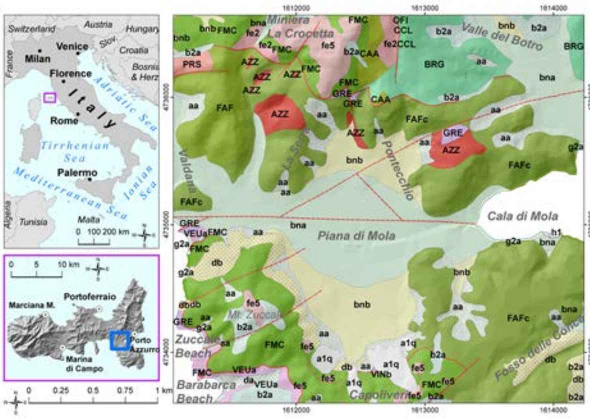

Figure 1 – Geological map of study area (both labels and colours of geological formations are conform with official legend of new detailed geological map of Tuscany Region at 1:10,000 scale, http://www.geologiatoscana.unisi.it

The Elba Island represents the westernmost outcrop of the Northern Apennines chain. The geological peculiarities of this island are linked to its complex tectonic pile of nappes and to the well-known Fe-rich ores, also to the well-exposed interactions between Neogene magmatic intrusions and tectonics (Trevisan, 1950, 1951; Keller and Pialli, 1990; Bortolotti et al., 2001). The structure of Elba Island consists of thrust sheets stacked during earlier late Cretaceous to early Miocene compressional phase, and that are cross-cut by later mid-Miocene to early Pliocene extensional faults (Trevisan, 1950; Keller and Pialli, 1990). The subsurface of study area is composed by quartzitic phyllites likely of Paleozoic age (FAFc in Figure 1), locally affected by contact metamorphism linked to the intrusion of Porto Azzurro granite pluton (AZZ in Figure 1). Dolomites and metaconglomerates of Triassic age outcrop above the quartzitic phyllites. Such complexes are cut by an important Low Angle Normal Fault (Zuccale LANF): on the hanging wall lie Ligurian units (Cretaceous Flysch, Ophiolitic basalts).

This study is focused to reconstruct the brittle structural model of this area by means of 3D modelling in order to investigate the rock mass fracturing systems conditioning the groundwater flow. This model highlighted a regional system of brittle deformation correlated to recent tectonic movements, which played a fundamental role in the actual geological structure of Elba Island.

This multidisciplinary study points out new elements for understanding the recent evolution of the brittle tectonic of northern Tyrrhenian sea.

METHODS

A multidisciplinary study on this area has been carried out in order to support the tectonic model by means of geological surveys of 4 km^2 at 1:5,000 scale, together with geostructural survey on 16 outcrops over all geological formations. The results show the area is characterized by two main fracturing systems, with regional character (S1 NW-SE oriented, and S2 EEN-WWS oriented), measured in all surveyed outcrops.

These systems decrease their joint frequency and increase their persistence getting close to the central part of study area, where rock mass is more tectonized. This could be justified by the presence of a faults system related to a brittle structure. Data outline a structural framework of both conjugated synthetic and antithetic joints, a brittle expression of left-normal fault crossing Mola plain in EW direction. outcrops over all geological formations. The results show the area is characterized by two main fracturing systems, with regional character (S1 NW-SE oriented, and S2 EEN-WWS oriented), measured in all surveyed outcrops.

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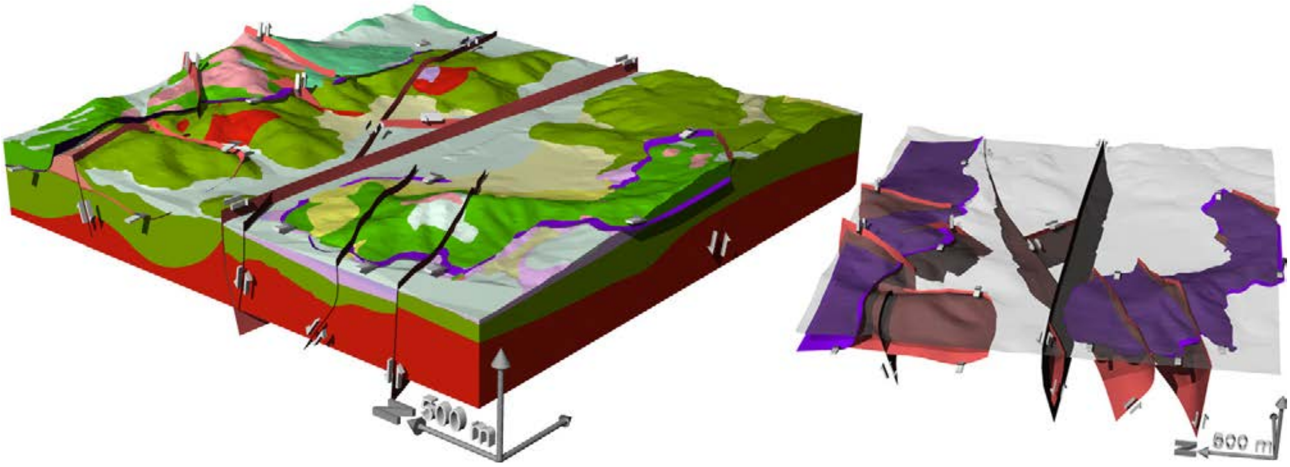

Figure 2 – 3D model of Mola plain area: Perspective view of geological formations volumes (on the left); B) main faults (red), Zuccale LANF (violet), and Digital Elevation Model (grey) in perspective view (on the right)

A detailed geophysics survey was simultaneously performed through electrical resistivity profiles. 11 electric tomographies were carried out by means of Schlumberger and Wenner Alpha arrays (10 m of interelectrodic distance, 10632 measuring points, total explored length 6810 m) sometimes near to existing boreholes with known stratigraphic logs. Where possible, the Roll-Along technique was adopted for keeping the continuity of data (Loke, 2004).

Both results of geological, geostructural, geophysical survey, and boreholes logs were interpreted, as input for drawing 15 geological cross-sections (7 N-S oriented, 8 E-W oriented), considered as input for geometrical modelling of contact surfaces and geological formations volumes. A geostatistical method of analysis based on NURBS surfaces (Non Uniformal Rational B-spline; Nale & Caraccia, 2003) was utilised, as other works illustrate (Tonini et al., 2009). Utilizing this interpolator in CAD environment allows to trait slips fault, especially if LANF.

The contact lines (CL) of geological map, boreholes stratigraphic logs, and vectorized cross-sections were interpolated by means NURBS surfaces, then checked by trials and errors comparison with intersections between modelled surfaces and DTM (Model Contact Lines; Tonini et al. 2009). Finally, volumes of any geological formation and tectonic surfaces were created.

CONCLUSIONS

Mola plain is a low morphological area due to brittle structural evolution. Such zone of crustal weakness seems to be related to a regional high angle strike-slip fault, EW oriented, having both a left horizontal displacement and in the western part a vertical displacement (Figure 2.A). Such a sector is characterized at SW of fault by an extensional duplex with several synthetic normal fault plunging toward NW with high angles. In the north part of main strike-slip fault we give evidence for a NE-SW lineament, with left horizontal displacement, coherent with a synthetic displacement. Antithetic faults were inferred by means of geophysical survey results. Moreover, different attitude of Zuccale LANF highlights the presence of the main regional strike-slip fault, in fact in the north part of this EW lineament (footwall) Zuccale LANF outcrops at 100 m a.m.s.l. while in the south-western part of the hanging-wall it outcrops on the seacoast at sea level elevation. This causes a vertical displacement along the main axis of Mola plain, higher in its western part.

We did this kinematic interpretation of this area by 3D geological model, which will constitute the basis for the rest of the project, i.e. groundwater flow numerical modelling of Mola plain.

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CONTRIBUTION OF POTENTIAL FIELD DATA IN DELINEATING THE STRUCTURAL-TECTONIC SET-UP OF THE EASTERN QATTARA DEPRESSION AREA, WESTERN DESERT, EGYPT.

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KEY WORDS: Qattara, Gravity, Magnetic, Matched Filtering 2D Modelling.

ABSTRACT

In this work, a reconnaissance study is presented to delineate the subsurface structures and tectonics of the Eastern Qattara Depression area using the available geophysical data; that include Bouguer gravity and aeromagnetic data. To achieve this goal, several transformation techniques and filtering processes were accomplished on the Bouguer gravity anomaly map and the total intensity aeromagnetic map, through both qualitative and quantitative analyses.

At first, the fast Fourier transform was carried out on the gravity and RTP magnetic data for establishing the energy spectrum curve and defining the residual (shallow) and regional (deep) sources. By the way, the frequency band pass filtering was used to enhance the anomaly wave lengths associated with the shallow and deep sources using the matched filtering. The equivalent depths of the isolated short wavelength anomalies are 0.759 & 0.340 km below the flight surface, and the depths of the intermediate wavelength anomalies are 1.28 & 2.00 km, as well as the depths of the long wavelength anomalies are 6.3 & 6.5 km for the gravity and magnetic data, respectively.

Finally, the qualitative and quantitative interpretations of the available Bouguer gravity and R.T.P. magnetic maps of the Eastern Qattara area, northern Western Desert, reflect the occurrence of the various types of structures (folds and faults) and their components (anticlines and synclines, as well as their dip-slip and strike-slip faults). Added, the main tectonic deformations of the study area have NNW-SSE, NNE-SSW, NE-SW, NW-SE and E-W trends.

POTENTIAL FIELD DATA OF THE STUDY AREA

The studied area lies in the central portion of the northern Western Desert of Egypt, between latitudes 28o 30\ & 30o 00\ N. and longitudes 27o 30\ & 29o 00\ E. (Fig. 1).

The available gravity and magnetic data of the study area are as follow:

GRAVITY DATA: The Bouguer gravity map, with a scale of 1:100,000 and 1 mgal contour interval, after (G.P.C. 1986).

MAGNETIC DATA: The total intensity aeromagnetic map of scale 1: 250,000 and 5nT contour interval exhibits some different style of positive and negative anomalies.

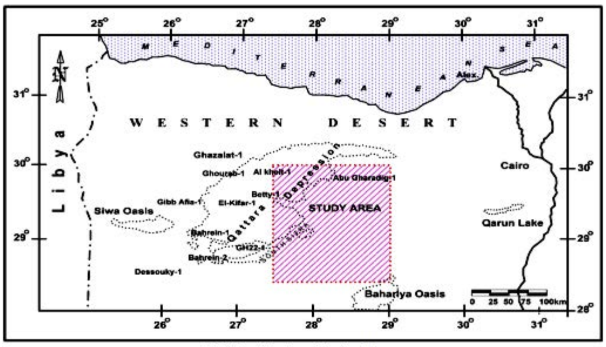

Fig.(1) Location Map of the Study Area

Figure 1 – Location map of the study area.

PROCESSING OF THE GRAVITY AND MAGNETIC DATA

Reduction to the North Magnetic Pole: In the present study, the total intensity aeromagnetic anomaly data are reduced to the magnetic pole (RTP), according to Geosoft Oasis Montaj 6.4.2, (2007) software.

Extracting the gravity and magnetic Sources using Matched Band-pass Filtering

The Fourier band-pass filtering can be used to isolate and enhance the anomaly wavelengths associated with the shallow (or deep) sources. For optimal separation of the signals, the band-pass filters must be designed for each survey using a process known as "matched filtering" (Phillips,2000), using program MFDESIGN of Phillips,(1997). The filters are applied to the observed gravity and RTP magnetic data, using MFFILTER program of Phillips, 1997, to separate the short, medium and long wavelength gravity and magnetic anomalies by apparent source depths. So, the equivalent depths of the isolated short wavelength anomalies are 0.759 & 0.340 km and the depths of the intermediate wavelength anomalies are 1.28 & 2.00 km, as well as the depths of the long wavelength anomalies are 6.3 & 6.5 km for the gravity and RTP magnetic data, respectively.

QuantItative Interpretation: In the present study, the quantitative interpretation of potential field data can be discussed under the following approach.

Forward Modeling: The quantitative interpretation used a 2.5-D gravity/magnetic interactive modeling package running on GM-SYS software (1999). The five profiles were traced and used as the observed gravity and magnetic modeling.These profiles were taken along NW-SE, NE-SW and NNE-SSW directions, at right angles to the major geologic features.

Structural Tectonic Evolution: Accordingly, the deep-seated structural features and the shallow-seated structural elements are represented in the study area, belt-wise and trend-wise, as shown as follow:

A- Deep-Seated Structural Features: The deep-seated structural features of the study area (Fig. 2), which mostly dissect the upper mantle and crust, are integrated as swell and trough belts intervened by faults of varying trends.

B- Shallow-Seated Structural Elements: Then after, the shallow-seated structural elements of the study area (Fig. 3), which intervene the basement complex and the overlying sedimentary sequence, are cumulated as anticlinal and synclinal zones dissected by faults of varying parameters

SUMMARY AND CONCLUTIONS

The present study aims to map the configuration of buried basement rocks, their structures and lithology. Also, it throws more light on the tectonic elements concerned with the distribution of the sedimentary basins and ridges, and the related swells and troughs of the basement complex, in addition to a reasonable picture about the shallow-seated and deep-seated structures intervening their rocks.

The aforementioned qualitative and quantitative interpretations of the available Bouguer gravity and R.T.P. magnetic maps of the studied area reflect the occurrence of various types of structures (folds and faults) and their components (anticlines and synclines, as well as dip-slip and strike-slip faults). These structural elements in the considered area can be arranged, trend-wise and depth-wise as follow: The deepest are the folds and faults of NNW-SSE, then those of NNE-SSW trend. These are followed upwardly by the faults and folds of NE-SW trend, these those of NW-SE trend, and finally the faults of E-W (ENE- WSW and WNW-ESE) trend is the shallowest.

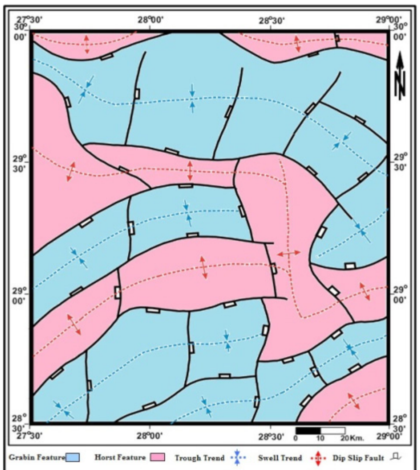

Fig. (2) Deep-seated Structural Features of the Study Area

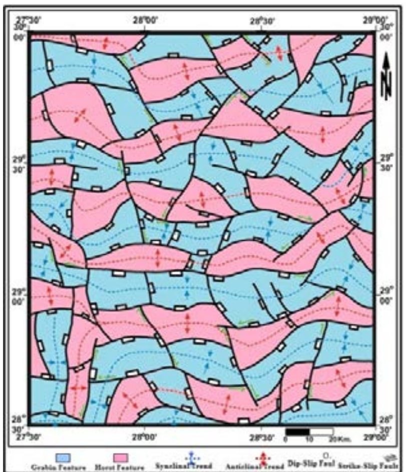

Fig. (3) Shallow-seated Structural Elements of the Study Area

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PETROLOGY AND DEPOSITIONAL ENVIRONMENTS OF THE SEDIMENTARY SEQUEMCE IN SHABRAWEET AREA NORTH EASTERN DESERT, EGYPT.

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ABSTRACT

The sedimentary sequence exposed in shabraweet area is of Early Cretaceous – Early Tertiarly. It is differentiated into eight formations, The Fayid, Galala, Adabiya, El Goza El Hamra, Maadi, Gabal Ahmar, Gharra, and marmarica formations.

Micrites, biomicrites, dolostones, and biosparites with their varieties are the main microfacies associations recognized in the carbonate facies, while quartz arenite, quartz wackes and lithic wackes are the main sandstone types recognized in the study sequence. The petrographic investigation also revealed that the sequence was subjected to different diagenetic processes. These are cementation, recrystallization and dolomitization.

Calcite is the principal cement in the carbonate rocks, while silica, calcite and iron oxides are the main sandstone cement, Neomorphic calcite was formed as a result of different degree of recrystallization, Tow phasis of dolomitization were noticed affecting the study sequence.

The Fayid Formation was deposited in a littoral to shallow neritic zone of open marine environment, while the Galala Formation was laid down under deep to shallow neritic conditions.

The El Gosa El Hamra Formation was deposited in an outer to shallow neritic zone of a regressive sea characterized by oscill. Ation movement. The Maadi Formation indicates deposition in shallow neritic to littoral zone. The Gabal Ahmar Formation is of fluvial origin. The Gharra Formation was deposited in a shallow neritic zone during sea transgression, while Marmarica Formation was deposited under deep conditions in the shallow neritic zone. The present topographic configuration of shabraweet area took place during the Pliocene to recent.

USING LANDSAT 7 ETM+ FOR GEOLOGICAL MAPPING OF PRECAMBRIAN AREA

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KEY WORDS: remote sensing, Aleksod, landsat 7ETM+, GIS, geological maps, Precambrian, Hoggar. Algeria.

For over thirty years, the images acquired from satellites contribute to the global recognition of our planet and, thus, to update its map data .During the last decade, making perfect the embedded technologies in satellites has made the remote sensing an almost indispensable tool for earth science and, especially, for geological mapping.

Indeed, classical geological mapping (based solely on field missions and aerial photos) is a long and complex work in order test the contribution expected from the remote sensing and especially the use of image processing Landsat 7 ETM + for mapping Aleksod (Central Hoggar, Algeria). This region corresponds to Precambrian outcrops in arid desert area. We recall that such a computer aided geological mapping and using satellite images is for both the making of new maps and correcting old maps (Chorowicz & Deroin, 2003).

The results clearly show that the nature of the lithologies of Aleksod can emerge out in extremely reliable way. Especially when using a prior thorough statistical study of the correlation and covariance between bands and treatments such as component analysis (PCA) and band ratios. The directional filtering and treatments such as Sobel and some colored compositions allow an accurate mapping of lineaments.

The results were excellent on the correlation between the map obtained by the processing of satellite images and map produced conventionally by Bertrand (1974). For example, the degree of identification of lithologies and their contours is greater than 80%, which is, when comparing this result to similar studies in the literature, quite exceptional.

This work shows that the method we present in this study may be extremely effective when combined with parallel work of literature and field (replaced in the case of Aleksod by the geological map of Bertrand, 1974) as a reference tool, verification and validation. It allows time savings both downstream and upstream field missions. Upstream, it can identify and locate structures, including lineament, and lithologies that arise when querying can be verified in the field. Downstream, it allows, for example, a much more precise finishing in delimitation training, including in areas of difficult access. This gives us, for a region, Hoggar, very promising prospects for geological mapping more efficient both in quality and in time of manufacture.

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PRESENT-DAY KINEMATIC PATTERN OF THE NORTHERN - CENTRAL ITALY FROM CGNSS MEASUREMENTS

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KEY WORDS: GPS permanent stations, vertical geodetic velocities, time series analysis.

INTRODUCTION

The data from Continuous GNSS stations (CGNSS) located in Central and Northern Italy are analyzed to provide the actual crustal movements. In particular, the attention is focalized on the vertical movements induced by the complex subsidence phenomena of Po plain. The spatial and temporal characteristics of this phenomena can be described by analysing the series of daily position of the sites distributed in the considered area. An attempt analysis of the actual GNSS horizontal kinematic pattern can also provide other important information about the tectonic components that contribute to the vertical deformations. Furthermore a comparison between the post-early Pleistocene deformation pattern and the present motion can provide constrains about the seismic risk in the Northern and Central Italian peninsula.

GNSS DATA

The 350 CGNSS stations located in the study area (Fig. 1), have been installed with different criteria and planned for scientific or commercial aim. Some public institution have developed CGNSS networks (Fig. 1), in order to support mapping activity, rescue and emergency services and real-time positioning (VRS and RTK). These commercial networks provide an important extension of the scientific ones managed by several Italian and European scientific institutions. The daily observation data acquired with a sampling rate of 30 s from January 1, 2001 to December 31, 2011 were analyzed with GAMIT/GLOBK software, adopting a distributed procedure. The 329 CGPS stations have been divided into 20 sub networks (cluster), each including the following six common sites: BRAS, CAGL, GARZ, MATE, WTZR and ZIMM (Fig. 1). The daily loosely constrained solutions of the 20 clusters were combined into a unique solution. The combined network of 329 CGPS sites were successively aligned into the ITRF2005 reference frame (Altamimi e al. 2007) by a weighted six parameters transformation (three translation and three rotation) using the ITRF2005 coordinates and velocities of the five common IGS stations, CAGL, GRAZ, MATE, WTZR and ZIMM, which are geographically well-distributed and are characterized by high quality data

Figure 1 – Distribution of the GNSS permanent stations analyzed in this study. The commercial and scientific networks are respectively represented by triangle and circle. The institutions and companies that manage the sites are identified with different colours. The positions of the 5 IGS sites used to align the daily solutions to the ITRF2005 reference frame are shown in the inset.

The daily time series of the North, East and Vertical position coordinate of each site were preliminary analyzed in order to detect and remove outliers. The cleaned data were analyzed to evaluate the linear trend, steps due to earthquakes or equipment changes, annual and semi – annual periodic signals and the amplitude of white noise and coloured noise, in order to correctly estimate the station velocity uncertainties.

KINEMATIC PATTERN

The actually horizontal kinematic pattern estimated from the CGNSS data is showed in figure 2. The velocity field shows that the outer part of the Central-Northern Apennines, moves significantly faster (3-4 mm/yr) and more easterly with respect to the surrounding zones, where velocities are mostly lower than 2 mm/yr. This evidence is fairly significant being coherently indicated by many velocity vectors. One may note that the faster domain in figure 2 roughly corresponds to the Apennine sector that has been characterized by greater mobility since the middle Pleistocene. This similarity might suggest that the dynamic context that acted in the most recent tectonic evolution, causing the lateral escape of this sector of the chain, is still going on and that, consequently, such extrusion may be almost continuous over time.

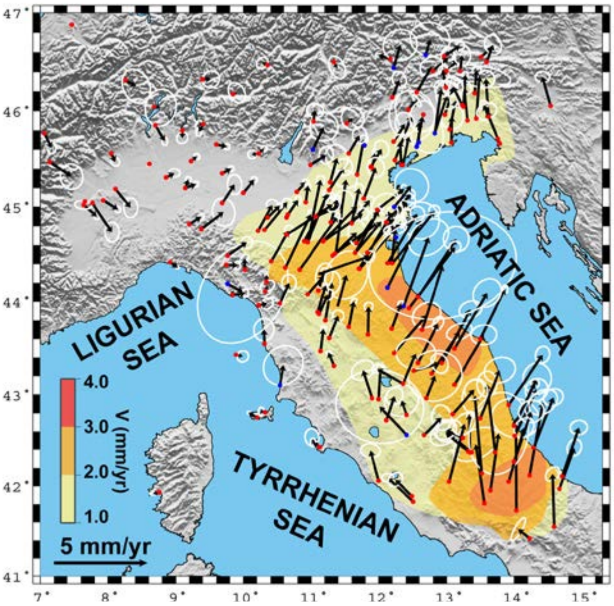

Figure 2 – Residual horizontal kinematic pattern in the Northern-Central Italian region. Residual velocities are computed with respect to a fixed Eurasian frame, modelled by an Absolute Euler pole located at 56.330 °N, –95.979 °E with a rotation velocity w = 0.261°/Myr (Altamimi et al., 2007). Ellipses indicate 68% confidence limits. The coloured domains are based on the horizontal interpolated velocity values. The interpolated velocity field has been obtained using a weighted least-square procedure with smoothing parameter.

The present-day vertical kinematic pattern in the Northern- Central Italian region is showed in figure 3. The sites located in the Alps and Apennine domains are characterized by a low uplift velocity, while in the eastern sector of the Po plan, affected by a subsidence phenomena, the comparison between the high density GPS network and the results obtained previously with different techniques (Baldi et al. 2009; Bonsignore 2007) indicates that the rates are stable or in some cases are decreasing as a consequence of the drastic reduction of water withdrawal.

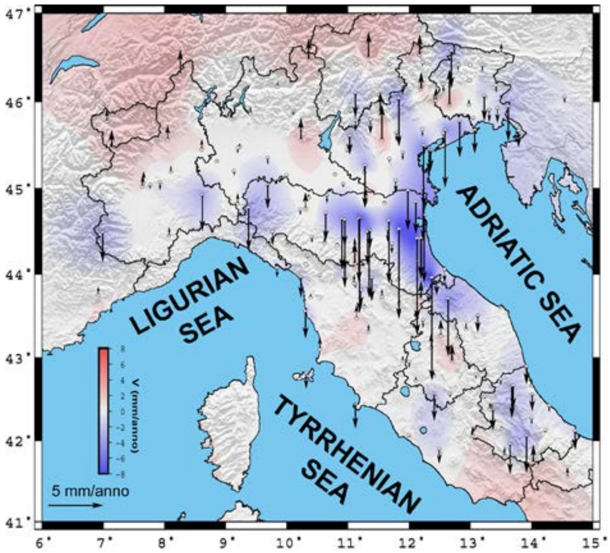

Figure 3 – Vertical velocities (black arrows) and contour map obtained considering the stations with an observation time span longer than one year. The contour map has been obtained by a statistical The interpolation pattern has been estimated using the kriging geostatistical method over a regular spaced grid (0.1°x0.1°).

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APPLICATION OF 3D GIS IN A RESEARCH PROJECT PLANNIG – AN EXAMPLE FROM THE UNDERGROUND RESEARCH CENTRE JOSEF, CZECH REPUBLIC

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KEY WORDS: 3D GIS, project planning, thermal loading, underground research centre

INTRODUCTION

Underground storage of thermal energy is an actual topic worldwide (e.g. Dincer & Rosen 2011). An influence of thermal loading and periodic temperature change however still has to be assessed.

A comprehensive research project "Rock thermal loading research – perspectives of underground storage of thermal energy" is located in a gallery of the Underground Research Center (URC Josef, Pacovský et al. 2007) in central Bohemia. The project studies multidisciplinary aspects of in-situ thermal loading of granitic rock. Complex thermo-hydro-mechanical and chemical coupling approach has been adopted.

After careful consideration a suitable locality was chosen within the URC Josef (gallery SP-47, Fig. 1). Subsequently, long-term in-situ heating experiment was designed to describe changes in geomechanical, chemical, petrological and hydrogeological properties of granite during and after repeated heating and cooling cycles.

To reach aims of the project it was essential to adjust the experiment design to geological settings of the selected locality. Thorough survey of the locality and preliminary modelling were applied. The information was viewed and compiled using ArcScene GIS software. Visualization provided a basis for detailed project planning including borehole and sensor localisation.

DATA PROCESSING AND VISUALIZATION

At the begining shape of the selected locality was acquired using 3D laser scanning technology. Walls of the gallery were also documented photographically. Detailed structural geological survey pointed out tectonic situation at the locality.

Laser scan data were transferred into ArcScene environment using the VRML data format. Multipatch geometry type was utilized to present surface of the gallery. Moreover the multipatch type is suitable for VBA macro based automated generation of 3D objects. In this way the fracture system at the gallery was reproduced. The gallery and structural model were combined.

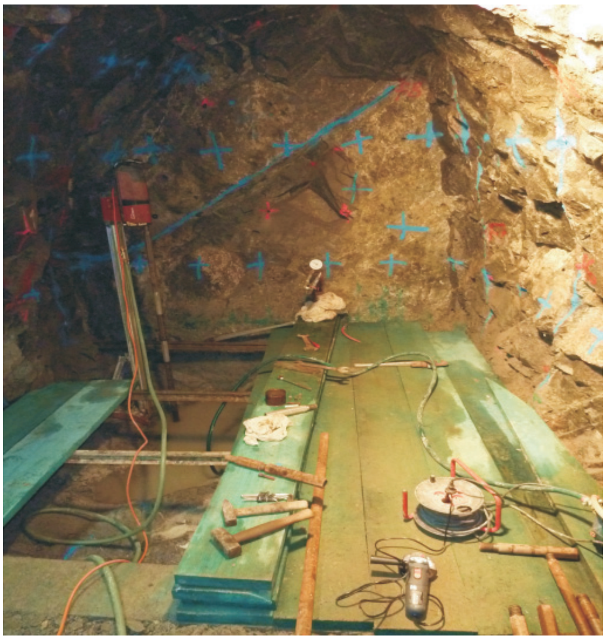

Figure 1 – Gallery SP-47, URC Josef.

IMPLICATIONS FOR THE PROJECT PLANNING

Following aims of the project: location, diameter, orientation and dip of the boreholes were discussed within the research team. Methodology and sensor requirements were taken into account as well. Large diameter (850 mm) horizontal borehole was decided to be situated in the centre of the gallery's head. Ten thin (60 to 76 mm in diameter) boreholes were placed in head and walls of the gallery surrounding the central borehole.

Analogical model of the planned boreholes was prepared using ArcScene. All three models (the gallery model, the structural model and the borehole model) were merged into a site descriptive model of the experimental locality (Fig. 2). The site descriptive model of the experimental locality provided localisation of boreholes stored in attribute table (x, y, z, trend, dip, length, diameter). For drilling companies this information is in combination with 2D view of borehole localisation sufficient enough to place the boreholes precisely.

The site descriptive model also provided a basis for an extensive project conception. The conception includes localisation of boreholes and sensors, enlists planned methods and specifies methodology.

During drilling new data were gathered. Core description and optical borehole inspection extend knowledge of the local granite characteristics and fracturing. Consequently additional in-situ tests are planned to describe hydraulic, geomechanical and chemical characteristics of the experimental locality. Thermal, geomechanical, hydraulic, petrological and chemical properties of the core samples are tested in laboratory. Both the research conception and site descriptive model of the experimental locality were kept up to date using learned facts. Finally, sensors for monitoring rock temperature, stress conditions, strain, hydraulic parameters and acoustic signals during the in-situ experiment were installed in the thin boreholes and on the gallery's head surface. Again the positioning was discussed over the actualized 3D site descriptive model of the experimental locality.

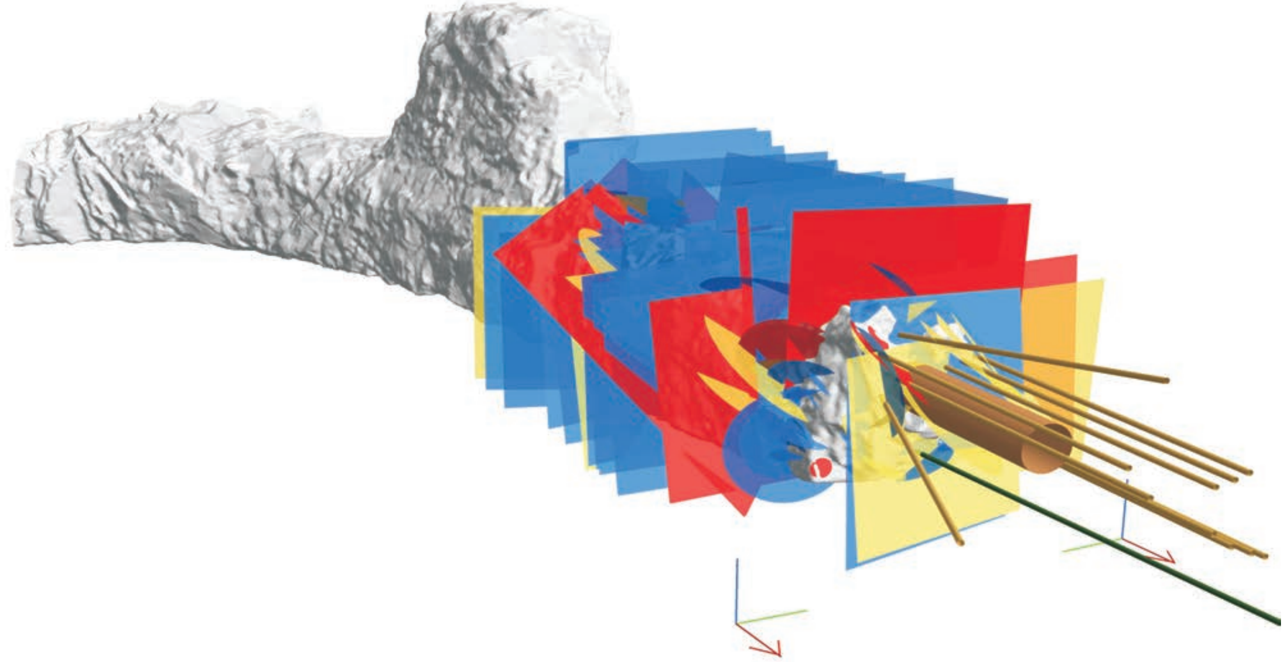

Figure 2 –Site descriptive model of the experimental locality including fracture net and boreholes.

LESSONS LEARNED

- User friendly environment of ArcScene and detailed visualization of a locality allow planning of sophisticated drilling without technical drawing knowledge.
- The VRML data format enables colleagues without GIS licence to work with a model.
- 3D visualization of the experimental locality simplifies sharing information within research team and the planning process of the research significantly.
- Combination of 3D laser scan, photodocumentation and structural geological survey provided a reliable information for inicial planning of the project.

ACKNOWLEDGEMENTS

We are grateful to the Ministry of Industry and Trade of the Czech Republic (FR-TI3/325) and our colleagues from the Arcadis Geotechnika Corp., Institute of Rock Structure and Mechanics Academy of Science of the Czech Republic, v.v.i. and the Technical University of Liberec. We thank the Centre of Experimental Geotechnics, Czech Technical University for hosting the project in the URC Josef Facility.

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ECONOMIC POTENTIAL OF GEOTHERMAL AREAS IN NORTHWESTERN ROMANIA

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KEY WORDS: Romania, Pannonian Basin, economics, geothermy.

ENVIRONMENTAL FRAMEWORK

The use of renewable energy in economy and geology has shown a remarkable resilience to changes in the environment, being one of the major targets, worldwide. However, all the natural changes in our environment occurred over extended periods of time and affected the human population while affording them a large natural buffer to adapt to, in close relation to available natural resources. The adoption of renewable energy resources implies the need for careful consideration of their relationship with the territory and the local scale (Bagliani *et al.*, 2010).

The call for a sustainable development of economic growth in the parameters of a protected environment was born out of conflicting realities. While, on one hand, economic expansion is crucial to attack the problem of widespread poverty, on the other hand, environmental quality has been deteriorating as economic activity expanded.

While there has been wide acceptance of the global agreements and strong compliance with them, a global cooperation mechanism for solving environmental problems through demonstrating the ability of markets to respond to global environmental problems has been defined (Speth, 2006). Many environmental problems now extend well beyond the local level, sometimes even threatening our planet's life-support systems. An integrated environmental policymaking and management framework concerning the tasks of a shared global ecosystem consists in the exploration for geothermal resources (Clapp & Dauvergne, 2005). Within this broad framework, the practical application of thermal water resources is being pointed out in boreholes drilled over the territory of Romania.

GEOTHERMAL AREAS IN NORTHWESTERN ROMANIA

Our area of interest concerns a sector of the eastern margin of the Pannonian Basin, in northwestern Romania. These main Romanian geothermal resources are located either in porous permeable multilayered formations (upper Miocene – Pontian - sands sealed by clays and shale), or in fissured and fractured collectors (Triassic and Cretaceous limestone and dolomite; Butac & Opran, 1985). The first ones belong to the Pannonian Basin Cenozoic molass filling, while the second to its older basement (Carpathian Inner Dacides; Săndulescu, 1984). This basin is notorious for its anomalous geothermal areas and heat flows due to the thinner Earth crust and astenosphere's upwelling (Demetrescu, 1982, Veliciu et al., 1985). Several known geothermal areas are exploited in the sector of our interest, as Săcuieni (Miocene) or Felix-1 Mai, Oradea and Borş (Mesozoic limestone and dolomite; Ţenu, 1981).

DIRECT USE OF GEOTHERMAL ENERGY

Direct use of geothermal energy from geothermal reservoirs, which are located a few thousand of meters deep in the above-mentioned rocks, is done as direct heating. The geothermal waters exploited from this area are classified as low enthalpy waters (50-120^{0}C; Ţenu, 1981). These temperatures are not suitable for electricity generation, but only for direct use like space and district heating, bathing, greenhouse heating, industrial processes, fish farming or animal husbandry. Sustainable economic environmental development is undergoing a new shape by expressing its interdisciplinary features over its economic, social and environmental dimension.

The economic dimension consists of the growth and maintenance of capital, resources and investment (Faber, 2008), while the social one is incorporating social equity and cultural identity, institutional and moral issues that have an important role in ensuring a balanced relationship between human activities and environmental issues, meanwhile the environmental dimension summarizes the elements that define the quality of ambient air, water, dwellers and environmental resources used by humans (Negucioiu & Petrescu, 2006).

By looking at the results over the analysed horizon, it is clear that the utilisation of district heating systems has a positive economic impact.

All market players, like the municipalities, citizens and enterprises, will have a relevant net benefit, out of the net present value of the projects implemented for district heating. The pillars in our area of concern, the northwestern part of Romania (Săcuieni, Marghita, Oradea, Livada, Borș, Felix-Băile 1 Mai, Beiuș), are Oradea and Beiuș, which supply a revenue of 6122053.7 lei and 1709471.7 lei, from a yearly production of 73344.36 Gcal respectively 25510.696 Gcal.

CONCLUSIONS

Geological ecological economics aims to study how ecosystems and economic activity are able to interrelate in a sustainable and scientific way, dealing explicitly with the constraints of nature and the acknowledgments that there are in reality limits to the growth of real income (Baumgärtner *et al.*, 2008).

The feasibility of supplying energy by means of geothermal energy in an ecological, sustainable, reliable, renewable and even profitable way is the topic of this work. Despite the large potential of geothermal energy it only supplies 0.4 % of the world's energy demands.

An important task for us is to promote geothermal energy, its various applications, and the many geological, environmental and economical benefits it carries.

In Romania, illustrative case studies are the ones of the eastern margin of the Pannonian Basin and its orogenic basement of the Inner Dacides. The fractured and fissured Mezozoic rocks of the Inner Dacides, as well as the upper Neogene (Pontian) sands are beraing geothermal waters suitable for direct use, exploited in some known geothermal areas as Săcuieni, Borş, Oradea, Felix-Băile 1 Mai.

The environmental sustainability in terms of economic benefits is considered to be high when the local geothermal energy resources in the operating district heating systems in the localities Săcuieni, Marghita, Oradea, Livada and Beiuș has been exploited in a small scale and their feasibility has been analysed for years, and is well known. While the capacity installed is up to 1.84, 2.01, 21.46, 2.43 and 20.33 MWth, the annual energy used is 5.79, 1.44, 426.83, 1.61 and 108.22 TJ/y.

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GIS-MAPPING MODEL OF LOW ENTALPHY GEOTHERMAL POTENTIAL IN SOUTHERN ITALY (VIGOR PROJECT)

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KEY WORDS: GIS, geoexchange potential mapping, VIGOR.

INTRODUCTION

The Geographical Information System is a powerful tool for visualizing, integrating and interpreting ground information. In this research GIS is used to determine a low enthalpy geothermal potential map of the Regions of Convergence in Southern Italy.

The aim of the study is to create a digital cartographic instrument that can be easily accessible and upgradeable to synthesize geological knowledge of the underground and that help territorial planning and environmental control.

Low enthalpy geothermal resource is a renewable energy taking advantages from ground fixed-temperature using ground source heat pump systems (GSHP). Knowledge about the factors that influence the efficiency of this technology has to be supported by a cartographic tool because of the need for a regional evaluation of power potential of this resource.

Within the framework of the VIGOR Project, a characterization of low enthalpy geothermal resources will be carried out in Sicilia, Calabria, Campania and Puglia regions.

Our research wants to suggest a methodological approach able to define the parameters that mainly influence “geoexchange” ground ability. Geological, hydrogeological and thermodynamic properties are shown in digital thematic maps that will be combine to determine a synthesis map: geothermal potential map.

Puglia and Calabria are the first regions studied, they have different geological and hydrogeological settings.

DATA ANALYSES AND GIS MODEL

In Italy, the diffusion of GSHP systems have to be supported by appropriate technical-scientific information which can define the territory ability to thermal exchange.

The analyses is based only on public available data, generally accessible but of different source.

It is necessary to collect and organize data in a synthetic digital database to create a digital underground map (Figure 1) and to spread results.

To present a significant low enthalpy potential map, the main features that influence the underground behavior have been identified. They include geological properties: grain size, lithology and stratigraphy; hydrogeological properties: water saturation of the ground and groundwater velocity; thermodynamic and climatic parameters: annual mean temperature of the air, thermal conductivity of involved materials, geothermal heat flow and gradient.

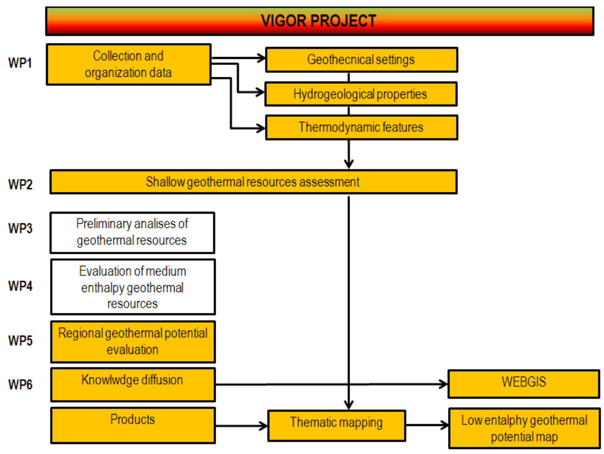

Figure 1 – Scheme of the Work Packages of VIGOR Project.

Maps	Puglia	Calabria
DEM	x	x
Geological maps	x	x
Hydrogeological maps	x	x
Well data		

Figure 1 – Scheme of necessary data.

In order to obtain a significant low enthalpy potential map, some thematic maps have been realized in GIS environment to achieve an underground model finalized on geothermal exploitation. The thematic maps are : annual mean temperature of the air; thermal conductivity map based on lithological and stratigraphic information; groundwater assessment; constrain areas map; geothermal heat flow and gradient.

The thematic digital maps that will be considered the most significant will be combine to generate the geothermal potential map in a worldwide format.

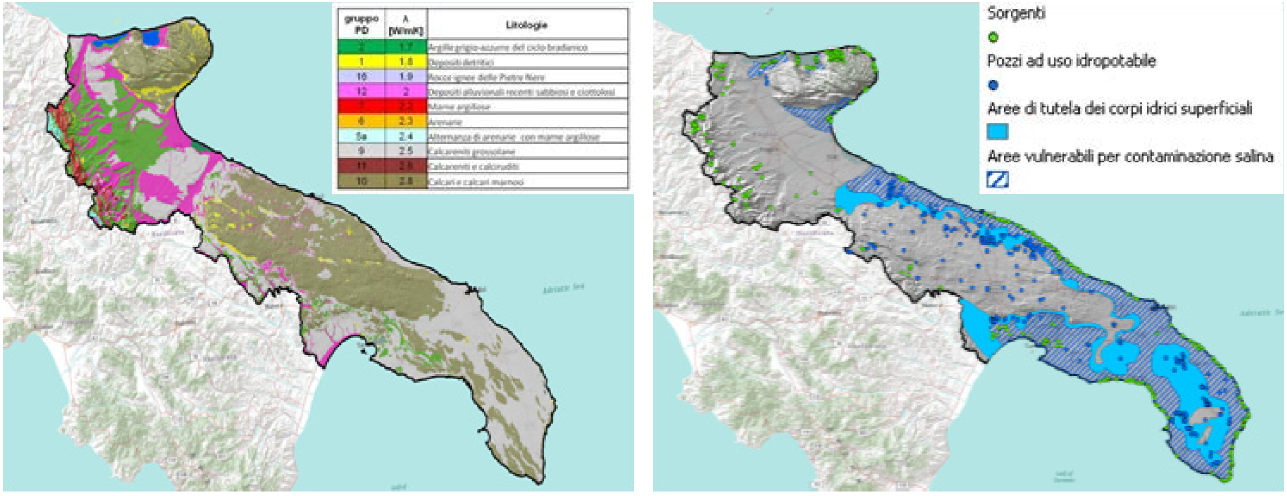

Figure 1 – An example of thermal conductivity map and of constrain areas map.

RESULTS

The aim of the low enthalpy geothermal map is to suggest suitability zone, classified in high, middle and low potential.

The thematic considered maps will be: thermal conductivity map based on litological and stratigraphic information; constrain areas map; geothermal flow map.

To organize as well as possible zoning of the geothermal potential, every map will be classified giving different geo-exchange ability values.

The final map represents ground characteristics on geoexchange prone areas and is the result of the proper arrangement of thematic maps. The restrictions e.g., in case of protected groundwater resources must be followed.

The resulting potential maps are useful tools to highlight convenient areas for low enthalpy geothermal energy use. They can probably give support to policy makers for decisions concerning increasing promotion or subvention of GSHP technology.

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EVALUATION OF A DISCRETE FRACTURE NETWORK (DFN) MODEL AND COMPARISON WITH FRACTURED CARBONATE OUTCROPS, MONTE CONERO, ITALY

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KEY WORDS: Discrete Fracture Network Model (DFN), 3D Stochastic Modelling, Fracture maps, Fluid circulation, Fractured carbonate outcrops, Mechanical fracture types.

INTRODUCTION AND METHOD

Characterization of fracture geometry and distribution is important for understanding fluid flow in fractured reservoirs and aquifers with applications in hydrology, petroleum- and mining engineering, storage of CO_2 and the use of geothermal energy. Because it is impossible to characterize every single fracture, modelling of fracture networks with Discrete Fracture Network (DFN) models (Jing, 2003) may be used, combining stochastic modelling, Monte Carlo simulations and fracture properties measured for example on outcrops of rocks (e.g. Massart *et al.*, 2010). FracSim3D, elaborated by Xu & Dowd (2010), is one of the available programs which offers representations in two and three dimensions and statistical tools for the analysis of the results.

The aim of this study is to compare the results of DFN modelling using FracSim3D with a map of a fractured carbonate outcrop. This evaluation is made in terms of the geometrical, mechanical and hydraulic properties of fractures, such as, length, connectivity, orientation, position and structural typology, in order to define the accuracy of the model for a fluid flow analysis.

The use of Geographic Information System (GIS), Excel macro-script and field-work data, was combined to create the input for FracSim3D. Fracture properties including orientation, length, opening and fracture type, were measured during field work on exposures of Mesozoic fractured carbonate outcrops near *Monte Conero* (*Le Marche* Region, Italy). In this sense *Monte Conero* serves as an analogue for a fractured carbonate aquifer or reservoir.

RESULTS AND DISCUSSION

Five different structural discontinuities have been observed on the outcrops of *Monte Conero:* veins, stylolites, joints, faults and breccias (as pockets and elongated areas). Figure 2 shows a map of an outcrop with three principal sets, one set of veins, one set of faults and one set of joints. They all appear open fractures which represent potential pathways for fluid flow. Each set has a different orientation, which allows to generate a connectivity network. However, the fracture length is finite and this creates voids into the network. Pockets of breccias, formed by small segments of rocks (from 1x1 cm to 10x10 cm), are also part of this outcrop. Stylolites occur along horizontal planes, but in agreement with Antonellini & Mollema (2000), Mollema & Antonellini (1998) and Schultz & Fossen (2008) these fractures have been ignored, since they are thought not to contribute to fracture permeability.

The methodology is summarized in the following steps:

- Digitalization of fracture traces from a photo-mosaic of an outcrop using a Geographic Information System (GIS), in our case ArcGis 9.3, and taking the properties of these lines, i.e., coordinates and length.
- Fracture properties, previously separated according orientation and fracture type, are prepared as input for FracSim3D through a statistical model. Lengths and orientations are organized in the self-elaborated macro-script for histograms (non-parametric model) while locations are represented in dispersion graphics to define their distribution model (generally it is a homogeneous Poison model).
- Simulation on FracSim3D of each set of fracture type (Figure 1).
- Definition of a virtual plane which intercepts the 3D simulation domain (a unitary cube, Figure 1), in the same position of our original fracture map. From this plane the fracture traces (Figure 3) are generated and compared with the original fracture map.

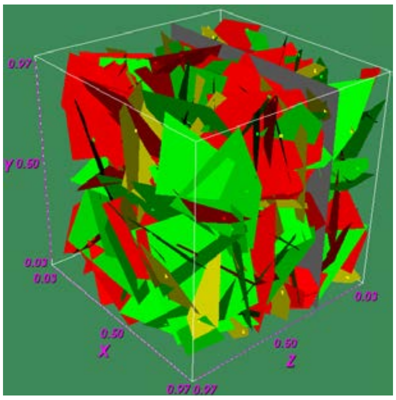

Figure 1 – Fracture sets represented in the 3-D simulation domain in FracSim 3D. The grey plane represents the virtual plane of simulation (X=0, Y=1 and Z=0.3). The red, green and yellow planes represent the fracture sets, whose symbology is the same that in Figure 2 .

Figure 3 shows a simplified representation of the fracture network, achieved through FracSim 3D. The different fracture sets can be distinguished as on the original map, although the fault set is horizontal in some areas of the simulation. The fracture properties and hydraulic parameters are altered. Fracture lengths have increased and the discontinuity of fracture traces is not represented, except in the upper left part of the map. Pockets of breccia could not be represented by the model. The simulated increase in fracture length also increases connectivity. However, the resulting decrease in the fracture density is a factor that reduces the probability of circulation of a fluid.

In general, the model has some difficulties to represent accurately small or very big areas, like pockets of breccia or the original dimensions of an outcrop. For this reason it is better to use the unitary cube for the simulations.

The problems associated with changes in fracture density can be resolved creating as many simulation domains as is necessary to represent the different levels of concentration of fractures, as we have proved with studies on other outcrops. However, this method does not guarantee the connectivity between the simulation domains and can generate conditional results.

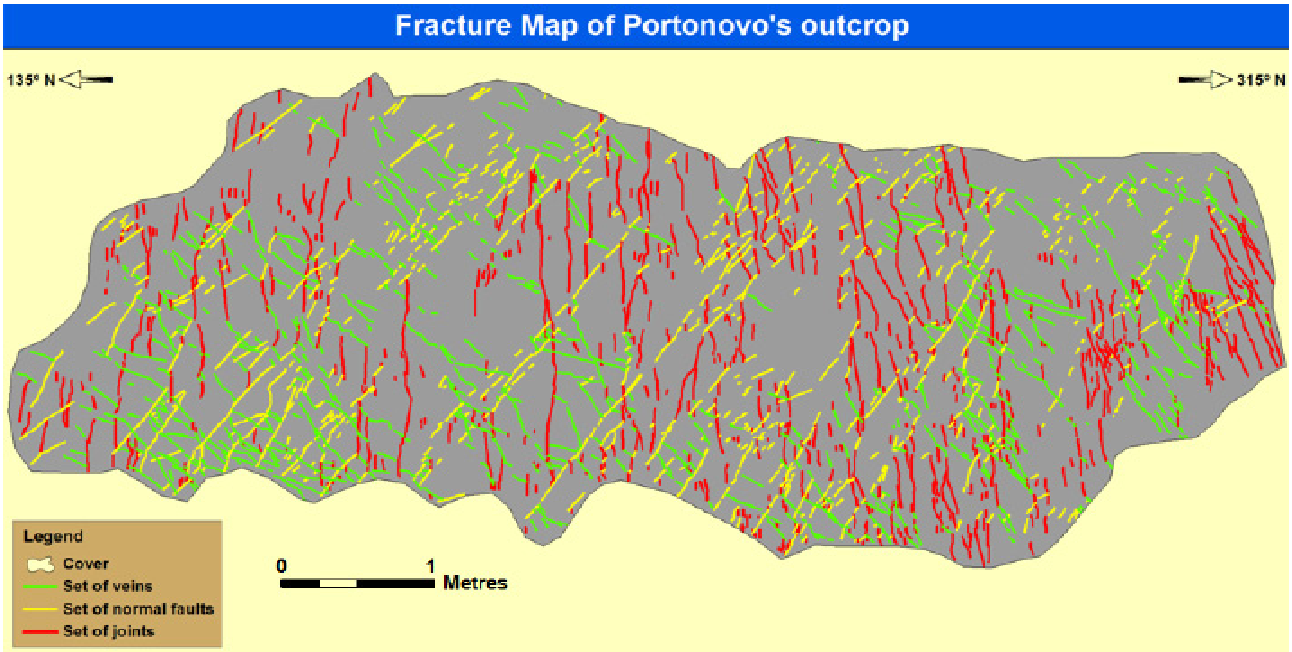

Figure 2 – Original fracture map of fractured Carbonate outcrop (Portonovo, Monte Conero, Italy)

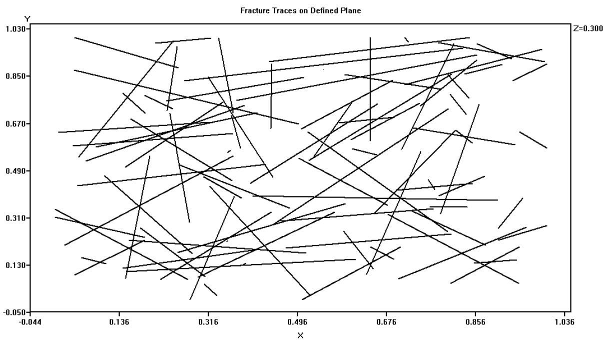

Figure 3 – Simulated fracture map elaborated on FracSim3D

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LITHOLOGIC IDNETIFICATION AND ITS EFFECT ON RESERVOIR CHARACTERSTICS FOR ABU ROASH FORMATION AT EAST OF BENI-SOUF AREA, EGYPT, BY USING WELL LOG DATA.

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KEY WORDS???

The Members C,E and G are made-up of calcareous rocks with arenaceous interbeds,.Some of the crossplot are used to determine the lithology which is mainly shale ,limestone ,sandstone ,and some anhydrites .Through a number of computer programs, based on the simultaneous equations ,an analytical way is used normally for accomplishing this target.

The area of study lies to the east of Beni-Souf city which is located to the north of Upper Egypt, where six wells is located(EBS-7X ,EBS-8X, EBS-6X, EBS-4X, EBS-3X,and EBS-2X).Abu Roash Formation represents one of the upper rock units of Cretaceous section, and is subdivided into seven members termed informally as A,B,C,D,E,F and G member, the Members A,B,D and F are mainly composed of calcareous rock with argillaceous intercalations .

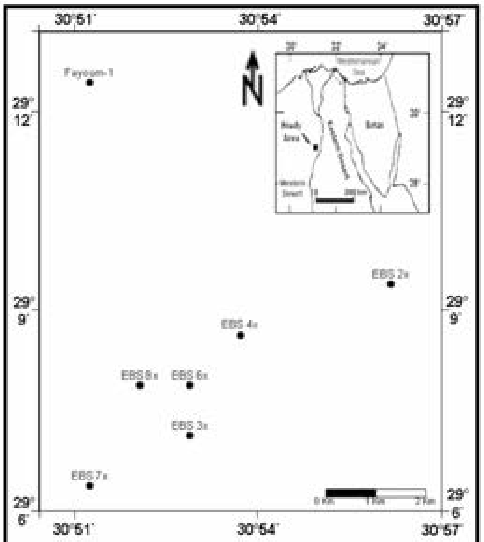

Fig. (2) Well location map of the study area.

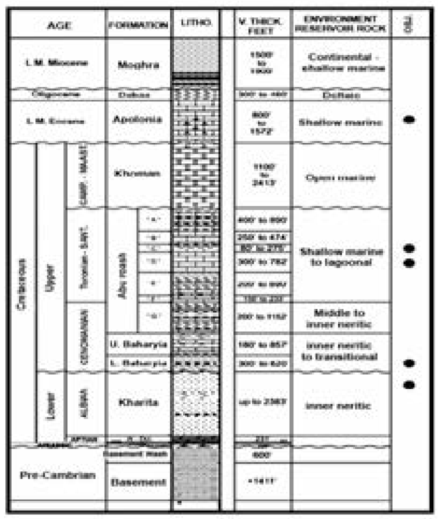

Fig. (3) lithostratigraphic column of the study area.

The lithologic percentages are represented laterally in the form of isoperimetric maps.The clay minerals present in a rock unit are a complex factor, which affects the reservoir characteristics. Their effects depend not only on the percentage, but also on the type and distribution.

INTRODUCTION

LITHOLOGIC MODELING
VOLUME OF SHALE DETERMINATION:

1- Methods of Shale Determination:

A – Gamma-Ray method:

B – Neutron method:

C – Resistivity method:

Correction of Shale Volume: (***Clavier et al.*, 1971**) $V_{sh} = 1.7 - \sqrt{3.8 - (\chi + 0.7)^2}$

The second formula is :

$$V_{sh} = \frac{0.5\chi}{1.5 - \chi}$$

(***Steiber, 1973***)

Shale distribution map for Abu Roash Formation:

Figure (16) shows the shale distribution map for Abu Roash Formation, where it reveals a gradual increase toward the northeastern side of the area, while the minimum values are observed at the southwestern direction .

***MATRIX IDENTIFICATION:**-2*

By this way, at first, three equations are formed according to the log types mentioned formerly, as follow :

For sonic :

$\Delta T = \phi\ \Delta T_f + V_1\ \Delta T_{sh} + V_2\ \Delta T_{silica} + V_3\ \Delta T_{carb.}$

For neutron :

$\phi N = \phi\ (\phi N)_f + V_1\ (\phi N)_{sh} + V_2\ (\phi N)_{silica} + V_3\ (\phi N)_{carb.}$

For density :

$pb = \phi\ p_f + V_1\ p_{sh} + V_2\ p_{silica} + V_3\ p_{carb.}$

Some modifications areapplied, where (V_4) is added to calculate the anhydrite fraction. When the log types (known data) are less than the unknowns (mineral volumes), the case is called underdetermined, then the matrix solution for the least-squares model becomes:

$V = C^T\ (CCT)^{-1}\ L$

A computer program was established by ***(Abu El-Ata `and Ismail, 1985)*** to achieve the matrix identification process.

CROSSPLOTS TECHNIQUES

Neutron-Density Crossplots for Abu Roash Formation:

M and N Crossplots for Abu Roash Formation:

Limestone distribution map for Abu Roash Formation:

Generally, the limestone distribution map of Abu Roash Formation shows high percentage of limestone in the middle part of the area, at EBS-6X well and decreases gradually outward of the area (Fig. 17).

SANDSTONE DISTRIBUTION MAP FOR ABU ROASH FORMATION:

The sandstone distribution map of Abu Roash Formation reveals high percentage (32.5 %) for the sand at EBS-3x well that decreases gradually toward the northwestern,northern and northeastern directions (Fig.18).

ANHYDRITE DISTRIBUTION MAP FOR ABU ROASH FORMATION:

The anhydrite distribution map of Abu Roash Formation shows that, the anhydrite increases toward the western direction and decreases toward the eastern direction at EBS-4X well (Fig.19) .

SUMMARY AND CONCLUSIONS

The area of study lies to the east of Beni-Souf area and is located to the north of Upper Egypt, where six wells are distributed(EBS-7X ,EBS-8X, EBS-6X, EBS-4X, EBS-3X and EBS-2X). From the cross plot technique, it can be conclude that the common lithology in Abu Roash formation is mainly shale, limestone, sandstone and some of anhydrite. The shale volume is determined through a lot of mathematical equations, but the other approach through the computer programs based on the simultaneous equations. The lithology component is illustrated through some iso-perimetric maps. The shale distribution map of Abu Roash Formation shows an increase toward the north eastern part of the area, while the minimum values are observed toward the southwestern direction. The limestone shows high percentage toward the middle part of the area at EBS-6X well and decreases gradually outward of the area. The sandstone reveals high percentage (32.5 %) for the sand at EBS-3x well and deceases gradually toward the northwestern, northern and northeastern directions, while the anhydrite shows increasing toward the western part and decreasing toward the eastern side at EBS-4X well . From the above mentioned, it can be concluded that, the western part is suitable for exploration of oil than the eastern part, because the percentages of sandstone and carbonate are increase toward the western part of the area.

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ASSESSMENT OF THE SUBSIDENCE IN INTERNAL MALIQI DEPRESSION USING GEOPHYSICAL METHODS

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SUMMARY

This study have covered the former Maliqi Swamp which of point view consists of the Quaternary overburden formations (Q_{1-4}) and the Upper Neogene, concretely not differentiated Pliocene and Pliocene-Quaternary (N_2-Q_1) formations The main objectives (intention) are:

- Investigation of the subsidence phenomenon, which may lead to the gradual formation of the Maliqi Swamp.
- Locating on eventual second turf layer under the known one and its control with integrated methods.
- The monitoring of the subsidence phenomenon

To achieve a good result for above the objectives there have been used geodesics, geological and geophysical (VES) methods. The integrated interpretation of geodesic and geogolical-gephysical date allowed drawing the following main conclusion:

- VES do not indicate the presence (at least up to70-80m) of e second turf layer; this is not a definitive conclusion. This conclusion can be verified by drilling up two holes 50m deep.
- The youngest formations (swampy ones) are about 30-35m thick and composed of two fine grained argillaceous layers and two sandy-argillaceous layers.
- The Maliqi Depression has been constantly having subsidence, at least since the swamp started to get dried out. In the period 1952-1977 the monitoring showed a vertical dipping from 0.5-3m.

Keywords: Maliqi Depression, turf, Electrical sounding, subsidence.

INTRODUCTON

Investigations were concentrated in an area of about 120km^2 from Zvirine-Podgorie Line in North to close to the Vashtemi-Shamall Line in South, which is the ex-swamp of Maliqi. Geologically the area is mostly made of the Quaternary overburden and the Neogene (Pliocene and non-differentiable Pliocene-Quaternary) formations. The Korça and Maliqi Field represents a graben-like structure, which has regionally been part of the internal depression of Marital tectonic Zone, more precisely of its southern part (Fig.1)

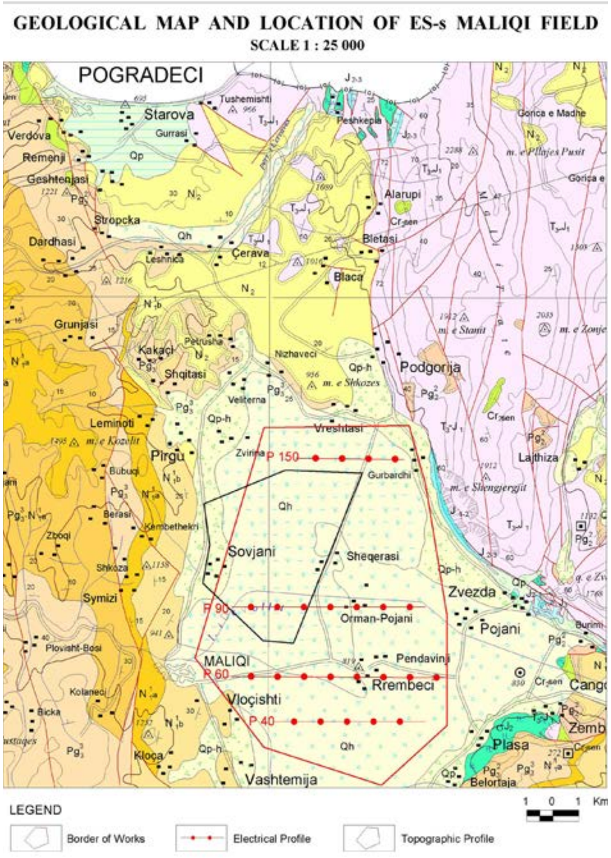


Fig. 1

MAIN OBJECTIVES

Main objectives of our study are as follow:

1.Investigation of the subsidence as a threat for gradual reformation of the Maliqi Swamp

2.Establishment of a monitoring network to control the subsidence dynamics

3.Exploration for an eventual turf layer under the known and already geologically explored one.

To achieve the two firts objectives we have used geodesic methods, while to achieve the third one we have applied both geological and geophysical (electrical soundings) method.

FIELD PROCEDURE

To achieve the two first objectives the following procedure has been applied:

1. Establishment of base polygon (high accuracy system of reference on the "stable" par of terrain, not affected by phenomenon of subsidence)
2. Accomplishment of measurement on open polygons on some lines of the investigated area
3. Selection and determination of some points in the "stable" and field part of the surveyed network which will be monitored in future. This field procedure is only acceptable in our actual conditions; otherwise the satellite system are used in such investigations

About electrical soundings (Schlumberger) in grid of 1000x500m have been carried out in the investigated area to explorer for turf formations not deeper than 100m to the surface. The following has been derived from the interpretation of these soundings:

a. Geoelectic sections for lines 150-40
b. Map of thickness of the turf layer (using and results of drill logs)
c. Map of thickness of the swampy sediments.

RESULTS OF THE STUDY

Some soundings were carried out close the previously drilled holes, which have intersected the following, section (after 20-25cm section has been build up based on the results of soundings)

- -Overburden 3-5m
- -Turf layer 3.8-10.2m thick, turf being not well formed, chumbly, brown, a little humid, easily oxidizable in the air, with calorific power of 1600-2400kkal
- -Turf layer 2-5m thick, turf being compact, dark brown, a little humid, quickly oxidizable, with calorific power of 3200-4000kkal
- -Fine-grained argillaceous layer, 10m thick
- -Argillaceous layer with sand, 10-15m thick, with resistivity of 15-25 ohm
- -Fine-grained argillaceous layer, 10-30m thick, with restivity of 5-8ohmm

Argillaceous-sandy layer, with resistivity over 20-50 ohm, thickness being undetermined due to the limited depth of investigation of soundings carried out in the area. This last layer might be the floor (basement) of the swampy formations.

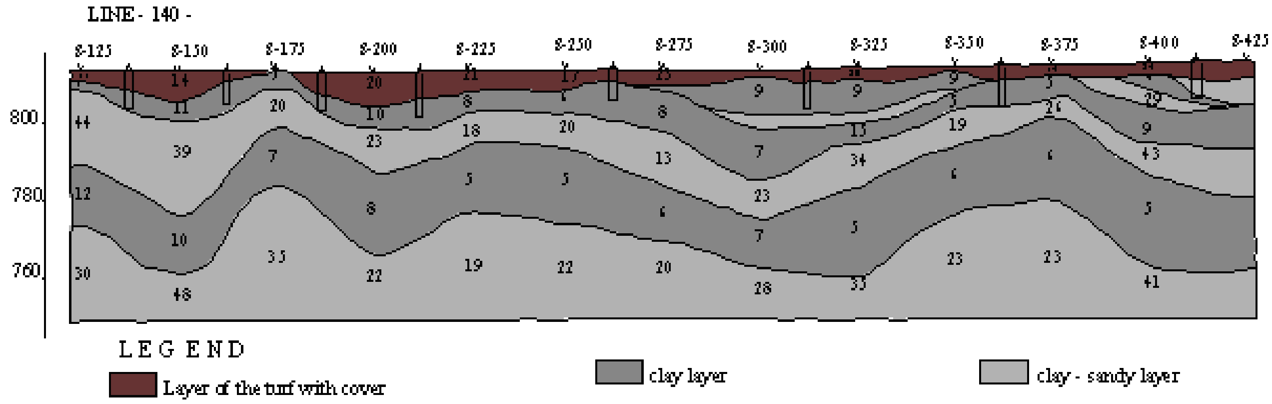
THE ANALYSIS OF WORKS

Based on the above logic by facing data of geological prospection to the sounding experimental data as was treated above, was done the interpretation of all carried out sounding in Maliqi Field. The analyses of works are done for every profile beginning from profile 150 north up to profile 40 south.

Profile140

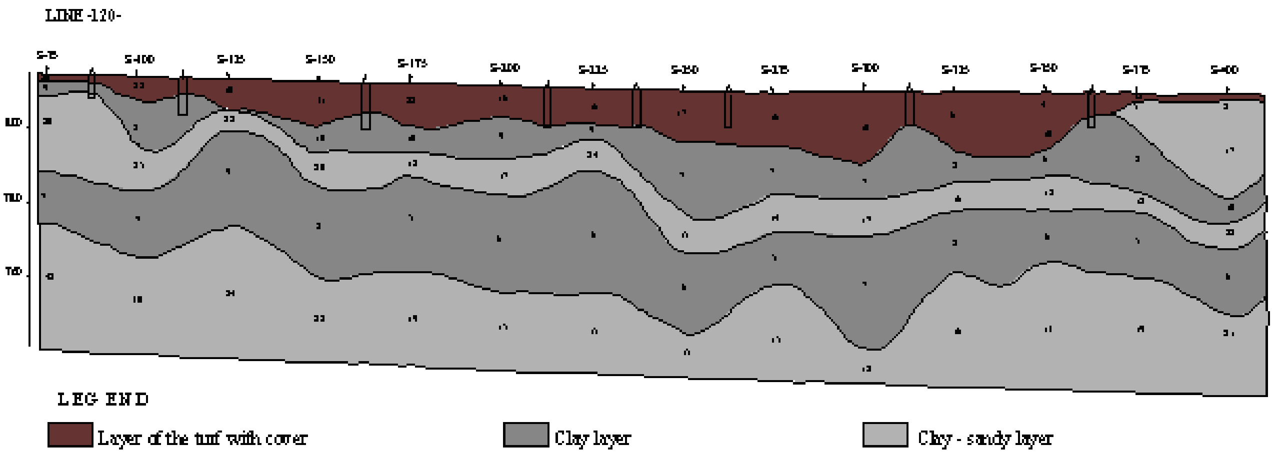
According the accordance of shallow drillings date, curried out by Korça Geological Enterprise in turfs, it is noted that turff bed is almost in the surface. It appeared on the surface from Es 175 up to ES 375. To the weas is ES 175 and more eastern to se 375, it is covered by a clay-sand of maximum thickness 10m. In fact must be noted that to the west of ES 175 and the east of ES 375 turff bed practically is going to be thinner or do not exist. Inside the interval Es 175-375, turff bed is clearly seen by two noted laminations of electrical resistance from 9 up to20ohm (lower post) and by the other bedding of resistance from 4 up to 14 ohm. These two laminations separated by noted electrical resistance, represent:

The bed of lower resistance represents marsh turff or clay-turff bed, while the bed of the higher resistance represents the true turff bed. As it is seen in the section, below the turff bed it is placed one clay bed of thickness from 3 up to 15m of electrical resistance which varies from 5 up to 10ohm. Below this bed is another bed of high electrical resistance which varies from 20 to 44ohm. This is clay-sandy bed of thickness from 10-20m. Below this bed is placed another one clay bed of resistance which varies from 5 to maximum 10ohm and has thickness from 15 to25m. This bed is fixed in all profiles measured by electrical sounding. According to the representative electrical resistance, this bed must be constituted by solid clay, no penetrated by water. We think that this bed, distributed all over Maliqi marsh (Judging by ES curried out up to day) it is geological view which influenced to the formation of the Maliqi marsh. Below this bed is one sandy-clay bed or clay-sandy bed of electrical resistance from 20 to 54ohm. Commonly, this bed is not penetrated by electrical sounding. Electrical sonds did not pas the depth more than 70m. Turff bed outcrop on the surface, as we told above and is oxidized intensively, accompanied with its burn. This is one of the reasons of Maliqi Field subsidence. In photo nr.1is showed local subsidence, expressed with depression of area where is rood, the bridge of which was deep basement, is placed just at the level of its construction. In photo 2 near the bridge is shown the plain where the turff is burnt and is seen ash on the surface. In photo3, 300 m to the west of the bridge, near ES 300 it is seen turff bed burning on the surface.



Profile120

In this profile, it is the same view, concerning the turf bed as in above profiles. Turff be is closed to the west around ES 100, while to the east is closed between ES 400 and 425. Electrometrical data are the same as in above mentioned profiles. Below turff bed is clay bed of thickness from 1-3m up to 18m. Below it is clay-sandy bed of thickness from 5 up to 25m (on the edge of the marsh). Below this bed is clay bed of thickness 10-30m and it as usually is clay sandy bed no penetrated by ES. In this profile, 250m south of Es 300 of profile 130 it is another bridge(photo 4), remained in the situation of the first building place, while the area around it is dropped by subsidence. Just in this proper, of about 200m north of ES 250, it is seen turff bed which is burning (photo 5). In photo6, 7 and 8 these are presented opened channels by farmers which bordered the distribution of the fire.



CONCLUSIONS

From the description of Geological-Geophysical Sections, which are in correlation with the geological map and with the performed complex studies as well, we concluded in the following results:

1. The survey with Vertical Electrical Soundings (VES) has detected the turf outcrops layer which in some parts is covered as it is shown in geological map and in the thickness map of the turf layer as well.

2. The VES carried out in this region do not depict the presence of a second turf layer, but this conclusion is not definitive.

The presence of this second turf layer must be verified or not, above the second clay layer. This ambiguity rises up from the fact that, the presence of a second turf layer with a thickness 10 m, is not detected by VES as a result of the equivalence principle on resistivity values interpretation. For this reason, the detection of this layer must be done with one or two drillings of 50 depths, close to profiles 120 and 140 around the VES points 250 and 300.

3. The new geological formations (swampy ones), have a thickness up to 30-35 m. They are composed of two fine clay layers. The upper layer is underlain to the turf layer and the second one which is thicker might be underlain directly to the possible turf layer. Between and below those layers the geological formation is composed from clays of some sand composition.

From these results we conclude that the depth of swamp at the firs stage of its creation was not more than 30 m.

4. During the early stage of Pliocene-Quaternary geological age, the field had the shape of a lake and the depth has been bigger. This fact can be seen on some profile sections such as 70, 90, 100, 110 where in the geological formations at which the VES method has not penetrated, some fine clay layers of lenses shape are detected at depths 70-90 m.

5. Maliqi field has constituted in a continuance subsidence since the swamp started to be dried up. From the geodetic monitoring, during the years 1952-1957 (fig 7), it is observed a vertical subsidence from 0.5 m up to 3m. The geodetic studies carried out during the years 2001-2002 has shown that the Maliqi field vertical subsidence compared with that of the year 1978 is from 0.6 m up to 2m and in some parts such as Zvirine and Nishavec regions is up to 3m. During the 2001-2002 periods this geological phenomenon is almost unpredictable but we can say that the monitoring period is too short as well.

6. From the results of this study we conclude to the fact that, the subsidence phenomenon in the region has two main causes:

a) The outcrops of the turf layer or close to the surface get oxidized and burned in contact with air. This phenomenon causes that almost the half of the mass is distributed on the shape of volatile elements or as hash from the atmospheric agents. Some rough calculations, has depicted an annually depression of Maliqi field in the range of 2-3 cm. As a consequence, if this burning phenomenon in this field will continue, the subsidence during the future 50 years will be 3 m.

The turf burning process has happened as a) consequence of the ecosystem disequilibrium (swamp dryness) and form the destruction of the irrigation system of the field as well.

b) The second factor of the subsidence which is also related to the ecosystem.

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DEEP MODELING OF THE MINERAL COMPOSITION OF THE LITHOSPHERE ACCORDING TO PT-PETROPHYSICS DATA AND DSS MATERIALS

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KEY WORDS: Elastic wave velocities; density; petrophysics; high pressure, temperature; thermobaric model.

GENERAL STAGES OF MODELING

In setting up petrovelocity models the determinative parameters are the velocity and density characteristics of the rock samples of different complexes taken in the upper crustal horizons and studied in laboratory deep PT conditions as well as the regional DSS information and the gravimetric data.

Consider some features of methodical means of petrovelocity thermobaric modeling. At the first stage the reference DSS data are analyzed blockwise along the geotraverse considered with constructing respective velocity columns and are subdivided into different-gradient parts. Then surface analogues of the prognosed deep mineral formations are selected with considering geologic-structural peculiarities of the study region and the detected most characteristic rocks at the surface along the defined profile sections. The rock samples are studied in the programmed PT conditions that correspond with their distribution in the Earth's crust of the region. Further, using the method of comparing velocity characteristics of some rock samples and seismic sounding data, rock are selected in separate horizons with similar values of their velocity and their analogous changes with depth. Thus, the seismic section is transformed into a primary lithological model. A method of thermobaric modeling has been applied to obtain a cross-section of rocks distribution with depth along the central part of the IV DSS geotraverse intersecting several low-velocity zones (LVZ) [Korchin, 2010, 2011].

MODELING RESULTS

After the statistical processing of the information on the elastic wave velocity distribution in the samples at atmospheric pressure and under the effect of high hydrostatic one, the respective groups of samples simultaneously studied at the P and T effect were selected. In these studies pressure and temperature are as mentioned above, changed according to the PT-program of possible regional change of these parameters with depth. According to the conditions of the experiment, a rock sample seems to "plunge" gradually to the preset depth and simultaneous measurements of the V_P, V_S and the volume decrement are made [Korchin, 2009].

The experiments show that the V_P,V_S=f(PT)=f(H) dependences have complicated regularities: on the curves velocity inversion zones with maxima and minima manifestation are marked (Figure 1).

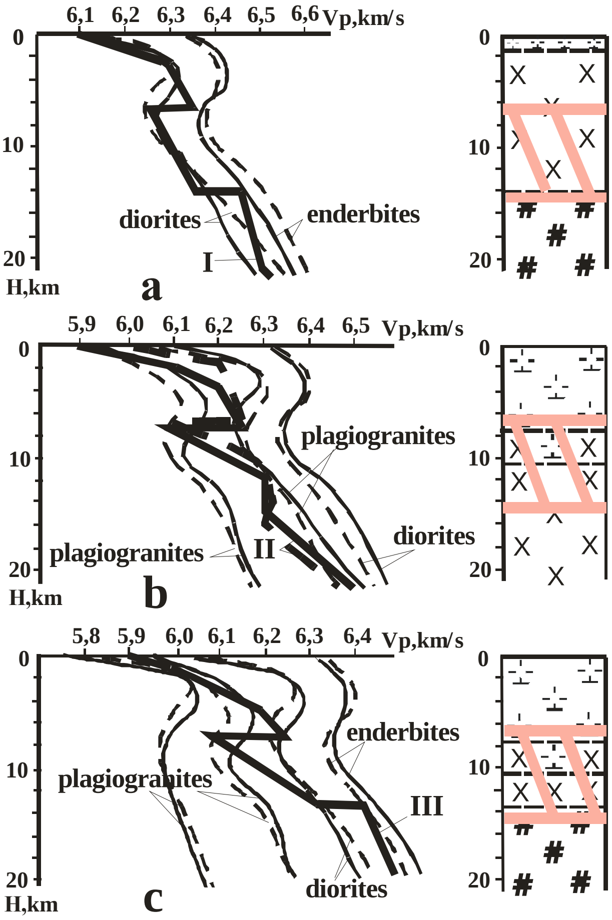

Figure 1 – Comparison of graphs Vp=f(H) change (curves I, II, III) from DSS data with materials of experimental researches of Vp=f(PT)=f(H) dependences: a – an east block; b – a central block; c – a western block. On the right in lithologic columns prognosis composition of the earth's crust is resulted. LVZ on columns are shaded.

According to these data and experiments, fulfilled according to the programs (low and high-temperature regimes), calculations have shown that in case of realization of low-temperature regime experiments ∂T/∂H<9-11 °C/km zones of velocity inversion are not reflected on the dependences V_P=f(PT)=f(H). If temperature gradient ∂T/∂H>15-20 °C/km in pressures interval is 1,8÷3,5 kbar dependences V_P=f(PT) of low velocity zones are revealed clearly. Decrease of velocities in these zones of different rock samples vary from 10 to 250 m/s under PT-conditions of the depth of H=5-15 km in the Earth's crust [Korchin, 2007, 2010].

Comparing the DSS data with the materials of the experimental PT-study of the velocity characteristics of different rocks of the study area with considering the general regional geologic-geophysical information we set up the most acceptable version of the model of the distribution of the surface rock analogues with depth. The modeled petrovelocity constructions are supplemented with the petrodensity ones with active application of gravimetric data and the experimental PT-dependence of the rock density. The data of the constructions agree with those of the velocity and density parameters of the rocks of the region, the reflectors structure, the location of boundaries and LVZ (Figure 2) [Korchin, 2009, 2011].

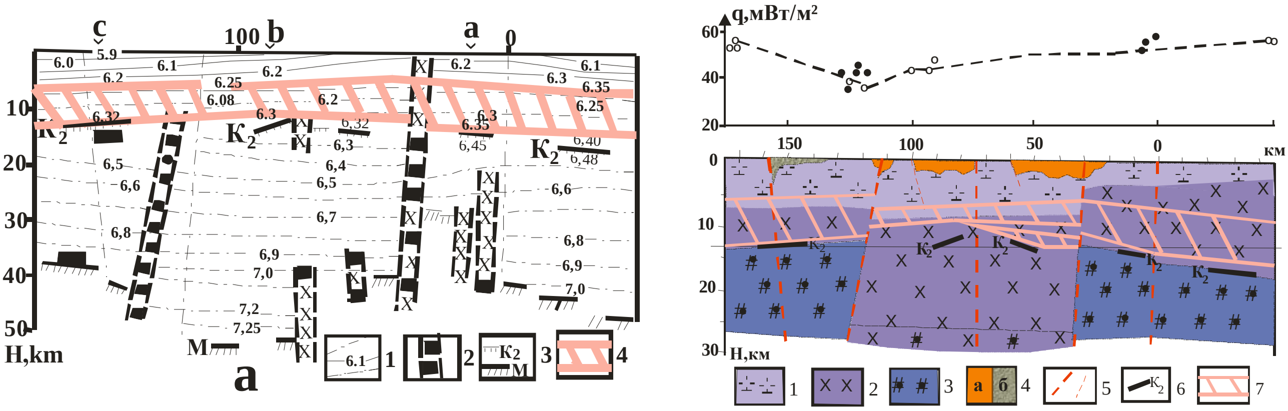

Figure 2 – The schematic cut fragment: a – the earth's crust along IV DSS profile. 1 – isolines of seismic wave speeds, 2 – zones of deep fault, 3 – seismic boundary M and K_2, 4 – LVZ; b – Material composition of the earth's crust of area of IV DSS profile. 1- plagiogranites, 2 – diorites, 3 – enderbites, 4 – sedimentary-volcanogenic rocks (a), granitoides (б), 5 – fault zones, 6 – boundary K_2, 7 – LVZ. q – thermal flow.

As a result, at the second stage the general structure, the position of the vertical and the horizontal boundaries of the blocks, their mineral composition are specified.

The deep layers of the crust (up to 40 km) have been formed by plagiogranites, diorites, and enderbites.

As a rule, the LVZ at a depth of 5-15 km are not related to mineral composition. In the first place, they results from the deep temperature regime of this USh segment. A joint analysis of DSS data and results of geothermic and petrostucture modelling from the IV geotraverse confirms that zones of higher temperature gradients in the crust are characterized by more complex bihaviour change in seismic velocity with depth when the intensive LVZ occur. The LVZ may be absent at all in colder areas of the crust.

The low velocity zones in the earth's crust are not related to mineral composition of rocks of region, but conditioned PT-parameters on the proper depths. Thus the border of K_2 is also related to growth of pressures and temperatures with a depth.

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FLANDERS' SUBSURFACE IN 3D

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KEY WORDS: 3D model, Flanders, Belgium.

INTRODUCTION

VITO has been working on a geological 3D model for the subsurface of Flanders (Northern Belgium) since 2006. The Flemish Government will make it available through the free web application "Databank Ondergrond Vlaanderen" (**http://dov.vlaanderen.be**) (figure 1).

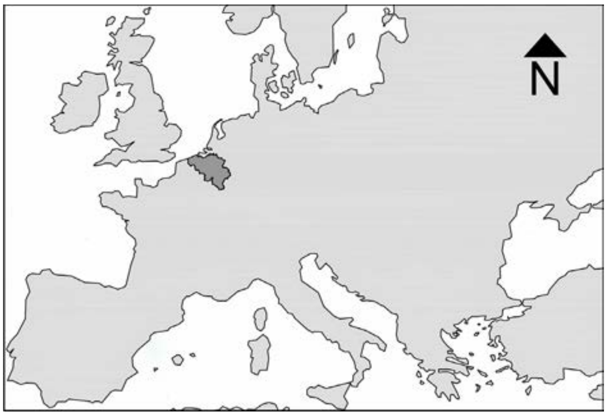

Figure 1 – Location of Belgium (dark gray area) within Europe.

GEOLOGICAL 3D MODEL

Dividing the subsoil by means of 3D surfaces into different lithostratigraphical units, each with a specific set of properties, is an important step in building a geological 3D model. These surfaces are stored as raster files, based on unit cells of 100 m by 100 m, characterized by the X-, Y- and Z-coordinates of their central node. Depending on the amount and type of data available and the type of 3D surface to be modeled, different methods are used to create the 3D surfaces. However, the geologist will have a major influence on the resulting model as he decides in which way the 3D surfaces are to be modeled. Indeed, he makes the difference between a mathematically or statistically 'correct' model and a geologically realistic model by introducing geological concepts into the modeling process.

PALEOZOIC AND MESOZOIC

Up to now, all major lithostratigraphic units of the Paleozoic and Mesozoic have been modeled. The 3D surfaces of the Paleozoic strata are based on subcrop maps by Langenaeker (2000) and isochron maps by Dreesen et al. (1987). These maps are mainly derived from seismic survey data. Thickness models were built for each unit by adding thicknesses, observed in boreholes, to the subcrop maps. Subsequently the 3D surfaces were constructed by adding the thickness models to the 3D surface for the base of the Mesozoic. The latter represents the subcrop surface for the Paleozoic strata. It was generated by using borehole and outcrop data and by adding the concept of block faulting in the Campine Basin and Roer Valley Graben area and the concept of a paleorelief, as a result of a pronounced differential erosion at the top of the Lower Paleozoic Brabant Massif (Matthijs et al., 2005).

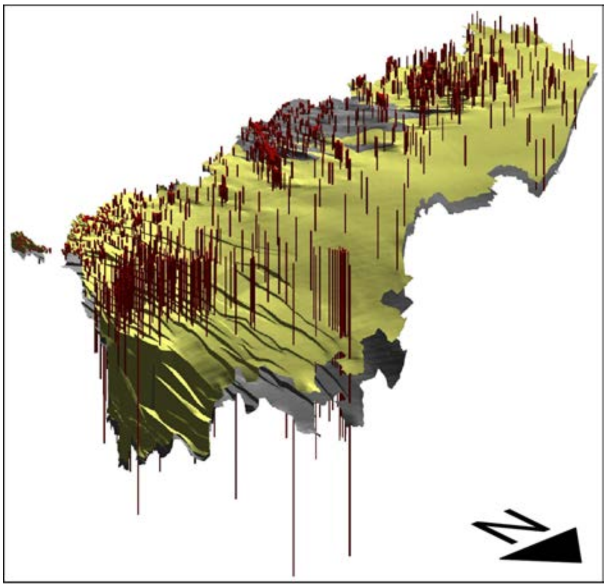

Figure 2 – View from the NE upon the top of the Paleozoic (gray) and Mesozoic (yellow) strata in Flanders, with the location of the used borehole and outcrop data (vertical exaggeration: 25).

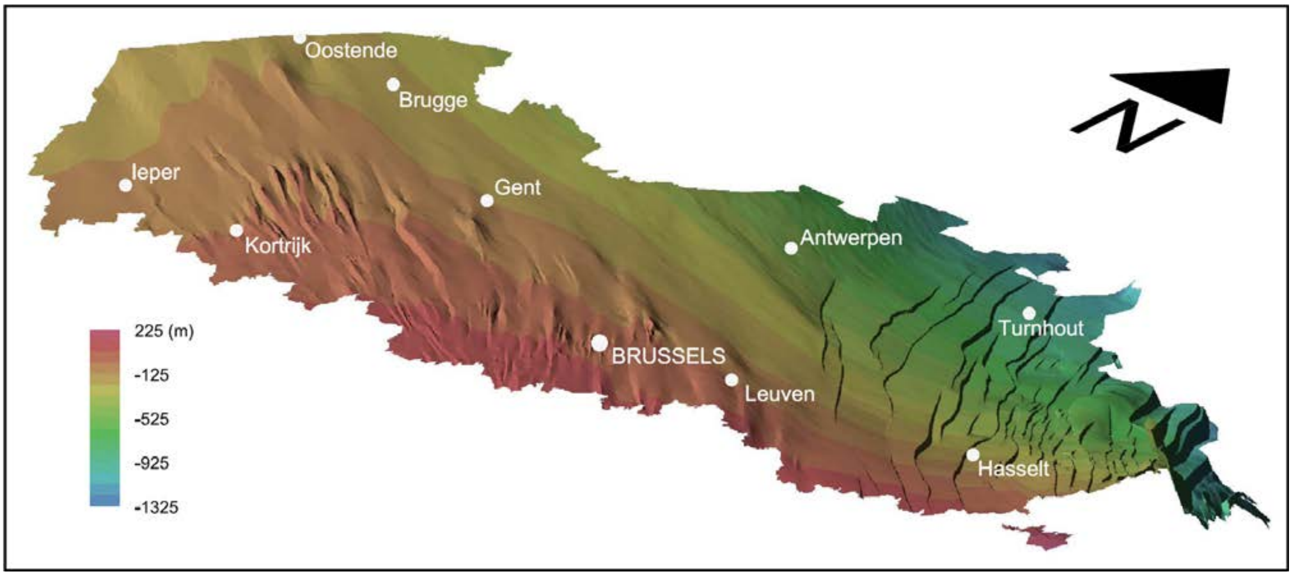

Figure 3 – View from the SSE upon the top of the pre-Cretaceous basement with the paleorelief of the Lower Paleozoic Brabant Massif in the SW and the block faulting of the Campine Basin in the NE and the Roer Valley Graben in the E (vertical exaggeration: 15).

The top of the Mesozoic strata was constructed in the same way (figures 2 and 3). The different lithostratigraphic units within the Cretaceous were modeled in a proportionate way, based on the percentage of the total thickness of the Cretaceous for each lithostratigraphic unit, observed in the boreholes.

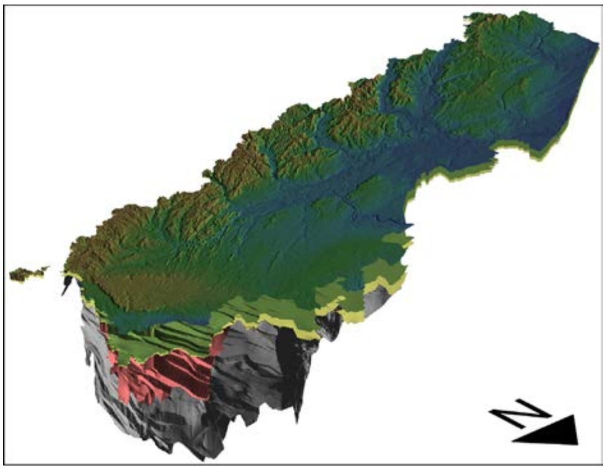

Figure 4 – View from the NE upon the stacked 3D surfaces of some major lithostratigraphical units in Flanders: top Lower Paleozoic Basement (gray), base Permian-Triassic (red), base Cretaceous (yellow), base Tertiary (green), base Quaternary (multiple colors) (vertical exaggeration: 10).

CENOZOIC

The Cenozoic strata in Flanders are strongly influenced by topography. Consequently a 3D model for the topography had to be built. Here, the aim was to reconstruct a 'natural' topography, thus without human artefacts. The 3D surface for the base of the Quaternary is the result of the numerical difference between the topographic model and a thickness model for the Quaternary. This was generated not only by using the boreholes and outcrops, but also by applying concepts derived from the correlation between the thickness of the Quaternary cover on the one hand and the lithology and inferred permeability of the substrate and the topographical position and slope on the other hand (figure 4). The base of the Quaternary constitutes a major subcrop surface for the Tertiary strata. The modeling of these strata is still in progress.

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SPATIAL ANALYSIS OF MICROSTUCTURES IN GRANITE – A CASE STUDY

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KEY WORDS: spatial analysis, scanning electron microscopy, granite matrix porosity, microstructures

INTRODUCTION

Various characteristics of granite have been studied in the context of granite as a physical barrier. The vast majority of its hydraulic properties result from tectonics and fracturing. However, over long time scales, high pressure or gas storage also needs to be considered in order to accurately evaluate granite matrix porosity. Recently, pores and microstructures within the granite matrix have been studied extensively (Menendéz et al. 1999, Mori et al. 2003, Nováková et al. 2010). This paper presents a detailed approach to the description of granite matrix. The spatial data were provided by scanning electron microscope and its subsequent interpretation was undertaken within a GIS.

METHODOLOGY

A detailed ongoing project investigates the characteristics of granite matrix, in the various granites of the Bohemian Massif. Both archive and newly drilled borehole cores have been used to obtain fresh or lightly weathered samples. In order to visualise granite porosity, SEM has been used. In this paper, the applied methods will be outlined with specific reference to sample MEV2-70.

Sample MEV2-70 is derived from a depth of 70 m from the MEV2 borehole in the Lipnice Granite Massif. It is a coarse grained non-porphyric double mica granite. The main minerals are quartz, K- and Na-feldspars, biotite, and muscovite while apatite is also common. Zircon, monazite, and spinel may also be found.

Samples are cut and polished carefully, as require by the scanning electron microscope method. For each sample, a small area (~ 5 x 5 mm) is scanned using a Quanta 450 SEM at a magnification of x 500. To cover the whole area, 81 raster images are generated. These are stitched together, either manually or using Microsoft ICE (Fig. 1). Microcracks, pores, and grain boundaries are manually drawn as separate vector layers from the stitched image. Structures as small as 0.5 µm can be identified thanks to the high magnification and resolution of the image. The major microcracks are then highlighted. In addition, mineral grains are determined using EDAX.

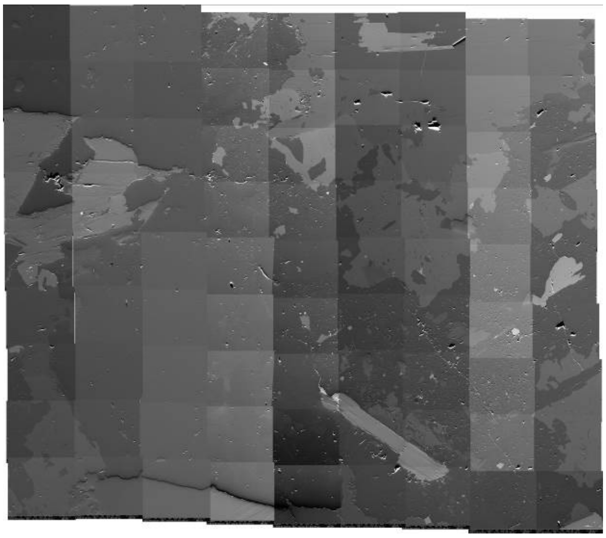

Figure 1: A mosaic of SEM scans from sample MEV2-70).

The layers are then imported into a GIS (Fig. 2A, 2B). MapInfo and QuantumGIS are used simultaneously to undertake the spatial analyses. These determine the number of pores and microcracks in the different minerals, the surface area of the minerals, and the microcrack trend.

OUTCOMES

In the SEM images, it is possible to find all four matrix pore types defined by Mori et al. (2003). 'Pores' represent solution pores defined by Mori et al. (2003). Grain boundary pores and crack pores join to become microcracks (see Fig. 2A). Sheet silicate pores were regularly observed but have not been depicted.

Moreover, the spatial analyses allow us to segregate pores and microcracks according to the various minerals. For example, the majority of pores occur in grains of Na-feldspar (Tab. 1) Taking the surface area of the mineral into account, the average amount of pores in Na-feldspar is double that of the whole sample average. A comparison between pore-rich Na-feldspar and pore-poor biotite or apatite is even more striking. A quarter of the observed microcracks are associated with grain boundaries. In general, the microcracks follow three main trends (Fig. 2C) while the major microcracks follow just two (Fig. 2D).

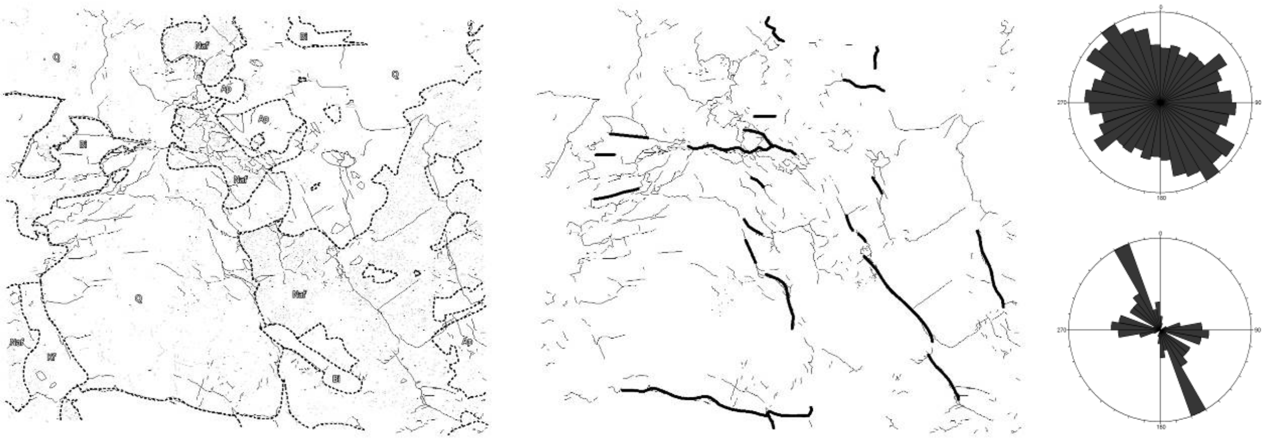

Figure 2: Vector data and its interpretation (Sample MEV2-70). A: grain boundaries (dotted lines), microcracks (full lines), and pores (grey dots); B: microcracks (full lines) and major microcracks (bold lines); C: rose diagram of microcrack trend; D: rose diagram of major microcrack trend.

Minerals	Area		Microcracks			Pores		
	mm^2	%	Count	%	per 1 mm^2	Count	%	per 1 mm^2
Na-feldspar (Naf)	9.43	29.2	256	31.8	27	3565	63.3	378
K-feldspar (Kf)	0.84	2.6	6	0.7	7	132	2.3	157
Biotite (Bi)	1.88	5.8	28	3.5	15	118	2.1	63
Apatite (Ap)	1.08	3.3	21	2.6	20	70	1.2	65
Quartz (Q)	16.08	49.7	256	31.8	16	1481	26.3	92
Other	3.02	9.3	21	2.6	7	270	4.8	90
Grain boundaries	-	-	216	26.8	-	-	-	-
Whole sample	32.33	100	805	100	25	5636	100	174

Table 1: The results of the spatial analyses for Sample MEV2-70.

CONCLUSIONS

The SEM images provide a large amount of information. Transforming raster images into vector data before undertaking the necessary spatial analyses is time consuming. It is, however, essential for statistical processing of data, required within the framework of the outlined granite matrix porosity project. It is clear that the identification of minerals or areas that rich in pores or microcracks represents an important stage in the overall evaluation of granite matrix porosity and hydraulic conductivity.

ACKNOWLEDGEMENTS

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DISTRIBUTION OF TEMPERATURE WITHIN AQUIFER SYSTEM DEVONIAN DEPOSITS OF CENTRAL AND NORTH-EAST OF BELARUS

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KEY WORDS: thermal field, thermogram, anteclise, heat flow, mathematical interpolation, anomaly.

PRACTICAL ASPECTS OF RESEARCH

Geothermal studies, as dictated by the further study of the geological structure of the territory of Belarus, the geodynamics of the Earth's interior, including the latest works to find minerals, including - the definition of the prospects of geothermal energy in the light of the continuing rise in prices for imported hydrocarbons ; search for alternative renewable clean energy, lack of quantitative data on radiogenic heat generation, and other practical needs, are becoming increasingly important.

Practical aspects of work::

- implementation of a quantitative evaluation of density of geothermal energy resources the most promising geological structures;
- assessment of geothermal potential;
- suggestion priority areas for the practical development of underground heat.

GEOTHERMAL STUDY OF THE TERRITORY

Thermal field of geological structures is largely determined by the history of geological development and it is closely associated with the evolution of the region. Unlike other geophysical fields (such as gravity and magnetic), a detailed study of the geothermal field is lower. The indispensible condition to register thermograms is the availability of wells for thermometric measurements, which has the long period of rest after the completion of drilling. But the majority of drilled wells put into operation in a short time, or disposed of (exploration, search, parametric) after completing their geological applications. Distribution of wells in geological structures of Belarus is very irregular. A dense network of wells is in the range of mineral deposits, and very rare - within the areas which did not reveal significant industrial mineral deposits. Small wells for drinking water are exceptions. The accumulation and collection of thermograms started in 1964 continues to this day. Gradually this allows us to close the part of the existing "white spots" and to create more detailed maps and graphs of temperature and heat flow. However, at the time of writing this article some territories in the region in terms of geothermal remain poorly studied. This territories include a strip along the border with Lithuania, Latvia and the Russian Federation, as well as the south-western border strip with Ukraine. It should also be noted that well drilling and geothermal research practically stopped in this zone after the Chernobyl accident.

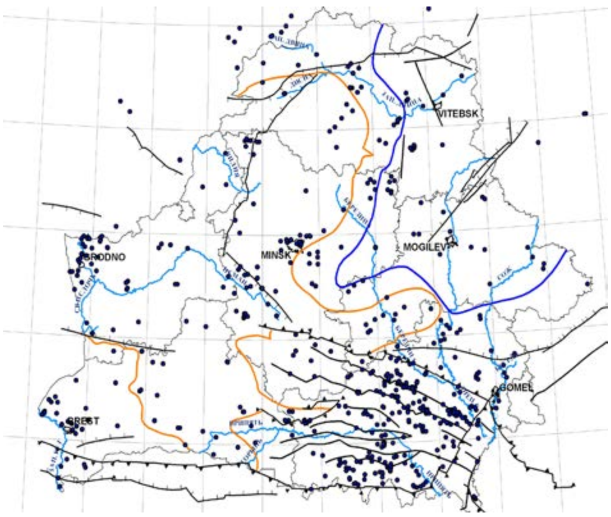

Figure 1 – Density of the geothermal research of region with the major geological structures and faults.

FEATURES OF THE TEMPERATURE DISTRIBUTION

As one of the least studied the central and north-eastern part of Belarus has been selected for the study. Devonian aquifer was selected as promising for use because its area is almost entirely related to the zone of fresh water.

The isotherms in Figure 2 performed by mathematical interpolation are made with the help of ArcGis software. The temperature of the roof of Devonian aquifer system varies from 7 to 10.5°C, the difference between the extreme values reaches 3.5°C. The most typical temperature for this region 7-8°C.

In the eastern part of the Orsha depression the

East-Orsha low temperature anomaly 6.5 - 7.5°C was first time marked. The anomaly consists of almost all of Mogilev mold.

Also the first time in this region was marked the meridional direction band of higher temperature. It can be observed in the western part of the Orsha depression and the eastern slope of the Belarusian anteclise. This anomaly goes in the south direction from Polotsk through Krupki and almost reaches the latitude of Bobruysk.

The lower temperature anomaly was detected in the north part of this region. However, it allocated uncertainly, because only one well (the sanatorium “Blue Lake”) has been studied in the adjacent Russian territory. On the Belarusian side to the north of Vitebsk only two wells are studied (Ruba and Surazh 1s2).

A Miory-Polotsk low temperature anomaly is also allocated in the depth of aquifer. On the longitude of Polotsk its western part is connected to a common low temperature anomaly, which is located in the eastern slope of the Belarusian anteclise and Cherven structural bay of Orsha depression.

Molodechno-Narochanskaya meridional direction higher temperatures anomaly (over 8.5°C) was marked.

Also it is possible to mark other temperatures anomalyes. However due to the lack it is impossible to establish the boundaries yet.

Identified anomalies traced at deeper layers allowes us to predict the most promising areas for the development of underground heat without deep wells thermograms. The same works are carried out for other horizons, and they are parts of the geothermal atlas of the Republic of Belarus project.

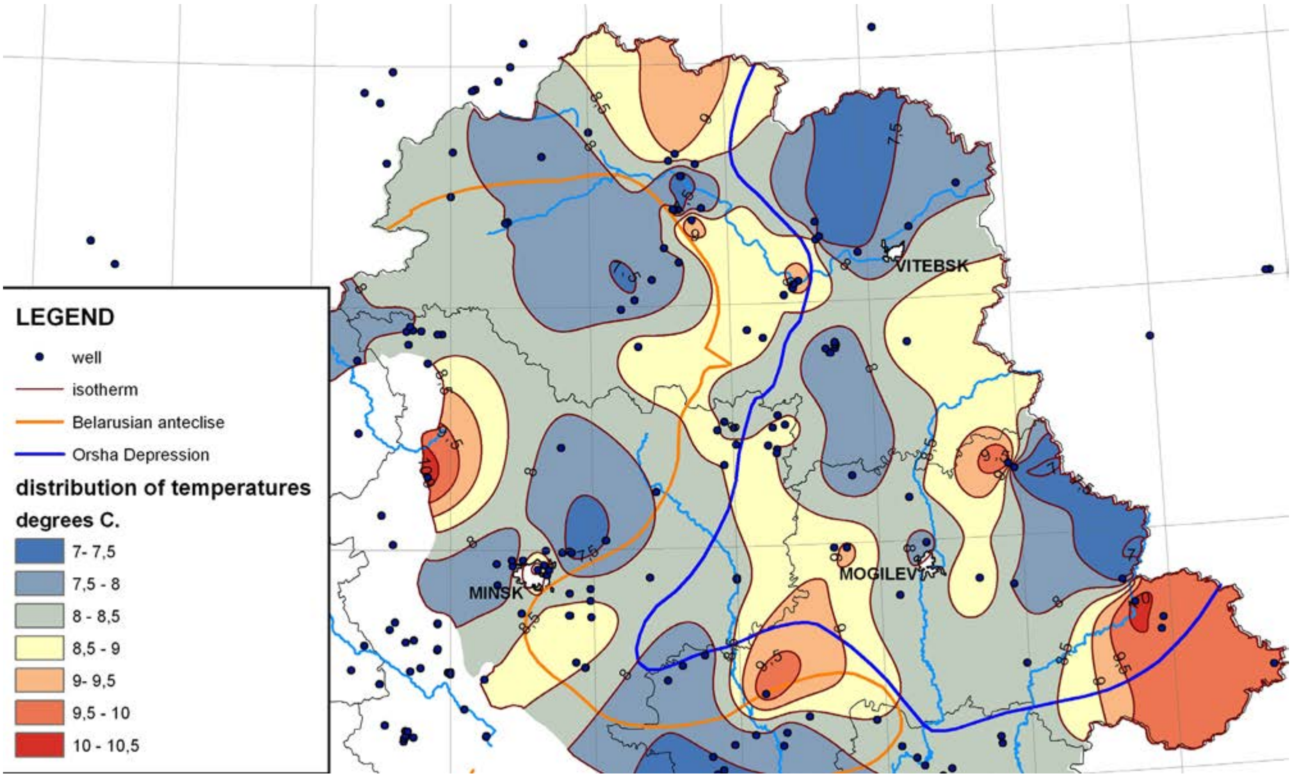

Figure 2– Distribution of temperature within aquifer system Devonian deposits.

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SHARING GEOTHERMAL DATA: THE GEOTHERMAL ATLAS OF CATALUNYA

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KEY WORDS: Geothermal energy, geothermal domain, atlas, Catalunya.

INTRODUCTION

Mainly inspired in geothermal Atlas published by the European Union (see references), the "Geothermal Atlas of Catalunya" has been build to supply the lack of information related with geothermal regime in Catalunya. It is the first step to evaluate the geothermal energy potential and a useful tool to promote its implementation.

The initiative to build a Geothermal Atlas comes from an initiative between ICAEN (Institut Català d'Energia), IGC (Institut Geològic de Catalunya) and ICTJA-CSIC (Institut de Ciències de la Terra Jaume Almera) with the support of IDAE (Instituto para la Diversificación y Ahorro de Energía), IGME (Instituto Geológico y Minero de España).

Since 2007 the existing data coming from different sources has been collected, harmonized and its interpretation updated following recent criteria. All the data has been incorporated into a databases for its analysis in a Geographic Information System. The obtained maps compose the Atlas.

The Atlas is planned as an open project that will be updated according to the new data acquisition and progresses in geothermal knowledge. This is a pilot project aiming to spread out to the rest of the country.

The Geothermal Atlas of Catalunya is only available on line at the www.igc.cat.

THE ATLAS STRUCTURE

The Atlas is divided in two main settings, the structural and the geothermal. Structural maps are needed to interpret geothermal data, as the heat flow lost by the Earth is perturbed in its way out through the lithosphere. The collected structural maps in the Atlas deals with: geology, geodynamics, faulting, hydrogeology and crustal and lithosphere thickness. The geothermal setting is divided in two domains, shallow and deep. The shallow geothermal domain includes the thermal data affected by weathering aspects. The deep geothermal domain includes the thermal data that represents the background heat coming from the Earth's interior.

SHALLOW GEOTHERMAL DOMAIN

The shallow geothermal domain is calculated from data measured in meteorological stations and wells. In the shallow crust major thermal perturbations occur due to groundwater circulation. These perturbations mask the background heat flow and, in general, are very limited in extension. In Catalonia, the shallow geothermal maps show many positive and negative anomalous spots related to the groundwater circulation through complex geological structures.

The shallow geothermal domain includes the following maps:

- Mean surface temperature reduced to sea-level (annual, winter and summer). This map shows the mean daily temperatures reduced to sea level by means of the local atmospheric gradient.
- Mean restored surface temperature. This map shows the expected mean annual surface temperature calculated from the previous map restoring the altitude effect from Digital Elevation Model.
- Mean surface thermal amplitude between summer and winter.
- Temperature at 100 m depth. This map shows the regional 100 m depth temperature deduced from direct measurements in wells.
- Thermal jump at 100 m depth defined as the difference between the temperatures measured at 100 m depth and at surface.
- Thermal conductivity obtained by correlating lithologies, age of rocks and laboratory measurements following Fernández et al. (1998).
- Surface geothermal gradient obtained from measurements at wells. The mean gradient is around 30 mK/m increasing from the Pyrenees to the Valencia Trough. The anomalies are related to downward groundwater circulation in the Ebro Delta (Fernández and Banda, 1990), and upward groundwater circulation in the Vallès and Osona basins (Fernández et al.,

1990; Cabal and Fernández 1995).

- Surface heat flow results from the thermal conductivity and thermal gradient equation. We can see a similar regional trend increasing from the Pyrenees to the Valencia Trough, and a regional anomaly covering the Prelitoral Chain. A larger resolution is necessary to elucidate whether this anomaly corresponds to separate local thermal anomalies or to regional groundwater circulation.
- Temperature at 3000 m depth inferred from downward thermal calculations considering an exponential depth decreasing porosity for sedimentary basin infilling.

DEEP GEOTHERMAL DOMAIN

The geothermal deep domain is calculated by means of a 3D numerical modeling (Fullea et al., 2009). The model geometry includes: sediment thickness, crustal thickness (Diaz y Gallart 2009, Grad et al. 2009) and lithospheric mantle thickness (Zeyen and Fernàndez, 1994; Ayala et al., 1996; Morgan and Fernández, 1992). The model fits geopotential data assuming steady-state and local isostasy. As a main result we conclude that there are not evidences of deep perturbations causing surface thermal anomalies.

The deep geothermal domain includes the following maps:

- Background temperature at 7 km depth.
- Background temperature at 15 km depth.
- Moho temperature

These maps aim to reflect the background heat from the Earth's interior. From the Pyrenees to the Valencia Trough, the 7 km and 15 km depth maps show a temperature increase related to the lithospheric thinning in this direction. Temperatures rise from 100ºC to 180ºC and from 200 ºC to 375 ºC, respectively. The Moho temperature map shows a different trend suggesting a differential thinning between the crust and the lithosphere mantle.

This theoretical background heat will be strongly perturbed by shallow effects related to lateral variations in the geological structure, groundwater circulation processes and weathering resulting in a different shallow thermal regime.

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GEOTHERMAL MODELING FOR BAHARIYA FORMATION OF BASSEL-1X WELL, NORTHERN WESTERN DESERT, EGYPT, BY USING WELL LOGS ANALYSIS.

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KEY WORDS: Well Logging – Geothermal Gradient - Thermal Conductivity – Heat Flow – Specific Heat Capacity – Heat Production.

INTRODUCTION

The aim of this study is to evaluate the geothermal potential for Lower and Upper Bahariya Formation of Bassel-1X well in the northern western desert of Egypt to determine the suitable reservoir rock by using the available well logging data.

MEASUREMENT OF THERMO-PHYSICAL PROPERTIES:

This measurement begins with the determination of formation temperature then the thermal conductivity, heat flow, specific heat capacity and heat production by the different empirical equations. All these parameters are determined to know the geothermal potential of Bahariya Formation and judge if these units of formation are suitable to be reservoir rock or not.

1-FORMATION TEMPERATURE

The temperature data usually available for analysis are bottom hole temperature and the surface temperature (Magoon, L.B. and W.G. Dow; 1994). The formation temperature can be calculated from the data of B.H.T and S.T.

$$T = T_o(h) + G.G$$

$$G.G = \Delta T/\Delta Z = (T_2 - T_1) / (Z_2 - Z_1)$$

2-THERMAL CONDUCTIVITY:

The thermal conductivity of rocks and sediments is an intrinsic physical property that is determined by mineralogy, porosity, and temperature. Most sedimentary rocks are an aggregate of minerals with pore spaces saturated with saline water. Their bulk thermal conductivity depends on both the solid rock component and the pore fluid. The major influence of mineralogy on conductivity is the proportion of high, intermediate and low conductive minerals. Minerals were determined by using well log data (Shazly, T.F. and Ramadan, M.A.; 2011) where, Lower and Upper Bahariya Formation consist of quartz, calcite, illite, montmorillonite and dolomite with very small quantity of smectite, the clay minerals have high percentage in the Upper Bahariya Formation than the Lower unit. Prior to estimating the bulk rock thermal property, the conductivity λ for each constituent must be established. Porosity and saturating fluids are the second factor controlling the conductivity of rock. If porosity is important the saturating fluid's thermal conductivity may significantly affect the bulk thermal conductivity of the saturated rock where, the thermal conductivity decrease by increasing the porosity, this is due to the three low conductivity of water, oil and gas which saturate the rock. The most important model to relate the thermal conductivity of an aggregate to its individual component is the geometric mean model which is adequate for computing the thermal conductivity of sedimentary rocks. This model was applied to the formation for which detailed mineralogy and porosity were available, where p_i is the volumetric fraction of the ith component of minerals having a conductivity λ_i. Experimental results (Roy, R.F. et al; 1981) show that temperature has a significant effect on thermal conductivity of rock matrix components for the range of temperatures found in sedimentary basins. Therefore, porous rock thermal conductivities must be corrected for temperatures in field applications. The matrix conductivity λ_m is proportional to the reciprocal of the absolute temperature (Chapman, D.S. et al; 1984). Water is also given temperature, but its effect is small relative to temperature effect on the matrix conductivity. Some equations are used to adjust the thermal conductivity of water ($\lambda_{w.T}$) for conditions of temperature (T) at different depths.

$$\lambda_R = \lambda_m^{1-\Phi} * \lambda_w^{\Phi}, \quad \lambda_m = \pi_{i=1}^{m} \lambda_i^{p}$$

$$\lambda_{m.T} = \lambda_{m.20} * [293 / (273 + T]$$

$$\lambda_{w.T} = 0.56 + 0.003T^{0.827} \qquad ; 0 \le T \le 50\,^oC$$

$$\lambda_{w.T} = 0.442 + 0.519 \ln T \qquad ; T > 50\,^oC$$

3-HEAT FLOW

The third step in studying the thermo-physical properties is the heat flow. The utility of heat flow studies lies in the ability to infer thermal conditions at great depth from measurements in shallow boreholes (John Michael B. and David S. Chapman 1982). Heat flow values have been calculated using thermal gradients and thermal conductivities measured for both Lower and Upper Bahariya Formation.

$$Q = \lambda * \Delta T/\Delta Z$$

3-SPECIFIC HEAT CAPACITY

Specific heat capacity is one of the most important parameters in estimating the thermo-physical properties, there is an inverse relation between heat capacity and both of thermal conductivity and heat flow. The porosity and the saturation of rock are important parameters in calculating the specific heat capacity where, the water content of a rock has a dominating influence on the total specific heat capacity (Scharli, U., and Rybach, L.; 2001).

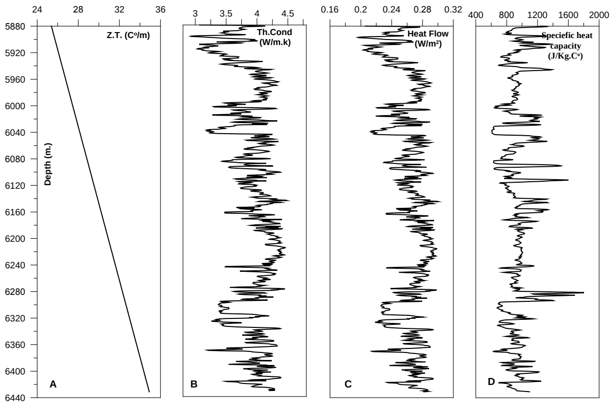
$$C_p = \frac{C_m \rho_m (1 - \varphi) + C_w \rho_w \varphi}{\rho_{ws}}$$

5-HEAT PRODUCTION

The formula of (Scharli, U., and Rybach, L.; 2001) is used to calculate the heat generation by knowing the concentration of uranium (U), thorium (Th) and potassium (K) elements and the density (ρ) of the rock. In borehole the K, U and Th content can be taken from the natural Gamma spectrometry tool (NGS) measurement and the rock density from the density log. After thermal modeling of Bahariya Formation we can use one of the most important evidences of its thermal growth, is the recognition that smectite portion of shale undergoes a transformation into another clay type called illite. This transformation is dependent on the temperature and time of cooking and requires the presence of potassium, which is usually available in the pore water (Aref, A.L.; 2007). A new procedure for measuring the thermal growth by using the logging tool is introduced (Dutta, N., and Hobart, S.; 1999). In this method the transit time was taken as an indicator for the degree of smectite / illite transformation in addition to utilizing the temperature to quantify the degree to which the transformation had completed.

SUMMARY AND CONCLUSION

Depending on the values of thermo-physical properties, Lower Bahariya Formation exhibits that it has the highest thermal conductivity and heat flow as well as the lowest heat capacity while, Upper Bahariya Formation illustrates that, the thermal conductivity and heat flow are low, while the heat capacity is high. The heat generation is calculated depending on radioactive elements, a good linear relationship is observed between the heat production and the GR. The thermal modeling is completed by observing the change in some of clay minerals (smectite) to another clay mineral (illite) by using sonic – density crossplot, these crossplots showed the change of smectite to illite especially in the Upper Bahariya Formation. From this modeling it was found that the Lower unit of Bahariya Formation has suitable values of geothermal potential (high thermal conductivity, high heat flow and low heat capacity) to act as a reservoir rock, in addition it is characterized by the presence of quartz minerals and the low percentage of clay minerals, while the Upper unit has not the suitable values of geothermal potential to be a reservoir rock.



Figure(1) Values of zone temperature, thermal conductivity, heat flow and heat capacity with depth for Lower Bahariya Formation of Bassel-1x well

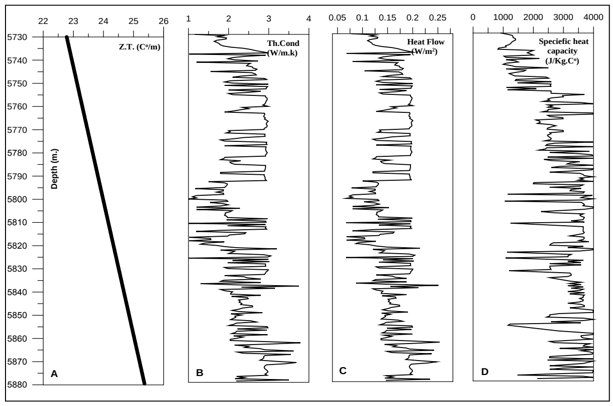


Figure 2–Values of zone temperature, thermal conductivity, heat flow and heat capacity with depth for Upper Bahariya Formation of Bassel-1x well.

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SPATIAL ANALYSIS OF SINKHOLES AS A TOOL TO UNDERSTAND THE KARST SYSTEM EVOLUTION. A CASE STUDY FROM THE MALTESE ARCHIPELAGO

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KEY WORDS: sinkholes, Malta, morphometry, spatial pattern, nearest neighbour index.

INTRODUCTION

Sinkholes are natural depressions caused by karst processes. These landforms may be generated as a consequence of the differential lowering of the surface by dissolution (solution sinkholes), a combination of subsurface dissolution processes and internal erosion (suffusion sinkholes) and/or deformation processes affecting the overlying material (collapse and sagging sinkholes) (GUTIÉRREZ et al., 2008). These depressions may be directly related with endokarst features. For example, a collapse sinkhole may be generated by the breakdown of the roof of a cave. Thus, the cavity network or the development of the karstification processes are usually reflected in the type and spatial dispersion of sinkholes. On the other hand, structural patterns, such as the densities and orientations of fractures and joints, have a significant impact upon the ultimate morphology of conduit systems (PALMER, 1991) and also in the distribution and morphology of sinkholes (WILLIAMS, 1972). Mapping and interpretation of lineaments in relation to sinkhole distribution and the application of morphometric techniques to karstic landforms provide an objective and quantitative way of karst description and analysis.

Limited attention has been given so far to the spatial characteristics of the Maltese enclosed depressions (Figure 1). There have been few investigations on Maltese karst features (e.g., PEDLEY et al., 2002; MARMARÀ, 2004; CALLEJA, 2010 and CORATZA et al., 2011) and they mainly provided inventories and general descriptions of the sinkholes. In this study, a spatial analysis of the sinkholes located in the Maltese archipelago has been carried out using the specific capabilities of Geographic Information Systems (GIS). The study aims at comparing the sinkhole spatial distribution with the geological data in order to help in the interpretation of their origin and present evolution.

GEOLOGICAL SETTING

The landscape of the Maltese Islands is mainly controlled by the geological structure. The NW-SE and ENE-WSW faulting produces a horst-and-graben system and the almost horizontal rock sequence creates a landscape of plateaus, buttes and canyons (PEDLEY et al., 2002). The Maltese archipelago is composed of a Late Oligocene (Chattian) to Late Miocene (Messinian) succession of sedimentary rocks, mainly limestones. As a result, karst features, such as sinkholes, dry valleys and caves, are common, mostly in the Coralline Limestone formations. The Maltese sinkholes developed in two different periods of time: Miocene and Quaternary; therefore they have been analyzed as two different families in order to compare them and to underlie differences in their origin and evolution.

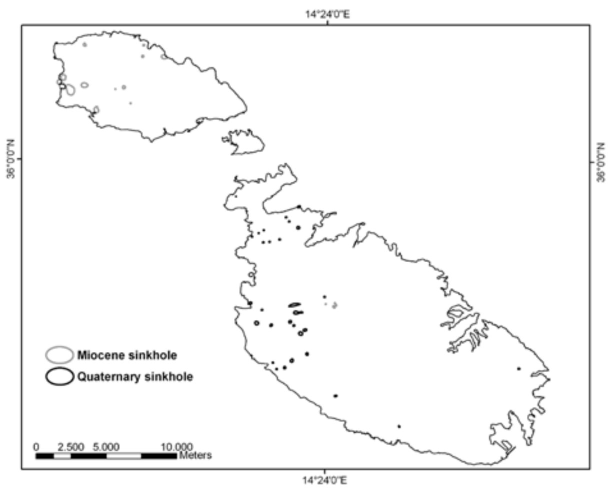

Figure 1 – Study area.

METHODOLOGY

A spatial analysis was carried out using a GIS platform (ArcGIS 8.3®) and specialized tools to calculate point distribution indexes (CRIMESTAT). Firstly, the morphometry of sinkholes has been studied to compare the characteristics of the different depression families observed in the archipelago. Secondly, the spatial dispersion of sinkholes was analyzed calculating the Nearest Neighbor Index (CLARK and EVANS, 1954) and Ripley's (1976) K statistic to determine whether the sinkholes have a clustered, homogeneous or random distribution. Thirdly, the directions of the lineaments and axes of sinkholes have been compared with the structural pattern observed in the archipelago.

PRELIMINARY RESULTS

The preliminary results of morphometric and spatial distribution analysis are outlined in Figure 3. Figure 2 illustrates the main directions observed in the sinkhole families and in the main structural features of the Maltese archipelago, that is the horst-and-graben normal faults.

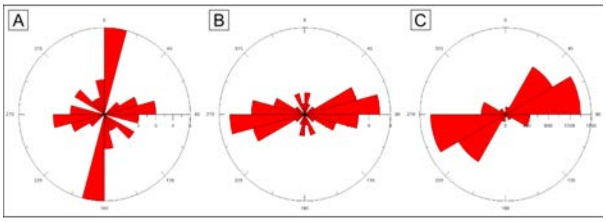

Figure 2 – Rose diagrams showing: (A) Prevalent N-S orientation of the major axes of the Miocene sinkholes; (B) Prevalent ENE-WSW orientation of the major axes of the Quaternary sinkholes; (C) Main directions of the Maltese fault system.

Type	Number	Am	At	AM	Lm	LM	Dm	DM	Vt	Clm	Elm	NNI	Pattern
Miocene sinkholes	19	56228	106	325741	234	796	59	120	60	1.04	1.25	0.38	Highly clustered
Quaternary sinkholes	29	16593	46	77964	153	639	20	80	9	1.05	1.35	0.79	Tending to cluster

Figure 3 – Parameters related to the different types of sinkholes. Am: Mean area (m^2). At: Total area (ha). AM: Maximum area (m^2). Lm: Mean diameter or length (m). LM: Maximum diameter or length (m). Dm: Mean depth (m). DM: Maximum depth (m). Vt: Total volume (hm^3). Clm: Mean Circularity index. Elm: Mean Elongation index. NNI: Nearest Neighbour index (0: Maximum clustering; 1: Random distribution; 2.1491: Maximum dispersion; Clark and Evans, 1954).

CONCLUSIONS

The sinkholes developed in the Quaternary period present different spatial and morphological characteristics than the Miocene ones. The latter have larger size and volume and reach greater depths. The Miocene structures are highly clustered being particularly concentrated along the NW coast of Gozo. On the other hand, the Quaternary sinkholes have a more random distribution. As shown in the rose diagrams of Figure 2, the sinkholes also differ in the orientation of the major axes; the Miocene sinkholes show a N-S prevalent direction while the Quaternary ones have an ENE-WSW orientation. The latter fits perfectly with the Maltese fault system.

The results of the sinkhole analysis may be used to propose or support hypotheses about the origin of the different sinkhole families and also to obtain new information to better understand the evolution of the karst system of the Maltese archipelago and its subsurface geology together with the possible risks related to the ongoing karst processes.

ACKNOWLEDGEMENTS

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3D GEOTHERMAL MODEL OF THE FERGANA DEPRESSION

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KEY WORDS: ArcGIS, 3D model, geological-and-geophysical database, geological map, geophysical map, Tools Analyst, Geostatistical Analysis, 3D Analysis.

TITLE OF SECTION SUBSURFACE GEOLOGY (GEOTHERMAL ENERGY, CCS, 3D MODELLING)

In ArcGIS environment the geological-and-geophysical database of the Fergana depression on Republic Uzbekistan territory on which basis the geothermal model on upper layer of Turkestani layers Palaeogene is constructed 3D is created and the estimation of its temperature resources on various depths is executed.

Within the Fergana depression geothermal researches in chinks are begun in the fifties last century (Simakov S.N., Klejberg V. G, Vorobev A.A. and oth., 1957). They had fragmentary character and, basically, are connected with the decision of questions of working out of oil deposits, their geology, hydrogeology of thermomineral waters and tectonics. Since 80th years the volume and quality of geothermal researches in which result the geothermal given temperatures are obtained, gradient and теплофизических properties on the big depths have increased. As a result for the Fergana depression thr maps of a geothermal field (Tal-Virsky B.B., 1982), isotherms on overlying bed of Turkestan layers of Palaeogene, gradients of temperatures (by Zuev Yu.N., 1983, 1985) have been done.

Now the huge actual material on a geological-and-geophysical level of scrutiny of territory of the Fergana depression is saved up. However all material is presented in the form of dot field gaugings and paper maps of the various scale which initial data have remained in the form of fragments of tables, maps and the schemes constructed at different times with use of different softwares. For an effective using of the geological-and-geophysical information and maintenance of data storage, the analysis and the organisation of spatial data in ArcGIS environment the geological-and-geophysical database of the Fergana depression including digital models of geologo-geophysical maps, and also primary data on chinks has been created (Tsay O.G., 2010a,b, 2011). The database is realised in the Delphi environment and presented in the form of Information blocks: «Geological study» and «Geophysical study». Data are collected in ArcGIS environment and SMDB Access. .

The block «Geological study» consists of following subblocks:

1. A geological structure

Geological map

Maps thickness of Jurassic, Upper and Lower Cretaceous, Palaeogene and Quaternary sediments

2. A tectonic structure

Tectonic map

The block diagramme on upper layer of Turkestani layers of Palaeogene

The block the «Geophysical study» consists of the following subblocks:

1. An earth crust structure

The scheme of a relief of Mohorovichich surface

The scheme of a relief of a granitic-gneissic layer

The scheme of a relief of a basalt layer

The scheme of a relief of a surface of Paleozoic foundation

2. Geophysical fields

The given subblock consists of the following sections

2.1 Seismicity

Summary map of a seismic level of scrutiny

Map of effective velocity of thickness $Pg_{2\text{-}3}$-N-Q)

2.2 Magnetometry

Map of an anomalous magnetic field

2.3 Geothermics

Map of a geothermal field

Map of isotherms on overlying bed of Turkestan layers of Palaeogene

Section Geothermics contains data: catalogues of geothermal investigation and characteristics of rocks.

As a result for the Fergana depression 3D model of isotherms on overlying bed of Turkestan layers of Palaeogene has been constructed and the estimation of temperature resources on different depths with use of Tools of ArcGIS (Tools Analyst, Geostatistical Analysis and 3D Analysis) (Figure 1) has been executed. The given model has been allowed to characterise the morphology of relief of overlying bed of Turkestan layers of Palaeogene and distribution of temperatures on this layer. Figure 1 showed the temperature maximum characterised by high temperature (220^{o}C).

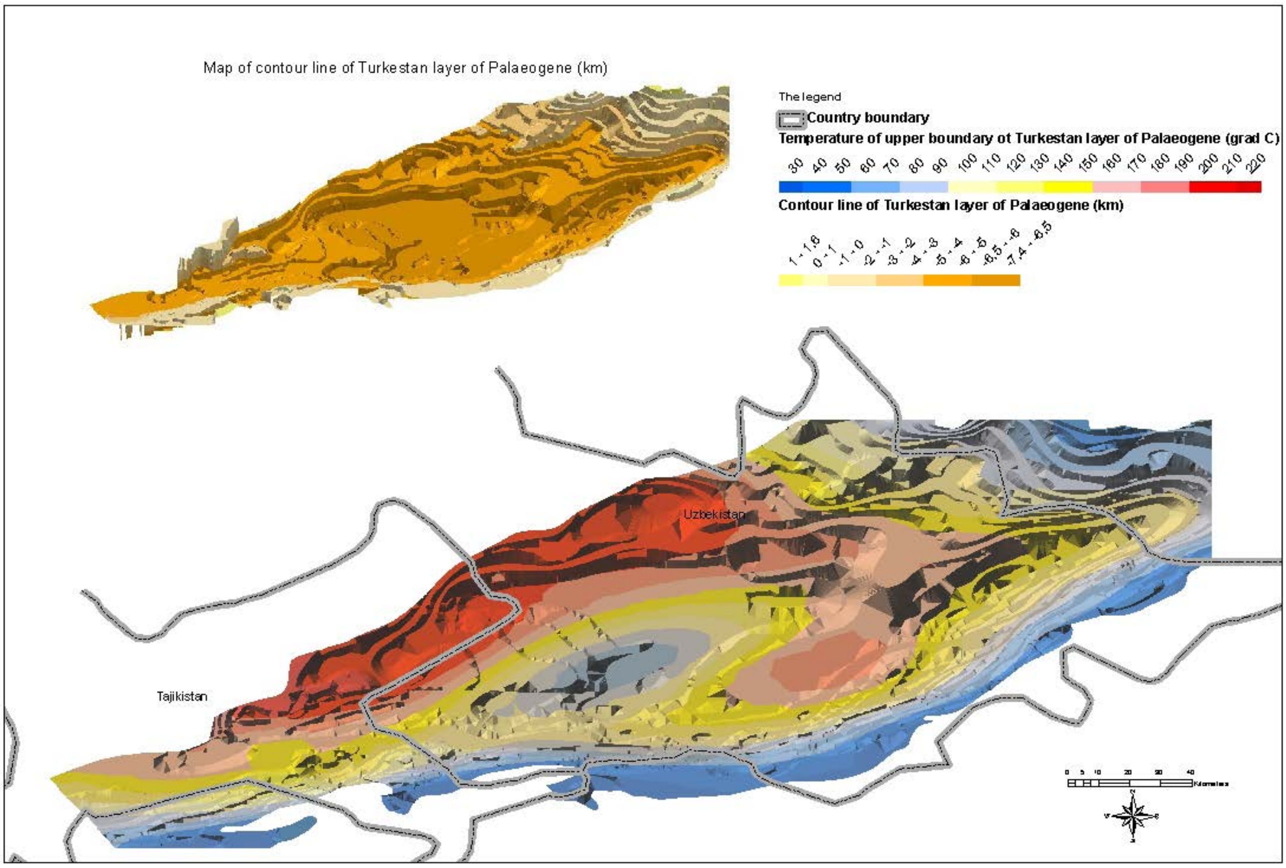

Figure 1 – 3D geothermal model of distribution of isotherms on overlying bed of Turkestan layers of Palaeogene of the Fergana depression.

As results on depths up to 3 km - prevail low-temperature resources (20 % of total area) and on depths more than 3 km - high-temperature resources (35%) (Figure 2).

The created geological-and-geophysical database has allowed on the basis of generalisation and analysis to execute an estimation of temperature potential of the Fergana depression. The database can be used for the decision of a wide range of task, in particular, the geothermal resources exploration, for modelling and forecasting of resource, and, in particular, for estimation of using the resource in agriculture, industry and community facilities.

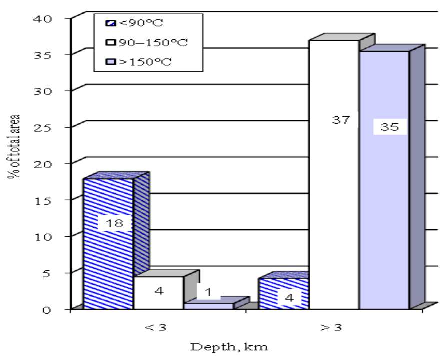

Figure 2 – Distribution of the areas of perspective geothermal sites of the Fergana depression (low, mean and high-temperature resources) on depths up to 3 km and more than 3 km

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HEAT TRANSPORT MODELLING FOR THE DESIGN OF A LOW ENTHALPY OPEN-LOOP SYSTEM

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KEY WORDS: geothermal energy, low enthalpy, open loop system, numerical modelling, SEAWAT code, thermal feedback, pumping wells, Treviso.

INTRODUCTION

Despite their high efficiency and ecological characteristics, the low enthalpy geothermal systems are still quite rare in Italy, mainly due to the disinformation about advantages and environmental rules too much severe (LO RUSSO & CIVITA, 2009) and authorization procedures quite long and complex.

Particularly, the open loop systems (where groundwater is pumped out and then pumped into the aquifer, through 2 or more wells located along the groundwater flow direction) need a detailed hydrogeological study and often a numerical modeling too during the design phase.

This paper presents an example of heat transport numerical modelling with SEAWAT 5.0 code (LANGEVIN, 2009) used to design a low enthalpy open-loop system for the cooling of an industrial plant in the northern part of Treviso Province (Veneto Region, Italy, Fig. 1).

The low enthalpy system has a thermal power of 256 KWh. The use of the geothermal source allows to produce 245 KWh, to reduce the CO_2 emissions of 12.6 tons/year and to save about 9400 €/year of electrical power.

The local stratigraphy is made by alternances of gravel and sand layers with silt-clay layers of fluvial and glacial origin; as a consequence, 3 different confined aquifers occur in the first 75 meters below ground surface on the study site, separated by 3 aquitard layers of variable thickness.

The third confined aquifer (25 m of thickness starting from 50 m b.g.l.) is the one exploited with the open-loop system and, despite che medium hydraulic conductivity (1.5E-05 m/s), it represents a good geothermal source thanks to the low variability of its temperature (mean value of 13.8 °C).

NUMERICAL MODEL IMPLEMENTATION

Firstly a groundwater flow numerical model has been made with the MODFLOW 2005 code (HARBAUGH, 2005), that allowed to reproduce at the stationary state the hydraulic head distribution inside the third confined aquifer and to optimize the parameters estimation through the simulation of a long term pumping test at the transient state.

The output parameters of this flow model have been transferred to the SEAWAT code in order to implement some transient state simulations of heat transport at short (1 year) and long term (20 years). These preliminary results allowed to optimize the distance between the pumping well and the re-injection well and to evaluate the possible impact of the open-loop system on the aquifer temperature.

a)

b)

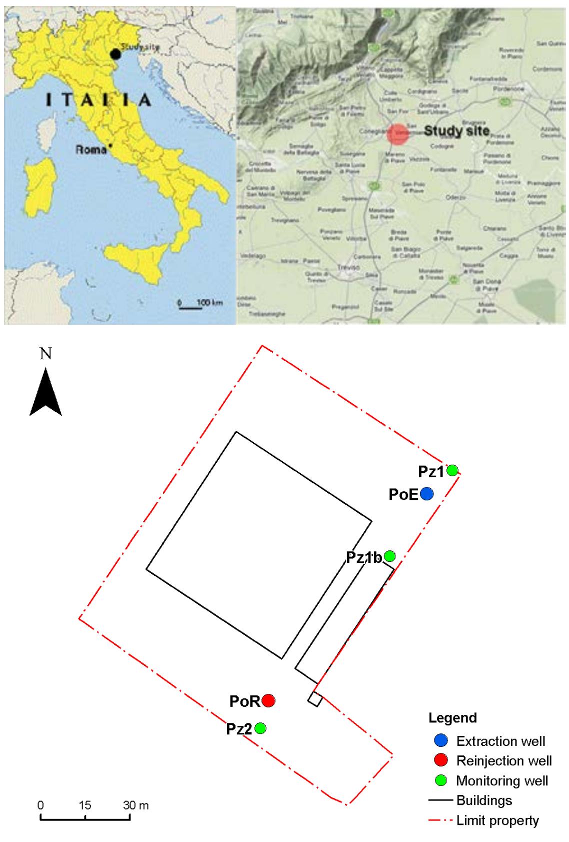

Figure 1 – a) Geographical location of study site; b) schematic map of well locations on the study site.

The modeling domain has a rectangular shape and dimensions of 1000x1500 m, centered on the pumping well and rotated along the main groundwater flow direction (NE-SW). The 3D grid is made by 60 rows, 59 columns and 6 layers. On the x-y plane grid cells have variable size (from 2.5x2.5 m to 110x110 m towards the borders). Along the z direction the domain is divided into 6 layers of the same thickness, included between top and bottom surface of the third confined aquifer.

Hydraulic conductivity (Kx, Ky e Kz) and storage values (Ss) optimized by transient state simulation of pumping test are respectively: 1.38E-05 m/s (Kx and Ky), 8.35E-07 m/s (Kz) and 2.5E-06 1/m (Ss). For the transport model these values have been used: effective porosity of 15%, longitudinal dispersivity of 10 m, transversal dispersivity of 1 m, vertical dispersivity of 0.1 m. The heat molecular diffusion coefficient has been set at 0.36 m^2/hour.

The piezometric gradient has been reproduced using 1st type boundary conditions (b.c.) at the NE and SW borders and 3rd type b.c. at the SW and NE borders of the modeling domain. Pumping and re-injection wells have been simulated by means of a 2nd type b.c. (well package), while the thermal regime and the temperatures of groundwater at the re-injection well have been reproduced respectively with a Constant Concentration b.c. (combined with the 1st type b.c. for flow) and a Point Source b.c.

The local piezometric gradient has been calibrated in a qualitative way, using the piezometric map of the Municipality Environmental Plan. The pumping test has been calibrated with the help of PEST-ASP code (DOHERTY, 2001), that allowed to reach normalized RMS of about 6%, indicator of a good level calibration.

MAIN RESULTS

Short term numerical simulations allowed to optimize the wells distance (> 85 m), avoiding in this way the thermal feedback phenomenon (e.g. pumping out the hot waters injected by the re-injection well, see Fig. 2) that would have taken place with the wells distance initially assumed by the project engineer (17 m), before the here presented hydrogeological study. The simulations results also suggested to locate the wells screens at different depths (inside the same aquifer).

Long term simulations showed that the heat plume reaches a maximum lateral extent of 800 m, while along the flow direction it develops for about 400 m downstream and 300 m upstream (due to diffusion process). The long term thermal impact on the aquifer is quite small, with a temperature increase of about 1.1 °C.

Modelling results and study conclusions confirm that a detailed site-specific characterization of the aquifer is very important in the design phase of low enthalpy open-loop systems.

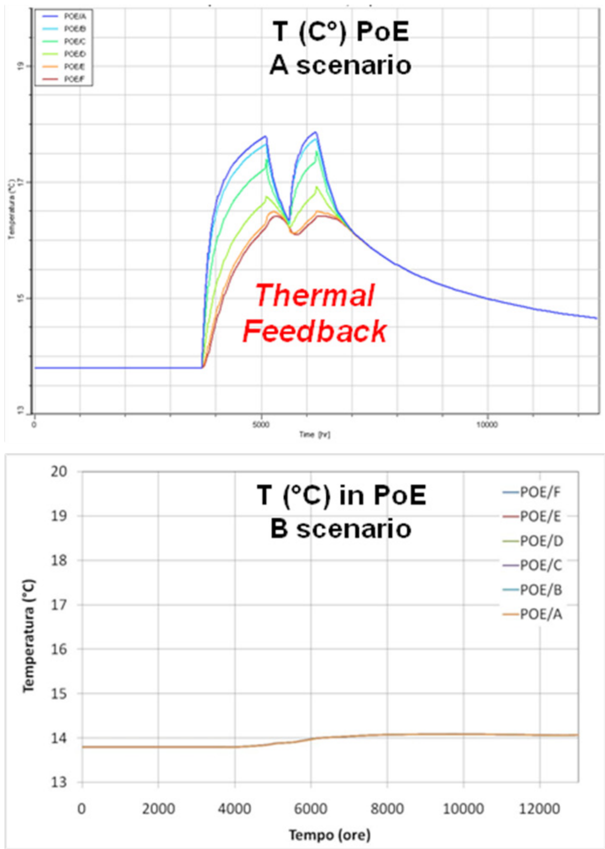

Figure 2 – Temperatures calculated by the model at the PoE re-injection well (at different depths: A, B, C, ...) in the two scenarios: A) distance between wells of 18 m, the thermal feedback is evident; B) distance of 87 m, the thermal feedback is negligible.

ACKNOWLEDGEMENTS

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THE LONG WAY TOWARDS THE CONSERVATION AND ENHANCEMENT OF THE GEOLOGICAL HERITAGE

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KEY WORDS: geodiversity; mine museums; eco-museum, geopark; geotourism; cultural heritage; geosites.

The enhancement and the conservation of the geological heritage represent a huge complex problem, even more challenging compared to the one related to the animal and vegetal kingdoms. The main cause is the poor perception of the value of the geological heritage by the general public. This is due to several reasons: the difficulty to simplify the academic geological language; the distrust of the public towards the geologists, whose figure is generally associated to natural disasters; the lack of concern in communicating to the wide public the issues related to the specialistic geological subjects. For a long time, this has kept away the geologists from the scientific communication system, mainly dominated by issues relating to biodiversity.

Fortunately in the last decades the interest of the general public and local administrations towards this "strategic" issue is growing. This is due, first of all, to a change of mentality, which considers the communication of the scientific subjects an essential aspect. Furthermore, to the high number of dissemination initiatives carried out by associations such as ProGEO (in Europe) and by institutions like ISPRA (in Italy), which have promoted the first geosites census. Finally, thanks to several organizations that enhance the geo-tourism as a new approach to the knowledge of the territory.

However, the way we have to run is still long.

The intent of the authors is to provide an overview on the state of the art of what was done, what is currently going on and what should be done in the future.

A – TOOLS FOR THE KNOWLEDGE OF THE TERRITORY AND THE GEOLOGICAL HERITAGE

1) basic geological cartography and geo-thematic cartography;
2) geo-touristic cartography (from protected areas to urban areas);
3) geological itineraries and geo-tourist guides;
4) numerous museums that deal with geo-sciences;
5) the synergies between these museums and the territory;
6) the census of the sites of geological interest (http://sgi2.isprambiente.it/geositiweb/)

With regard to this point, the availability of products for the general public has increased significantly in the last years. After the first timid experiences, often still designed for specialists, new products have been prepared to be used also by the general public, despite their scientific rigor. Nowadays is quite easy to find suitable material, both surfing the web and in the bookstores, to plan a hike through the geological beauties of a certain location.

B - THE PROTECTION LAWS AND THEIR ENFORCEMENT, RELATED RESOURCES

1) International, national, regional and local regulations. A study on the international and Italian regulations concerning the geological heritage is available on ISPRA's INDEKS website (http://www.envidocnet.isprambiente.it/INDEKS/public/exposeMuseoVirtuale.do?idVoce=2.3);

Fig. 1 – INDEKS Indexing and Networking of Documents on Environmental Knwoledge Sharing

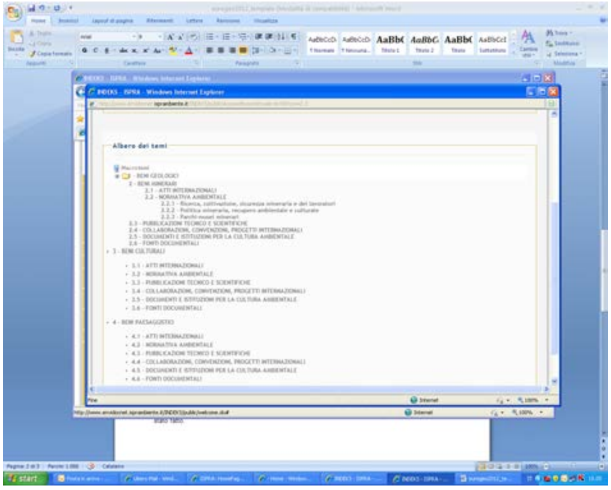

Fig. 2 – Search: Virtual Museum Area - Scheme divided as follows: Property geological, mining, culture, landscape.

2) the establishment of areas designed for the geo-preservation: Geoparks, the European EGN network (www.europeangeoparks.org) and the global GGN network, mining museums and parks, eco-museums;
3) the inclusion of the sites of geological interest in the territory planning politics.
   Several Italian Regions (e.g.: Puglia, Liguria, Emilia-Romagna) and many foreign countries (e.g.: Spain, Portugal, Greece, Holland) enacted specific regulations, not so much for the enhancement but for the conservation of the geologic heritage, particularly in areas which are not yet protected. Unfortunately, it is necessary to underline that at the moment many of these regulations have not sufficient financial resources and don't provide the employment of dedicated staff. The implementation is often delegated to municipalities that have even less appropriate resources. However, it can be considered is already a good result the fact that in the urban planning, it is necessary to report the geological emergencies.
4) the availability of resources for the conservation/enhancement.

C - THE AWARENESS AND RESPONSIBILITY OF LOCAL MANAGERS

1) Integration of Science (researchers), Administration and Management;
2) the creation of synergies between areas with similar geological features;
3) the ability to use the funding towards effective projects (shared and with long-lasting effects).

This aspect, not separated from the former, should be the cornerstone of any project that includes the promotion of the geological heritage. Keeping separate the scientific world and the political world, as frequently happens, is a losing strategy. The researcher and decision maker must work side by side, looking for the necessary resources and the way to use them more effectively.

D - THE DISSEMINATION TOOLS FOR THE ENHANCEMENT OF THE GEOLOGICAL HERITAGE

1) The museums as instrument for the transmission of knowledge and the stakeholder engagement;
2) the museums in situ as a means of direct enhancement of the territory and geological processes;
3) the presence of organizations in the territory, from the institutions to the cooperatives and to the voluntary service, involved in the preservation, dissemination and enhancement of the geological heritage (e.g.: www.geologiaeturismo.it);
4) the organization of exhibitions and events at national and local level;
5) mass media, information technology (the ease of access to information is an indisputable advantage), publishing.

Very seldom the mass media dedicate space to specific topics related to the geological heritage, while they prefer to point the attention to the disaster breaking news. Generally we hear talking about geology in the broadest sense of the term only on the occasion of natural disasters. The programs refer to the natural beauties, but hardly describe the mechanisms necessary to understand how everything around us is not the result of an accident. Like the animal species have a specific evolution, our planet has its own evolution and "life" too: the natural heritage is at risk of extinction as well

There would be a lot to say about the subject of dissemination. The museums are important tool of witness, but steps 3 -5 should be developed; finally, the information technology tools are excellent instruments through which it is possible to reach capillary the general public. There's still a lot to do, although much has been done already.

Experiences of geological heritage enhancement in some European countries (Spain, Portugal, Greece, Netherlands) and in parts of European States (Emilia-Romagna, Catalonia, Bavaria) are reported as evidence of the path.

GEOLOGICAL MAPS FOR POPULAR USE: ANALYSIS AND ADVICE BY CATALUNYA, EMILIA-ROMAGNA AND BAVARIA REGIONS

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KEY WORDS: geological maps, popular geosciences, geological heritage, landscape.

INTRODUCTION

The role of Geological Surveys (GSs) is to acquire the necessary data on the geological assets of the territory and of its subsurface, to turn it into information and knowledge and to make it available to support policy makers and the needs of society.

These are the main tasks entrusted to our GSs, which are technical entities that have the mission of **supporting regional government policies** dealing with land planning, sustainable use of natural resources, mitigation and prevention of natural hazards, among other issues.

The main users of the geological knowledge are technicians within the public administration, professionals, research institutes, teachers, private companies and other agents that operate on our regions.

At present all this knowledge and the issues we are dealing with are often underestimated or not understood enough. Many people and particularly social and political decision-makers lack a sense of appreciation for the importance of the geological knowledge.

REASONS FOR DEVELOPING OUTREACH PROGRAMS FOR GEOSCIENCE

As public entities we have a responsibility to make our wealth of knowledge in the field of Earth Science part of the political and economic process and part of people's common knowledge.

Therefore it is the duty of the GSs to develop outreach programs as a response to several needs:

- There is a growing request from the public for geo-environmental information. We should promote awareness of geology and its significance.
- The GSs must provide citizens with simple explanations about the natural processes which occur in the entire region, on their possible dangerous consequences and, especially, on the work undertaken to prevent them.
- The geological heritage belongs to society. GSs have to promote the cultural values of the geoheritage to encourage its protection and conservation.

All these actions are a way to raise the GSs' profile within our regions and to achieve social visibility.

PREVIOUS WORK

GSs of three regions have done many activities in the field of popularisation of geoscience.

The most relevant publications include: Bavarian Hundret Meisterwerke – die schönsten Geotope Bayerns (LfU), Il Paesaggio Geologico dell'Emilia-Romagna (SGSS) or the Atles Geològic de Catalunya (IGC).

However most of the knowledge about the soil and the subsurface is expressed via specific geo-thematic maps. In addition, papers and technical reports, thematic bulletins and leaflets, among other things, have been produced. At the present time a great part of these products are available on the GSs' websites which are the most powerful tools for outreach.

EUREGEO AND THE WORKING GROUPS

The collaboration between the regions of Emilia-Romagna, Catalonia and Bavaria in the field of Earth Sciences began in 1992. In 2006 our GSs started to exchange views on issues related to the popularization of geology and geoheritage. In 2009 the three regions undertook to structure their partnership, creating a number of working groups one of which is dedicated to Popularisation of Geosciences (WGPopGeo).

WGPopGeo decided to focus on popular geological maps because they are the best way to show the geological constitution of an area. Among other tools, they could contribute to raising awareness of geology and to bringing it closer to society.

Each of our GSs already had a considerable experience in making educational/popular geological maps. The aim of the WGPopGeo was to establish a methodology for the compilation of a new generation of geological maps for popular and educational uses.

These new maps would be prepared to be understandable for the layperson, regardless of the final formats of presentation and distribution: printed maps, websites or the technologies and applications that are being developed.

GEOLOGICAL MAPS FOR POPULAR USE: ANALYSIS, FORMAT AND CONTENTS

The first stage of our project involved the analysis of over twenty educational/popular geological maps produced by the GSs of the three regions and by other leading Geological Surveys. This made it possible to identify all the elements used to produce the maps and to find the optimum solutions to improve our future maps.

Analysis of the maps studied resulted in a number of preliminary considerations and a list of suggestions which would be incorporated as standard in the geological maps for popular use in our regions. We also defined the map's target-readership and the objectives that we wanted to achieve:

The popular geological maps are addressed to general public, visitors to a region or Natural parks, Earth Science enthusiasts, teachers, guides and environmental educators. They must serve as a tool to discover geological aspects of the territory, setting them in context and connecting any other important features of our regions.

Here are summarized some of the advice and suggestions:

- Selection of the area: overall Natural Parks and Geoparks.
- Format and size: not too large, manageable.
- Scale: should strike a balance between the area of the region and the size of the map.
- Layout of the map: the front side is the space reserved for the geological map, the legend and the key; the back side is reserved for more in-depth information.
- Topography: partly hill shading and enough topography data for orientation on roads and trails.
- Geological content: simplified geological map, few cartographic units and simple codes to identify it. Grouping geological formations in landscape units encourage their recognition in the field.
- Legend and key: short descriptions with photographs, plain explanations, simple vocabulary. Geological symbols explained through figures and block-diagrams.
- Additional geological content: geological interpretation of the landscape, sketches, interpreted photographs, explanations, glossary, further reading, etc.
- Additional information: geosites, trails, cultural sites, among others. Related guides, leaflets, websites, etc.

CONCLUSIONS

Starting from these standards each member of WGPopGeo intends to make a map prototype that we hope will be more attractive, easy to read and interesting for citizens.

We aim to bring geology to the people, by making geological maps accessible to everyone, by providing the citizens with the tools they need to better understand the relationship between the land or the landscape and its geological constitution.
Furthermore it is necessary to use modern communication media like internet and mobile phone applications to involve mostly young people. Games like geocaching and earth caching are a chance to arouse the interest in geology and geoheritage.

All these initiatives should encourage people to get in touch with the land where they live or with the places they visit. Our aim is that people discover and enjoy geology in the field, which is the best place to find it, as well as increase appreciation of the geoheritage of our Natural parks and Geoparks. We also hope these maps and games will be helpful for teachers and environmental educators.

We strongly believe that field experience is the most direct and effective way to improve people's knowledge of the natural environment, in this case, the geological constitution of an area. This knowledge may also help to explain to people the reasons for environmental protection and to encourage their involvement in it.

ACKNOWLEDGEMENTS

We are grateful to the former members of the WGPopGeo, Dr. Lagally, Dr. Teipel and Dr. Glaser (LfU) for all his work on this project. We also want to acknowledge all the GSs who have worked in popularizing geology, in particular BGS (UK), TNO (The Netherlands), BRGM (France), IGME (Spain), USGS (USA) and GSC (Canada).

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BAVARIA'S 100 MOST BEAUTIFUL PLACES OF OUTSTANDING NATURAL BEAUTY ("GEOTOPE") – A SUMMARY

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KEY WORDS: Bavaria, nature's treasures, geosites, Geotope, geosite conservation, geotourism, environmental education.

THE REASON WHY

Many people and particularly social and political decision-makers lack a sense of appreciation for nature's treasures in front of their doorstep. They do not know about their impressing evolution, their scientific importance and that it is vital to protect them. Therefore, reasonable decision-making requires profound understanding for the protection of the places of outstanding natural beauty ("Geotope").

100 MOST BEAUTIFUL GEOSITES

In 1985, the former Geological Survey of Bavaria provided the basis for the conservation of geosites by establishing the "Geotope Register of Bavaria". True to the motto "Experience Geology", the Bavarian Environment Agency has selected 100 geosites that qualify for "Bavaria's most beautiful geotopes" in order to raise public awareness for their conservation.

Figure 1 – Staatssekretärin M. Huml from the Bavarian State Ministry of the Environment and Public Health presents the information board of the geosite "footprints of saurians" Euerdorf, NW Bavaria (Rhön).

Figure 2 – Flyer of the geosite "Watzmann mit Eiskapelle".

The geosites have been selected according to their popularity and their equal distribution all over Bavaria. Sites such as waterfalls, isolated cliffs, basalt pillars etc. have been preferred to less attractive, yet scientifically interesting objects. This occasionally results in a conflict of interests as the selection is strictly limited to 100. Essential information on geosites is provided online, in flyers, and there is a uniformly designed information board on-site. Town councils and other sponsors commonly take care of the geosite.

In September 2011, the last one of the 100 most beautiful geosites in Bavaria was announced and a book with the 100 geosites was published. But even at this stage, the program's acceptance is beyond expectation. When the project started in 2001, activities such as geocaching (a GPS-based orienteering outdoor activity) were not known, but nowadays, they additionally enhance the popularity of geosites.

In conclusion, the concept of "Bavaria's most beautiful geotopes" has proven to be hugely successful.

FROM ONE-DIRECTIONAL POPULARIZATION OF SCIENCE TO MULTI-DIRECTIONAL PARTICIPATORY CONCEPTS – THE POTENTIAL OF CROWDSOURCING

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KEYWORDS: popularization, crowdsourcing, social media, added value, concept, web 2.0

INTRODUCTION

Popularizing research can freely be defined as ‘presenting information in a widely understandable or acceptable form to the public’. Alternatively, the meaning of popularization can be expressed as ‘adding the general understanding of science’. Traditionally popularizing research has actualized in delivering the research results or other research outputs as publications as well as producing specific simplified material for e.g. educational purposes. Common to all of these, popularization has been comprised as a one-directional process where the scientists deliver the ready-made popularized content to a rather passive audience.

Regardless of the 1990’s rise of internet and rapid digitalization of data and products the nature of popularization itself did not change at once. Although the form of research content became digital, it still did not change the role of the public which remained passive. They still were just objects who were delivered e-publications, digital data and products. Just from the beginning of 2000’s the development of web technologies and standards as well as a change in social attitudes led the web content growing and the research results being put available to a broader public in more interactive applications and user interfaces. By using these, the end users were more able to give feedback and have an influence on the form in which they receive the content for instance by filtering, sorting, re-analyzing and visualizing it.

The recent demand within the public appears to lead the research community more and more towards bi- or multi-directional interaction between science and public communities. Examples of such a relation are to be seen in various fields as megatrends of web 2.0, social media and crowd sourcing currently rampage complete business concepts and industries.

This paper discusses the relationship between the research and public community and their roles in terms of the changing nature of popularization. It also makes considerations on the potential added value of the current trend that the actors (e.g. national geological surveys) could utilize in renewing their concepts and services.

THE NEED AN D POTENTIAL OF RENEWING THE POPULARIZATION CONCEPTS

There are several drivers that change the role of research community and organizations. First, the research is less and less isolated from the rest of the world. It needs to prove its added value and gain its general acceptance by producing outcomes (knowledge, products and services) that are applicable to society in the equivalent manner to business. Considering a public research institute this general acceptance culminates in communicating (i.e. popularizing) the research outputs as added value to stakeholders (e.g. ministries) in an understandable manner but is also affected by general grass roots views within a society. Secondly, the research community needs to respond to the public demand in making it possible for people to contribute to the research or research-like processes. To do so, participatory concepts need to be developed. Thirdly, the crowd, its interest to participate and expertise is to be regarded as a significant pool of resources, considering of which - particularly within the era of potentially cut budgets - is to be taken seriously. Harnessing the voluntary labour to enhancing the productivity, applicability and quality of the outputs of research is a win-win scenario for all the parties involved.

In order to evaluate the potential of e.g. crowdsourcing within the research process, the process in whole has to be taken under examination. While previously the actual popularization actions took place in the end of the process and were separate functions, currently the demand and potential is embedding the public contribution as part of all the stages within the process. Potential cases of using crowdsourcing are to be identified in e.g. field data collection, digitalizing, refining or delivering the products.

Also knowledge sharing concepts such as science 2.0 in form of e.g. science blogs and wikis where unfinished research results can be displayed and further developed are growing in number and constituting more interdisciplinary connections and allowing people outside the academic world to participate. Depending on the case, popularization now finds its variations from traditional delivery of ready-made outputs to advanced synergistic co-sourcing or value network-like cases and everything in between. The more advanced the approach the more the involved parties must give up their protectionism and open up their knowledge resources for creating common good with all parties recognized for the results.

POTENTIAL CROWDSOURCING USE CASES IN GEOINFORMATION MANAGEMENT

Going back some years there has been a 'tradition' of crowdsourcing applications with geology. Most of the applications have been developed to collect every man's observations such as various hazards (e.g. USGS's Earthquake hazards program). (Heipke, 2010).

Representing a slightly different approach in Finland there are currently several ongoing cases where crowdsourcing is being applied. An example of an advanced crowdsourcing application is 'digitalkoot' ('digital volunteers' in Finnish) by the Finland's national libraryElectrifying the Finnish cultural heritage.

It was recently recognized globally as one of the Netexplo Top 100 innovations of 2012 (Netexplo, 2012). The idea of the application is to set Electrifying the Finnish cultural heritage simplesimple text recognition tasks potentially misrecognized by computer into an on-line game interface available to public. By playing the game people simultaneously help the organization to digitalize the cultural heritage (e.g. historical documents). During the first year of the service 100 000 volunteers have visited the 'digitalkoot' site and donated around 5000 hours of work by accomplishing more than 6 million micro tasks. This sort of approach might be to some extent applicable also in digitalizing geoheritage, geological maps and other surveying data.

A rather traditional way of using voluntary labour is using the amateur geologists to supply the surveys with mineral samples found in nature. Moreover, other hobbies such as geocatching and 'treasure hunting' with metal detectors are growing in popularity. Due to constantly evolving amateur equipment the concept could well be further developed to people donating also the data collected when working on the field. The data could include spatial data, data from various instruments, photographs etc.

A potential way for the surveys to exploit extra-organizational expert resources in their information processes is delivering certain raw observation data set freely and establishing incentives to refine to data e.g. through a modeling competition, the results of which would return to the organizer with adjacent rights to re-use them. By this sort of crowdsourcing (or co-sourcing) not only would the work be crowdsourced in terms of quantity but also the outcomes may be more innovative and of higher quality than it would be using only internal resources and expertise.

New concepts set new requirements to service and transaction platforms and applications. In all applications based on crowdsourcing there is a growing need of controls and using standards to manage quality and information security. The typical challenges in opening up the process to the public deal with the availability, confidentiality, integrity of data (cf. Ruitton-Allinieu, 2011). Moreover, the importance of making clear the terms and conditions of participating and using the outcomes derived from crowdsourced concepts is to be emphasized.

CONCLUSIONS

As the business concepts so does those of research field need to evolve according to the operational environment. The changes of concepts are often strategic issues with influence on data politics and require new kind of thinking. In national geological surveys' case the demands of the steering ministries shift towards a more service oriented direction and creating more innovative products with higher quality and productivity is today's reality. On the other hand the surveys focused on applied research have a rather good chance of re-positioning themselves in the value network. By taking unprompted actions towards the expected direction the surveys can show their maturity and ability to renew. The new concepts require opening up data policy but by doing so in a wise manner the surveys have a chance of getting the resources and expertise of the crowd as a gift in return. Altogether, deploying new concepts may in best case scenario add more value to the network creating new synergies, expertise and innovations to the society.

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GEOHERITAGE AND GEOTOURISM MAPPING VERSUS GEOMORPHOLOGIC MAPPING: SCALE AND SYMBOL ISSUES.

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KEY WORDS: Geoheritage, Geotourism, Maps, Scale, Symbols, Geomorphologic mapping.

INTRODUCTION

Geoheritage and geotourism maps are, as geomorphologic ones, a type of thematic maps applied to earth science domains of research.

However, as we said in a previous paper (Rodrigues & Fonseca, 2010), despite a lot of discussion that has been made concerning the scale and legends of geomorphologic maps (see, for instance, Klimaszewski, 1968; Demek, 1972; Demek & Embleton, 1976; among many others), these issues has not yet been properly discussed and applied in the assessment and mapping of geosites and geomorphosites. Nevertheless the studies about geoheritage and geotourism have a lot in common with the geomorphologic ones. As geoheritage consists on the entire set of abiotic natural elements existing on the Earth's surface (emerged and submerged), which should be preserved due to its heritage value (Rodrigues & Fonseca, 2008), it includes mainly the geologic, geomorphologic and hydrologic heritages. So, to assess and map the geoheritage of an area it is necessary to survey its geologic, geomorphologic and hydrologic values, what it is clearly less arduous than to do a systematic detailed geomorphologic map. We can say that geoheritage maps are a sort of applied geomorphologic maps, those called by Embleton & Verstappen (1988) as pragmatic geomorphologic maps, using only the information connected with the abiotic values to be preserved.

In what concerns the geotourism maps the same reasoning should be done. For us (Rodrigues, 2011), geotourism can be defined in strict or in large sense. In strict sense, geotourism is a segment of tourism focused on the sustainable usufruct (by geotourists and local communities) of the geoheritage fruition. In a broader sense it can be considered a segment of tourism focused on the sustainable usufruct (by geotourists and local communities) of the geoheritage fruition to which can be added the cultural heritage (material and immaterial) of the areas. So, geoheritage is the driving force of the geotourism itineraries, but the cultural heritage it is also added to increase the value of the regions.

In the next sections we will focus the main problems connected to the use of scale and symbols in geomorphologic, geoheritage and geotourism maps. Unfortunately it is not possible to exemplify these questions with maps taken from examples of Portugal and Italy. That will be done in the oral presentation and in the coming paper.

SOME GUIDELINES FROM GEOMORPHOLOGIC MAPPING

The Subcommission on Geomorphological Mapping (Commission on Applied Geomorphology), created in the XIX Congress of the IGU (Stockholm, 1960) under the leadership of Klimaszewski, had among its objectives to introduce the geomorphologic mapping in the research and to prepare common concepts and principles in the construction of detailed geomorphologic maps.

The maps were classified according to their content in general or partial and to their purpose in basic, applied and special ones (see Demek, 1972). Later, Embleton & Verstappen (1988) presented another classification according to the purpose of the geomorphologic maps: analytic (similar to the basic ones), synthetic (for multidisci-plinary studies) and pragmatic (for specific objecti-ves). So, if we want to follow these designations, the geoheritage and geotourism maps could be classified as applied maps (Demek, 1972) or as pragmatic maps (Embleton & Verstappen, 1988).

In what concerns the scale there are a lot of discussion and different positions. As we cannot debate them here we present a personal classify-cation made some years ago (Rodrigues, 1988):

- Geomorphologic Plans, up to 1:2000;
- Detailed Geomorphlogic Maps, smaller than 1:2000 and up to 1:10 000;
- Large-scale Geomorphologic Maps, smaller than 1:10 000 and up to 1:25 000 or 1:50 000;
- Medium-scale Geomorphologic Maps, smaller than 1:50 000 up to 1:500 000;
- Small-scale Geomorphologic Maps, smaller than 1:500 000 up to 1:1 000 000.

The discussion made about the symbols and legends to adopt in the geomorphologic maps, and particularly in the detailed geomorphologic mapping, it is so vast that it is impossible to reproduce it here. However, we can point out some important ideas: i) most of the researchers agree that it is necessary to use contour lines to give an idea of the altitudes present in the areas (nowadays we can also use a Digital Elevation Model – DEM - to represent the relief); ii) the colour, when used, is mainly applied to distinguish each set of landform processes; iii) the majority of the proposed legends are made for morphogenetic maps.

GEOHERITAGE AND GEOTOURISM MAPS: SCALE OF REPRESENTATION AND SYMBOLS

The choice of which **scale** is suitable to do the geoheritage or the geotourism map of a certain area it is not fixed in advance. It depends on several factors such as the spatial dimension of the area, the degree of detail used in the survey and, above all, the purpose that we want the map to fulfil. It can give only a general idea of the geoheritage at a national or regional scale and so we use a map of small or medium scale, but it can also give a detailed geoheritage and geotourism information about a certain protected area or municipality and then we must use a large scale or a detailed map.

A first approach to the question of scale in geomorphologic sites mapping was made by Carton *et al.* (2005). Beyond the discussion about the differences between maps for specialists and non-specialists, those authors are known by fixing the limit between what they call small scale maps (less than 1:200 000), "which should be consider-ed prevalently as index maps", and large scale maps (greater than 1:200 000), were "geomorpho-sites will be best shown by means of the traditional symbols used in detailed geomorphological maps". In the first ones geomorphosites should be repre-sented by small **symbols** like dots, squares, flags, etc., i.e., using symbol shapes or colours to discri-minate the differences. However, as we know, the symbols shape and colour are not very suitable for a good map contrast, fundamental in the cartogra-phic legibility. Indeed, when the shapes or colours multiply, the map reader is not able to memorize all the types of correspondences (geosites), and have to use the legend each time what corres-ponds to an elementary map reading.

More recently, Coratza (also co-author of the previous paper) & Regolini-Bissig (2009) wrote about methods for mapping geomorphosites and, in the state of the art, focused in the paper of Carton *et al.* (2005) never mention the limit of 1:200 000 scale between small and large scales pointed by the authors. Instead they mention that Carton *et al.* (2005) consider that in the maps for specialists "it is necessary to use a sufficiently large scale (not less than 1:25 000)". Besides these inconsistencies, Coratza & Regolini-Bissig (2009), refer medium and large-scale geomorpho-site maps (giving as example two maps at 1:25 000 and 1:12 500 scales) and small-scale maps. However, there is no discussion about scale and it is even written that the working scale can be international, national, regional or local. In the Table 1, about guiding principles for geomorphosi-tes mapping, the authors present very general ideas. For example in the component scale the guiding principles are "the scale of the maps depends on the area to be covered and the way in which the geomorphosites are to be visualized: point symbols, pictorial or pictograph symbols, classical geosciences mapping symbols". Conclu-sion, there are no information about the scales to be used and there a confusion between scale and symbols, although the two things are connected.

DISCUSSION

In what concerns the **scale** of the geoheritage and geotourism maps there is nothing that prevent us to adopt the same classification made for the geomorphologic maps and presented in the 2nd section: Plans, Detailed Maps, Large-scale Maps, Medium-scale Maps and Small-scale Maps (Rodri-gues, 1988). The question of the symbols to adopt in these type of maps it is more difficult to discuss in short space and without some examples of maps. Of course everybody agree that we can use point, line or area symbols and that in the maps for specialists it is possible to use symbols from geomorphologic legends (when the scale is large enough). However, even in this case, often we have to deal with a new parameter: the geosites or geomorphosites have value to be represented (scientific and additional values). In these cases we have to use size or a value scale (equal value grey scale) to represent the variable. The use of abstract or pictorial symbols is also related to cartographic generalization and its principles. So, in conclusion, we must combine the procedures of geomorphologic mapping with well established cartographic methods.

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GEOCAMP: THE ONLINE PUBLISHING PLATFORM OF GEOLOGICAL GUIDES

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KEY WORDS: GEOCAMP, geology, field trips, website, geological guides.

THE INNOVATIVE CHARACTER OF AN INTER-UNIVERSITY PROJECT

In 2002, a group of professors of geology from the Universitat Autònoma de Barcelona, University of Girona and the Polytechnic University of Catalunya launched a project focused on innovative teaching practices in field geology. To develop this project we attended various calls and we could get public funding[1] to promote this initiative (Brusi *et al.*, 2011).

As a result of more than eight years of work, has been developed GEOCAMP: the portal of field activities in Geology (Fig. 1).

Figure 1 – Home of the web GEOCAMP (subject to changes)

- GEOCAMP is a web that brings together numerous resources and links specifically designed to optimize the learning process in the activities of field geology.
- GEOCAMP is a free access website to serve teachers and students from universities and secondary levels to conduct field activities as part of their learning. It may also be interesting to many fans of Earth Sciences who wish to engage in recognition of the regional geology.
- GEOCAMP is an experience that has been widely used by university students in which the team of authors teaches. Its potential and has allowed unrestricted use spread to other schools and educational levels in both the rest of the country and abroad.
- GEOCAMP was initially developed in Catalan but today is available in Spanish, English and will be translated into other languages soon.
- GEOCAMP incorporated, since 2008, a specific application that allows automated publishing of geological field itineraries for any geologist around the world.

GEOCAMP incorporates a desktop publishing tool that lets you enter text and figures that make up the description of outcrops, trips, museums, and urban routes of geological content. From the information provided, it generates a document with an own layout that can be consulted in HTML or downloaded as a PDF and used as a field guide.

Its handling is very intuitive from an Editing menu. It is necessary to fill a template with different fields:

- A general information sheet: heading for the item of interest of the site or trip, authors, affiliation, the mean goals, geographical area, etc.
- A chapter of generalities: in order to provide sufficient a previous knowledge of the area before entering the descriptions of sites of geological interest.
- In the case of trips, the application allows to define a "main itinerary" structured in stops (observation points) on the basis of a theoretical reflexion previously developed from some team

1 The GEOCAMP project has benefited from three assists for calls MQD (Millora de la Qualitat Docent) from AGAUR (Agència de Gestió d'Ajuts Universitaris Recerca) from the Generalitat de Catalunya in 2002, 2005 and 2008. MQD (2002): "Optimization in multimedia field practices" in the subject of Geology "MQD (2005):" Field trips in Earth Sciences: Proposed cross and Multimedia "MQD (2008):" GEOCAMP-EDITOR. An online informatics tool to publish itineraries on field Geology". The project also received financial support from the IGC (Geological Institute of Catalonia) to develop pilot examples of itineraries in our country.

members (Bach et al., 1988; Brusi, 1992 b).

- A section of “other points of interest,” to describe, briefly, other sites that can complement the main itinerary.
- A field of “educational activities or suggestions” that provide resources to teachers to carry out the trip with their students.
- A “references or web links” provide more information about the area or subject matter described.
- An acknowledgments chapter for those who wish to mention the personal or institutional support.

The application allows successive modules include text in any language, images (graphics, tables, pictures) and figure legends. In all sections provide instructions to facilitate the resolution of doubts. Users can edit their itineraries to the rhythm they want. Like any tool, the GEOCAMP-EDITOR allows you to save changes and leave the session temporarily.

The ultimate goal of the promotion team is to make this editor GEOCAMP of geological sites in an electronic publication, free and open to the scientific community. Therefore, the software processes all the information entered in per itinerary to be presented with an HTML or an A4 format, downloadable as PDF (Fig. 2).

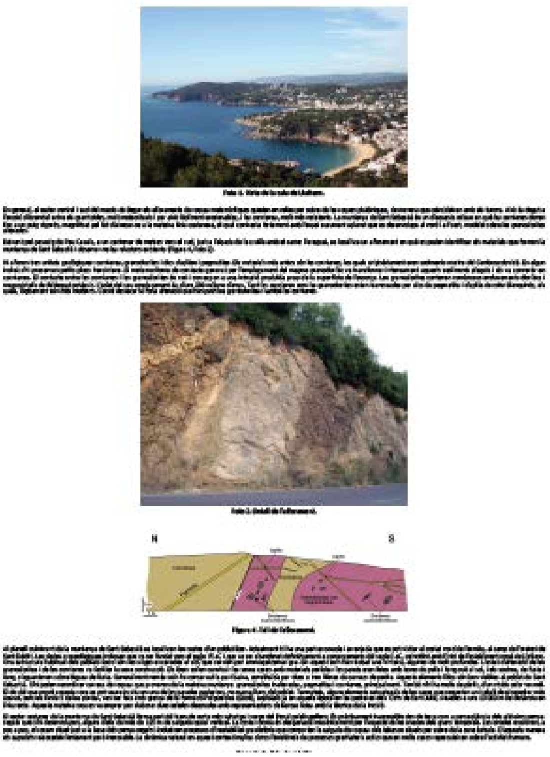

Figure 2 – Example of a GEOLOGUIDE page.

At any time the author (or group of authors) can be accessed through the menu, a “preview” that displays a document that generated the application combining your text and figures.

When the author decided to finish the input, can leave the edition mode and “publish” their point of interest or itinerary. At that moment, the application automatically feed a database and the GEOLOGUIDE be visible to anyone from the GEOCAMP website.

A search tool facilitates the localization of the published schedules, either by the name of the author, by geographic area or by type of geological interest.

Assuming the impossibility of having a review team that can address the expected volume and diversity of content, GEOCAMP promoters decided to leave to users the valuation process. Thus, GEOCAMP incorporates a questionnaire that asks various aspects:

- Scientific rigor
- Originality
- Geological Interest
- Quality of graphics
- Utility for teaching

The number of evaluations and the average score users are available to the public for each GEOLOGUIDE. The comments and reviews about each of them are automatically sent to the first author and the editor responsible for the application.

GEOCAMP aims to become a collaborative tool from which to divulge geological heritage as field guides prepared by specialists, teachers and institutions.

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A PROMISING WAY FOR THE POPULARIZATION OF GEOLOGY - THE "DAY OF GEOSITES" IN GERMANY

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KEY WORDS: geosite, geo-heritage, day of geosites, geoscience, popularization, Germany.

1. IDEA

In 2002, the "Year of Geoscience" was celebrated in Germany with nationwide projects and also by introducing the "Day of Geosites" as an annual special event. It is based on an idea developed by the Geosite Branch of the German Society of Geosciences (DGG) together with the Academy of Geoscience and Geotechnologies and the Paleontological Society. These institutions had perceived an increasing interest of the public in geo-heritage resulting from the intensive efforts toward the conservation of geosites made by the German geological surveys since the 1980s. For ten years now, the Day of Geosites takes place every year on the third Sunday in September.

2. CONCEPT

Main target of the Day of Geosites is to bridge the gap between geosciences and the general public by using geosites as tangible examples for the explanation of certain geological features. The public is to be made aware that individual and economical life is influenced by its geo-environment in a broad, to many parts of the public unknown complexity. Therefore, people who are unfamiliar with the subject are a special target group. Everybody in Germany is invited to participate in the event. And as most of the important organizations are taking part in the project, it consequently covers most of the topics where geology influences base and life of our society.

3. ORGANIZATION

Since the event comprises a large number of individual actions all over Germany it cannot be carried out by one single institution. Supervision of the entire event is practiced by the German Geoscientific Society, coordination of the individual activities in the different states, however, lays in the responsibility of the state geological surveys. Their obligation is to promote events in their respective region and to examine the announced actions before they are made public.

Also, the supervision includes the production of advertising and information material, the operation of website and database,and a wide press coverage well in advance of the action. Moreover, a person of high standing or an influential institution is asked to accept the patronage of the Day.

Figure 1 – Poster of the "Day of Geosites" in Germany for the year 2011

Numerous members of societies and museums, students, staff of the raw-material industry and competent private persons contribute to the various actions on the Day of Geosites. They volunteer explanations at geosites and give guided tours to geo-related installations. Special emphasis is put on the explanation of the respective features: The language must be easily understandable for all visitors, technical terms have to step back.

4. ACTIONS

Before the annual event starts geo-institutions like university institutes, geological surveys, museums, geo-societies, interest groups, and also educational institutions receive an invitation and information poster. Also, a website is established (www.tag-des-geotops.de) that is regularly updated. It features a directory of all actions presented nationwide and also an archive listing previous events. A search tool enables the visitors to select geosites in specific areas as well as different types of geosites, museums, raw material operations etc.

In addition to the large advertising poster, a small flyer for individual printing is available on the internet. It has a layout similar to the one of the poster reminding of the nationwide action. Important information about the major aims and project organization is pre-printed, but plenty of space is left for the promotion of individual events.

Figure 2 – Pre-designed flyer for individual use by local stakeholders (front)

Many of the geosite presentations are announced in local newspapers, covered by regional TV-programs and all are available on the internet. At some geosite locations and via geological periodicals special leaflets are spread to the public. Local guides offer special explanations of selected geosites, tours to geo-museums, historical mines or caves. They also allow visits to open-pit mines, quarries and other “geo-objects” usually not accessible to the public.

5. RESULTS 2011

In 2011, the Day of Geosites set another new record: more than 300 different events were offered to the public almost nationwide. In Bavaria, a total of 112 events proved the growing interest by stakeholders and public likewise. Although the public response was influenced by changing weather conditions, it is estimated that the same number of visitors as 2010 (approximately 30.000) attended the manifold presentations and activities.

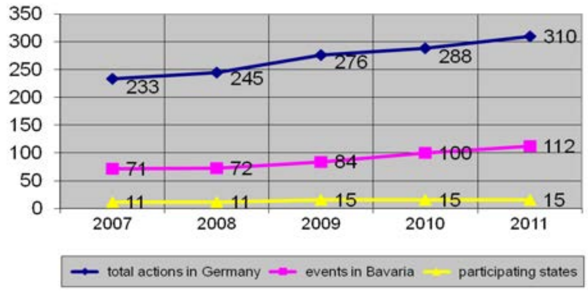

Figure 3 – Development of actions and participation of the Day of Geosites from 2007 to 2011

6. CONCLUSION

After 10 years of experience, the Day of Geosites in Germany proved to be a successful way for promoting geosciences. Within this period, the number of events and visitors increased progressively. People were not only attracted by the geological heritage, but also by many more issues of geosciences. Still a problem is the modest interest shown by the media. Best response was reached on a local level where most likely personal relationships between press representatives and stakeholders existed and worked well. Particularly on that level, the good contacts should be maintained and expanded in the future. In Germany, the idea has contributed to a better understanding and acceptance of geosciences in the general public. Since special geological problems do not end on state boundaries it is important that this successful initiative is pursued also in neighbouring countries.

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SPREADING GEOSCIENCES THROUGHOUT ITALY: THE INTERNATIONAL YEAR OF PLANET EARTH

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KEY WORDS: International Year of Planet Earth, Italian Committee – Festa di Primavera/ OneGeology, Yes Congress, Geology and Wine, Pianeta di Geo

POPULARISATION OF GEOSCIENCE AND GEOHERITAGE

The Italian International Year of Planet Earth (IYPE)Committee adopted a specific targeted approach to spread Earth Sciences all over the country during the IYPE triennium.

The entire world, and Italy in particular, is going through a rather difficult moment from both the political and economic point of view: natural resources, in the process of disappearing in some countries while in others not adequately exploited, are influencing global economy on the basis of their different exploitation modes. Natural resources, either renewable or not, have crucial implications as far as human health. wealth or society are concerned.

The natural disasters, also related to climate changes, which have marked our world in the course of history require a reconsideration of the way of conceiving preventive measures.

Through extremely violent seismic activity the planet has often warned us how important it is not to break the balance of the earth and not to neglect its constant and countless transformations. Man has only one way for trying to limit natural disasters and exploiting resources at best while protecting their existence and the health of the planet: knowing it. That is why, for the first time in history, the United Nations decided to proclaim 2008 as the INTERNATIONAL YEAR OF PLANET EARTH, with the support of 191 member states. Therefore National Committees were set up all over the world with the aim of penetrating the social fabric in order to increase its culture and responsibility.

Moving from the assumption that so far Earth Sciences priceless heritage of information on issues such as climate, water and other natural resources, energy, health, soil and subsoil, oceans, natural disasters or life itself, remains, not only unknown to the general public, but often inadequately exploited by policy makers, IYPE aimed to spread information in order to build a proper culture.

IYPE IN ITALY

Italy has immediately understood the importance of joining an international event of this magnitude attracting general attention from its commitment and national mobilization.

Italy, in fact, was part of the countries that officially inaugurated the International Year of Planet Earth at the UNESCO headquarters in Paris. On that occasion Italy gave a keynote speech at the opening ceremony along with Ministers of France, Norway, Egypt and Tanzania in the presence of delegates from all over the world.

The fact that Italy was part of the inner circle of the 5 countries that launched the Year at global level, demonstrated its commitment and raised the attention of the International community for its sensitivity and awareness of environmental protection needs.

But this was only the beginning. In Italy, in fact, needed a kind of divulgation at all levels: social, political, and educational ones.

It was decided to start from the Italian highest Institution. The International Year of Planet Earth was proclaimed in Italy by the President of the Republic who dedicated to the event the annual ceremony called “Spring Day”- “Festa di Primavera”, in the presence of the Ministers of the Environment and of Education.

Meanwhile - also thanks to the Italian commitment - the International OneGeology project involving over 80 countries, among which Italy played a prominent role, was launched. the OneGeology portal - which was presented at the International Geological Congress in Oslo - for the first time in history made the geological information about the whole world territory available. Nowadays users have at their disposal an exhaustive and technologically advanced example of the geological mapping of the Earth just as they can get a view of the surface of the Earth through Google Earth.

The Italian Committee also organized a number of events dedicated to geological issues, such as Geology and Wine, a combination which has kept inspiring events so far. Through a calendar full of initiatives organized by the Italian Committee – such as educational walks and lectures, we managed to make the approach to geology possible even to people who had never been interested in it before thus letting them know - for example - the secrets linking the type of territory to wine.

The Italian Committee was also the promoter of the first International Geo-Science "Yes Congress" which got together Under 35 Geo scientists and professionals from all over the world in Beijing from Oct. 25th to 28th, 2009. The Beijing meeting represented not only an opportunity for the young to express their opinions and suggest solutions to the Earth Sciences global challenges concerning the International Year Planet Earth subjects – energy, water, climate changes,– but also encouraged a dialogue among them aimed at building a world net of young scientists.

The effects and activities of the Italian Committee went on in schools until last year and will most probably go on in the future. Through publications such as "Geo's Planet" – "Pianeta di Geo", a comics book which explains the secrets of the Earth, geosciences became part of primary school teaching. During 2010 some Italian schools organized classes and didactic trips under the guide of ISPRA experts.

All these initiatives became widespread trough media, arousing also the interest of national TV channels, which broadcasted live the launch of the IYPE and realized several specials, including one entirely dedicated to OneGeology - and, in addition to all news agencies, a number articles on national newspapers.

DISCOVERING THE MYSTERIES OF OUR EARTH: A JOURNEY FOR EVERYONE

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POPULARISATION OF GEOSCIENCE AND GEOHERITAGE

The International Year of Planet Earth was a joint initiative by UNESCO and the International Union of Geological Sciences (IUGS) and ran from January 2007 to December 2009. The main objective of IYPE was to make people aware of the strategic role of Earth Science for the future of the human society, through both outreach and scientific projects and activities. The IYPE promoted wise (sustainable) use of Earth's materials and encouraged better planning and management to reduce risks for the world's inhabitants, including the promotion of geological heritage through programs that increase the public awareness of geological phenomena and to draw attention to the importance of geology in everyday life. Geological features and phenomena are often observed by the general public, but with little understanding beyond the fact that rocks are hard and solid. Very few realize that modern amenities of life, such as television sets, houses, cars and computers would not be possible without minerals and their by-products.

To address these issues the Italian IYPE Committee, launched a series of actions planned on the basis of the target audience; for instance children, teenagers and adults require different approaches and techniques. Through the use of different approaches tailored to different targets, it was possible to have a very strong response.

Among several projects of the IYPE, three of them achieved significant success: Via GeoAlpina, OneGeology-Europe and the Y.E.S. Network.

This paper describes those projects and the communication methodologies adopted by the Italian IYPE Committee for implementing them.

Via GeoAlpina: Its aim was to spread among decision makers and the general public the significant amount of information of Earth Science topics such as water, energy, health, soil or natural hazards, through simple and direct messages. Getting this information directly on site represented the most direct way of applying Earth Science in everyday life.

Austria, France, Germany, Italy, Slovenia and Switzerland offered the opportunity to learn about the ancient and deep origins of their most fascinating areas throughout the entire Alpine chain, as an accompaniment for tourists and hikers of all ages in discovering the Earth's secrets. Complex geological processes, which originated long before the appearance of man on Earth and characterised life, culture and traditions of the communities, have been made known through walking trails and tours, carefully selected and available free of charge. The proposed routes have various levels of difficulty to attract anyone from expert hikers, to tourists as well as school groups. The descriptions of the trails can be accessed and downloaded from the Via GeoAlpina website or are available at the partners' tourism offices, parks, geoparks,etc. Permanent information points along the trails provide cultural and geological information and allow the visitors to autonomously enjoy their journey without the need for a guide. Several events were organised in the participating villages in order to promote the trails.

To attract more people, several marketing materials were produced such as gadgets, colouring books, books on geology, etc.

OneGeology-Europe: Europeans live on a piece of the Earth's crust that has had a very long and eventful history, some of it shrouded in mystery. Our land is a source of material wealth and water, but it is also a location for major engineering projects or a place to deposit waste. Government and industrialists may look at the landscape and see the challenge of combining mineral extraction with a respect for the environment. The public will rightly have a view on these matters too, but may also simply wish to enjoy and understand the land they live on.

Geological data is essential to the prediction and mitigation of landslides, subsidence, earthquakes, flooding and pollution. They are indispensible to the proper exploitation of our natural resources.

The aim of OneGeology-Europe was to make geological spatial data held by the Geological Surveys of Europe more visible and accessible. The project has also accelerated the development and deployment of an international interchange standard for sharing geological data. Prime outcomes of OneGeology-Europe are an interoperable geological spatial dataset at 1:1 million for Europe, accessible through a multilingual discovery portal, and a world-leading data model and technical infrastructure. OneGeology-Europe has also addressed the licensing and multilingual aspects of data access and has helped move geological knowledge closer to the end-user where it will have greater societal impact. Geological Surveys have data and knowledge that can help us all to address current and future problems. Whatever each of us may feel about the economic, environmental and aesthetic costs and benefits of our future plans for our landscape, there cannot be an informed decision without knowledge of the ground below our feet. Today we are one Europe, with one geology. Whatever happens in one part of our continent has the potential to affect us all.

Across Europe users of geological data require consistent, usable (understandable) information and knowledge, both nationally and trans-nationally. Users need this knowledge and information to meet a broad spectrum of purposes – education, tourism, hazard mitigation, mineral and energy resources exploration, groundwater protection, civil engineering, land and property development, planning and policy making and insurance.

The scope of OneGeology-Europe was to develop products and service in order to meet user needs and enhance the quality and consistency of service to the public and private sectors. The generic requirements of users were that data must be digital and web-accessible. Web access portals were built up to be easy to use, facilitate searching and enable visualisation of the datasets from across Europe. Access to the data should ideally be free to use, or incur little cost. There was a clear requirement to present data to the public in a form they can easily understand. The OneGeology-Europe project had 28 partners in its consortium from 21 European Member States. There were 20 geological surveys (data providers) and 6 representatives of the user community, an expert on legal aspects of spatial data access and a representative of the umbrella organisation for all the geological surveys of Europe (EuroGeoSurveys). The working team has been subdivided into 10 Work Packages.

The OneGeology-Europe project began in September 2008 and was successfully concluded in October 2010.

GEOLOGY FOR EVERYONE - MADE IN SWITZERLAND

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KEY WORDS: evaluation, five different approaches, uniformity, public science strategy

The Swiss Geological Survey belonging to the Federal Office of Topography swisstopo - mainly responsible for the establishment of national geological maps, but also for the acquisition and the compilation of geological data - took notice of an awakening interest of the public in geological topics. Throughout Switzerland there are sites of outstanding geological and scenic importance which stand comparison to the best sites in the world. A these locations, visitors can observe at first hand examples of different geological phenomena, and also unique rock, mineral and fossil occurrences.
To increase public awareness of these localities, almost 100 new geological nature trails are being established, exhibitions organised, and online information provided. Many of these geologically important localities have now been developed into national or regional GeoParks.

A NEW PROJECT

The Swiss Geological Survey considers the public awareness on geological subjects as an essential task and launched the project “GeologiePourTous” (Geology for everyone) in 2012. The aim of this project is to work out a public science strategy focussed on different approaches wherein the Swiss Geological Survey plays the role of a mediator between the scientific and public aspects of geology.

Depending on motivation or level of technical knowledge in Geology, the public need for information is very unequally distributed, which makes the task of popularisation of geological topics a complex challenge. For this reason we elaborate in collaboration with various partners five different modules to reach the public interest.

- Geological guidebook
- Smartphone application
- Combined hiking and geological map
- Surveys in communities and schools
- National events and meetings

These five modules help to analyse the public response to different transmissions of geological information and allow the Swiss Geological Survey to adapt its public science strategies for 2013.

GEOLOGICAL GUIDEBOOK

The Swiss Geological Survey collaborates with the community of Val de Bagnes in the Canton Valais to develop a geological guidebook of this region. The resulting guidebook gives us the opportunity to directly contribute to a public scientific publication and develop a standard model for future guidebooks. With this collaboration the community of Val de Bagnes obtains access to the approved standards of geological maps and additionally of the notoriety of the Swiss Geological Survey, whereas the Swiss Geological Survey can work out guidelines for a series of future geological guidebooks based on the experiences made during the elaboration of this pilot guide book.

SMARTPHONE APPLICATION

During the last years the use of various applications (apps) for mobile phones increased enormously. By developing a smartphone application as a guide for geological natural trails, the Swiss Geological Survey attempts to follow this trend. Smartphone applications will mainly attract younger and technically adept public but also spontaneous hikers, who found the geological path by chance. The smartphone guide can be downloaded at home or in the field and leads the hiker by GPS supported trails and maps and shows him geological information at interesting spots. Within this module the advantages and disadvantages of a smartphone application, as well as technical and social limits and constraints will be tested on a pilot project, the Gastlosen geological path. The aim is to elaborate an application with an attractive and self-explanatory design with a structure containing different levels of simplification which will also be applied as model for other geological paths.

COMBINED HIKING AND GEOLOGICAL MAP

Within this module, the Swiss Geological Survey attempts to combine two products of the Federal Office of Topography swisstopo, the hiking maps and the geological maps. The Swiss Tectonic Arena Sardona, a UNESCO world heritage area, acts as test area for this module. Thanks to the numerous well-marked hiking trails and the clearly visible geological phenomena, this region is highly qualified for an educational transmission of the geological themes to an interested audience. With a combined map, interested hikers obtain a standard hiking map with additional geological information, a simplified geological map on the back page and propositions of trails with point of interest.

SURVEYS IN COMMUNITIES AND SCHOOLS

The Swiss Geological Survey aims to produce rich and diverse educational resources for school children and university students. The support extends from participation in classrooms, career fairs and public exhibitions, to resources for research and study. A survey is planned to more closely analyse the interest and needs of the cantonal education departments in integrating or enlarging geological subjects in the syllabus. The questionnaire will also give an indication if new teaching material needs to be provided. Another survey addressed to tourist information centres and Swiss communities will give information about current demands for more public geological information and about the need of a series of geological guidebook. A prime goal of these initiatives is to ensure the education and training of a new generation of Earth scientists.

NATIONAL EVENTS AND MEETINGS

In the framework of the International Year for the Planet Earth (IYPE), two geological nature trails have been proposed as Via Alpina to a broad public. The Swiss Geological Survey participates also in the organisation of Swiss-wide geological events like the next festival of “Geologie Vivante” in 2013 in collaboration with the Platform Geosciences of the Swiss Academy of Sciences (scnat). ”Géologie Vivante” consists of a variety of events and activities bound to geological topics: 160 geo-events all over Switzerland give hands-on insight into the geology of the everyday life and on the other hand try to raise the public’s awareness for the beauty, the curiosity and the peculiarity of our geological heritage. The aim of this module is to show how the Swiss Geological Survey could be more visually present and get in touch with the geology interested public.

These five modules point out where a need for action is present concerning the transmission of geological information for a general audience and how to adapt its public science strategies for 2013. Furthermore, they give us an idea how to communicate with the majority of the interested public, is it by the means of a smartphone or a traditional geological guide book.

PRESERVATION AND PROTECTION OF GEOHERITAGE IN SERBIA

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KEY WORDS: Serbia, geoheritage, protection;

INTRODUCTION

Origins of the legal protection of nature in Serbia date back far to the past, and the first regulations that protect nature and preserve natural resources dating from the fourteenth century. The first area which is under protection in the territory of Serbia was Obedska bar, under the protection since 1874. The first protected areas in Serbia declared 1948. They were forest reserves Oštrozub, Mustafa and Felješana around Majdanpek. Fruška Gora National Park, declared 1960, is the first national park in Serbia.

Geoheritage objects in Serbia are actively studied since middle of the 20th century, and only since 90's allocation methodology establishes the modern facilities and evaluating geoheritage. In recent years, many researchers dealing with this issue (Lješević M. 2002, Đurović P. et al. 2006, Belij S. 2009, Simić S. et al. 2010, Glavonjić T. et al. 2010, et al.).

THE CURRENT STATE PROTECTION OF GEOHERITAGE

Serbia is located in the central part of the Balkan Peninsula, where converge: the southern rim of the Pannonian basin, the western parts of the Vlaško-Pontic basin, southeastern parts of the Dinarides, the central part of the Carpathian-Balkan mountain range, Rhodope massif and Šar-Pindus mountains. The diversity of lithological, structural, relief, soil and other processes and forms caused many natural landmarks in Serbia.

At the first scientific conference dedicated to the geoheritage of Serbia, organized by the Institute for nature conservation of Serbia 1995, the official definition was given to the geoheritage of Serbia, which says: "Geoheritage of Serbia includes all geological, geomorphological, pedological and special archaeological values originated throughout the formation of the lithosphere, its morphological formation and interdependence of nature and human cultures, which have to be a special concern of all social factors in Serbia due to extreme scientific and cultural significance, as well as unique geoheritage of Europe i.e. world" (Declaration of the Conference "Geoheritage of Serbia") (Simić et al. 2010).

The inventory of Serbian geoheritage site was created in 2005 as a result of efforts of the National Council of Geoheritage, formed 1995. It is presenting a list of the 651 objects (geological, palaeontological, geomorphological, speleological and neotectonic), which are divided into 12 groups (and a number of subgroups). Institute for nature conservation of Serbia has so far protected the geoheritage of some 80 objects, mainly caves.

Most of the geoheritage objects located *in situ*, in nature, except for collections (mineralogical, paleontological, core drilling ...) which are *ex situ* - in the museum rooms.

Protected geoheritage of Serbia includes:

NATIONAL PARKS: Šar mountain, Đerdap;

NATURE PARKS: Lepterija – Sokograd, Mileševka river gorge, Miruša;

NATURAL RESERVES: Dajićko lake, Boljetinska river canyon, Gornja Resava river gorge, Suvaja river gorge, Osanička river gorge, "Kamilja" limestone reef, Jelašnička river gorge;

SPECIAL NATURAL RESERVES: petrified forest Lojanik, site of mammalian fauna Prebreza, Deliblato Sand, Uvac river gorge;

MONUMENTS OF NATURE:

Geology: "Old Square" Museum of mineral, Miocene reef limestone, Tašmajdan (Belgrade), Cretaceous limestone reef, Mašin mine (Belgrade), Sea neogene reef Kalemegdan (Belgrade), Site of the Pliocene, Skull of the Megaceros, Tectonic erosion unconformity Stari Slankamen, Beočinska beach, volcanic tuff (Beočin), Profile of Upper Cretaceous sediments (Beočin), Orlovac (Beočin), Site of Pleistocene mammalian fauna Baranica;

Geomorphology: River canyon Vratna with two natural arch, natural arch of the river canyon Zamna, natural arch on Valja Prerast, Prizrenska Bistrica, Bušan kamen, natural arch Samar, natural arch Prerast, Ostrovica, Source of Beli Drim with waterfalls and cave "Radavac", Rugova gorge, canyon of the Beli Drim at Švanjski bridge, Đavolja Varoš, Lazar canyon;

Hydro(geo)logy: Waterfalls Velika i Mala Ripaljka, karst source Potajnica, Lisine, spring Krupačko, Promuklica, Waterfall stream Bigreno, spring Veliko, spring Mlava, karst source Potajnica, spring Krupajsko, Sopotnica, thermo-mineral source in willage Vuča;

Speleology: Gaura Mare Velika cave, Lazareva (Zlotska) cave, Prekonoška cave, Ravna cave and Propast pit, Radoš cave, Velika Atul cave, Petnička cave, Ravanička cave, Topla peć cave, Potpećka cave, Cerjanska cave, Samar cave with natural arch Samar, Popšićka cave, Popov Čot cave, Mermerna Pećina cave, Petrlaška cave, Bogovinska cave, Vrtačelje pit, Hadži-Prodanova cave, Kovačević cave, Bukovik cave, Stopića Pećina cave, Ribnička cave, Mali bezdan cave, Rćanske cave, Resavska Pećina cave, Risovačka cave.

CONCLUSION

In cooperation with the National Council of Geoheritage, Faculty of Mining and Geology, Faculty of Geography and other institutions involved in the study of the Earth Science in Serbia, Institute for nature conservation of Serbia has established a network of cooperation, promotion and popularization of geoheritage in Serbia.

ACKNOWLEDGEMENTS

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DATABASE OF IMPORTANT GEOLOGICAL SITES OF THE SLOVAK REPUBLIC

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KEY WORDS: geoheritage, important geosite, database.

Thanks to a varied geological structure and complex geomorphological evolution Slovakia is rich in numerous geological attractions. Some sites are protected under Law. 543/2002 Coll. of 25 June 2002 on the Protection of Nature and Landscape as National Natural Monuments, Natural Monuments, Nature Reserves and National Nature Reserves; some of them have been even declared by the Convention on the Protection of World Cultural and Natural Heritage. Yet, most of the stratigraphic and palaeontological sites are not protected by law, but from a scientific and academic point of view they are extremely valuable geological objects, which should be maintained for future generations as geological heritage. Moreover, the Slovak education system at elementary and high school lacks of the subject geology. The downwarding trend in the geological knowledge level of the Slovak population is reflected in degrading perception of the environmental links among the compounds of the landscape – rocks, water, soil, atmosphere and biota.

Within the period of 2008-2011 the State Geological Institute of Dionýz Štúr in Bratislava (SGIDS) solved a geological project **Database of important geological sites of the Slovak Republic.** The database groundwork was retrieved from geological guides through Slovakia, issued on the occasion of events KBGA and IGC, as well as important monographs, for example, Mišík, M., 1976: Geological field trips in Slovakia. Furthermore, the selection of sites is based on own erudition of the authors and relevant literature study. In creation and loading of databases feedback from a broad professional and laic geological community contributed significantly.

In the scope of the project solution 479 geological sites of regional-geological, historical mining, mineralogical, geomorphological and hydrogeological nature were identified, all of them of utmost scientific (educational) and aesthetical value with a potential to become a firm component of the Slovak, even the European geological heritage. Each site is documented in the inventory sheet which was subsequently included in the MS Access database (Fig. 1).

High-quality photo-documentation of the vast majority of sites along with the geological sketches and pen drawings by the Slovak volcanologist Vlastimil Konečný (Fig.2) and the attached English summaries of each site are the values added of the database. In the scope of the project Geological Information System (GeoIS) the database has been published on the SGIDS website: www.geology.sk in order to disseminate the results among the public. The database is open for further inputs and for modern presentation of the geological heritage of the Slovak Republic.

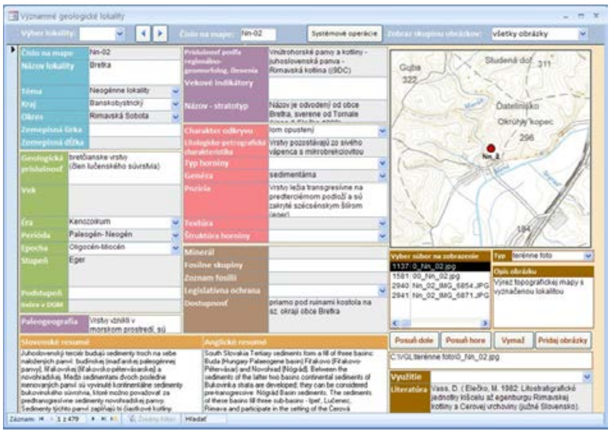

Figure 1 – Inventory sheet in MS Access, Bretka site.

Figure 2 – Lava flow of pyroxenic andesite with columnal jointing, site Stangarigel, drawing by V. Konecny

THE GEODIVERSITY AND THE “APPENNINO GEOPARK PROJECT

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KEYWORDS:
Geology, Geodiversity, Appennines.

THE APPENNINO GEOPARK PROJECT APPLICATION DOSSIER TO THE EUROPEAN AND GLOBAL GEOPARKS NETWORK UNDER THE AUSPICIES OF UNESCO.

A dossier is being prepared to present the Bologna Apennines as a candidate for enrolment in the list of European and Global Geoparks Network (EGGN) http://www.europeangeoparks.org

The area selected is a portion of the Emilia territory, comprehend 29 municipalities from the Corno alle Scale mountain to the Gypsum Vein Park. See the poster.

In this area the concept of *geodiversity* has been previously applied (Panizza and Piacente, 2008).

Geodiversity (Panizza, 2009) is defined as: “the critical and specific assessment of the geological features of a territory, by comparing them in a way that is both *extrinsic* (with other territories) and *intrinsic* (with the territory itself). It takes into account the level of their scientific quality, the scale of investigation and the purpose of the research”.

In the case of *extrinsic geodiversity,* the area selected can be considered as an exemplary case in the Apennines owing to its typical geological features: it is in fact an educational example for illustrating tectonic evolution, stratigraphic sequences and lithological peculiarities in this chain compared with other mountains in the world. On the other hand, *intrinsic geodiversity* concerns first of all the complexity and variety of geomorphological features: LGM glacialism, karst landforms in the gypsum formation, the spectacularity of badlands and high frequency of landslides, which are also a sort of outdoor laboratory for investigations on their hazard. Other characteristics of intrinsic geodiversity are related to mineralogy (e.g., baritine, which Goethe defined as “phosphoric stone”), or petrography, such as the ophiolites (known also as the “Devil’s stones”) or palaeontology, including some specific types of fossils.

Finally, it can be observed that, considered from the standpoint of *geodiversity*, the territory of the Bologna Apennines shows a multifaceted and complex image, depending on the various points of view of scientific observation. In order to carry out a thorough territorial analysis, it is therefore of paramount importance to first choose the goals of our investigations and, consequently, the most appropriate conceptual and methodological path also for applied purposes.

ACKNOWLEDGEMENTS

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FROM SCHOOLS TO SOCIETY: THE USE OF MULTIMEDIA PRODUCTS TO DISSEMINATE GEOLOGICAL HERITAGE

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KEY WORDS: geoheritage, geosites, geological tours, dissemination, multimedia products, Piemonte, NW Italy

INTRODUCTION

The multidisciplinary research project "PROGEO-Piemonte" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale (GIARDINO et al., 2011). The assumption is that Geoheritage sites ("geosites") can serve both the public and private interests (WIMBLEDON et al., 1999).

Nine strategic geothematic areas were selected to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities.

Specialized research teams will analyze critical aspects to advancing knowledge about the geological history of the Piemonte Region.

In this context, an interdisciplinary research team covers the aspect of the geodiversity action plans for dissemination activities, including didactic tools for educators, schools and public in general (BELLUSO et al., 2011). This group is collaborating with a publishing house in Turin to edit a multimedia product in Earth Sciences devoted to Secondary Schools, entitled "Geological tours in Italy", whose format could be used to include and disseminate the outcomes of the PROGEO-Piemonte project.

CONTENTS AND STRATEGIES

The multimedia product "Geological tours in Italy" supplements the new Earth Sciences' textbooks edited by the publishing house. The aim is to stimulate students and teachers to explore the contents of the textbooks through the proposal of virtual or real geological tours in Italy. For this purpose, we chose 20 places considered important from the geoheritage point of view, whose geological features were described in the textbooks.

The product consists of a map of Italy (taken from the Blue Marble images), on which the 20 geosites are located and linked to the information pages (Fig. 1).

Figure 1 – Visual interface of the multimedia product: from the map, it is possible to select geological tours.

Each page is devoted to a geosite and is composed of an introductory text, several images (photographs, maps and drawings), videos and downloadable documents (Fig. 2). Users can create folders and personalized tours, where images could be compared.

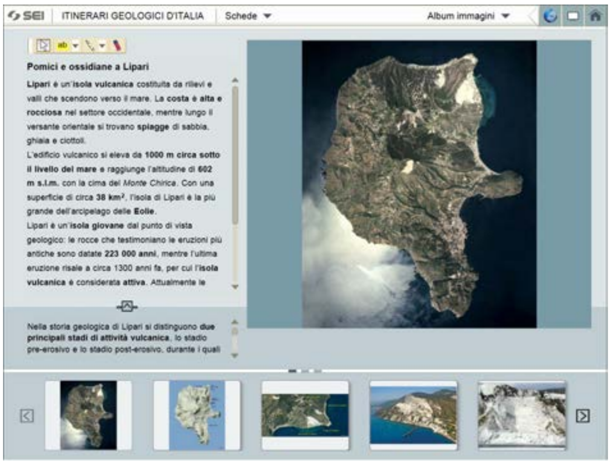

Figure 2 – Information page: each multimedia content has his own caption; images can be visualized in full screen, put in personalized folders and compared.

The design of the multimedia product poses a lot of attention to the visual aspect. In fact, the main challenge of the editing work is to propose high quality images and videos, being:

- meaningful from the geological point of view;
- effective for didactical purposes;
- able to stimulate wonder and curiosity (CARRADA, 2006; ORION, 2007).

To achieve these goals we contacted University researchers and professors, Insitutions and professionals involved in studying or preserving each geosite, in order to achieve the most updated scientific data. Moreover, we believe the local contacts are fundamental because of their knowledge about the management of the geosite and the existence on the territory of recommended associations that deal with school trips. In fact, a “contact section” is set up for each geosite page, as a suggestion for teachers interested in visiting the proposed areas. This information could create a network among schools and local Institutions and organizations, that in Italy are not so frequently connected.

Finally, a list of book and website references is given for each geosite. This would stimulate teachers and students to explore the proposed topics and to discover other relevant geologic aspects of the territory.

APPLICATIONS IN RESEARCH

One of the aims of the PROGEO-Piemonte research project is to design and test new tools and teaching strategies to disseminate the geological values and contents of the nine geothematic areas identified in Piemonte.

The preliminary work on the multimedia product “Geological tours in Italy” would be a way to test how the information on the geosites can be collected and proposed in an appealing format, without neglecting the didactic and scientific aspects.

When the multimedia product will be used in schools, we could open a website devoted to the Earth Sciences dissemination. This could invite students and teachers to ask further information on the geosites. Moreover, it could be a webspace to discuss if the virtual tours really stimulate the will of knowing the territory and visiting it. The access in the website could be monitored.

We think that our multimedia approach could increase the interest about the geoheritage and help to pose the attention to relevant topics like risks and resources. Besides, it could have an economic impact to the local communities near the geosites, by attracting visitors. In a few words, this project is intended as a didactic tool for disseminating the geoheritage of the territory.

CONCLUSIONS

In the PROGEO-Piemonte research project, a multimedia product similar to “Geological tours in Italy” could be edited, taking advantage from the previous experience acquired.

This product is planned to be used in schools with the Interactive Whiteboard and the PC, but it is also suitable for tablet and smartphone. Then, we could propose a combination of virtual and real tours, by associating interactive lessons with open-air experiences.

A didactic analysis could be performed by evaluating the effectiveness of the multimedia approach combined with the real tour on the territory. In this context, many relevant aspects are involved, like the ability to use a map, to orientate, to recognize geological structures and connect them to risks and resources (REYNOLDS et al., 2002). In few words, the effectiveness of stimulating multimedia products can be proved if they really increase the awareness about the territory, having influence on the use of the land and the prevention of risks. other relevant geologic aspects of the territory.

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DINOSARAGÓN: PALAEONTOLO-GIS

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KEY WORDS: GIS, Heritage, Palaeontology, Dinosaur, Teruel, Aragón.

INTRODUCTION

Along the last years Fundación Conjunto Paleontológico de Teruel-Dinópolis (FCPTD) is developing a Geographic Information System (GIS). This Palaeontolo-GIS is part of two consecutive projects based on the Palaeontological Heritage as a resource to develop and apply a valuation and integral management model of the sites with dinosaurs in Teruel (VALDINOTUR R&D Project) and Aragón (DINOSARAGÓN R&D Project)

DINOSARAGON GIS project (Alcalá *et al.*, 2011) is an update and extension of VALDINOTUR data (Alcalá *et al*., 2010) and provides a way to map and evaluate occurrences of dinosaur sites (and their faunal lists) in the Autonomous Community of Aragón (Spain). The DINOSARAGÓN (dino-sites database) spans the Mesozoic time period from Upper Jurassic to Late Cretaceous. The GIS cartography includes a series of different source geo-referenced thematic layers (Mampel *et al*., 2009): a) Boundaries, b) Communications, 3) Hydrography, 4) Protected Natural Areas, 5) Topography, 6) Geology, 7) Erosion, 8) Cultural Heritage elements and 9) Palaeontology: dinosaur bones and footprints sites.

Concerning the Palaeontology layer, data were entered for 300 dinosaur fossil patches (256 with dinosaur bones and 44 with dinosaur footprints) (figure 1; last update: Dec/2011). The list of sites and the data about them come from: a) published scientific studies and b) our own data –FCPTD; Aragón Government- about sites and evidences not published yet.

The sites had to be described well enough so they could be geographically placed (by a Global Positioning System: Trimble GeoExplorer 6000 series or Trimble Epoch 10 both with submeter accuracy), including taxonomic information, stratigraphic and temporal information (geological formation and stage) and their evaluation. This systematic evaluation follow several previously proposed indicators (Cobos, 2004; FCPTD-IDPI, 2008 and Mampel *et al*., 2009) grouped in three categories: Scientific value, Socio-cultural value and Deterioration risk.

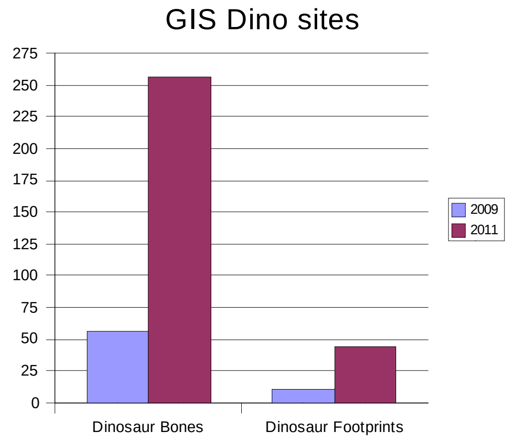

Figure 1 – Dinosaur site added to GIS database since 2009.

PALAEODIVERSITY MANAGEMENT

A widely used method for assessing the availability of geological resources is the McKelvey box (Gray, 2004) reinterpreted to palaeodiversity as a resource (figure 2). GIS helps to keep a perfect control of identified palaeontological sites (as part of the Palaeontological Heritage). For example, using the proposed valuation system (integrated in GIS) we can compare the Deterioration Risk estimated value of the identified sites. In consequence it is possible to develop effective preservation strategies in those sites with a higher Scientific and Socio-cultural Values but in risk, obtaining a graphical presentation of the results.

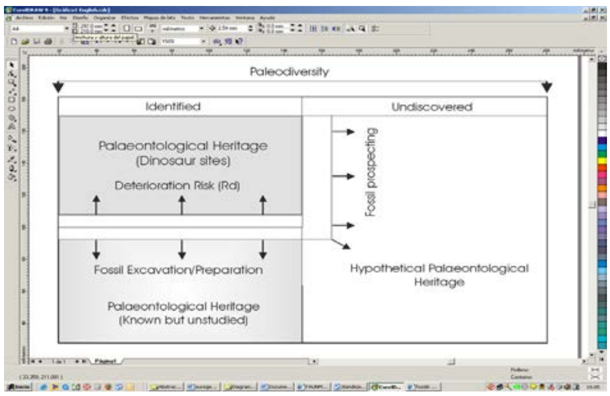

Figure 2 – The McKelvey box with Paleodiversity as the resource (modified from Gray, 2004).

It is also possible to carry out the Scientific value estimation of the identified sites and to submit a proposal for their excavation and preparation.

The use of GIS applied to palaeontology allows predictive prospecting looking for new dinosaur sites (that form part of the undiscovered Palaeontological Heritage; figure 2). As an example of this application, along the years 2010 and 2011 FCPTD made systematic prospecting with the aim of finding new dinosaur sites in Aguilar del Alfambra (Teruel, Spain). The field work planning was based on GIS (figure 3) looking for outcrops in the geological formations liable to contain vertebrate fossils, and considering data as dip of strata, accessibility, or the number and distribution of previously identified sites). As a result new interesting sites have been found with direct and indirect dinosaur remains.

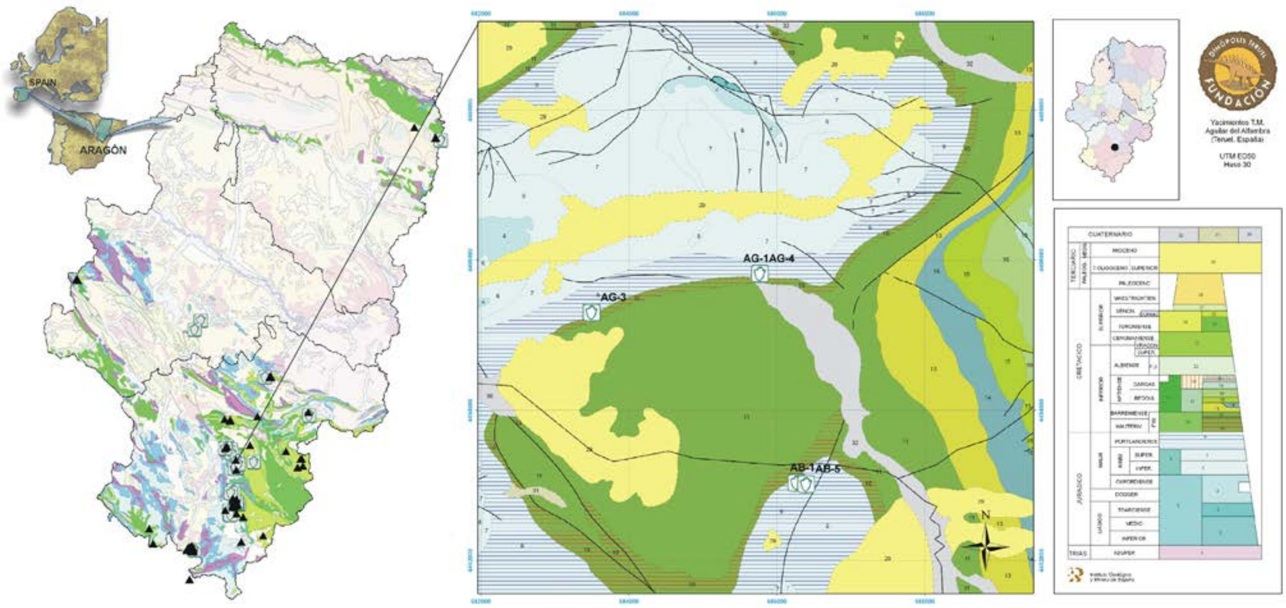

Figure 3 – DINOSARAGON GIS dinosaur footprint sites example (Aguilar del Alfambra municipality, Teruel, Spain).Source: FCPTD, Aragon Government, IGME (1:50.000 geological map).

RESULTS AND CONCLUSIONS

GIS is frequently used to analyse spatial data and is an essential tool to find and to support the management of the Palaeontological Heritage. On the other hand, combining the different options of directed searching, allows field work planning (within the palaeontological systematic prospecting) in an efficient way obtaining positive results.

ACKNOWLEDGEMENTS

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OPENALP 3D: DISCOVERING THE GEOMORPHOSITES OF THE SAN LUCANO VALLEY

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KEY WORDS: Geotourism, Popularization, Belluno Dolomites, Geomorphosites, GIS, GEO Browser3D

INTRODUCTION

In June 2009, Italy's stunning Dolomites Mountains have been declared a United Nations World Heritage Site. In the Agordo territory, where the distinctive scenery of the Dolomites becomes the archetype of a "dolomitic landscape", 4 UNESCO systems are included, the largest is the Pale di San Lucano and Belluno Dolomites system.

The combination of geomorphologic and geological values creates a property of global significance and is the ideal context to promote public outreach activities (AA. VV., 2011) in order to develop programs for communicating geoscientific knowledge and environmental concepts at the geological site.

A model for environmental and cultural tourism should achieve the following objectives: to educate the general public about issues in geological sciences and their relation to environmental matters for preservation of their geoheritage, to ensure sustainable socio-economic and cultural development (de Grosbois et al., 2008).

OPENALP® is born in 2006, supported by European Fund for Development of Regional Community INTERREG IIIA Italy-Austria-ven111072. The cooperation among the Agordina Mountain Community (CMA), the Technical-Industrial Institute of Mining "U. Follador" (ITIM) of Agordo (BL) and the CNR-IDPA, produced in 2008 an Information System regarding the Agordo area, with ESRI® software.

The key requirement for any incentive project for geo-cultural tourism is the immediate fruition of the information by more diversified users as possible.

OPENALP 3D

Since 2010, CNR is updating the OPENALP® database with new original contents, focusing on to all the information of natural and historic-cultural value. The conceptual model also has been enriched with the introduction of new categories (nature, culture, territory, itineraries, accommodations). Always in order to make easier the exploration of the spatial database, we have chosen to use the 3D Geo Browser, developed by "*GIS Solution"* professional studio: this new web-based application consists of a real-time system with interactive and three-dimensional navigation of areas with a high level of details. This browser is designed to be a powerful tool to support knowledge and planning, but allows also an easy navigation, intuitive and fast for everyone.

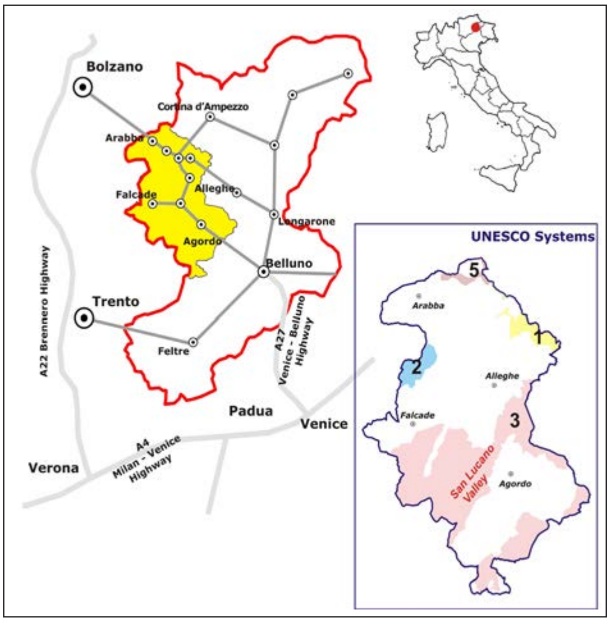

Figure 1 – Agordino territory and San Lucano Valley location in UNESCO Dolomites

The application OpenAlp 3D is aligned with recent EU directives and is derived from the Open Source World Wind project of NASA, which implements the technology, "3D Virtual Globe" high performance developed in Java. It is compatible with Windows, Mac OS X and Linux. The 3D performance is guaranteed by the use of the graphics library OpenGL® via Java (JOGL), normally supported in all modern PC.

The data interoperability is guaranteed by full support for popular geographical formats recognized as standard by the Open GIS consortium, interpreting the information returned by means of levels or layers. The levels consist of graphics that can be:

- superimposed images as satellite photos, Corine Land Cover, the geological map, etc.
- spatial elements: point data (eg, geological sites, place names, points of interest, etc..), linear data (eg geo-tourist routes, GPS tracks, etc.) or polygonal data (eg SIC, ZPS, parks, etc.)

Openalp 3D is an interactive application, you can query individual vector elements and obtain information both textual and graphic.

OpenAlp 3D also offers more advanced tools: by selecting the degree of transparency you can achieve the fusion between different layers, measuring tracks with the GPS extension, you can create, edit and save tracks, by the stereo mode you can activate stereoscopic vision (requires special glasses) for a full 3D effect.

The use of mobile devices, especially those equipped with GPS, in the field of web mapping applications are becoming more widely used. So the next evolution of application for these devices, will be a 2D version of the Geo OpenAlp browser: the application, easy to use, will be designed for touch screen interfaces for use with browsers on all mobile environments (also on the desktop environments). It is based on HTML5-CSS3 technologies, based on Open Source libraries, OpenLayers, cross-device, visible to all major mobile operating systems (Android, IOS, Windows Phone, etc.) and desktops (Windows, Linux, Mac).

Next, we plan to develop an 'Apps' dedicated to mobile devices into 2D (all major mobile OS) and also in the 3D environment (for the Android OS).

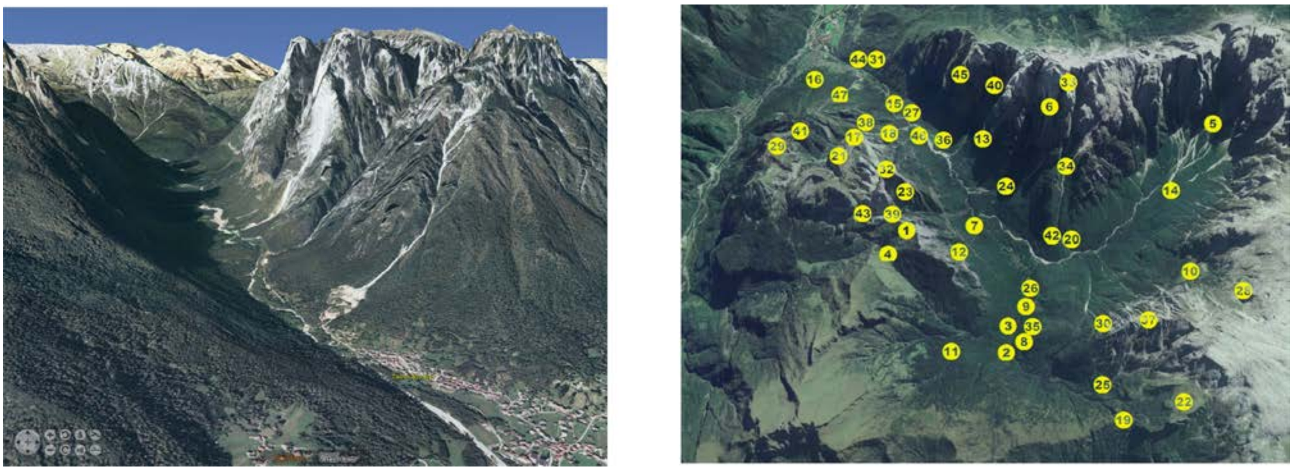

Figure 2 – A) Visualisation of San Lucano Valley with GEO Browser 3D; B) Localisation of the 47 geomorphosites in San Lucano Valley.

DISCOVERING THE GEOMORPHOSITES

The aim of OPENALP 3D was to inherit all the past environmental, geological and cultural data. San Lucano Valley (Taibon Agordino municipality) (Giordano, 2011), already known to hikers and holiday tourism, holds 47 geomorphosites (Fig. 2) (Bertini, 2011), identified as: "characteristic shape of the landscape with particular and significant geomorphological attributes that qualify as part of the cultural heritage of a territory" (Panizza & Piacente, 2005). This is a perfect sample to test the new Territorial Information System (SIT), updated and integrated in a knowledge model.

The user can explore the valley by the screen across the 47 geomorphosites, see the attached documents as the pictures of the site, read the description of the location and their geological and/or geomorphological features, acquiring information on the additional value, that depends on factors such as rarity nature, educational, cultural and historical value, etc. (Bertini, 2011).

ACKNOWLEDGEMENTS

We are grateful to Agordina Mountain Community for active support.

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LANDSCAPES AND WINE: HOW TO COMMUNICATE GEOLOGY FOLLOWING A CULTURAL APPROACH

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KEY WORDS: Landscape; Maps; Geoheritage; Vineyards, Italy.

WINE LANDSCAPES AND GEOHERITAGE

Wine and wine production are very important in many cultures, and play a determinant role in local as well as in global economic development.

In the Italian culture, vineyard cultivation is a well known kind of land use; the wine production represents an activity full of significance. In the Italian territory, relatively narrow and elongated and full of different land settings, the geologic and geomorphologic system influences strongly the land use arrangements. Vineyards are linked to the ground more than other kinds of cultivation, through many scientific, social and cultural reasons, as testified by history, religion, myths. Referring to the deep link among landscape, terroir and geomorphology, some kinds of vineyards can be considered as a precious kind of geoheritage: the vineyards in the Valle d'Aosta region or in the "Cinque Terre National Park" in Liguria, show an almost heroic way in land use, such as the terrace vineyards in high altitude, on almost vertical slopes. These areas need a special management, in order to safeguard both of the aspects (natural and cultural) and to apply well balanced programs for the local development, that promote the typical production -referring to wine- and its special link with the Landscape. A very useful tool for the territorial planning and management, can be represented by maps and GIS: by integrating many different information we can analyze the link between vineyard cultivation and landscape, referring to the geomorphological settings. Moreover, it's possible to recognize and identify those landscapes so special and significant to be worthy of a protection as geoheritage. A way to reach a complete comprehension of the landscape is performed by a holistic approach that considers and integrates all the components of the studied system, with a special attention to the point of view typical of geomorphology. Each individual landscape, studied at different scales, shows distinctive elements; at a synthetic scale (e.g. 1:250.000 scale) physiography is the feature that best approximates the results of a landscape classification performed following an holistic approach. The considered parameters are mainly related to the morphologic settings and to geologic and landcover settings. The parameters and the physiographic components considered in Landscape analysis are:

- Elevation and energy of relief (A)
- Drainage pattern (B)
- Lithology (C)
- Land use (D)
- Landscape physiographic Units (E)

Integrating these components and the gathered data is possible to identify and describe the so called Landscape Physiographic Units.

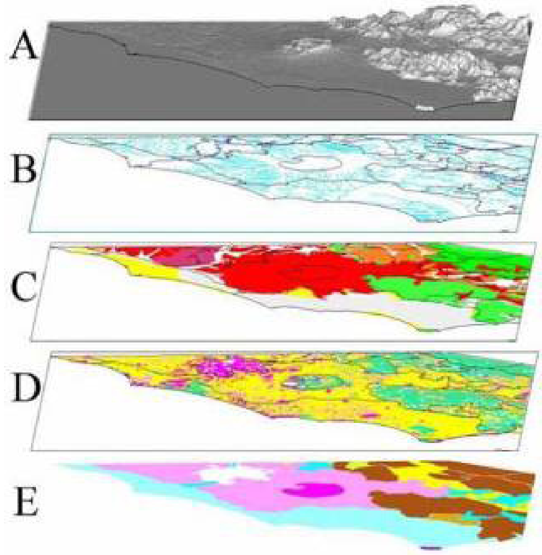

Figure 1 – Landscape parameters and physiographic components

Overlaying the thematic maps, such as the Geologic and the Phisiographic ones, and integrating the gathered data, we can identify within a reasonable approximation, those areas of both natural and cultural importance.

HOW TO COMMUNICATE GEOLOGY FOLLOWING A CULTURAL APPROACH

In the last years, a new current in the field of earth sciences has proposed a new theoretical approach that integrates nature and culture, offering new powerful tools for educational programs and for a new dialogue between researchers and territorial managers. Following this trend, we dedicate this work to Lucilia Gregori, Professor of Geomorphology at the University of Perugia, dead in January 2012: she has been for many years a protagonist in the field of research on geology and wine, following an approach that integrates nature and culture. She proposed the new term “Winescapes” to denote the link between the wine landscape and the so called “Terroir”. One of the most important projects created by Lucilia Gregori, within the University of Perugia and the “Geology and Tourism” Italian Association, is to provide labels that tell the geology of the land where wine is produced.

The link between Earth, Landscape and Wine is a link between Nature and Culture. It is essential to try a new kind of popularization of scientific heritage, in order to involve the whole society in a common action towards a sustainable territorial management.

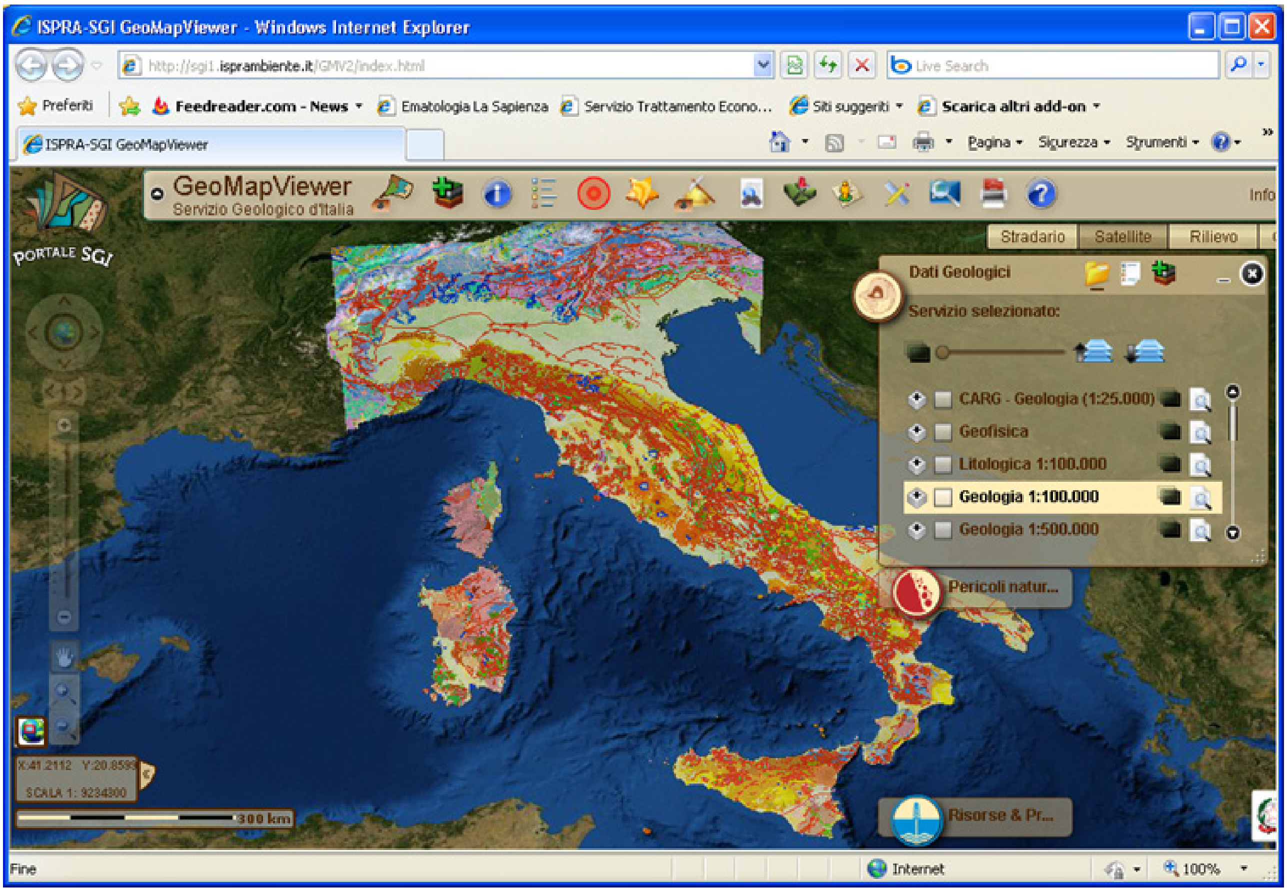

Figure 1 – Geological Map of Italy - GIS

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THE EMILIA-ROMAGNA SPELEOLOGICAL FEDERATION (FSRER) AND ITS CONTRIBUTION TO THE KNOWLEDGE, PROTECTION AND POPULARIZATION OF THE REGIONAL KARST

Paolo Forti [(1)]

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KEY WORDS: Evaporite karst, Exploration, Mapping, Cave science, Safeguard, Geoheritage, Web-GIS, Emilia-Romagna

THE KARST OF THE EMILIA-ROMAGNA REGION

The karst outcrops represent only 1% of the Emilia-Romagna territory: over 90% of them consist of gypsum (Messinian and Triassic in age) (Lucci & Rossi, 2011), while the remaining ones are in different lithologies, from sandstones to ophiolites and from clays to travertines. Despite it scarce abundance some of the karst phenomena of our Region are amongst the most interesting ones in the world (especially those developed in gypsum and anhydrite). Besides external forms (dolines, blind valleys, karren, tumuli etc.) the karst outcrops contain over 870 caves with a total development of underground passages of more than 88 km. Among them there are the longest (Spipola-Acquafredda karst system near Bologna) and the deepest epigenic gypsum caves (Caldina cave, Reggio Emilia) in the world.

The Emilia-Romagna region was one of the first places in the world in which scientific studies on gypsum caves and karst have been carried out (Aldrovandi, 1648) and still now Bologna hosts the Italian Institute of Speleology and the largest Speleological Documentation Centre of the World.

THE ACTIVITY OF THE F.S.R.E.R.

In the Emilia-Romagna Region the first organized speleological explorations started at the beginning of the last century, but only in 1954 Prof. Mario Bertolani founded the Regional Commission for the Cave Register with the aim to uniform and to keep updated all the data related to the caves of the Region. Later in 1974 this Commission was transformed into the Regional Speleological Federation of Emilia-Romagna (FSRER) to which adhered all the speleological associations working in our territory.

Since then the FSRER widened its interest although maintaining it first mission of exploration and mapping; thus fields like cave science, protection and popularization became among its main targets.

In the same years a strong co-operation was settled up between FSRER and the Emilia-Romagna Regional Government which, since 1979 up to present, led to the publication of several important divulgative books on the karst phenomena of our region (Bertolani & Forti 1979; Bertolani et al 1980; FSRER 1996-2009).

But perhaps the most important field in which the contribution of the FSRER was fundamental for the Regional Government has been, and still is, that of the protection and valorization of most of the regional karst areas. In this field members of the FSRER, due to their specific knowledge, were inserted in the commissions that had the task to prepare projects to transform karst areas (like those of Gessi Bolognesi, Vena del Gesso Romagnola, Onferno Cave, Gessi Triassici dell'Alta Val di Secchia, Labante cave, etc.) into National and Regional Parks, Reserves or, at least, SIC. Thank to the efforts of the FSRER actually over 90% of the whole regional karst outcrops fall at least in one of these kinds of protected areas.

In the mean time the FSRER co-operated with local Universities and Research Centres to perform multi-disciplinary scientific research within selected regional karst cavities and/or areas: among them are worth of mention the study of the Triassic Gypsum of the Upper Secchia Valley (Chiesi & Forti, 2009) and of the Stella-Basino karst system (Lucci & Forti, 2010). Recently FSRER was requested to participate in a LIFE+ Project 08NAT/It/000369 "Gypsum", co-ordinated by the "Gessi Bolognesi and Calanchi dell'Abbadessa" Regional Park, in which the main habitats for bats and other endemic species and the quality of the karst waters and their variability in time are studied.

KARST GEOHERITAGE AND WEB-GIS OF EMILIA-ROMAGNA

In the past few couples of years the two most important projects in which the FSRER has been involved by the Emilia-Romagna Government

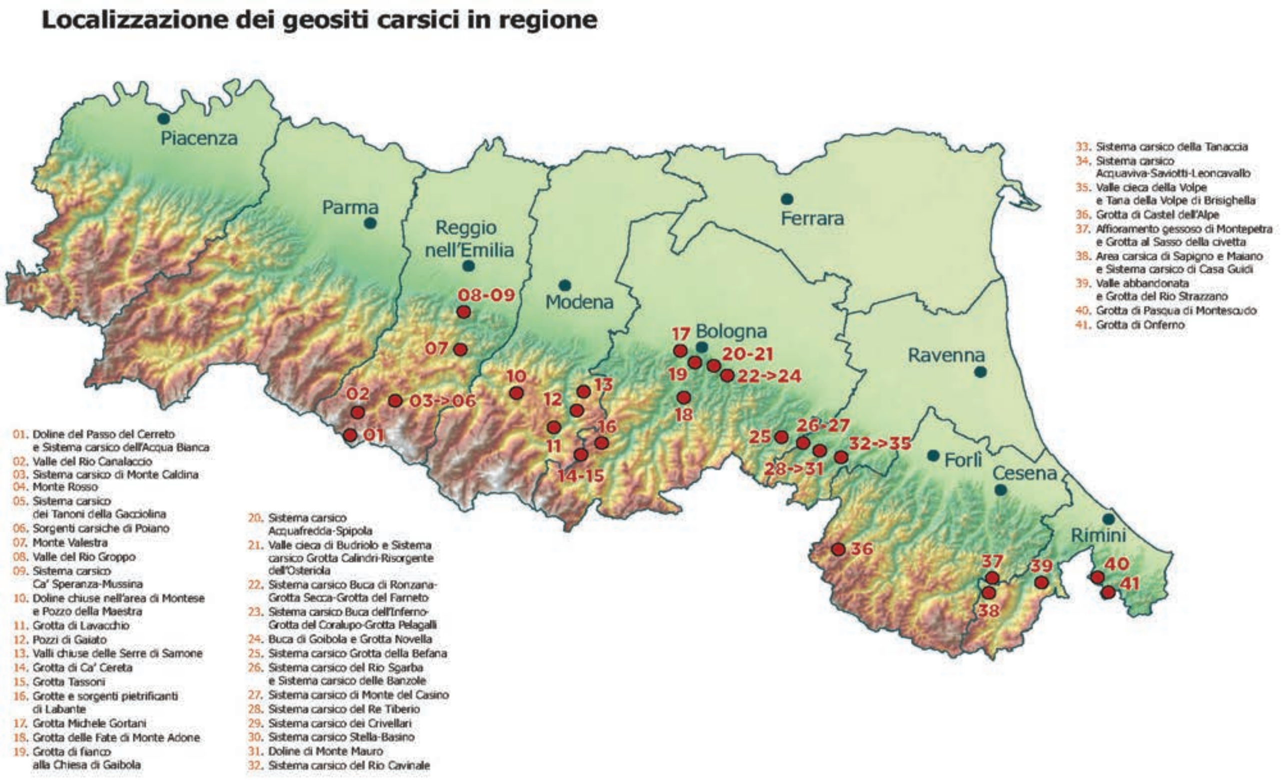

Figure 1 – Location map of the 41 karst geosites of the Emilia-Romagna Region (after Lucci & Rossi 2011)

were a) the location and description of the karst sites worth to be defined regional Geoheritage and b) the implementation of the regional WEB-GIS with all the data related to caves and karst.

Thanks to the strong support and strict cooperation given by the Regional Geological and Seismic Service, the point a) was completed in 2011 selecting and describing 41 karst geoheritage sites (Lucci & Rossi 2011), thus allowing not only for their protection but also for their popularization.

The point 2 is a "never ending" job because several new caves are discovered and explored each year. Anyway most of the actual knowledge on the karst of our Region is already inserted in the Emilia-Romagna WEB-GIS, where it is possible to extract practically any needed information on each of the actually known natural cavities: from its location to the geological context, from its longitudinal profile to the cross-sections, from the biological to the archaeological or hydrological etc. interests, supplying also the related bibliographic references.

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MUSEOTORINO: SCIENCE AND IMAGES TELL THE STORY OF TURIN (ITALY) BEFORE THE CITY.

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KEY WORDS: Museum, Quaternary Geology, Geosciences popularisation, Geoheritage, Piedmont (Italy).

INTRODUCTION

The scientific data collected over more than 20 years by researchers at the Earth Sciences Department of The University or Torino (Italy) allowed detailed reconstructions of geological history and evolutionary stages of the geo-environments in the western Mediterranean basin and particularly in the Piedmont area (NW-Italy). Much of this information has been already published in scientific papers, rarely it has been used for publications devoted to popularizing Earth science contents.

On the occasion of the 150th anniversary of the Unification of Italy, thanks to "MuseoTorino: history of a city" project of the "Assessorato alla Cultura della Città di Torino" (Cultural Department of the Municipality of Turin), we carried on an activity for popularizing geoscience contents through the multimedia product entitled "Turin, before the city". It is part of an audiovisual reconstruction of the history of the city of Turin (Italy). In the specific case, our aim was the reconstruction of the geomorphological, climatic and geo-environmental setting of the area of the city of Turin, before its urban settlement.

Through the analysis of geological and geomorphological heritage sites still preserved and accessible in the Piedmont region, we described the history and evolutionary stages of basins, watercourses, plains, hills and mountains of the central Piedmont region from 5 million years ago until the birth of *Augusta Taurinorum* (latin name of Turin) about 4000 years ago. With the present work we wants to emphasize the dynamic aspect of geo-environments that characterizes the transformation of a given territory and to highlight the continuity between space and time in Earth science reconstructions. These objectives were achieved through two different multimedia products: a virtual-reality movie and a website.

GEOLOGICAL AND GEOMORPHOLOGICAL CONTEXT

The evolution of the central part of the Piemonte region has been described in the time interval between about 5 million years and a few thousands years ago. This large geographical area including the Turin area has been analyzed starting from its old marine configuration, within a deep inlet of the local sea almost surrounded by land ("Golfo padano", Padan Gulf), to the most recent setting as a continental area, which form the western end of the Po plain.

Between Pliocene and Holocene times, the geological history of the area had its most important episodes, leading to the formation of the most characterizing elements for the history of the city of Torino: the mountains (Western Alps), with their defensive climate, the Monferrato and Torino hills, which determine the N-SE shape of the settlement, the Po plain, which "accepted" this settlement and favored its growth, and the 3 rivers (Po, Dora Riparia, Stura di Lanzo) whose confluence provides energy and facilitate irrigation and transportation.

By analyzing the geological history of the area we individualized some "steps" that allow to describe both long stages of its slow, continuous evolution, both periods of time characterized by significant environmental changes, as a result of a complex series of geological, geomorphological and climatic events. This dynamics goes beyond the central Piemonte region, because it is part of the evolutionary stages of the larger northern Mediterranean area. Here we outline the interaction of different and important geological structures: the western Alps, the Po basin and the Apennines, whose extreme north-western part is represented by the complex of the Monferrato and Torino hills.

The data collected during previous geological and climatic studies allow summarizing the history of the area in four main steps, numbered from the ancient one:

(1) from 5 to 2.5 million years ago;
(2) from 2.5-million to 700.000 years ago;
(3) from 700.000 to 10.000 years ago;
(4) from 10.000 to 4.000 years ago.

Figure 1 – One of the four maps included in the web site www.museotorino.it.It represents the palaeo-geomorphology and palaeo-environment of the the Piemonte area from 2,5 milions to 700.000 years b.P.(step2) (S. Russo).

VIRTUAL REALITY MOVIE

The representation of the evolution of paleogeographic and paleoenvironmental context of the considered period of time was achieved through a dedicated multimedia product, a virtual-reality movie including 3D Digital Elevation Models and elaboration from aerial views.

With the support of Virtual Reality MultiMedia Park (VRMMP) we focused on 3D virtual environments with interactive and immersive audiovisual interfaces, which can shed light over many issues concerning environmental evolution of the Central Piemonte Region. In particular, we adopted the paradigm of real-time 3D computer graphics to re-create credible scenarios of the "steps" individualized in the project.

From a scientifically authored elevation maps, we elaborated scenes including the appropriate color masks and light maps; then, we elaborated the real-time graphic materials to be associated with the scene surfaces, and, finally, we imported the complete scene in the interactive environment MESH for designing the visualization application and capturing the video.

As a final product, a movie of a few minutes shows the origin of the Alpine chain and of the Turin Hill, the setting of the hydrographic network, the evolution of the Quaternary glaciers and the shaping of the surface where will arise Turin. From a subtropical environment in the Pliocene (between 5 and 2.5 million years ago) characterized by the presence of a deep inland sea with cetaceans, we witness the gradual shift to a continental environment, to the formation of the reliefs and to the Pleistocene organization of the Po river.

The video also represents the climatic change that occurred around 1.8 million years ago that gives rise to the formation and expansion of the Susa Valley glaciers.

WEBSITE

For each of the four mentioned evolutionary steps it was produced an interactive map that collects various information (fig. 1).

Each of them represents in a simplified way the palaeogeography and the paleoenvironment that characterize the corresponding period of time. The main elements of the landscape and the most significant paleoclimatic indicators (e.g. sediment facies, vegetation, rivers pattern,...) are represented with simple symbols. Each map is accompanied also by texts that describe the main environmental, geomorphological and climatic characteristics of the step.

More than 40 geological sites (geosites) are geo-located with serial numbers: they are considered fundamental for the reconstruction of the geological and geomorphological history of the Piemonte and Turin areas. Each geosite is linked to a descriptive form of its paleo-environmental significance

ACKNOWLEDGEMENTS

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'SCENES SO LOVELY…….'!?

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KEY WORDS: Popularisation, education, google earth, geomorphological phenomena, mines, human impact, geosites.

POPULARISATION OF GEOSCIENCE AND GEOHERITAGE BY MEANS OF GOOGLE EARTH

When Livingstone in 1855 followed the Zambesi river he came to a gigantic waterfall the local people called ' the smoke that thunders', now the Victoria Falls. Livingstone was so impressed by the beauty and majestic force of this geological and geomorphological phenomenon that he later wrote: *'scenes so lovely should have been gazed upon by angels in their flights'.*

What in his time was supposed to be only possible for angles, is now possible for every human being by using Google Earth.

It will be demonstrated that that this tool can be of use to enhance interest in earth sciences by the general public..

First, examples will be shown of geomorphological phenomena from all over the world, such as coastlines, volcanoes, meandering rivers, glaciers, karst and thermokarst features showing the beauty and variety of the geomorphology of the earth.

Second some open mines will be shown (copper, marble, browncoal, iron and diamonds) showing the diversity of material we use and distribution over the earth in relation with geology.

Also some examples will be given of town building (New York/Manhatten and Venice).

Finally human impact on the landsurface as well as geosites will be shown focussed on the alluvial areas in the Netherlands.

So far it has been proven that using Google Earth this way both for the general public as well as for teachers in geography has been very succesfull. It is cheep, easy and accessible for almost everybody

GEOAL, AN ALGERIAN GIS DATABASE FOR THE DEVELOPMENT OF A GEOLOGICAL HERITAGE

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KEY WORDS: Geoheritage, GIS, Algeria, WEB.

GEOAL PROJECT

The project "GeoAl" is to create a GIS database of the main Algerian geological sites of scientific and or touristic interest . Indeed, Algeria with its 2,000,000 km2 is the largest country in Africa. It contains a wide variety of geological and geomorphological sites which are among the most unique and important in the world:

- paleovolcans among the finest that we know as those of the Askrem in the Hoggar,
- Sites with dinosaur footprints in the Saharan Atlas (Amoura, Ain Sefra, El Bayadh, etc ...)
- Archean having experienced one of the most extreme metamorphism with temperatures above 1050 ° in Ouzzal area (Hoggar),
- The oldest carbonatites always in the Ouzzal,
- Sites that combine archaeological engravings to geological wonders like the Tassili,
- Sand dunes among the finest and largest in the world (Sahara);

This list, by no means exhaustive, is only a small fraction of geological treasures concealed in Algeria. Despite these natural riches, no site is listed by UNESCO and none Geopark has been set up by the Algerian authorities.

The constitution of this database is part of the effort that lead the Algerian scientific community and international collaborators to publicize this heritage, and raise awareness of the importance of these sites in the protection of national natural resources and their ability to be an economic engine, with the development of geological tourism, handicrafts and small business. It is intended for optimal dissemination of the results of the work we do, that database is accessible through the web and it is accompanied by an educational content targeting an audience as wide as possible.

THE "ANCIENT RAILWAY TRACK": PROPOSAL OF A GEOSITE IN THE VESUVIO NATIONAL PARK

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KEY WORDS: geosites, Somma-Vesuvio, touristic paths, self-guided tours.

INTRODUCTION

During the last decades the sensibilisation and the interest of public opinion toward the preservation of naturalistic resources greatly increased, as the publication of new laws dealing with this matter and the establishment of new natural reserves testify. Among the natural resources, the geologic valuables are fundamental to understand the landscape evolution and, when opportunely promoted, they can represent an attraction for their singularity (Dingwall, 2000; Gray, 2004). Some peculiar sites can be considered possible "geosites", defined as geological and geomorphological "objects" having scientifically value for a better understanding of the history of the Earth, being it historical-cultural, aesthetic or socio-economic (Wimbledon, 1996). A geosite represents a tool for environmental education, because it gives to people basic instruments for the knowledge of geological and geomorphological aspects of an area. This knowledge, on the counterpart, is fundamental for preservation and promotion of natural resources through a correct policy of territorial management and decision planning. Most of the geological heritage is still poorly known, although since the last years a new type of tourism, known as Geoturism, is rapidly developing. Geotourism helps people to look to geo-diversity as to the key factor influencing the biodiversity and, as a consequence, the whole of natural landscapes.

THE *"ANCIENT RAILWAY"* PATH

In the Campania Region (southern Italy), owing to its outstanding cultural and naturalistic resources, it would be of utmost interest to recover and reutilize some sites that are very important both as environmental as educational sites.

For the purposes of the present work we chose a site along the Somma volcano slopes, pertaining to the San Sebastiano al Vesuvio municipality (Fig.1).

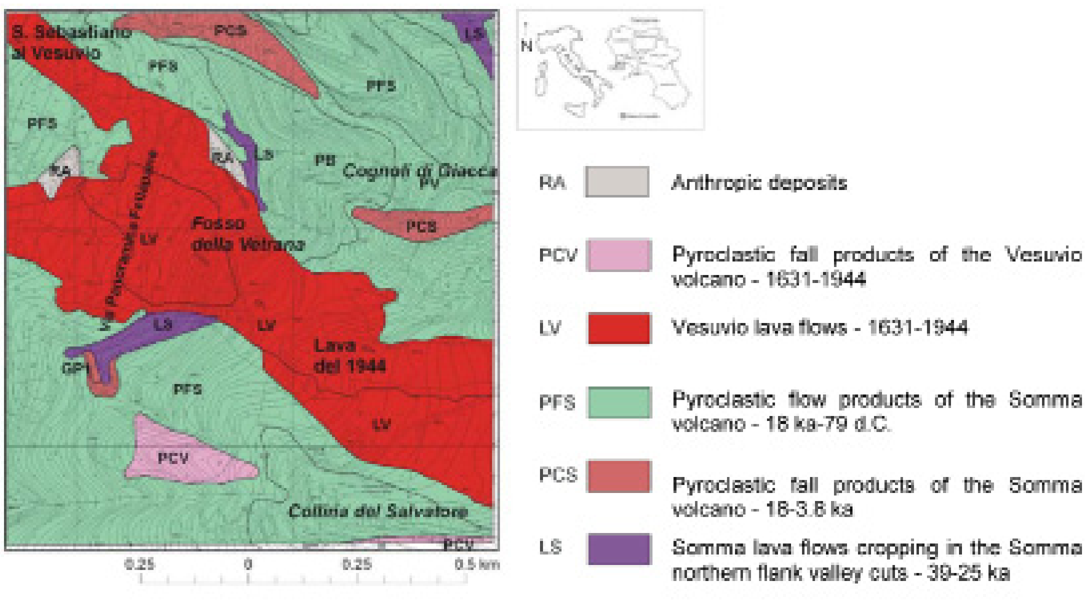

Figure 1 – Geolithological map of the "Ancient railway" path area.

Despite of its being already the seat of one of the "visiting tracks" of the Parco Nazionale del Vesuvio, partly crossed by the ancient Cook railway route, at present the site is very poorly preserved and difficult to be enjoyed by visitors.

Starting from the fact that a restoration of the touristic resource is impending, we tried and verified if the area is worth a valorisation of the geo-volcanological resources together with the naturalistic aspects, that the Vesuvio National Park mainly takes care of.

In the investigated area the products of the whole sequence of the Somma-Vesuvio activity crop out, starting from the ancient lava flows that makes up most of the structure of the ancient stratovolcano (the Somma), ranging in age between 39 and ca 25 ka. The explosive products of the Somma plinian events are well represented, both as pyroclastic fall and as pyroclastic density current deposits. The 1944 Vesuvio lava flow closes the stratigraphic sequence.

After the revision of the scientific literature dealing with the area, we carried out a field survey 1:5000 in scale, drawing both a detailed geological map, and a geo-lithological map (Fig.1) to be used as the geological support for the promotion of the geological resource. In the geolithological map the geological formations mapped have been grouped according to the source volcano (Somma or Vesuvio) and to the eruptive mechanism emplacing the single deposit (lava flow, pyroclastic fall or pyroclastic flow). This simplified map was thought to represent a geological tool also for secondary school students and non-expert visitors.

In the following phase of the work, we passed to the evaluation of the site based on the four main attributes: scientific, historic, educational and aesthetic value (Panizza and Piacente, 2002), which are needed to verify the quality of a possible geosite. The results of this evaluation brought us to the conclusion that the site was very idoneous as a geosite. The area, in fact, joins the peculiar geological heritage to several different aspects of landscape, as the outstanding Mediterranean bush, and historic remains, as the ancient track of the Cook railway, that in the first half of the XX century made it possible to reach the intermediate station of the Funiculare Railway, and from there to climb the Gran Cono. The site displays a good accessibility, a singular feature for the Somma-Vesuvio volcano where most of the good outcrops pertained to quarry sites and are now hardly accessible, because quarrying activity is forbidden in all the National Park area. This is a not trivial feature, because a site has greater potential to be visited if it can be reached by any means of transport (at least to a nearby point) by roads in good state (Gray, 2004). The fruition resulted very good both for expert people (earth science students and/or researchers) and for common people fond of all the aspects of nature. In the light of the future restoration of the visitors' tracks existing in the area, we planned to insert a geo-volcanological path, named "The ancient railway track" (Fig. 2) that partly corresponds to one of the already existing touristic tracks managed by the Parco Nazionale del Vesuvio. Accessibility of the path, from two different entries located on main roads, is very easy, and walking along it is not difficult and enjoyable all over the year. The uppermost entry faces the historic site of the Vesuvian Observatory, and the visit to the Museum therein can be favorably coupled to the visit to the geosite. For self-guided tours, aiming at making easier to understand the description, at both the entries of the itinerary a colour poster that contains the photos of each planned stop and describes the main features of the geosite was prepared. More detailed panels were realised for the single stops. As previously anticipated, we hypothesized the geosite to be visited not only by geologists and naturalists, but also by common citizens, tourists and students from primary school to college. This is the reason why the description of the stops was planned at various difficulty levels, taking into account the different features and background of possible visitors.

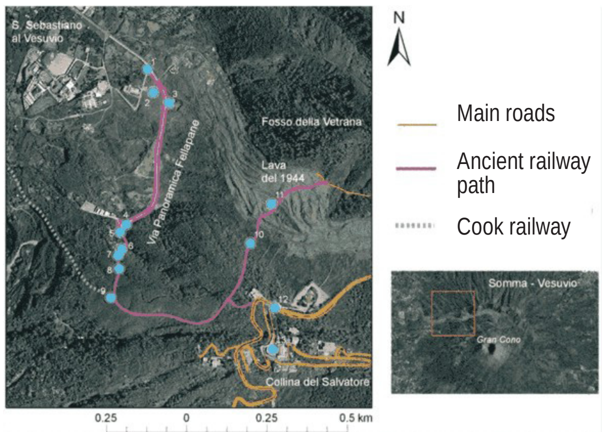

Figure 2 – Orthophoto map of the "Ancient railway" path. Blue circles are planned stops.

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ASSESSMENT OF GEOMORPHOLOGICAL SITES FOR RECREATIONAL PURPOSES

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KEY WORDS: recreational and geomorphic potential, geomorphosites, assessment, attractiveness, geoheritage

INTRODUCTION

Attractiveness of relief, diversity and rareness were always the basic features of overall recreational attractiveness of a territory. Relief often determines technological peculiarities of land use (means of transport, location and territory zoning, safety for recreational system and people involved in recreational activity). Regions with high geomorphic diversity served as model for first recreation and tourism researches (Bredikhin, 2010). It is no mere chance that first seats of recreational activities emerged in highland regions and coastal areas. The above features often favoured sustainability of touristic system. Unique relief forms are commonly referred to natural sites. They differ from the others in structure or have some morphological and morphometric characteristics not found in other forms of the earth's surface. Such monuments form the main natural functional kernel for a recreation system which is created and exists around them.

The functions of geomorphological sites in recreation can be divided into socio-cultural and economic. Socio-cultural function is the principal function of recreation. It responds to the cultural or spiritual needs of people such as the knowledge in the broader sense, knowledge of the world and their place in it. The economic function is to create consumer demand for goods and services, and sometimes an entire economy sector.

Natural sites are particularly vulnerable to dangerous occurrence of endogenous and exogenous processes as guarantee of environmental stability is an essential condition for a proper system functioning. This requires a comprehensive study of relief dynamics, monitoring and forecasting its evolution in protected areas.

THE ASSESSMENT METHOD

Currently, there are methods of assessing the recreational potential of the territory, including its location, climatic conditions, attractiveness and other factors which are valuable for recreational purposes (Reynard et al, 2009). It is generally used to determine the cadastral value of land.

There are two general domains of relief and recreation mutual influence: recreational and geomorphic (RG) risks and RG attractiveness.

In the context of recreational and geomorphic research risk is a measure of the probability and severity of an adverse effect to life, health, property, or the environment. This effect could be caused by recreational use of a territory or natural geomorphological processes. Thereby the interaction between geomorphological basis and recreational activity could be represented as a special field of risk. The tension of this field could be measured by value of risk which corresponds to consequences weight.

Attractiveness of relief should be determined by a complex parameter, composed of particular relief properties (uniqueness, diversity, aesthetic appeal).

Estimation of attractiveness and risk value must be carried out by means of composite indexes which include particular rates of relief features (rareness, diversity, aesthetical attractiveness etc.) (Blinova & Bredikhin, 2011). Field of attractiveness and field of risk together form some kind of coordinate system. The value of relief capacity for having positive influence on a person (physical, psychological etc.) can be placed in it. This quantity which indicates a complex functional suitability of an area for recreational purposes should be called "recreational and geomorphic potential" (RGP).

Comparison of risk and attractiveness values for different feasible types of activities gives an average risk and attractiveness values for a certain area. Selecting the average value in the evaluation component of recreational and geomorphologic potential allows to unify the scale of assessments for various recreational systems, and for different types of tourism activities within the system.

Taking into account the obtained averages of RGP components the whole potential for organizing a particular type of recreational activity can be attributed to one of four types (Tab.1).

Thereby a concrete system (or a geomorphosite) acquires some kind of "coordinates" in relation field of recreational and geomorphic potential of area.

Risks	High	1	1	4
	Medium	2	3	3
	Low	2	3	3
		Low	Medium	High
		Attractiveness		

Table 1 RGP dependence on risk-attractiveness ratio.

Types of RGP:
1 - Insufficient – characterized by high risks and low attractiveness
2 - Medium – characterized by low risks and low attractiveness
3 - Optimum – characterized by low risks and high attractiveness
4 - Extreme – characterized by high risks and high attractiveness.

INTERPRETATION

After estimating recreational and geomorphic potential of a certain area we can analyse its structure, i.e. the set of presented or potentially possible recreational activities

All recreational activities can be divided into 4 functional groups:

- Medical (climatotherapy, balneal, mud cure)
- Health-improving (bathing, hill walking)
- Sports (hiking, skiing, diving, rafting, fishing etc.)
- Educational (environmental education, cultural education)

Visually this classification could be represented as a pie chart (Fig. 1).

The diagram consists of two parts: the inner circle, divided into 4 parts and the outer cells. The inner part of the diagram reflects different functional groups of recreational activities. Then, for each group there is a set of specific recreational activities, realized or potential within the touristic system. The latter are represented in the form of cells. Depending on the value of RGP for each of them, the cell can be painted in green (the optimum RGP), yellow (medium) or red (extreme) colour. If RGP is insufficient for implement some kind of recreation the respective cell stays white.

Such diagrams allow us to compare specializations and recreational and geomorphic potential of different territories. Thereby it is possible to optimize decisions on the proper tourist product choice, or on organization of recreational activity. The last confirms the necessity to assess the RGP for different parties of recreational system - the organizers and tourists. Estimation of recreation attractiveness and geomorphic risks is particularly important for prospective recreational regions. The decision-making concerning to creation a new tourist cluster depends basically on resource assessment. Various functional types of activity within a recreational and geomorphic system could have different potential. Taking into account the structure of recreational and geomorphic space is the information basis for effective functioning of existing systems and for creation new ones.

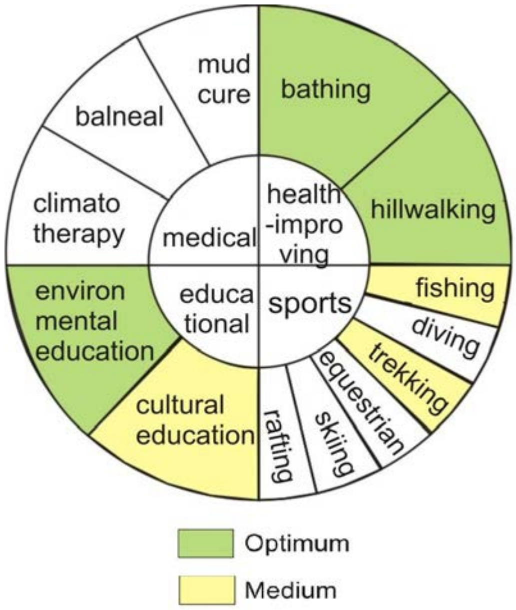

Figure 1 – Scheme of recreational and geomorphic potential structure.

The approach to assessment of recreational and geomorphic potential introduced in this paper allows elaborating concrete recommendations in organizing recreational activities (for well-known touristic areas and also for areas of new recreational development).

Next phase in the development of prospective recreational system is to compare the results of recreation and geomorphological assessment with the economic potential of the area and use value.

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THE 1:200 GEOLOGICAL MAP OF VILLAGGIO FILATURA IN TOLLEGNO, BIELLA (ITALIAN WESTERN ALPS) – THE LARGE EDUCATIONAL POTENTIAL OF A SMALL EXPOSURE OF BASEMENT ROCKS

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KEY WORDS: Metamorphic rocks, Mapping,

BASEMENTS ROCKS: UNDERESTIMATED ITEMS IN THE POPULARISATION OF GEOSCIENCES

Crystalline basements are the association of metamorphic and magmatic rocks and form the backbone of the Earth's crust. They originated from multiple petrogenetic phases involving magmatic and metamorphic processes generally related in space and time with the growth and destruction of an orogenic chain. If magmatic rocks are familiar to the large audience, metamorphic rocks and metamorphism are somewhat less known. Metamorphism is when a rock enjoys pressure and temperature conditions different from those under which the rock originally formed. Metamorphic rocks can be subjected to higher temperatures and pressures as they are buried deeper in the Earth's crust/upper mantle along convergent margins. These pressure and temperatures gradients have profound consequences on the mineralogy and the (micro)structure of metamorphic rocks. After residing for a lapse of time at depths, crystalline basements undergo exhumation towards the Earth surface: during their travel back to the surface they experience additional deformation phases, partial melting and/or intrusions of silica-rich liquids (melt or fluids).

Despite the high potential to retain the geological record of fundamental events occurring in the deep Earth, exposures of crystalline basement have a limited impact on the popularisation of geosciences and they rarely appear as the main attraction of outreach activities. This study, which stems from the results of an undergraduate mapping project, demonstrates the wealth of information gathered in the crystalline basement outcropping near the Villaggio Filatura in Tollegno, Biella (Figure 1). These information will help to design popularisation activities using apparently difficult-to-understand rocks but with a distinctive beauty and appeal for both local inhabitants and visitors.

THE VILLAGGIO FILATURA OUTCROP IN TOLLEGNO (WESTERN ALPS)

Between Biella and Tollegno (Figure 1), the Cervo River has carved its talweg into the crystalline basement belonging to the Ivrea Zone. In this area, the Ivrea Zone consists of rocks metamorphosed during the Variscan orogenic cycle related to the continental collision between Laurussia and Gondwana. Detailed mapping of the River Cervo banks at Villaggio Filatura allow the identifications of different rocks types and clear cross-cutting relations (Figure 2).

Figure 1 – Location of Tollegno.

The outcrop, which is easily accessible, consists of femic amphibolites and alternating clinopyroxene-bearing calc-silicate and carbonate-silicate gneisses deformed together by close to isoclinal folds. The parent rocks of amphibolite and metacarbonates (basalts and marls, respectively) possibly originated in pre-Devonian times and were transformed under amphibolite-facies conditions during the Variscan collisional acme occurred about 340-330 Ma ago. This basement was later intruded by silica-rich melts that solidified to give rise to medium-grained granodiorites. The age of this intrusion is still unknown but the lack of an amphibolite-facies overprint points to a post-Variscan age. The granodiorite-basement contact is underlined by the presence of mm- to cm-thick skarns.

The Variscan basement and granodiorite were intruded by latitic trachyandesites belonging to the Oligocene igneous activity that affected the Alpine belt along the Periadriatic Line. At the Villaggio Fila tura, the dykes are cut by E-W trending faults. High-resolution images can be reached and downloaded from the website http://www.geomin.unibo.it/strutture/Pag_pers/Braga/Le_Migmatiti_di_Tollegno/Home.html devoted to the metamorphic and igneous rocks of Tollegno.

THE EDUCATIONAL POTENTIAL

The metamorphic and magmatic rocks of the Villaggio Filatura in Tollegno form a very special geological site related to fundamental processes occurring during the evolution of the Earth. The detailed map unveils a few square metres where one can find a variety of educational topics. For example, in the outcrop it is possible to carry out:

- Exercises of reconnaissance of different rock types such as metamorphites, a small magmatic intrusion with clear hypidiomorphic texture and porphyric volcanic dykes;
- Unravel cross-cutting relations among the different rock types and establish a relative sequence of geological events;
- Introduce the not-so-easy topic of metasomatism using the skarns that originated when rocks with strongly different chemical compositions (silica-rich vs. carbonate-rich) interact;
- Analyse the displacement of the latitic dykes to explain how rocks are displaced along faults. From this simple field observation should be easy to lead the interested audience towards one of the most important issue for the society: earthquakes.

The Tollegno rocks possess the attributes to be considered as a Geological Heritage in that they demonstrate how Earth dynamically evolves through the deep Time.

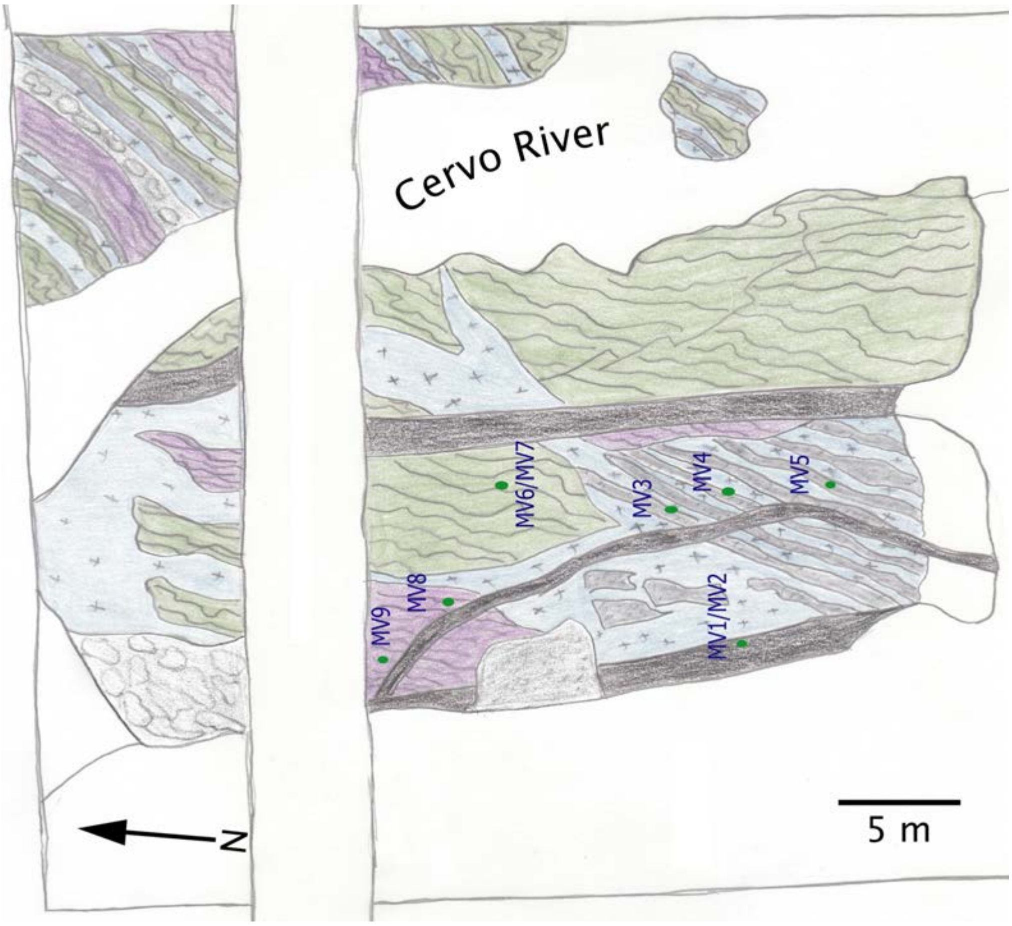

Figure 2 – Sketch of the outcrop at Villaggio Filatura, Tollegno (Biella). It forms the basis to design outreach activities

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EXAMPLES OF VALORISATION OF GEOLOGICAL HERITAGE IN SICILY

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KEY WORDS: Geological heritage, Geopark, Eco – geo tourism

INTRODUZIONE

Sicily region, in order to protect the geological heritage, has ongoing approval of an administrative regulation for recognition, classification and protection of geological sites. While waiting for this regulation, the Environmental Department of Sicily is still aiming to achieve the objectives of protection and dissemination of geological heritage, through a survey of the most interesting geological sites in Sicily.

Currently, the catalog consists of 500 geosites between "reported" and "proposed" and about a hundred of geosites that are cataloged in a complete manner according to the criteria of the Department of Environment of Sicily, already shared with the national census.

The collected data are divided into three classes of census, corresponding to an increasing degree of depth of information. For each of the three categories, prerequisites are however an indication of the importance that characterizes the site (geomorphology, paleontology, volcanology, etc.) and its location, with particular attention to the accuracy of the geographic coordinates provided (gps, google earth, toponomastic, etc).

A part of the poster represents the geological sites surveyed in Sicily categorized as "Inventoried", "Offered" and "Recommended".

The census work and implementation of the "*Catalogo dei Geositi Siciliani*", leading to an homogeneous and specific knowledge of the geological heritage. This will allow more accurate land planning of Sicily, through choices of sustainable development with environmental protection and for the promotion of the territory resources. Another goal of the census is to assist people engaged in environmental protection, to an easier design of educational courses or tourist development. In this context, the Department of Environment of Sicily promotes partnerships to implement cultural and educational public use projects.

Below are illustrated three tourist and educational-in sites projects that differ in type and degree of protection concerning public and private areas.

The sites are:

- *Grotta della Molara*. Example of scientific project made in collaboration with the reserve management entity.
- *Magapillow di Acicastello*. Example project of scientific dissemination and enjoyment in collaboration with private partners.
- *Scala dei Turchi*. Example project of scientific dissemination and use in public area

GROTTA DELLA MOLARA

The Natural Reserve "Grotta della Molara" was established to protect karst areas characterized by considerable interest, either hypogeous or epigeous, and palaeoethnology. In particular, the geological site of Grotta della Molara is the largest of the cavities that develop in the district of Contrada Petrazzi, falling in the urban area of Palermo, and is of "great importance to the presence of paleontological remains of the extinct quaternary fauna "(Bonfiglio L., 2004).

Mannino (1975) also described the environment of epigeous Contrada Petrazzi "a spectacular karst landscape, perhaps the most beautiful of the island".

The cooperation between the managing association (CRES) and the Environmental Department of Sicily has led us to define a path that winds from Grotta della Molara to the entrance of the Cave of Dead Rabbit and finally to the Cave of Spirits.

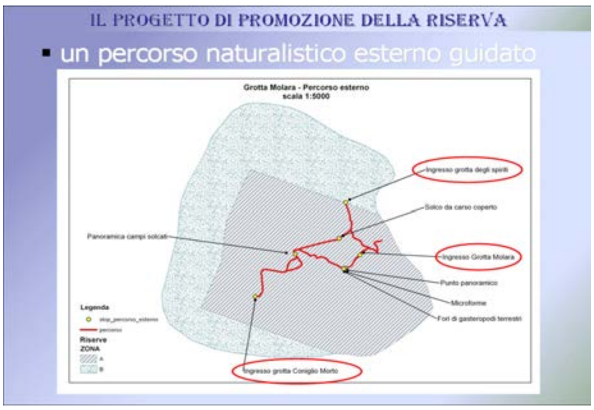

Figure 1 – Project "SOS Desertification", planning a route between the geological sites of the Reserve Grotta della Molara made by two third classrooms of the ITT Marco Polo in Palermo.

This route, which passes through various vantage points and observation of geological peculiarities (such as small and micro karst features), has been the subject of a work done in the educational project “SOS Desertification”, aimed at high school level to sensitize students on issues of land protection.

In particular, students have planned the use and advertising of the Grotta della Molara, chosen because it is a good example of how, through the establishment of a reserve, you can rip desertification part of the urban area.

The project was therefore an opportunity to test a path designed to disseminate earth science using a pattern that, putting it ahead of traditional lessons, make students the actors of their learning process.

MEGAPILLOW DI ACICASTELLO

Under the protection and disclosure of geological heritage is essential to involve the private sector in sustainable use of natural good hanging on their property.

In the territory of Acicastello, through the various geological heritage that characterize this area, an important role have the presence of “Megapillow” unique in its kind, whose origin is related to pre-Etnean volcanism of about 500 thousand years ago. This megapillow, visited by scientists from around the world, plays a strategic role both from the scientific point of view, as a deepening of the volcanic phenomena, both for tourism development in the area.

In the area is present the farm “La Fungaia” located along an old railway track disused and abandoned. The farm built inside the railway tunnel cultivation of mushrooms, produces a variety of Mediterranean herbs and Aloe. Moreover rare species of birds are present.

The farm can be the reference point of a tourist-trail between “*Le vulcaniti di Castellese*” which winding within the municipality in a particular environment and picturesque landscapes and natural beauties, connects the various geological features of the area represents the first manifestations of Etna.

Stage of particular interest is the nearby Marine Protected Area “Cyclops Island”. Here you can do an excursion by boat to the island of Lachea and the Faraglioni of Acitrezza with the responsibles of the management of the reserve. This path is also an opportunity to visit places of historical and architectural interest such as a Norman Castle.

SCALA DEI TURCHI

The Department wants to promote at local authorities level, projects for the construction of educational and tourist routes. The aim is to disseminate the regional geological heritage giving a boost to economic development in municipalities.

The coastal part of Realmonte (AG), is characterized by strong color features related to geological variability, together with the salt mine “Realmonte” lends itself to a path of this type.

The route starts from the “Scala dei Turchi”, a cliff overlooking the sea, consisting of marl and “Globigerines” calcareous marl (locally “Trubi”), with its characteristic white color, a major tourist attraction for the strong color contrasts between the rock and the sea.

The site has a huge natural staircase of limestone, which provides an opportunity to describe both the sedimentological processes that have created the white rock in the Pliocene age, both geomorphological processes that have sculpted above the steps.

The area of Scala dei Turchi is part of the Capo Rossello composite section in which the geologists established a Global Stratigraphic Section and Point for the Zanclean stage (Eraclea) And Piacentian stage (Punta Piccola). These sections are of worldwide scientific importance.

These sites will be stop points of a route structured with message boards, posters and post labels.

The route will also touches the promontory of Capo Rossello, a viewpoint that, for the presences of red limestone (jointed with the areas of Pergolas and Monterosso), is the point of transition between two chromatically different zones: the “Red Zone” to the east and “White Zone” (Scala dei Turchi) to the west. The final stop of the route is the salt Mine, one of the most important in Sicily, in which a church was formed, called the “salt Cathedral” for features statues sculpted in the salt.

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THE PROTECTION OF THE GEOLOGICAL HERITAGE OF EMILIA-ROMAGNA: A PRELIMINARY OVERVIEW ON THE STATE OF THE FACT

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KEY WORDS: geological heritage, census, regional legislation, territorial protection, parks and natural reserves.

THE GEOLOGICAL HERITAGE OF THE EMILIA-ROMAGNA REGION

The Geological Seismic and Soil Survey (SGSS) of the Emilia-Romagna Region set up the census of the geoheritage in 1998. The census is a work in progress both for the contents and for the number of the sites scheduled. At present, SGSS has identified 711 “elements of the geoheritage”. The territorial extension of the scheduled sites is about 53.000 hectare, which represents 2,5% of the regional territory.

The census led to the identification and selection of about 90 sites which represent “geosites of regional significance”.

In collaboration with the Speleological Federation of Emilia-Romagna, SGSS also set up the census of the hypogean geoheritage (caves). At present, 775 caves have been identified and 41 have been selected as hypogean geosites of regional significance. All the data of both census are available on the SGSS website in the section dedicated to web-gis.

The status of protection for the hypogean geoheritage is not covered by this presentation.

THE LEGISLATIVE FRAMEWORK

In 2006 Emilia-Romagna Region approved a regional legislation on the protection of the geodiversity (“Norme per la conservazione e valorizzazione della geodiversità dell’Emilia-Romagna e delle attività ad essa collegate” (9/2006). This legislation set up the cadaster of the geosites, which includes the natural hypogean geosites, because it recognizes the public interest of the regional geodiversity and the geoheritage as repository of scientific, environmental, cultural and touristic-recreational values. The legislation states the difference between geosite and element of the geoheritage and it defines the procedure for the formal institution of a geosite. Furthermore, the legislation provides that the cadaster of the geosites be included in the framework of the cognitive tools for land and urban planning. This legislation has certainly encouraged the activities relating to the promotion of the geological heritage but has not yet led to the definition of criteria and standards for its conservation, protection and management. To ensure the full implementation of the legislation, the Region has still to provide the guidance document on the conservation and enhancement of geodiversity in Emilia-Romagna.

It is now necessary to proceed with official institution of the “geosites of regional significance”. that have to be submitted to the recommendation of the Scientific Committee headed by the regional law 9/2006 to this procedure. Afterwards, Emilia-Romagna Region will submit a selection of the regional geosites to the Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) that is responsible for the National Catalogue of the Geosites.

At present, no geosite has been officially instituted. For this reason, the protection of the geoheritage in Emilia-Romagna is strictly connected with other forms of territorial protection and, in particular, those in act for the natural heritage. In other words, the Emilia-Romagna’s geoheritage is under protection only if it is included in the existing protected area (national and regional parks, regional reserve, etc.).

STATUS OF THE PROTECTION FOR THE EMILIA-ROMAGNA GEOHERITAGE

At present, the protected areas of Emilia-Romagna Region are:

2 National Parks (Law n. 394 del 1991)
17 State Reserve (Law n. 394/1991)
1 Interregional Park
14 Regional Parks (Regional Law 6/2005)
15 Regional Reserve (Regional Law 6/2005)

33 Areas of ecological re-balancing (Regional Law 6/2005)

3 Natural and semi-natural protected landscapes (Regional Law 6/2005)

153 sites **of** Natura 2000 network (SIC - **Sites of Community importance and ZPS- Special Protection Zone, instituted in accordance with the Council Directive 92/43 EEC 21/05/1992 received** at regional level by L.R. 7/2004, L.R. 6/2005 and D. G. R. n. 1224 del 28.7.08.).

It is important to note that the laws that rule the listed protected areas do not make any distinction between the natural heritage and the geoheritage. However the geoheritage is mentioned as object to be protected in al lot of specific protected areas: the Parks of Vena del Gesso Romagnola, Gessi Bolognesi, Appennino Tosco Emiliano, Delta del Po, Sassi di Roccamalatina, Stirone e Piacenziano; and the Reserve of Salse di Nirano, Contrafforte Pliocenico, Dune fossili di Massenzatica, Sassoguidano, Fontanili Corte Valle Re, Grotta di Onferno, Rupe di Campotrera and Monte Prinzera. Integrating data on geoheritage within the data provided by the colleagues of the Park Survey has made it possible to define the consistency of the geoheritage which enjoy some form of protection.

In the areas protected by the national law n. 394/1991 (National Parks and State Reserve) are comprised 9 geosites and 76 elements of the geoheritage. In the areas protected by the regional law n. 6/2005 (the rest of the protected areas listed before) are comprised 59 geosites and 302 elements of the geoheritage.

At present about 75% of the geosites enjoy some form of territorial protection, while only 50% of the elements of the geoheritage are included in a protected area.

AN APPROACH TO DEFINE PRIORITY IN GEOSITE INSTITUTION

Define the priority criteria for the establishment of geosites means finding the way to identify which of the selected geosites are at higher risk of damage or loss as a function of their state of preservation, the risk of degradation to which they are exposed and the state of the protection to which they are subjected. The state of preservation and the risk of degradation are two elements evaluated by the census of the Emilia-Romagna geosites. The state of the protection is the subject of this first study.

The long-term objective of the “geosite project” of the SGSS is to attain the formal institution of all the geosites selected. As illustrated before, the regional law 9/2006 is the legislative tool for the official institution of a geosite in Emilia-Romagna. The law identifies in a Scientific Committee the authority competent to take a decision about which of the 90 geosites of regional relevance have the requisite to became a geosite of the Emilia-Romagna Region.

Starting from the previous evaluation on the status of geoheritage protection in Emilia-Romagna, it becomes clear that even if a great part of this heritage benefit from some form of protection the rest is totally lacking. For the latter therefore there is an urgent need to provide for their formal recognition as required by the regional law. For the geosites placed out of the protected area we aforementioned, the law estabilishes the form of protection defined by the instruments of urban and territorial planning.

It is now necessary to verify in which way the geoheritage is included in the main instruments of regional territorial planning of Emilia-Romagna (Regional Territorial Plan –PTR; Regional Territorial and Landscape Plane – PTPR; Provincial Territorial Coordination Plans –PTCP). At present, every provincial administration has requested to the SGSS of the Emilia-Romagna Region the census of geosites for inclusion in their Provincial Territorial Coordination Plans. On this side, with the Province of Reggio-Emilia we started a very fruitful process of sharing data that brought to the acquisition of all elements of the geological heritage in the Provincial Territorial Coordination Plans.

CONCLUSION

The delivery to the provincial governments is the best tool so far identified to achieve the protection and enhancement of all areas identified in the Geoheritage Project of the SGSS. At the local level, all elements of the geological heritage are an important part of the territorial tissue who deserve to be treated, as the others, as it has been done in the Province of Reggio-Emilia.

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THE TERRESTRIAL UPPERMOST CRETACEOUS HERRITAGE: PROPOSAL FOR A NEW GEOPARK IN ALBA COUNTY, ROMANIA

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KEY WORDS: geological heritage, Latest Cretaceous, fossil vertebrates, geological reserve, Transylvania, Romania.

INTRODUCTION

Several national parks, natural monuments, protected landscapes or geological reserves already exist in Transylvania (Romania) (Fig. 1). Some of them are located in Alba County (Bleahu, 2004). They are due to the peculiar geology of the area where the southeastern corner of the Apuseni Mountains is in contact with the sedimentary Basin of Transylvania. In the following, we propose a new protected area, based on the presence of the upper Cretaceous terrestrial deposits, particularly rich in vertebrate fossils. These fossils are unique, reflecting peculiar island evolution in Maastrichtian.

GEOLOGICAL SETTING

In Alba County, the uppermost terrestrial Cretaceous deposits are exposed between Alba Iulia, Şard, Vurpăr, Pianu de Jos, Petreşti, Sebeş, Berghin, Teleac (Codrea et al., 2010) (Fig. 2). The continental megasequence may be considered as the first unit of the Apuseni Transylvanides post-tectonic cover, after the upper Cretaceous ("Laramian") tectogenesis (Balintoni, 2003).

The following upper Cretaceous formations were coined in this area (Codrea & Dica, 2005):

- Bozeş Fm. (Santonian-Early Maastrichtian);
- Vurpăr Fm. (Earliest Maastrichtian);
- Şard Fm. (Maastrichtian-?Paleogene).

From these three formations, only the last one is strictly continental. Bozeş Fm. is deep marine (flysch), while Vurpăr Fm. is deltaic, but bears few marine interbeddings, documented by marine mollusks assemblages recorded mainly between Vurpăr and Pâclişa, but thinner deposits are also present in Sebeş Valley, downstream of Petreştii de Jos.

The Şard Fm. is dominated by red beds referred to braided fluvial environment, with frequent internal bars, red mudstone with pedogenic levels and sand and gravel as channel fills. There are also pond-like and even small lakes tendencies, as those ones at Oarda de Jos.

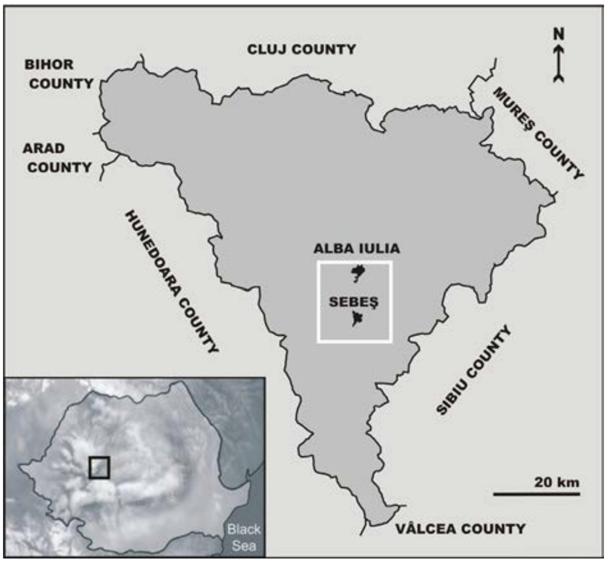

Figure 1 – Location of Alba County in Romania. The rectangle outlines the proposed protected area.

The Şard Fm. deposits are rich in vertebrate assemblages. Among them, the most peculiar are the dwarf dinosaurs belonging to same taxa as those from Haţeg Basin, described firstly by Baron Francisc Nopcsa more than one century ago.

The Maastrichtian vertebrates are the following ones: fish (Lepisosteidae and Characidae), lissamphibians (*Albanerpeton*, Discoglossidae), teiid lizards, turtles (*Kallokibotion*, Dortokidae), crocodilians (*Allodaposuchus precedens*, *Acynodon*, *Doratodon*), pterosaurs (*Quetzalcoatlus* [= *Hatzegopteryx*] and probably a smaller sized representative), the hadrosaur *Telmatosaururs transsylvanicus*, the euornithopod *Zalmoxes*, the ankylosaur *Strutiosaurus transilvanicus*, indeterminate sauropods, carnivore dinosaurs (as *Richardoestesia*, ?*Paronychodon*, *Balaur bondoc*), birds (Enantiornithidae), multituberculate mammals (Kogaionidae). Apart from vertebrates, there are also invertebrates (freshwater mollusks, crabs) as well as plants (*Sabal major*, *Telephragmoxylon transsylvanicum*).

PROTECTION OF THE GEOLOGICAL HERITAGE

Until now, only a single geological reserve is legally protected. It is Râpa Roşie, located 3 km northeast from Sebeş, a large outcrop (800 m in length and 120 m in height) with red beds of badlands-like aspect, belonging to Şard Fm. Obviously, the protected area should be largely extended on the whole Maastrichtian exposures. Therefore, we propose a new geopark in this area outlined by the following localities: Pianu de Jos, Blandiana, Vurpăr, Ighiu, Teleac, Berghin, Câlnic, Săsciori. Apart from the dwarf dinosaurs-bearing deposits, the geopark would include also historical monuments of interest (e.g. the antique Apullum and the Middle Age vestiges of Alba Iulia, the Martinuzzi Castle, the center of Sebeş town built under Germanic influences, the Câlnic and Petreşti Middle Age fortresses etc.). This location (the whole area is outlined in Fig. 1) is easy to access by a large public, as far as it is crossed by two main European roads (E81 and E68).

The proposed geopark could complete other two already existing ones in Romania, the Mehedinţi Plateau Geopark and the "Dinosaur Geopark" in Haţeg Land.

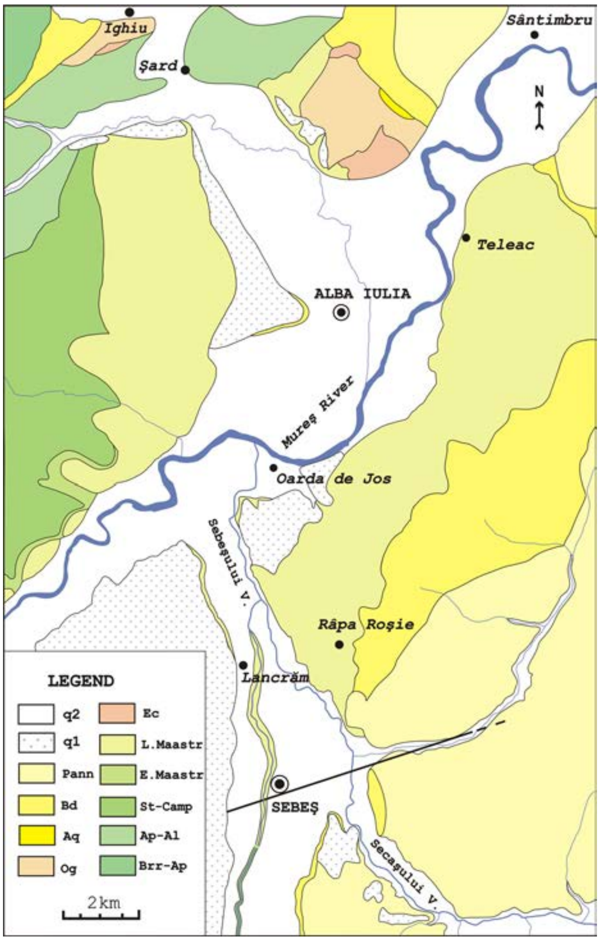

Figure 2 – Geological map of the main interest area

CONCLUSIONS

In Alba County the area with terrestrial Maastrichtian deposits is of special interest owing to the unique fossil vertebrate taxa. Among them, the dwarf dinosaurs are outstanding due to their peculiar evolution in island environment. In the latest Cretaceous a large part of Transylvania was part of an island belonging to a larger archipelago of the Tethys Ocean. Therefore, due to their rarity, these fossils need special protection against human influences as buildings, stone mining, etc. Now we are proposing a protection area outlined by several localities where the Maastricthian deposits are rich in vertebrate fossils. The region excels also in a rich historical heritage (Antiquity and Middle Age) that complete the geological heritage. In our opinion a new geopark in this area could be the best solution for a convenient protection of this geological heritage, unique in Europe. A geopark in Alba County could develop the tourism and is also suitable for educational aims too, rather for understanding the geological evolution and the history of Transylvania.

ACKNOWLEDGEMENTS

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LANDSCAPE MODIFICATIONS THROUGH THE EVOLUTION OF THE INDUSTRY IN ANDENNE (BELGIUM) SINCE 18TH CENTURY: A GIS CASE STUDY.

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KEY WORDS: landscape, Andenne geology, coal, industry, Belgium

INTRODUCTION

Man exploits systematically all natural resources (mineral and organic) he needs, available on its territory. He extracts, transforms and trade raw materials and finite products with neighbouring communities, regions, and countries. So doing, it indelibly affects the landscape, following the major both economic and technologic developments, political and demographic trends of the moment. The regional geological history of Andenne endowed the city unique natural mineral resources in Belgium: limestone, dolostone, sandstone, quartzites, coal, sulphides ores of lead, iron and zinc, oolithic ironstones, rock alum, plastic clay, cherts, alluvial clay, sand and groundwater. Both archaeological and historic evidences show those raw materials are mined continuously, from the Palaeolithic to the present, together with the more and more diversity of material types. It generated a lot of work and wealth. Used "raw" in the beginning, then cut, sawed, polished or dried they were then transformed, crushed, boiled, melted, washed, recrystallized, coked ... to extract more and more complex products that meet the more demanding industry's needs.

The Belgian National Geographic Institute (IGN) has been working for almost 180 years, producing regularly updated official topographic maps that meet societal needs. The map of the Office of The Austrian Netherlands, known as "Ferraris," mapped between 1771 and 1778, is the first large-scale map covering almost the entire Belgian area. It will be followed between 1846 and 1854 by publishing maps well known as "Vandermaelen maps". These two maps sets will be mainly used and faced to modern maps and aerial photos in order to compare and extract the landscape evolution.

GEOGRAPHICAL AND GEOLOGICAL SETTINGS

Andenne is a small Belgian city of 25,000 of inhabitants situated at the border of the Namur Province, covering an area of 86 Km². The river Meuse cross the city from W to E and its alluvial plain has permitted the development of a swamp area where nowadays days the city is built. The flanks of the alluvial plain are steep as the river flows along sandstones and limestones. Thanks to the Meuse River and its tributaries, many outcrops popped out along its course giving the city an excellent potential for the extraction of stones.

The great diversity of geological material is due to a regional favorable geological context: a large stratigraphic interval (nearly continuous Ordovician to Quaternary) underlined by strong variations of palaeoclimate and paleogeography, the variscan deformation, the post-variscan peneplanation, the cretaceous and tertiary deposits, mainly preserved in karstic systems and the incision by a well-developed river system.

Open and underground quarries have been developed as ornamental stones and for aggregates. White namurian sandstones (quartz arenites) and pure limestones and dolostones (Dinantian) were used afterwards for the iron industries and in order to produce high quality (do)limes and by-products for industries and biotechnology. Lhoist and Carmeuse Belgian Groups are world leaders for the production of (do)lime and (do)lime products.

LEAD-ZINC EXTRACTIONS AND LANDSCAPE MODIFICATIONS

On the two-sides of the valley of the Meuse, between Marche-les-Dames and Huy, many deposits were mined for lead, zinc and pyrite. The development of this industry leads to the modification of the landscape, quality of the water, creation of slagheap. As example, the situation of one exploitation will be discussed.

On the map of 1870, the shaft "Maudit champs" and "Haie-Monet" (Fig.1) are represented separately. Many technical facilities around the mine area were present at that time. A road conning to the Haie-Monet to the Boltry (Seilles) is visible on the 1870 map, absent on the 1970 one and its trace can be found on the aerial photography.

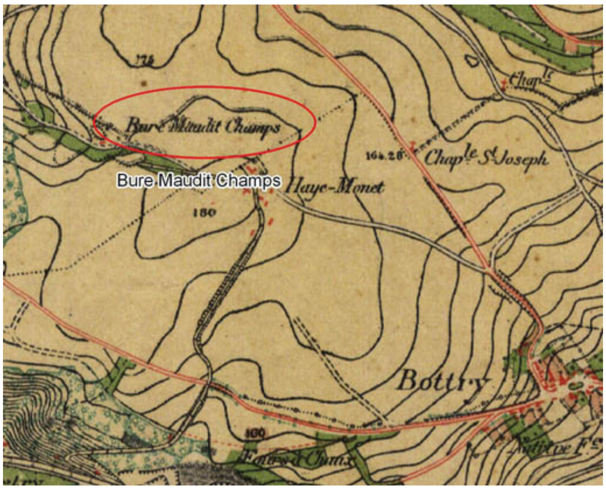

Figure 1 – 1:20,000 topographical map 1875, “War warehouse”, Andenne, 48/1. Map collection.© IGN.

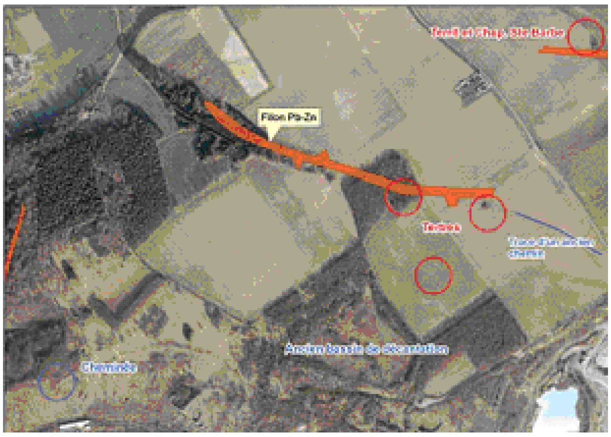

Figure 2– Aerial photography.

On the figure 2, shows three mounds representing former metal (Pb-Zn) mining pits, “Haies Monet” and its metal veins trace on the surface are visible. Note the passage of a vein to the right of the chapel where St. Barbara a wooded mound is still visible on the ground. The limestone quarry operated by Carmeuse and its settling pond are clearly present. The aerial photography of the same area still shows more than thirty years later, traces of mining and landscape changes related to the extraction of limestone

LIMESTONE, DOLOSTONE, SANDSTONE EXTRACTIONS

The extraction of limestone and dolostone in the Meuse valley corresponds to the major extractive activity nowadays. The coal also present is not mined anymore. The region of Andenne has been massively exploited for the quality of its limestone. The Carmeuse quarry development trough the time is the best example of the evolution of the area. In the map of 1870 (Fig. 3a) by Ferraris, two extractive areas situated in NW of Andenne are represented separately. The figure 3b shows a recent picture of the quarry. At the present time, the two extractions zones are completely merged and even abandoned to a third one situated at the NNE.

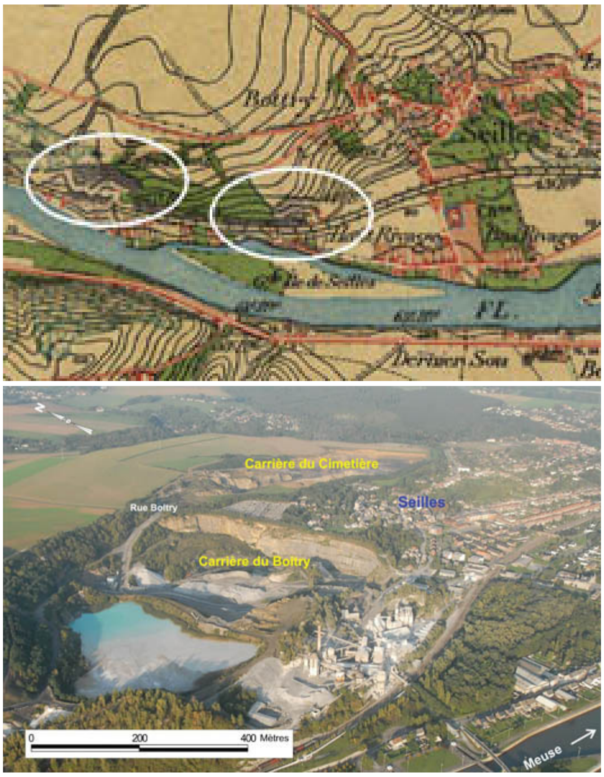

Figure 3– a. . 1:20,000 topographical map 1875, “War warehouse”, Andenne, 48/1. Map collection.© IGN; b: Recent picture of the Carmeuse quarry.

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THE NEW GIS-BASED GEOLOGICAL MAP "SPIGNO MONFERRATO" 212 QUADRANGLE: A STARTING POINT FOR FURTHER PROJECTS OF GEOHERITAGE MANAGEMENT

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KEY WORDS: geological mapping, Geographic Information Systems, HP metaophiolites, Voltri Massif, Western Alps, geological heritage

INTRODUCTION

We are carrying on a geological map project, financed by Regione Liguria, that covers the Ligurian part of the Spigno Monferrato 212 quadrangle. The mapped area (about 350 km2) straddles the Savona and Genova provinces in central Liguria and covers a hilly to mountainous region with the highest peak of Mt Beigua (1287 m, centre of the Beigua Geopark) at only about 8 km from the Ligurian Sea. We perform the field mapping at 1:10,000 scale, for a final drawing at 1:25,000 and 1:50,000 scale.

Geological maps are a fundamental product to popularise the new geological knowledge of the region and represent the starting point for further projects of geoheritage management.

In order to produce a high cartographic-quality map and to create a geological database, we used a vector drawing software with GIS capabilities (Adobe Illustrator CS4 and Avenza MaPublisher 8.3.3).

THE MAP

The mapped area falls inside the HP metaophiolitic Voltri Massif of the Western Alps (Fig. 1) (e.g. Chiesa et al., 1975; Capponi and Crispini, 2002) and thus encompasses rocks belonging to the Ligurian-Piemontese Domain and locally to the Piemontese and pre-Piemontese Domains.

The bedrock is made up largely of serpentinites and metasediments, with subordinate occurrence of metabasite, peridotite and metagabbro. Two metaophiolitic units crop out, re-equilibrated either in peak eclogite (Voltri Unit) or blueschist facies (Montenotte Unit) metamorphic conditions. The Montenotte Unit is frequently associated with a carbonatic Unit of pre-Piemontese affinity, made up of largely by dolostone.

Moreover, a small portion of a basement unit, made up of paragneiss and anfibolites, crop out at the southern margin of the map.

The bedrock is covered by late- to post-orogenic deposits either belonging to the Tertiary Piedmontese Basin (TPB) or to Pliocene marly sediments.

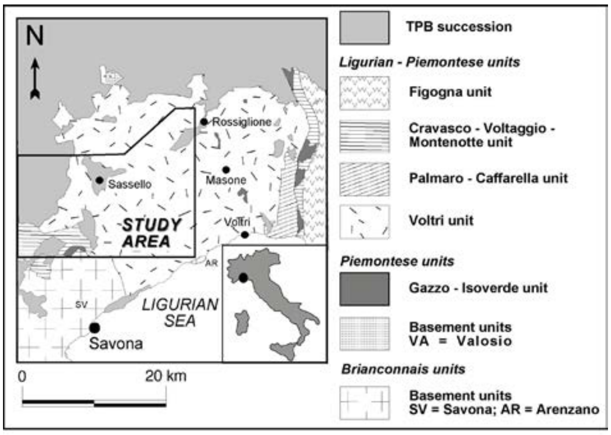

Figure 1 – Location of the mapped area.

Figure 2 – Students during fieldwork

This area is characterised by a long-lasting geological history that spans from ocean opening in Jurassic times, to alpine orogeny during Cretaceous to Eocene times and late- to post-orogenic deformation and sedimentation in the Oligocene to Pliocene interval.

The long-lasting evolution as long as the high geological diversity make the area very suitable for educational purposes and thus it has been the main site of geological excursions both for students and for geo-tourists (Fig. 2) since a long time.

Structural complexity is highlighted by the superposition of different folding phases developed during the subduction-collision events that created the present orogenic belt. Moreover, several sets of tectonic lineaments cross the mapped area shaping the landscape (Fig. 3).

The mapping project involves also the report and description of the most important paleontological sites distributed on the area.

Another important aim of this project is the report of quarrying and mining sites. In the mapped area several old small excavation sites, especially in serpentinites and dolostones, are present; in the past they were used as building material and now ruins of the exploitation works, sometimes investigated by archaeological studies, are still visible. We mapped also two test mines, one in the Orba Valley and the other one near Sassello village: the first one was excavated in serpentinites for gold exploitation, whereas the second one was a copper mine. Both were abandoned due to their unfruitfulness. During the 1960's in the Orba Valley there was also an attempt to mine Titanium from rutile-bearing eclogites. The extreme hardness of the wall rock and the scatter distribution of rutile in it prevented the development of the exploitation project.

All these data are contained in a georeferenced database that is used as a powerful instrument for divulgative purposes: a gis-based geological map in fact, can be used to extract different divulgative and touristic informations like geo-touristic paths, panoramic points and paleo-industrial sites or ethnographic emergences.

Figure 3 – Riverbed shaped by tectonic lineaments

CONCLUSIONS

This new geological map provides an up-to-date instrument of territory management and represents a good basis for future projects of geoheritage valorisation through education, training and tourism.

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THE APPENNINO GEOPARK PROJECT

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KEYWORDS:
European Geoparks, Geoheritage, Geotourism, Geology,Appennino, GalBologAppennino,Europe.

THE EUROPEAN GEOPARK NETWORK UNDER THE ASPICIES OF UNESCO.

Estabilish in 2000 due to a successfull Interreg IIIB EU project between four territories from Greece, Spain,German and France, now it includes.. Members from 18 Countries

- The aim of the EGN is protect the geoheritage, support the sustainable economy and develop the geological tourism .
- The network operates primarily by continuous electronic communication, frequent coordination meetings, annual conferences and the establishment of common projects through which territories can exchange ideas, experience and best practice thereby supporting each other to fulfil our common goals.
- Geology is the main idea but partners also consider the natural and cultural heritage as a key point together with the local community involvement.

THE APPENNINO GEOPARK PROJECT PROMOTED BY THE GAL BOLOGNAPPENNINO.

Gal BolognAppennino is a mix public-private Company in charge of the Leader plus European fund management, by the Emilia Romagna Region, together with other 4 Gal.

The Leader plus programme is a Fund in the agricultural field to promote undeveloped areas with several kinds of actions through its main instrument: the Local Action Plan an investment plan for 15 million Euro (2007-2013).

Since last Leader programme,Gal BolognAppennino has been invested resources to valorise the geological heritage through several local actions, in collaboration with other Local Institutions and private companies.

Several initiatives have been carried out: the implementation of the geological education paths in Sasso Marconi, the setting of the “Geoagritur”: geotourism database, etc.

Since 2009 a new idea approached to Gal BolognAppennino: create a cultural system underlining the importance of the geological heritage of the Appennines taking in consideration the natural, cultural and gastronomic elements.

The features organized together in order to follow specific criteria can create a special “body” suitable to be recognized from UNESCO as a Member of the Europan Geoparks.

From 2010 the efforts in that sense have been increasing through several actions at local, National, European and International levels.

Gal BolognAppennino attended to European and International Meetings in order to improve its competences in Geoparks, exchange good practices and share experiences.

During this year the project had obtained new approval by the Board and several public and private institutions and private person have been involved.

Gal BolognAppennino is working very hard to reach the standards defined into the European and Global Geopark guidelines,the next goal will be apply to the Network hopefully for November-December 2012.

ACKNOWLEDGEMENTS

We are grateful to the Emilia Romagna Region, Agricultural Department, the Emilia Romagna Geological Survey for the possibility to attend the Conference.

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ISPRA GEOSITI GEODATABASE: AN INSTRUMENT FOR PROMOTING A BETTER KNOWLEDGE OF GEOLOGY.

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KEY WORDS: geoheritage, geosites, inventory, geodatabase, website, geoconservation.

INTRODUCTION

The wide range of Italian landscapes and their uniqueness is strictly connected with its geodiversity. The geological diversity have also influenced land use and distribution of habitats and location of human settlement. Ecosystems and biodiversity within them depend on geological features for their survival. Geoconservation is a key element in nature protection as a whole and geodiversity deserves as much interest and recognition as landscape, biotic nature and other elements.

The protection and conservation of geodiversity is integral part of ISPRA, Institute for Environmental Protection and Research, statutory functions. In the last few years (since 2002) ISPRA (former APAT) set up 'Geositi' a program to promote geoconservation, focusing on the identification of geological significant sites, in order to have a representative selection of local, regionally and nationally significant geosites.

THE ISPRA GEOSITES PROJECT

The 'Geositi' project aim is to produce an evolving, comprehensive inventory and database of the most valuable sites for geology that we called geosites, according to Wimbledon, 1996.

The sites have been first get together into an inventory following different paths: local governments, - freelance, geological students, - geological mapping, - a great number of them originates from a past agreement with the Italian University of Genoa. The information have been then collected in a database which was recently transformed in a geodatabase (2011) and published on ISPRA website.

The geodatabase Geositi contains more than 3000 sites embracing the range of geological and geomorphological features of Italy.

For each geosite the geodatabase includes the location of the site, photos, references and information on accessibility as well. A geological explanation, a description of the main geological features (lithology, geocronology, etc.), a description of the main scientific interest (sedimentology, palaeontology, mineralogy, etc.) and information about statutory protection of the area. In the past database the location of the sites was generally indicate by a point and its coordinates. In the new geodatabase geosites are going to be represented by polygons (areas) and ISPRA is going to up-to-date the information gradually throughout the geodatabase.

The geodatabase is easily accessible for the general public through the ISPRA website (www.isprambiente.it). To navigate the information in the geodatabase one can search a geosite by name, or location data or most of the categories of information collected for each site. A GIS interactive map is available so that a person can select an area on a map of Italian territory and find geosites in that area. Clicking on a red symbol one can open the related form and read any information about that site, collected in the database. Further information about threats to geological sites and about their state of preservation are available too. In Italy there is not a specific law dealing with the geological heritage conservation and a site monitoring has a very important role in the process of geological site conservation. We intend to up-to-date these information to regularly check sites are not degrading and in order to readily identify the appropriate actions to be implemented and what legislative measures are required.

Figure 1 – ISPRA Geodatabase Geositi homepage.

The Geositi is dynamic and may be updated as new outcrops are located and new ones decay or modify. Our aim is establish whether to promote a greater knowledge of geology amongst a wider public and local growth of geotourism or to support geosites protection.

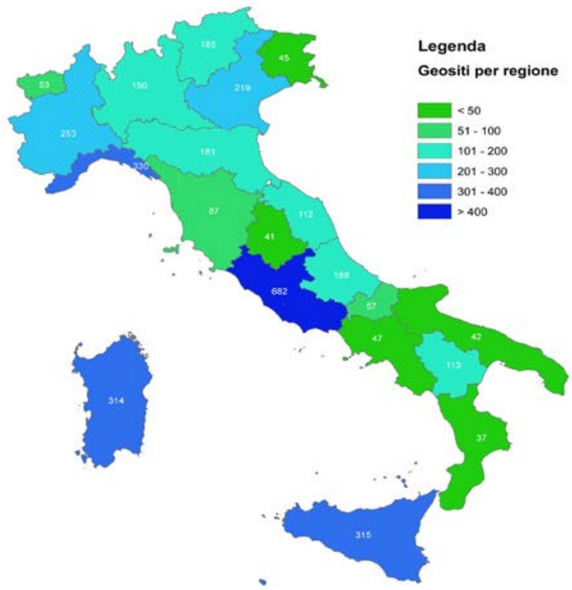

Figure 2 – Italian Map of Geosites

POPULARIZATION OF GEOHERITAGE

ISPRA believes geodiversity has an educational value: it is the key to understand the evolution and history of the planet and how life evolved. There are numerous approaches to communicating geology and geodiversity to the public and we think ISPRA geodatabase can serve to widen people understanding of the surrounding environment.

We plan to work both in improving the scientific quality of information collected in Geositi geodatabase and in using a more understandable language to communicate geology and geodiversity to the public.

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Figure 3 – Geodatabase: type of queries.

THE PLASTIC CLAY INDUSTRY IN ANDENNE (BELGIUM), A GEOLOGICAL AND HISTORICAL APPROACH.

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KEY WORDS: Andenne geology, plastic clay, extraction, industry, Belgium

INTRODUCTION

In 2010, the Geological Survey of Belgium focused its interested on the exploitation of raw materials coming from the region of Andenne. To support the research and the data collection and documentation, a GIS database has been created. More than 100 maps covering different topics such as topography, geology, mines have been integrated in the database. One of the major issues was the georeferencing of the oldest maps.

CONTEXT AND HISTORY

Andenne, a small Belgian city situated in the Province of Namur, is known for its richness in raw minerals and ores, but mainly for its white plastic clays regionally called “blanche derle”, the best clay mined during the Middle-Age in Europe!. The “Ceramic Andenne” is the heir to a regional tradition, experienced and innovative craftsmen. Sometimes bold, they perfected the techniques of shaping, decorating and cooking the clay. Indeed Andenne is situated in the heart of the “ceramic Meuse region,” a hydro-geographical area focused on the Meuse River and characterized, in each period of its history by similar technological and typological traditions. The oldest identified pottery workshops are Gallo-Roman (from the first century) and the activity has continued until the Middle Ages (15th century). The clays used were alluvium, colluvium, and alluvium and regolith generating pink or red products. The potters have settled urban areas along the river near the resources of clays, communication roads and essentially next to potential markets. The first plastic clay exploitations started before 1532 and permitted the devolvement of new products such as pipes, ceramics, piece of earthenware … Those object were exported all over Europe for their beauty and quality. The development of the metallic ores processing industries of the Val Saint Lambert crystal needs specific refractive clays which enhance the reputation of Andenne. Finally, a refractory industry has developed strongly in the early 20th century, rivaled later by importing minerals richer in alumina. In 1960, the mining activity of the plastic clays of Andenne stops along with a slow industrial decline and the clays are imported from Germany to feed the pipe industry, which will end in 2010.

GEOLOGY AND MINERALOGY OF THE PLASTIC CLAY

The Condroz landscape is characterized by a series of topographic undulations NE-SW oriented following the succession of anticlines (Frasnian limestones & Upper Frasnian and Famennian siliciclastics) and synclines (Dinantian limestones), folded and faulted during the Variscan orogeny (end of Carboniferous).

Most plastic clay deposits occur in cryptokarstic depressions that highlight the passage of the limestone bands in the landscape, sometimes close to their borders or within them. The plastic clay deposits (Fig. 1) form strings along several alignments detailed and mapped by Calembert (1945). This map has been modified and updated with new data and maps from this work.

South of the Meuse valley, three parallel bands are present from north to south:

- a first strip of 6 km in length (Dinantian syncline), in Andenne Mozet which includes the main deposits of Vaudaigle, Trixhes...
- a second strip 18 km long (2nd Dinantian syncline), starting from Naninne to Coutisse, and through Wierde Haltinne
- a third minor band, at Sorée Jamagne (Givetian-Frasnian limestone band).

North of the Meuse valley, small white clay veneers were also mined

Plastic clay deposits in the Andenne basin are overwhelmingly deposits of Tertiary age sediments accumulated in evolving karst. Sedimentary deposits fill the depressions that are growing by dissolving the underlying limestone. The products of continental erosion are transported by a network of rivers filling the karstic zones. The karstic drawdown active during the favorable times, allows 1) the successive deposits of sands, silts, clays and accumulated peats 2) the deformation of the layers. Under the influence of acidic water, the leaching process and transformation into halloysite of the clays took place allowing the formation of white clay with high levels of alumina, low iron and alkali content. All of the characteristics to make products cooking white and manufacturing refractory products.

Clays, sands and lignite were extracted. The best clays have been exploited by wells and galleries up to 100 m depth. Each layer of clay had its chemical characteristics and its own specific industrial applications. To prevent the intrusion of water into the clay body from limestone host rock, a clay envelope ("crawe") was maintained. The operation was dangerous because of the presence of firedamp due to the decomposition of organic matter. Exploitation of clay left on the surface depressions now occupied by small lakes with a specific biotope. Today, the Museum of Ceramics of Andenne revives 20 centuries of history, extraction and processing of clays.

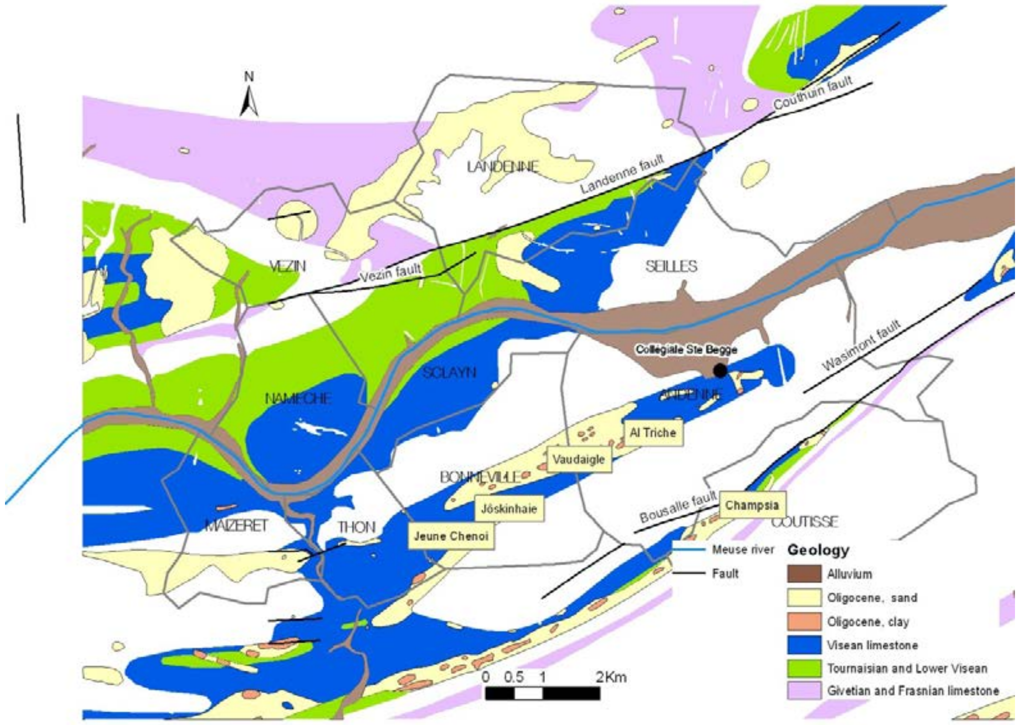

Figure 1 – Geological overview and plastic clay exploitation of Andenne.

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A.A. CHERNOV GEOLOGICAL MUSEUM: POPULARISATION OF KNOWLEDGE ABOUT MINERAL RESOURCES OF THE NORTH-EASTERN PART OF EUROPEAN RUSSIA

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KEY WORDS: A.A. Chernov, geological museum, Komi Republic, mineral collection.

THE HISTORY OF A.A. CHERNOV GEOLOGICAL MUSEUM

Museum was named after professor Alexander Chernov (1877 – 1963) – the outstanding geologist, who studied the mineral resources of modern territory of Komi Republic and organized the systematic geological investigations, which led to the foundation of Institute of Geology of the Komi Science Centre of the Uralian Division of the Russian Academy of Sciences in 1958. In 1924 A.A. Chernov opened the great Pechorian coal basin.

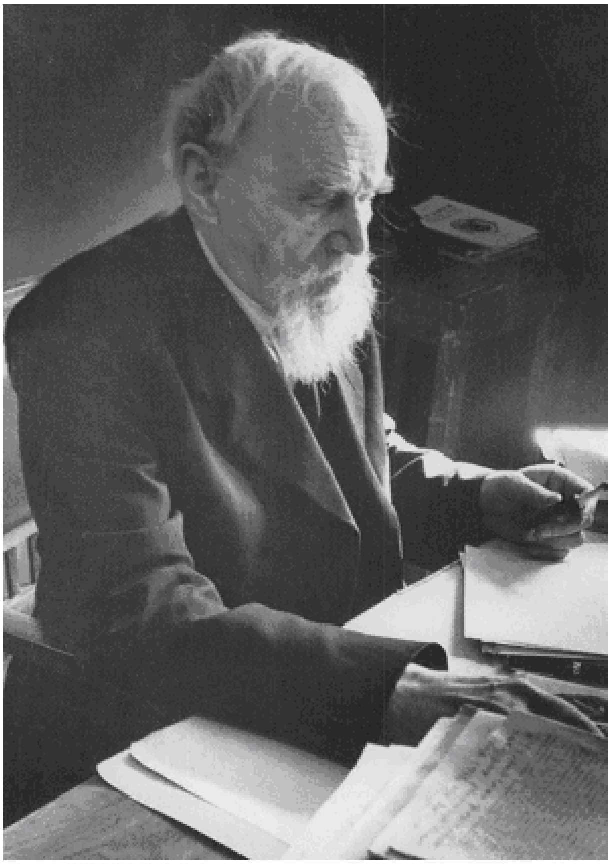

Figure 1 – Professor A.A. Chernov.

Geological museum was founded in 1968 as a scientific division of Institute. The main task of the museum is the formation of scientific collections, which expose the results of examination of mineral resources of European North-East of Russia (Subpolar and Polar Urals, Timan, Pai-Khoy, Vaigach Island, Novaya Zemlya and neighbouring territories). First 10 years the museum served as the depository of stone materials, collected during the numerous expeditions.

Figure 2 – Institute of Geology of the Komi Science Centre of the Uralian Division of the Russian Academy of Sciences

The first stationary exposition was open in May 1978.

Since the origin of museum its staff began to form the numerous mineral and ore collections for schools, colleges, scientific and industrial organisations.

MUSEUM ACTIVITY

Today the museum obtains 540 monographic collections with total amount of 58 100 units and 145 working collections with 83 200 units. There is a numerous change fund.

There are many unique samples in museum collections: the gigantic quartz crystal from the Subpolar Urals (Dodo deposit, weight 1300 kg, two-apex), Arctic turquoise from Pai-Khoy, amber from the co ast of Arctic ocean, rare minerals chernovite and yushkinite (both named after prominent scientists of Institute), agates from Timan and etc.

The stationary expositions occupy the square of 350 m^2. They contain the next halls: life evolution on the Earth, mineral resources, mineralogy, petrography, lithology, gems, the collection of stone figures “Noah ark”. The palaeontology hall and Memorial room of A.A. Chernov are under organization.

Besides the stationary expositions many temporary exhibitions are organized every year in special showcases and stands on the floors of Institute, at its foyer and Science Council Hall.

Nearly 300 excursions are guided every year by museum staff. The categories of visitors are various: government delegations, businessmen, students, children. Many foreign delegations were the guests of the museum.

Figure 3 – Stationary exposition “Mineral resources”.

THE LANDSCAPE APPROACH AND THE POPULARIZATION OF THE GEO-ENVIRONMENTAL HERITAGE

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KEY WORDS: Landscape, Geology, Maps, Sport, Popularization; Italy.

LANDSCAPE AND GEOSCIENCES

Territorial and environmental problems, ever more delicate and dramatic in Italy, require the constant presence of the geologist in all the social, cultural, economic and territorial contexts.

A first step in this new direction is to pay a deeper attention to the environmental geology and, at the same time, to create a new kind of communication that can activate a wider and conscious target. The Italian National Council of Geologists and the Regional Professional Orders are organizations concerned in this project and, today more than ever, is urgent an efficient and timely activation in geo-environmental protection as well as in the field of scientific communication. One of the most important goals is the popularization of the Earth sciences. An interesting experience has been performed within the International Year of Planet Earth, a project that has divulged the scientific heritage using topics more accessible to the people. Landscape plays a key role in the knowledge processes: it is the result of the endogenous and exogenous activities that mould Earth's surface and, at the same time, can be considered the result of the interaction of many natural and cultural components; being the object of human perceptions it could become a "medium" to communicate the Earth Sciences to the whole society. The goals of the Landscape approach in the field of geo-environment assessment and geo-sciences popularization are basically the following:

- provide principles, theoretical reference criteria and methodologies to the study of landscape;
- enable environmental diagnosis and assessments, also through indices and specific quantitative models;
- provide synthetic models to predict the evolution of the landscape;
- lead the choice of territorial conservation and management;
- allow controls on the planned changes

GIS, SCIENCE POPULARIZATION AND SPORT

The rocks, as elements of the landscape, condition the evolution of environment and form the base of spatial-temporal development of a region.

A path trough landscapes is a path trough the earth sciences: nature, culture, sports will be useful tools in the hands of a modern geologist, in this new challenge. The popularization of the geo-environmental heritage walks often the same paths of tourism. A special attention is going to be devoted to an original link between landscapes and sports, such as road cycling events e.g. the "Giro d'Italia": a new field for new actions, in order to reach the common aim of territorial safety and a shared well-being. The study of landscape is a complex process: maps are the most complete tools to give us a deep understanding and a clear image of the studied areas. The thematic maps allow the identification and the monitoring of the state of the natural environment; at the same time they are powerful "medium" to communicate the territory to the society.

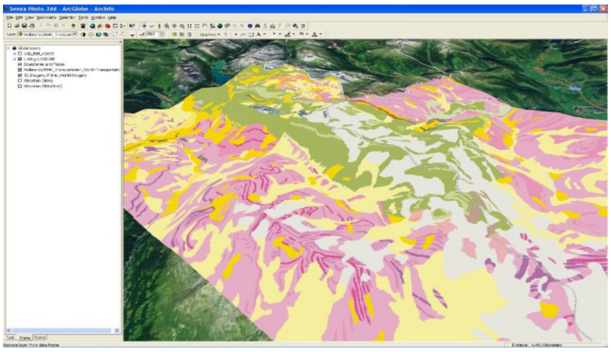

Figure 1- Lithological Map-Stelvio area, a mountain race course of the "Giro d'Italia"

The CARG (Geological CARtography) project is coordinated by the Department for Soil Defense –Geological Survey of Italy - ISPRA, and involves over 60 structures including Local Bodies, CNR, University Departments and Institutes, as well as the Regions and Autonomous Provinces. The project provides for the realization of 652 geological and geo-thematic sheets on a scale of 1:50,000 covering the entire national area. The Project involves the creation of a database supplying more detailed geological and geo-thematic maps enabling cartographic data to be used for many different purposes. It will provide the cognitive tools – geological data – required for proper territorial planning and management and, in particular, for the prevention, reduction and mitigation of hydro-geological risk. Another project made within ISPRA is the Carta della Natura (law 394/91) that aims at assessing the state of the environment in the whole Italian territory. The methodology follows a holistic approach, considering all the components of a landscape and integrating the information. Remote Sensing methods, supervised by fields controls, play a primary role in these kinds of multi-scale Landscape studies. By integrating different information about the geo-morphological arrangement and the land use of a region, it is possible to reach a complete knowledge of the territory: a multi-scale Landscape approach is even more adopted in the modern geological research.

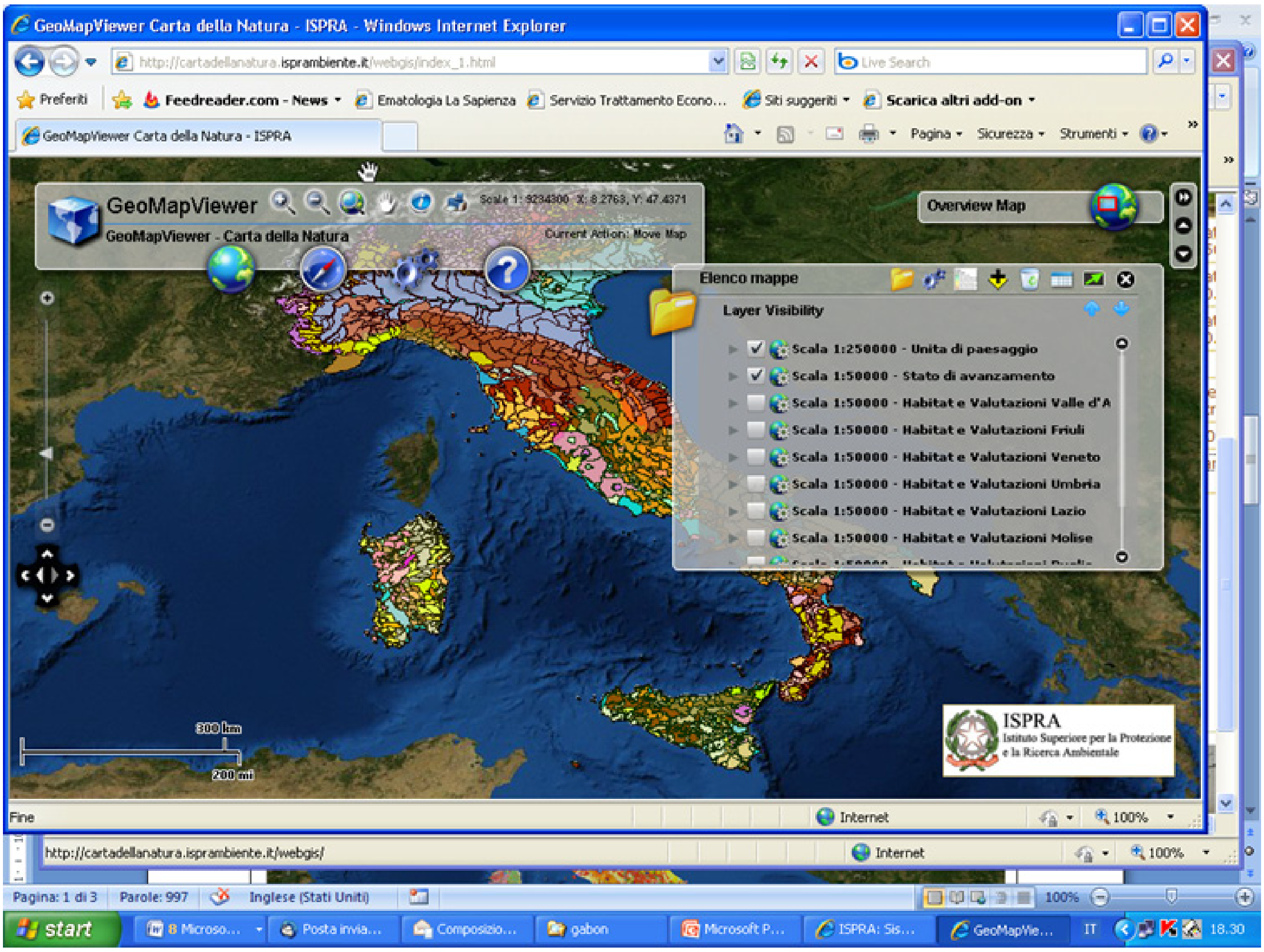

Figure 2"Carta della Natura" GIS

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THE CHARACTERIZATION OF NATURAL AND CULTURAL HERITAGE IN THE FILMIC COMMUNICATION.

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KEY WORDS: *Landscape, Geological Heritage, Popularization, Fiction, Maps, Italy.*

A SUGGESTION TO INVOLVE THE SOCIETY IN THE WHS SUSTAINABLE DEVELOPMENT

Tourism is one of the most important activities in the Italian economy: being it strictly linked to the territory and its history, it could be a “medium” to communicate the importance of the natural and cultural Italian heritage. In this work a new approach is purposed, trying to integrate the complex aspects of the landscapes and the historical development of some areas of special interest, in order to make the territory comprehensible to the society using a special medium: TV movies. A very famous Italian TV serial is “Il Commissario Montalbano” (“The Inspector Montalbano”); the film has been made out of the novels written by the sicilian writer Andrea Camilleri, known by millions of readers and fans. One of the authors of this paper, Cesare Bocci, is a geologist and plays a very important role in the fiction: this combination suggested us the potential of the filmic communication in the popularization of the natural and cultural heritage. The stories are located in Sicily,, particularly in some World Heritage Sites as Noto Valley, Ragusa Ibla, Modica, Scicli, Agrigento, Siracusa, Aeolian Islands.

Figure 1 – Segesta archaeologic site

The landscapes and the archaeological sites that characterize the scenes of the movie, are spectacular and full of significance, as precious components of the Italian natural and cultural heritage. Particularly the landscape, as a component of the movie location, offers new paths and new communication codes, powerful tools in order to divulge the scientific knowledge and to involve the society in a common aim: a balanced management and a sustainable development, based on a common consciousness of the territory. In many episodes, the geological arrangement of the landscape where the movies are made, is an important component in the dramatization. The natural scenography brings to the fiction a special significance: the local population, as well as the tourists re-cognize the territory and can better appreciate its value. Communicating natural and cultural heritage trough movies and fictions could represent a new way to involve the society in a common consciousness of the territory, and contribute to promote eco-tourism and sustainable development in Italy. A special attention is devoted to the natural heritage and to the landscape. The social-economical scenario of an area is strictly linked to the geological one: even at different scales, the endogenous and exogenous processes, and the rocks, as elements of the landscape, condition the evolution of environment and form the base of spatial-temporal development of a region. Thanks to the Geographical Information Systems it is possible to synthesize, manage and represent a large amount of data; A further interesting opportunity is to discover, analyzing the landscape, the areas of special geological, environmental and cultural value, which in some cases can be considered geosites. Remote Sensing methods play a primary role in the multi-scale Landscape studies. Thanks to the integrated information about the geo-morphological arrangement and the land use of a region, it is possible to analyze the link between landscape shapes and the socio-economical development of an area. A proper technical and cultural approach to the problem of the environmental management and protection, requires a multidisciplinary methodology that aims at a balance between use and respect, in order to reach a development sustainable for both

the natural and social systems. A possible path for development could begin from the idea of taking advantage of the natural environment, applying policies oriented to
ecotourism, productive for the local economies and safe for the environment.
As would be expected, eco-tourism has so far been directed towards places known for their physical beauty, many of which are protected areas, but now it can develop further, to address unusual scenery and present new opportunities.
Anyway, the aim to protect places of significant geological interest, derives from the need to guarantee a conscious and enjoyable use of landscape in all its forms for future generations: the development of an area walks on the same path of the eco-tourism. The suggested way of popularization of the natural and cultural heritage trough the TV movies, could help new strategies for a balanced and sustainable management of a land.

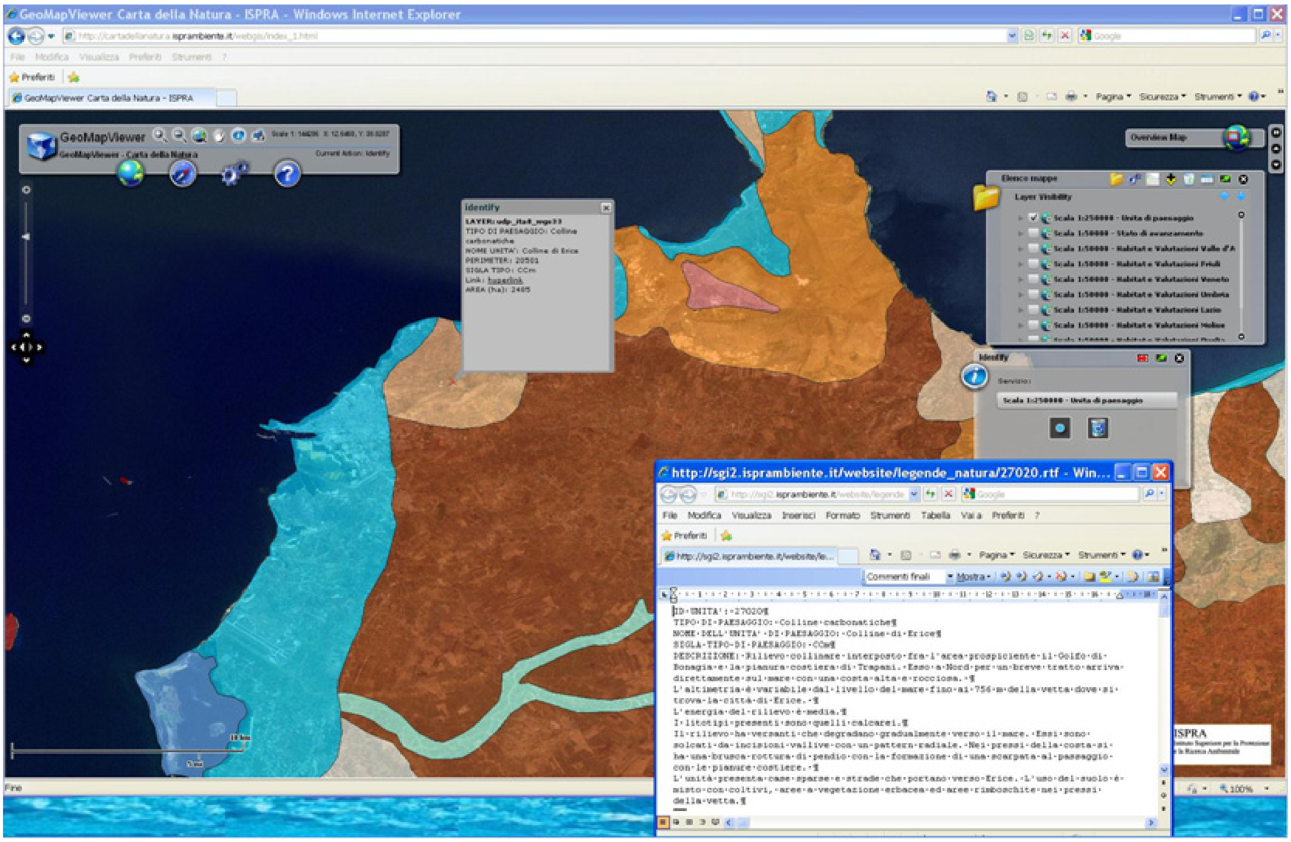

Figure 1 – The Physiographic Units in Erice area (Trapani - Sicily)

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TWO PROJECTS FOR THE TERRITORY AND THE CULTURAL HERITAGE OF GEORGIA

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KEY WORDS: GIS, cultural heritage, buffer zone, war, Georgia.

INTRODUCTION

The city of Mtskheta (Georgia) and that of Byblos (Lebanon), two cities that are patrimony of the humanity which were recently threatened by war, are involved in the War Free World Heritahìge Listed Cities (WFWHLC) project.

The War Free World Heritage Listed Cities project – started in 2010 and actually in progress - is designed and co-financed within the framework of the ENP Instrument through the CIUDAD programme for a duration of 30 months and a budget of 540,740 Euro. It is an international cooperation project between the Council of the United Municipalities of Byblos, together with its partners the Head of the Board of the City of Mtskheta (Georgia), the World Association for the protection of Tangible and Intangible Cultural Heritage in times of armed conflicts – WATCH (Italy) and their associate partners, the Friends of Cultural Heritage Society – FOCUH (Turkey) and the NEtwork per il REstauro Avanzato NEREA – ENEA (Italy). The project focuses on urban and regional planning for cities that are registered in the World Heritage List and located in critical areas being exposed to the threats of conflicts.

We are also engaged in another EU project relevant to territory and cultural heritage (CH) of Georgia, namely the Twinning Project GEORGIA (Twinning Number GE11I/ENP-PCA/OT/13), entitled “Support to the institutional development of the National Agency for Cultural Heritage Preservation of Georgia”, that is starting this year (2012) and is funded for one million euros.

This Twinning Proposal was presented by the Italian Ministry for Cultural Heritage and Activities (MIBAC), supported by the Heritage Agency of Denmark, combining the resources of the country with the richest national cultural heritage in the world and the experience of the European Agency whose institutional structure is closest to the model adopted by the Georgian beneficiary. These partners are then supported by the Italian National Agency for New Technology, Energy and the Environment (ENEA), a national research agency with a worldwide reputation, active in the field of new technologies and environmental protection, and currently involved in a project for risk analysis concerning the Cultural Heritage in Georgia, and by Formez PA, the in-house public agency of the Italian Ministry for Public Administration, which specializes in support to the reform and modernization of the PA, both in Italy and internationally, and in the management of EU Twinning projects.

In this paper, we present these two research projects in details, with reference to the investigation of territory and its cultural heritage, their mapping and preservation, the implementation of a web GIS, also cataloguing the works of art and the archaeological artefacts.

THE TERRITORY AND CH OF MTSKHETA

More than 30 armed conflicts are currently ongoing around the world. Alongside the tragic loss in human lives, more and more valuable heritage sites are turned into the battlefield within the war theatres. More historic and archaeological patrimony is being vandalized, looted, illicitly traded spoiling Unesco World heritage listed historic city cores.

These events posed to the local administrations of both cities, Byblos and Mtskheta, an additional concern, alongside that of the safety for the local civil community: setting protective measures to protect the world heritage listed cities from destruction.

Our work is focused on Mtskheta that is the ancient capital of Georgia, nestled in a picturesque setting located in a valley at the confluence of the rivers and Aragvi Mtkvari (figs.1-2) and is 20 / 25 km north-west from Tbilisi (now the capital of Georgia). From a moral point of view, Mtskheta has a formidable impact on the Georgians, as Masada was for the ancient Jews. The site is in fact a kind of inner sanctuary of artistic and religious culture of the country: Here, in 334 AD Georgians were converted to Christianity (according to history they were the second people to take the plunge, just four years after the neighbouring Armenians) and Mtskheta, from III BC to V AD was the capital of the Kingdom of Georgia (even after the capital in the sixth century became Tbilisi, Mtskheta continued to be place of coronation and burial of the Georgian kings until the end of the Kingdom that took place in the nineteenth century). Christianity was then introduced in the fourth century in Mtskheta, and more generally in Georgia, by Saint Nino, and the first wooden church was built in the garden of the Royal Palace where now the cathedral of Svetitskhoveli stands.

Svetitskhoveli Cathedral (XI century) and Djvary Monastery (IV century) are still major landmarks, symbols of the country, together with the fortress of the Acropolis of Bebris Tsikhe, built by Armaz Tsikhe in the III century. The city is still the seat of the autocephalous Georgian Orthodox Apostolic Church: it has therefore retained a central role as a religious center of the country and home to the Katolicos (later elevated to Patriarch), an important reference point for the Georgians and the believers in other parts of the world.

In 1994 Mtskheta has joined the UNESCO World Heritage List for its historic medieval churches risen to one of the most significant examples of the early Christian architecture in Georgia, with a strong impact on the subsequent development of Georgian architecture. The document of the 18th session of the World Heritage held on 12 to 17 December 1994 in Phuket, Thailand states:

The Committee, in inscribing this property on the World Heritage List, suggested to the State Party to change the name to "Historic Churches of Mtskheta (…) That this property be inscribed on the World Heritage List on the basis of criteria iii and iv: Criterion iii - the group of churches at Mtskheta bears testimony to the high level of art and culture of the vanished Kingdom of Georgia, which played an outstanding role in the medieval history of this region; Criterion iv - the historic churches of Mtskheta are outstanding examples of medieval ecclesiastical architecture in the Caucasus region".

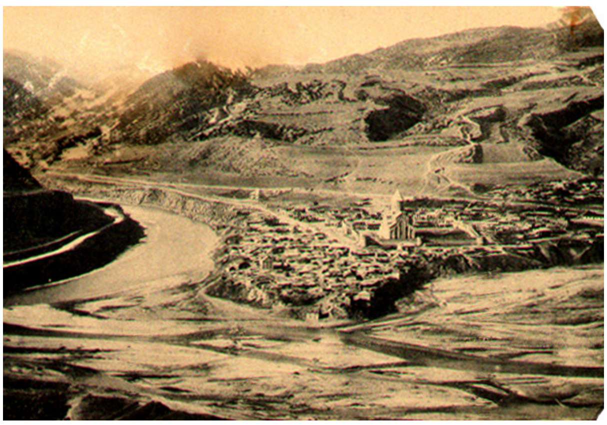

Figure 1 – Mtskheta at the beginning of XX century.

Figure 2 – A view of Mtskheta nowadays.

A study in progress by our team in order to map the territory, to catalogue the moveable artistic objects, to put all this information in a web GIS database and, finally, scientific analyses have been performed to characterize the sandstone used in building ancient churches and monasteries of the region, for optimal preservation and restoration and for identification of the ores of provenance of the stones.

Figure 3 – Map of archaeological sites and monuments of Mtskheta (1:10,000), included in UNESCO World Heritage List in 1994.

Figure 4 – Neolithic archaeological site near Samtavro.

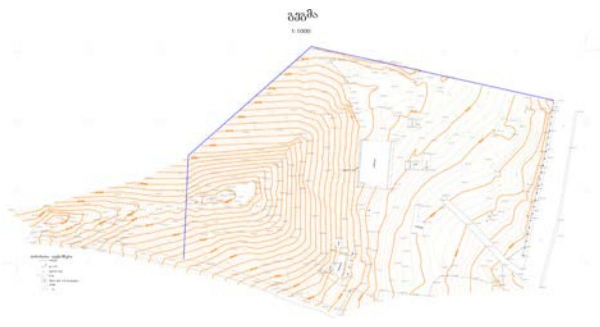

Figure 5 – Map of Samtavro Monastery and nearby archaeological site.

As for the second project, the overall objective of the Twinning project is to introduce internationally recognized best practices in the heritage sector in Georgia with the aim of improving heritage conservation and management, thereby contributing to economic and social development.

CATALOG OF FOSSIL VERTEBRATE LOCALITIES OF THE QUATERNARY IN THE PROVINCE OF CIEGO OF ÁVILA, CUBA

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KEY WORDS: fossils, geology, paleontology, natural heritage, vertebrates.

ABSTRACT

This catalog was made from all the localities in the caves of Ciego de Avila studied by the Xaxabi Speleological Group since 2000 up today, where there have been fossils of vertebrates, together with other elements. The samples were photographed cataloged and the osteological variables were taken as possible. Subsequently, with the information gathered a media was produced to facilitate the data management. This inventory includes 7 locations, 6 of which are caves located in the Sierra de Jatibonico and a salt dome located in the Punta Alegre. We analyzed 320 taxoregisters of which were taken as reference the best preserved, being the most representative taxa: *Megalocnus rodens*, *Neocnus gliriformis*, *Ornimegalonyx sp. Acratocnus sp*, *Macrocapromys sp.* and *Nesophontes sp*. The multimedia (CD ROM) was donated to the Provincial Speleological Committee, the University and the National Museum of Natural History as a study material for the cavers, students and general public to do their work in a better way, always emphasizing that they must protect any recorded paleontological evidence, and should not be removed if you do not have the required skills for this. The fossil record is also in a territory part of the natural heritage.

DISCUSION

We worked in 7 locations in the province of Ciego de Avila, mainly in collection´s material, making a provincial inventory of sites that have some kind of evidence of fossils from the Quaternary, mainly mammals. This rescue, at least in photography the paleontological heritage, because many times private collection owners do not want to donate samples or making them available to researchers in science, so the samples are often damaged, or lose by not being properly preserved and identified.

This work ensures that the material comes in photos collection to all potential users in an easy and enjoyable, using a simple multimedia system. In this the user can also see the bibliography compiled on each of the species studied, as well as the images receiving the specimen a literature review expanded on it.

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GEOMATIC METHODS AND APPLICATIONS FOR EVALUATION AND MANAGEMENT OF PIEMONTE GEOHERITAGE (PROGEO-PIEMONTE PROJECT)

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KEY WORDS: geological heritage, geosites, Piemonte Region, Data collection, data management.

INTRODUCTION

The multidisciplinary research project "PROGEOPiemonte" (PROactive management of GEOlogical heritage in the PIEMONTE region) aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte region by means of the development of techniques for recognizing and managing its rich geodiversity both at local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. Geological history, climate and environmental changes, natural hazards, soil processes and earth resources will be popularized with geosites, museum collections, evidences of mining activity and quarrying, science exhibits and nature trails.

In order to define the state of the art in geosites studies and to identify existing geoconservation projects developed by public or private institutions, a bibliographic research joined with field data collection was performed. Unfortunately, information is highly heterogeneous, hence the need to develop a common methodology to improve collection and management of data. A specific activity of the project will be aimed to systematically collect scattered information by means of geomatic and IT (Information Technology) applications for geoheritage, The goal is to meet the following needs:

- allowing faster and accurate storing of data;
- enabling the realization of a common and interoperable database;
- facilitating transfer of knowledge between different expertises and across different knowledge domains;
- ensuring accessibility of information.

COLLECTION, MANAGEMENT AND VISUALISATION OF DATA

The development of a tool for cataloguing and evaluate geosites, was made by analyzing and comparing different already in use methods and following the "National Census of Geosites" guidelines proposed by Ispra (Institute for Environmental Protection and Research).

Figure 1 – Pocket PC device, Regional base map and Geosites forms examples.

The proposed method has been structured in a form consisting of two main parts: inventory and evaluation.

In order to facilitate field data collection, the inventory form has been inserted as a mobile GIS customized extension loaded on a hand-held digital device. It consists of several sections requiring mandatory information, in order to have an olistic point of view on a geological site.

The second part of the form allows determinating value of geosites. It is divided into seven sections, where a series of parameters allow giving a numerical value to each of the aspects taken into account, so that, at the end of the process, each geosite gets a score. Depending on the final purpose of the evaluation, geosites with higher score will be taken into account.

The digital inventory and evaluation forms has then been moved into a database that allows data retrieval and making data accessible over the Internet. Information are particularly stored and connected through mysql database and google maps envinronment.

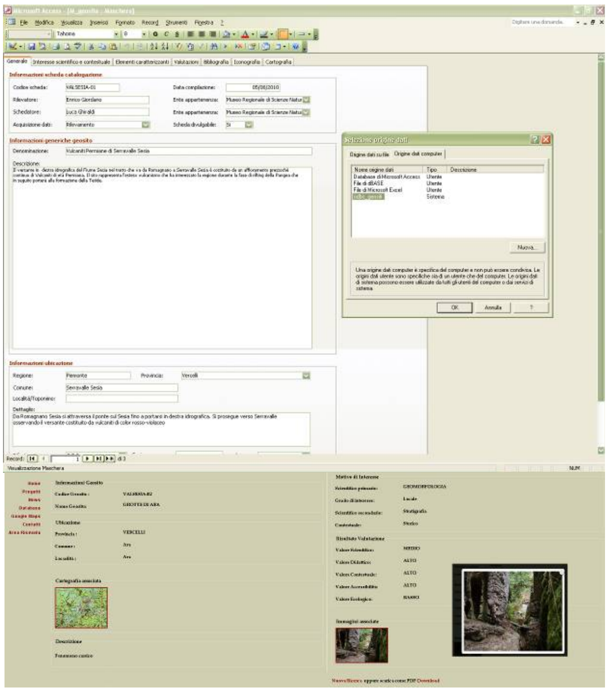

Figure 2 – Example of Database project and Reporting .

The web-mapping tool (Google Maps API with extension GoogleEarth) allows enhancing an user-friendly interface, with various additional features offered by today's Internet Mapping.

Figure 3 – Example of Web-mapping Layout.

A further step of the proposed method consists of metadata compilation. Metadata particularly allow giving methodological information (how geosites have been collected, classified and processed) and describing peculiar features.

Each geosite is described through the meta-information provided for the ISO 19115 (the metadata standard for spatial data sets developed by the International Organisation for Standardisation) and according to the INSPIRE (Infrastructure for Spatial Information in Europe) "Metadata Implementing Rules".

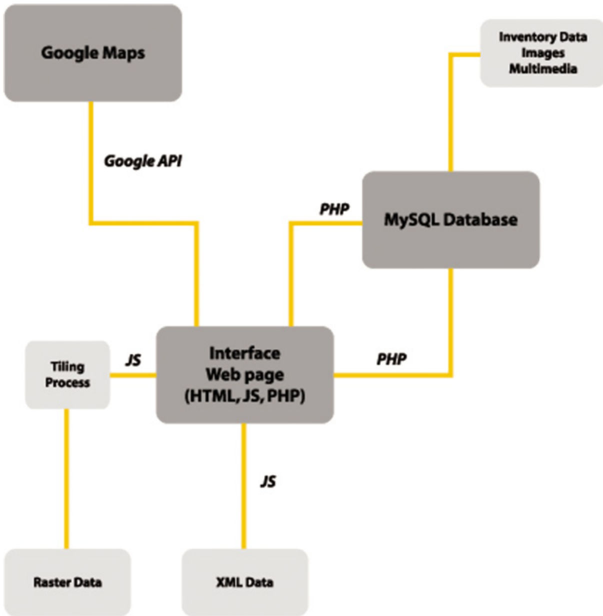

Figure 4 – Scheme of project functionality.

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VANISHING GEOLOGICAL HERITAGE IN A NATURAL RESERVE: A CASE STUDY FROM VESUVIO NATIONAL PARK.

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KEY WORDS: geological heritage, Vesuvio National park, inactive quarries

INTRODUCTION

As a consequence of the increasing sensitivity for preservation of the natural environment at least 400 natural reserves were established in Europe in the last decades. Nowadays the whole of the Italian territory hosts 25 National Parks, that with many other natural reserves managed by local agencies cover about 22% of the whole territory. The presence of a natural reserve mostly has positive consequences: the environment is preserved in all its aspects, floral and faunal singularities are protected from the extinction, in the towns pertaining to a reserve, unruled building is strictly forbidden and also restoration of pre-existing buildings is controlled. Vesuvio National Park is the main natural reserve of the Napoli Province; it was established in June 1995, and since then the landscape of the fourteen municipalities falling within it is preserved and protected: this represents a severe turning with respect to the previous decades, when the area had been the theatre of dense and unruled urbanization even along the slopes of the volcano (Petrosino et al., 2004). Quarrying is one of the most important anthropic activities prevented in the area after the institution of the Vesuvio Regional Park. Loose pyroclastic material, in fact, was exploited until that date in many quarries mainly located along the Northern Somma slopes, and lava blocks were caved along the Vesuvio western flank. As a matter of fact, an active quarry represents a wound on the flanks of a mountain and, as an anthropic modification, is one of the worst damages that man can cause to landscape, so quarrying is now properly forbidden in the natural reserve. On the other hand, in a volcanic area as Somma Vesuvio, active quarries represented an open-air laboratory for geologists. Quarrying activity, in fact, continuously exposed buried ancient deposits and freshly cut walls where stratigraphic successions of the products of different eruptions could be observed. At present these open air laboratories are progressively vanishing because the inactive quarry floors are rapidly filled in with loose reworked material, debris fans develop at the foot of the walls and dense spontaneous vegetation masks the stratigraphic successions. The need to preserve at least some of the inactive quarry sites for visitor access and investigation and sampling by experts becomes urgent, in the framework of the protection and preservation of the geological heritage. In areas exposed to natural hazards, in fact, the fruition of the geological heritage can increase locals and visitors' awareness concerning the impendent risks.

THE TRAIANELLO QUARRY SITE

Among the several inactive quarries located along the norther Somma flank, we chose to investigate the possible reclaim of the geovolcanological heritage at Traianello Quarry (Fig. 1). This quarry, located at Caprabianca site of Somma Vesuviana, was one of the most visited by volcanologists because along its walls an almost complete stratigraphic sequence of all the products of the Somma Vesuvio complex was exposed.

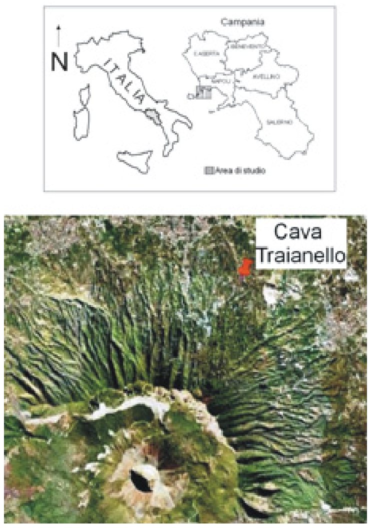

Figure 1 – Location map of the investigated area.

The most ancient products cropping in the area are the Somma lava flows, ranging in age between 39 and ca 25 ka. The explosive products of six plinian events are well exposed, spanning from the Basal Pumice (ca 20 ka) to the 472 A.D. Pollena eruption products. products. In this site, in particular, the complex relationship between fall and pyroclastic flow deposits of the same eruptive event is clearly recognizable. Several stops have been planned in the quarry area, with explicative posters and panels reporting full description of the

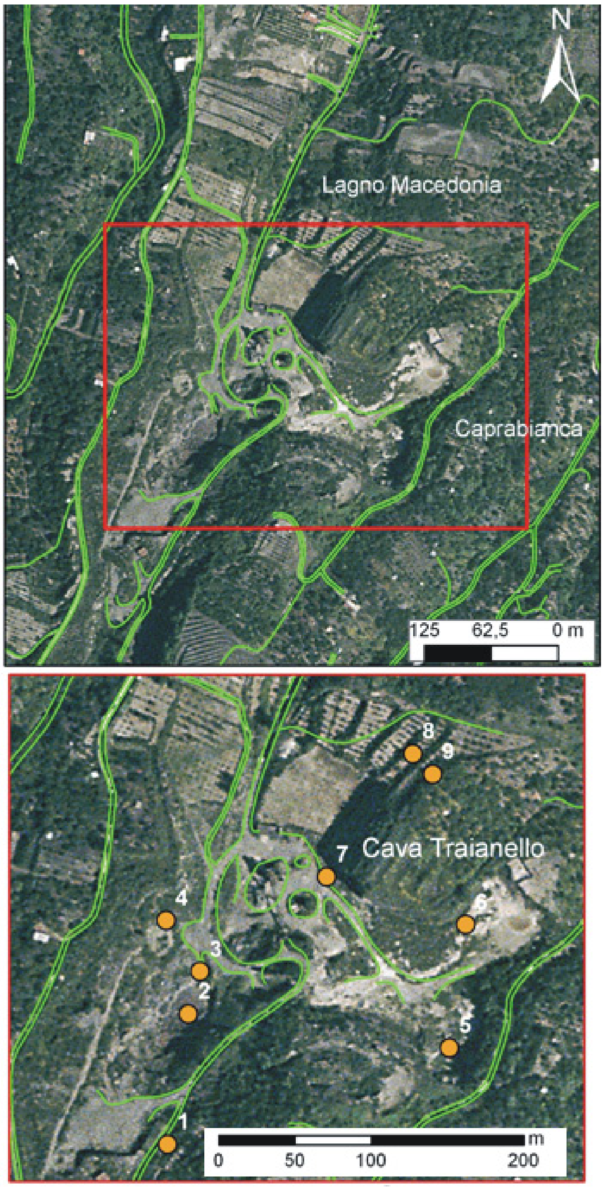

Figure 2 - Location of the single stops inside the Traianello Quarry site. 1- Panoramic view of the quarry, 2- Ancient Somma lava flows (39-25 ka), 3- Products of the Basal Pumice Formation (ca 20 ka), 4- General view of the stratigraphic sequence, 5- Products of the Greenish Pumice Formation (ca 16 ka), 6- Pyroclastic fall products of the Mercato-Ottaviano Formation (ca 9 ka), 7- Pyroclastic flow products of the Mercato-Ottaviano Formation (ca 9 ka), 8- Products of the Avellino Formation (ca 4.0 ka), 9- Products of the Pollena Formation (472 A.D.)

deposits and of the eruptive mechanisms emplacing them. Figure 3 illustrates the stop 4, where the middle part of the stratigraphic sequence can be observed, together with the products of the Pomici Principali Formation, a plinian deposit of a Campi Flegrei eruption, emplaced also on the Somma slopes.

Figure 3 – View of the quarry wall at stop 4.

Although the visit to the Traianello Quarry is of utmost interest for earth science students and researchers, its present state totally prevents the access and the fruibility. Because of this, we hypothesited and prepared a virtual tour of the quarry that, up to when the local authorities will provide to the restoration of the site, can be used to illustrate the importance of the site

A not negligible added value of the site is to possibly insert its fruition in a geoeducational programme devoted to enhance the volcanic hazard and risk perception in young people living in the Vesuvian area, which is the highest risk area all over the world. According to Armiero et al. (2011), in fact, a direct experience of the geological heritage of their territory helped young people living in Campi Flegrei to rapidly assimilate the topics dealing with volcanic hazard and it proved to be a valid tool to make them aware of the impending risks. Present teen agers are the future decision makers of the area where they live, and what they learn today will help them to take the right decisions for their territory tomorrow

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ERINAT PROJECT EDUCAZIONE AI RISCHI NATURALI (TRAINING ON NATURAL RISKS): FROM INFORMED CHILDREN TO KNOWLEDGEABLE ADULTS

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KEY WORDS: natural risks, knowledge, how to act, self-protection, prevention, earthquakes, landslides, floods, forest fire, safety.

The *ERiNat project Educazione ai Rischi Naturali (Training on Natural Risks)* offers training on environmental safety within the context of Life Long Learning through a permanent training process aimed at providing the population with a basic education (knowledge, awareness, how to act, self-protection and prevention) on natural risks and at creating a cultural milieu which ensures a turn-over of citizens that choose to take part in the voluntary world.

THE *ERINAT PROJECT*: A BRIEF HISTORY

During academic year 2004/2005 (*EriNat 2005*) the educational experiment promoted by the Land Protection Sector of La Spezia's Civil Protection Service began, developing the *EriNat Project* with the Regional Education Office for Liguria Office V - Territorial Sector of La Spezia and the Prefect's Office of La Spezia. The INGV (Istituto Nazionale di Geofisica e Vulcanologia) of Portovenere, manages the organization and realization of the project which envisages interactive lessons in the classroom with students in their final year of the Province of La Spezia's lower secondary schools. Informational material is handed out at the end of the lessons for subsequent reflection with teachers, families and peer groups (Peer Education) and evacuation drills are carried out under the guidance of the Fire Brigade assisted by the volunteers from the Civil Protection Associations of the Province of La Spezia.
In *ERiNat 2005, 2006, 2007 and 2008* the lessons lasted around two hours and were held by INGV research staff and personnel from the Fire Brigade.

The project was initially offered to schools in the Province of La Spezia (*ERiNat 2005 and 2006*). *ERiNat 2007* was experimentally addressed only at schools in the town of La Spezia. *ERiNat 2008* once again took in the towns of the province, with the exclusion of La Spezia. To meet the numerous requests, since *ERiNat 2009* all the final year classes of the lower secondary schools in the Province of La Spezia have been given the chance to take part in the project which is included in the POF (Training Offer Plan).

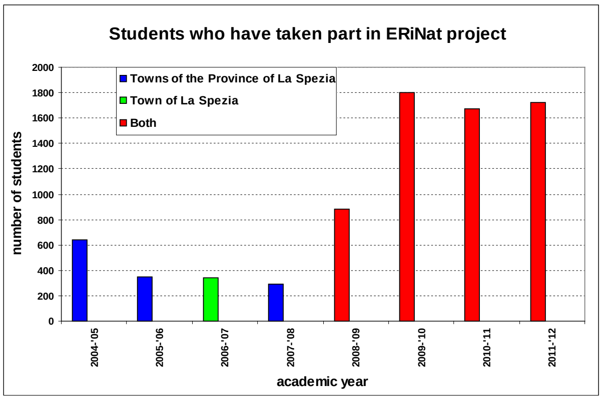

Figure 1 – Number of students who have taken part in ERiNat.

The success of the initiative (figures 2 and 3) and the growing number of enrolments (figure 1) have encouraged the organizers to plan *ERiNat* in greater detail and turn it into an educational process that places greater emphasis on self-protection measures and the behaviour to adopt in the case of natural disasters, teaching the participants how to tackle natural risks and their potential destructive effects and how to adapt incorrect individual and collective behaviour. The contents have been supplemented and the number of lessons doubled; the hydro-geomorphological risk (lesson given by experts from the Provincial Authorities of La Spezia) and the question of forest fires (organized by the State Forest Rangers Corps of La Spezia) have been included alongside the seismic risk and what to do in the event of an earthquake. This is because of the vulnerability of the territory; just think of the recent events: fire at Riomaggiore on 15 October 2011 and the tragic flood of 25 October 2011 which brought the zone to its knees. Since *ERiNat 2009* the Province of La Spezia has promoted a competition to encourage in-depth study of the subjects dealt with. The prize for the schools of the three winning classes is teaching equipment and material for a value of Euro 1200, 800 and 500 respectively for the first, second and third classified and the students from the three winning classes take part in a guided tour by the Forest Rangers Corps, GEV (Voluntary Ecological Guards) and volunteers from the Civil Protection Service of the Province of La Spezia.

Within the framework of *ERiNat 2011*, the Province of La Spezia and the Provincial Coordination of Civil Protection Associations also organize free summer campuses "I am the Civil Protection too". These campuses are open to all children from the province but priority is given to those from schools that have taken part in the *ERiNat Project* as a reward for their commitment. The campuses are greatly appreciated by the children and their families both for their didactic/educational value (conclusion and completion of the *ERiNat* course) and for their fun/recreational activities such as climbing with Mountain Rescue, overnight camping, fire-fighting drills with the Fire Brigade and nature trails.

1	What is your opinion on the *politeness*, *openness* and *friendliness* of the *ERiNat* teachers?
2	How did the teachers deal with the subjects:
2 a	*Seismic risk*
2 b	*Tackling an emergency*
2 c	*Forest fire risk*
2 d	*Hydrogeological risk*
3	How interested were you in the subjects dealt with?
4	How will what you have learned help you to tackle emergencies?
5	How did the *ERiNat* lessons help you with the study of your normal school subjects?

Figure 2 – Questions included in the Customer Satisfaction questionnaire filled in by students in academic year 2009/2010 and represented in figure 3.

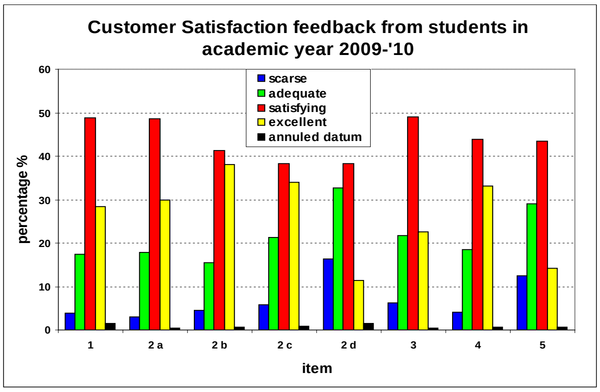

Figure 3 – Customer Satisfaction feedback from the students who took part in the ERiNat Project in academic year 2009/2010.

THE KEYS TO THE PROJECT'S SUCCESS

The strengths of the project are the research of stimulating didactic and communication models; the choice of trainers who come directly from risk management organizations, the future reference people for citizens and volunteers; the high level of motivation, sharing and transparency among the team members; the transferability of the project to other Provinces and Regions and other sectors of the same organization and others.

ERiNat is one of the most significant initiatives of the project developed by the Province of La Spezia "Piano di attuazione e miglioramento in itinere di un processo formativo nell'ambito della prevenzione dei rischi naturali" ("Implementation plan and ongoing improvement of an educational process on natural risk prevention") for which it won an award in the competition "Premiamo i risultati" ("We reward results") promoted by the Ministry of Public Administration and Innovation.

CONCLUSIONS

The *ERiNat project (Training on Natural Risks)* has been educating students from La Spezia and, in an indirect way, the adults in their family, on safety since 2004.

The project aims to encourage the community to take an active part for the good of all. Unfortunately, natural risks cannot be eliminated and the recent floods in our area are proof that anything can happen. Even to us. We have to be aware of this. Sometimes a little is enough to save your own life and that of others but you have to know exactly what to do. It is for this reason that citizens must be trained and informed, starting from the youngest, through a permanent training process.

ACKNOWLEDGEMENTS

We are grateful to the *ERiNat* team: La Spezia Prefect's Office's Civil Protection Department (M. S. Ariodante, R. Carpanese, E. D'Amico, M. R. Alberti), the Provincial Education Office (A. Majocchi), the Provincial Fire Brigade Department of La Spezia (G. Fundarò, A. Gilone); the State Forest Rangers Corps (B. Castiglia, R. Massari); the expert technician A. Stoppelli and the staff of the Provincial Civil Protection Service (G. Mancini, C. Cassinoni, S. Lualdi, M. Lombardo, G. Savoldi), the voluntary Civil Protection associations and the GEV of the Province of La Spezia.

Thanks are also extended to Olivia Zocco for her careful review of the English language.

The first author wishes to dedicate this paper to her son Valerio.

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STONE MATERIALS FROM THE SPINA NECROPOLIS: THE TOMB SIGNS

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KEY WORDS: carbonate and silicate rocks, Spina, geological patrimony

INTRODUCTION

The collaboration between University and the National Archaeological Museum of Ferrara was materialized into the creation of a museological and educational itinerary dedicated to the geological and petrographic classification of the stone materials used as tomb signs in the Etruscan necropolis of Spina. The archaeological finds were discovered starting from 1922, when the draining process of Lagunas basins "Valli di Comacchio" (Province of Ferrara) began and during which, the area of the necropolis was documented (Alfieri 1979). The great number of the tomb signs constrain the research to be concentrated only on the deficiencies' artefacts. For this reason, despite the abundant series of recognized rocks, we cannot exclude the presence of a wider spectrum of rocks.

For the exhibition purposes some of the representing samples were polished in order to facilitate the observation of the esthetical and compositional characters. The goals of the present study are focused on:

- The petrographic characterisation of the tomb signs.
- Geological characterisation and indication about the provenance of the tomb signs
- Indication of the probable source area and also of possible commercial and cultural exchanges in the Spina's Etruscan culture.
- Creation of the museological and educational itinerary in order to make public the geological patrimony represented by the tomb signs.

ANALYTICAL METODOLOGY

The petrographic study which implied an optical microscope with transmitted light allowed the observation of the structural and textural characters of the thin sections. The predominant elements, but also those scarcely documented in every sample were obtained through XRF (X-ray fluorescence) analysis, using a spectrometer on long dispersion ARL Advant'XP's wave.

DISCUSSION

The archaeometric analysis have confirmed a great lithological variability of the tomb signs, consisting mainly of terrigenous sedimentary rocks and followed by carbonate sedimentary rocks, metamorphic and magmatic ones.

Figure 1 – Geomorphological reconstruction of the archeosurface of the Spina necropolis

The petrographic classification allowed in most cases to identify the geological formations of sampling and then we can state some hypothesis about the possible origin area of these stone materials. The sedimentary terrigenous rocks (generally litharenite) belonging to the Apennine zone located in Emilia-Romagna Region, and partially with a Tuscany-Emilia origin (e.g. Pietra Serena and Pietra Paesina), Another type of tomb signs have a calcareous origin. In this case, the petrographic and paleontological study (Luciani et al, 2011) revealed a correspondence with basin sequences like Scaglia Cinerea and Calcare di Chiusole from the Veneto and Trento region, and also the correspondence with a carbonate platform like Lessini shelf (Bosellini, 1989) and Monte Baldo Luciani, 1989).

The Triassic lithic types, usually called "Portoro" and originally from Liguria are present in a smaller quantity, but having the same importance especially in determining the trade routes of the Etruscans from Spina. The silicate lithologies as well as being represented by terrigenous sedimentary rocks consist of igneous and metamorphic rocks related almost exclusively to the area Alpina. The basic extrusive igneous rocks and porphyry have a possible affiliation to the magmatic - lithic types of the Porfiric Atesino Complex. It also rocks have low to medium metamorphic grade also features of the Trento region (Val Sugana, Val di Non) so we can be assumed instead the possible supplying areas from the high valley of the Adige where emerge as the metamorphic basement as volcanic rocks derived from the Porfiric Atesino Complex.

In addition to the analysis compositional was performed to identify the morphology of the clasts environments supply. Were recognized: a) Rounded clasts from river transport with elements that recall also transport ice, whose sizes and shapes are assumed withdrawals from fluvio-morainic amphitheater of Garda, where among other things are found the igneous and metamorphic lithologies recognized; b) ovoidal blocks of sandstone are assumed to be derived from the extraction of degradation for exfoliation cipollate; c) volcanic prismatic fragments characterized glassy edges with morphologies typical of volcanic bombs.

In addition to natural forms are recognized anthropogenic factors that have marked and reworked with engravings natural elements.

The identification of the lithic types and of the possible supplying areas consent to enlarge the knowledge about the trade and cultural changes of this important people and also to draw a red line between the geological provenance and the testimony of the commercial/trade routes of the Spina emporium. The tomb signs have distinguished one of the most important archaeological sequence of the Po’s territory favouring the identification of the necropolis. Therefore, they necessitate a peculiar attention and valorisation. Their discovery is firmly bonded with the history of the ancient Spina.

In this paper by geological and petrographic classification of the Spina necropolis’ tomb signs conserved in the Archaeological Museum of Ferrara was possible to individuate the diverse supply areas of these artefacts, and also to offer a possible interpretation about the trade and cultural connections above all with the people from the inner Italian territory. Also by geological and petrographic classification has started an educational and exhibition at the Archaeological Museum of Ferrara with which to encourage new generations to the earth sciences.

SiO2%	68,66	72,50
TiO2 %	0,38	0,20
Al2 O3%	15,29	13,54
Fe2O3%	2,70	2,30
MnO%	0,05	0,04
MgO%	0,15	0,41
CaO%	1,63	0,99
Na2O%	3,16	2,78
K2O%	5,82	5,92
P2O5%	0,13	0,07
LOI	2,03	1,25
TOTALE	100,00	100,00
	TRACHIDACITE	RIOLITE

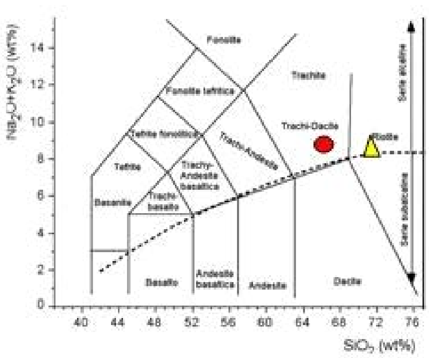

Figure 1 – Chemical analysis of the dominant elements of the porphyries and the corrispondent petrographic classification through TAS(Total Alcali/Silice) chart

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THE GEOLOGYCAL LANDSCAPE OF THE PROVINCE OF COSENZA: AN ENHANCEMENT PROJECT IN CROWDSORCING.

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KEY WORDS: geological heritage, GIS, croudsourcing,

INTRODUCTION

The Province of Cosenza and the Association Terr.A 360 are involved in the project 'The Landscape Geology of the Province of Cosenza', based on participation and aimed at the promotion of geological heritage.

The actions of the project include the census and cataloging of geological heritage sites of the province, in order to identify sites preserving significant geological evidence and that therefore deserve to be protected and valorised. To identify the type of information to be connected to significant geological sites, the project team has analyzed national and international experiences and studies, and has taken account of characteristics of the area of Cosenza as well as of project's objectives. The data are collected and managed by a Geographic Information System that allows an immediate reading of geographical, geological and administrative constraints of each site covering all the surveyed areas. The database can also contain images, detailed text, bibliography and will be continually updated relating to developments of knowledge, the environmental dynamics and environmental changes induced by human activity. Data collection has taken place in croudsourcing, with the collaboration of many experts who have shared their knowledge, and through a campaign of surveys conducted by a team of geologists of the Association Terra 360.

The database of geological heritage constitutes the basic tool for identifying sites to be enhanced and protected, and will therefore be available to the public, schools, research centres and professionals.

THE PROJECT AND THE PARTECIPATION

The reference idea was that the census of geosites is both a moment of construction of cognitive frameworks and a chance to build a network of relationships for the overall enhancement of provincial territory. This is why the activities of the project where opened to the broader participation and contribution of both institutions and local authorities involved in the management of geological heritage, and the Community of experts, composed by universities and research institutions, professionals and professional bodies and informal groups working on environment and territory. The idea was to build a space where each person could give a contribution in terms of knowledge and skills. We are convinced that only the participation and role of professionals, academic experiences, experts, enthusiasts, interested in the physical components of the territory, can make this process efficient, offering policy makers with a contribution of knowledge, skills and incentives necessary to achieve the objectives.

This is why participative processes where carried on to define the types of geological sites to be covered during the census, to draw up guidelines for surveying sites and to identify the methods and procedures for storage of geographic databases of detected items.

The project included a series of initiatives within "The Spring of Earth Sciences", thought as a moment for deepening some issues related to the concepts of geo-resources and geo-diversity, which has allowed us to collect contributions from professionals, experts from Public Administration and academia, enthusiasts of the physical structure of the polyhedron environment.

These initiatives have represented an opportunity to consolidate the assumption of collective work put into the field, verifying progressively the materials shared, the difficulties perceived and good practices implemented.

"The Spring of Earth Sciences"has included two types of activities: a cycle of seminars with specific focuses and thematic tours aimed at setting common standards for survey of geological sites included in the census.

The seminars covered the following topics:

- "The geo-resources in territorial planning: the identification of geological sites in the experiences of the PSC";
- "The concepts of geodiversity and geological site: scientific studies and research".

The first involved mainly professionals and administrators, while the second involved primarily the world of research. The project also provided the organization of onfield excursions: a first trip was made in San Lorenzo Bellizzi, an excursion to define operational standards for the survey of geological sites, a second trip was made to Malvito, where an administration particularly careful to the importance of geo-resources has expressed interest in regard of the project, offering active cooperation.

THE CENSUS OF GEOSITES

Among the various initiatives that the project "The Landscape Geology of the Province of Cosenza" is developing, is planned to construct a cognitive framework of the geological features of the territory.

The first two knowledge tools that have been realized are:

- the complete list of geological sites;
- the collection of information useful to characterize the Geosites of interest.

The cognitive tools are created and managed using spatial DBMS technology.

In particular, it was realized the DB Geosites. A geographic database containing information about geological features, and special applications for entering and accessing data.

The DB Geosites is the tool used to collect reports from people who have collaborated in the project. It can be used for simple reports, but also to define all the information needed to characterize a geological site, including spatial information.

Some sections of DB Geosites were compiled through geographical analysis (sections relating to the location, the presence of protected areas and Natura 2000 network, cartographic references, etc.). Other sections were completed by inserting the shared data from experts and enthusiasts, or through systemic work conducted by the surveyors.

The full list of geological sites should not be considered a static product but as work in progress to be further integrated.

According to the literature searches carried out, around sixty geological sites have been identified, through all the thematic analysis necessary for inclusion in the ISPRA national catalogue.

PLANNING THE GEORESOURCES

The Regional Planning Guidelines consider several times the themes of geodiversity and geological site, but they do so in a disarticulated manner.

On the base of the careful examination of the contents of PTCP established by the Guidelines, the provincial plans must include requirements for localization of the growth areas and infrastructure, based on exclusionary and limiting factors, the geological sites are on the lists of factors to be considered.

The project team has prepared a document that will be integrated into the provincial plan, containing a description of the methodology used and an article in support of the legislation.

The plan provides for the geological sites the following guidelines: 1) promote actions for the protection and maintenance of physical characteristics of the sites, 2) promote the different types of visiting: scientific, social, cultural, educational, ecological, provided the maintenance of absolute integrity of the different components of landscape, 3) promote the multimedia and museum exploitation of geological sites.

Access to geological sites is to be considered free subject to the rights of the landowners, where the sites fall within private property, who may provide for specific regulation of access also for the tourist enjoyment.

In geological sites is forbidden to litter, altering the water regime, alter the morphology of the land or the condition of the premises; remove or damage to rocky outcrops, concretions, or the elements of belowground biodiversity, plants, fossils, and paleontological palaeoethnological, create new quarries and landfills.

The Plan also specifies the actions that municipalities will have to undertake within their planning instruments.

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CAMPOTRERA OPHIOLITE (REGGIO EMILIA, NORTHERN ITALY): AN IMPORTANT NATURAL PRESERVE FOR GEOLOGY AND MINERALOGY

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KEY WORDS: natural preserve, ophiolite, pillow-lavas, datolite, fluid inclusions

The Natural Preserve of Campotrera, in the Enza river valley (Reggio Emilia province, Northern Apennine), was established in 1999 and its management was entrusted to Canossa municipality, where the preserve is present. This Natural Preserve includes a huge ophiolitc outcrop, composed by pillow-lavas basalts and subordinately by polygenic and ophiolitic breccias.

Campotrera ophiolitic block, together with nearby Rossena and Rossenella ones, represents an ophiolite (Campotrera ophiolite) belonging to the External Ligurian Units, composed by ophiolitic slide-blocks embedded in a sedimentary melange that marks the base of flysch-like sequences of Cretaceous-Eocene age. These basalts underwent a low-grade metamorphism (oceanic metamorphism), represented by prehnite-pumpellyite to greenschist-facies assemblages. The main chemical effect of this transformation is silica liberation and calcium mobilitation. In ophiolitic basalts plagioclase is transformed into albite+prehnite±epidote±pumpellyite association, clinopyroxene is partially replaced by chlorite+amphibole (actinolite) and Fe–Ti oxide phases are frequently converted into titanite. Many hydrothermal veins, up to 30 centimetres in thickness, are hosted in basalt-pillows and breccias, and here several minerals occur: datolite, calcite, prehnite and to a lesser extent natrolite, analcime, barite, hematite, magnetite. Sometimes these minerals can occur as well-faceted crystals. Indeed, Campotrera is one of the most famous places in Italy for the beauty and the size of its minerals, especially centimetric red datolite crystals.

Since 2000, the SRSN has been cooperating with Canossa municipality in order to reconstruct the mining history of these ophiolitic bodies (Borghi & Scacchetti, 2002) and to investigate their mineralogy. For this purpose, the SRSN established a collaboration with the University of Parma (Department of Physics and Department of Earth Sciences) and with the Department of Applied Geological Sciences and Geophysics of Leoben (Austria).

At the beginning of this collaboration, according to the Canossa municipality provisions, we sampled and then identified by micro-Raman spectroscopy the major number of mineralogical phases (Bartoli et al., 2003). Afterward, several rock samples from Campotrera ophiolite were investigated by electron microprobe analyses and a fluid inclusion study (Zaccarini et al., 2008) along with a crystal chemistry characterization (Rinaldi et al., 2010) were carried out on datolite crystals. Micro-Raman spectroscopy enabled the discovery of new minerals in the ophiolite, such as magnetite, pumpellyite, and hematite. Thin sections obtained from a datolite vein show a symmetrical structure with i) coarse grained datolite in the vein core, characterized by mosaic texture and triple junctions and ii) palisade-like aggregates of minute datolite crystals typically elongated normally to the contact with the wall rock. Thin sections of reddish veins show a lot of small inclusions of calcite and hematite along growth faces of the red datolite crystals.

Two-phase (L+V) fluid inclusions were observed, texturally identifiable as primary and secondary. Microthermometry analyses suggested a NaCl-H2O system for all inclusions. The calculated salinity is in the range of 10-16 wt% NaCl equivalents. Paragenetic considerations and mode of occurrence of datolite from these ophiolitic basalts indicate that the mineral precipitated from hydrothermal fluids circulating through the ophiolitic rocks during some post-magmatic stage.

The chemical analyses show no significant site substitution. The single-crystal structure refinements confirm the structural model of datolite previously reported (with a ~ 4.83, b ~ 7.61, c ~ 9.63 Å, and β ~ 90.15°, space group P21/c).

ACKNOWLEDGEMENTS

We are grateful to Fabio Biserni for the field work.

Figure 1 – A basaltic pillow of the Preserve.

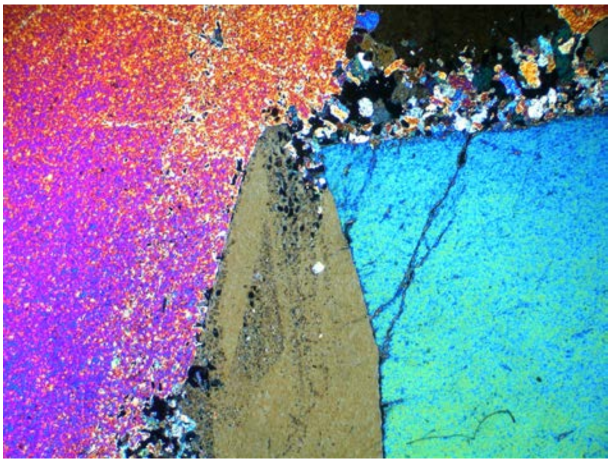

Figure 2 – Microphotograph of some datolite crystals, with small inclusions of calcite and hematite. Crossed polars. The lenght of the subject is about 1 mm-

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EMPOWERING MASSES FOR ENVIRONMENTAL CONSERVATION THROUGH ARTS AND MEDIA: A CASE STUDY OF AN INDIAN ARTIST

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Abstract for session 04 Popularisation of Geosciences and geoheritage

EMPOWERMENT, EDUCATION, COMMITMENTS, ARTS AND MEDIA, COMMUNITIES, CRITICAL ENVIRONMENT

Environmental education refers to organized efforts to teach about how natural environments function and, particularly, how human beings can manage their behavior and ecosystems in order to live sustainably. Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi Declaration, 1978). Environmental education includes-:

Awareness and sensitivity about the environment and environmental challenges

Knowledge and understanding about the environment and environmental challenges

Attitude concern for the environment and help to maintain environmental quality

Skills to mitigate the environmental problems

Participation for exercising existing knowledge and environmental related programs.

Minimizing environmental threats to human well-being from the environmental causes and consequences of conflicts and disasters.

The roots of environmental education can be traced back as early as the 18th century when Jean-Jacques Rousseau stressed the importance of an education that focuses on the environment in Emile: or, On Education. Several decades later, Louis Agassiz, a Swiss-born naturalist, echoed Rousseau's philosophy as he encouraged students to "Study nature, not books." These two influential scholars helped lay the foundation for a concrete environmental education program, known as Nature study, which took place in the late 19th century and early 20th century.

Planning must be applied to human settlements and urbanization with a view to avoiding adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all. In this respect projects which are designed for colonialist and racist domination must be abandoned. To achieve this environmental goal will demand the acceptance of responsibility by citizens and communities and by enterprises and institutions at every level, all sharing equitably in common efforts. Individuals in all walks of life as well as organizations in many fields, by their values and the sum of their actions, will shape the world environment of the future.

Above objectives are being achieved through the participation of the students community and the viewers among the general public of the society. In India The Head Quarters of the Regional Cultural regions organize Shows based on various Topics of the Environment and Ecosystems through paintings and canvas. It is a popular method to promote Environmental Education and Empowerment of the Rural Communities at Various regions of India. Presentation of my paper is based on the theme of the Arts, Media and community participation to save the Critical Environment and Ecosystem.

ICZM PROTOCOL AS A FRAME FOR MANAGING COASTAL SYSTEMS IN THE MEDITERRANEAN

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KEY WORDS: Coastal Zone Management, ICZM Protocol, Mediterranean

ABSTRACT

The entering into force of the Protocol on Integrated Coastal Zone Management (ICZM) in the Mediterranean in 2011 marked the important milestone in the timeline of coastal zone management. One of the main principles is the application of the ecosystem-based approach to coastal planning and management that should respect the geographical coverage and inter-relationship of coastal ecosystems so as to ensure preservation of the integrity of coastal landscapes and geomorphology.

Therefore, the integration of land and sea is crucial in coastal management which should be supported by adequate information systems, including appropriate indicators and data, national inventories and monitoring and observation mechanisms. These should allow for the rational planning of activities and sustainable development of coastal zones, as well as for reporting on state and evolution of coastal zones and assessments of their use and management. All these has been agreed by the Mediterranean countries in February 2012 as a priority in the Action Plan for the implementation of the ICZM Protocol.

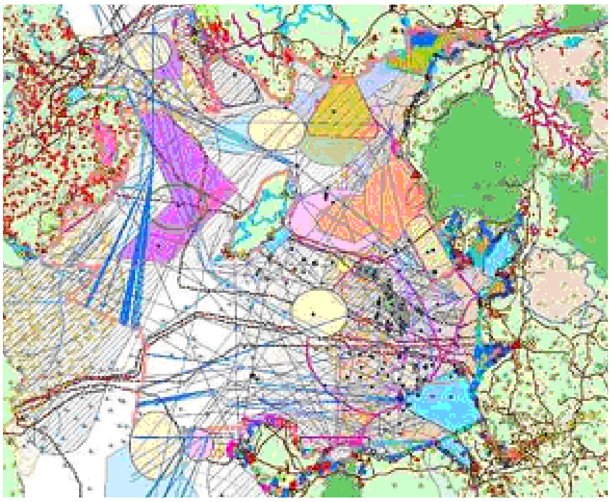

Figure 1 – Complexity of uses in coastal zone – Example from the Irish Sea

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A TOOL TO OPTIMISE "WINTER DUNE" PLACEMENT USING REAL-TIME COASTAL RISK PREDICTIONS, EMILIA-ROMAGNA, NORTHERN ITALY

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KEY WORDS: coastal erosion, early warning systems, beach scraping, numerical modelling, Italian coastline

INTRODUCTION

The Emilia-Romagna coastline, situated on the Adriatic Sea in Northern Italy, comprises some 130 km of low-lying sandy beaches. The majority (57%) of beaches on this coastline are protected by some type of coastal defence structures, e.g. emerged and submerged offshore breakwaters, groins and sea walls Tourism activities dominate the local economy, generating an annual budget of approximately 8 billion Euros, or 8% of the regional GDP (Perini *et al.*, 2008). To accommodate the hundreds of thousands of tourists that visit this coastline each year, private bathing establishments known as *bagni* have been constructed on the beach that provide a range of services such as changing facilities, food and drink outlets, recreational activities and deck chairs. These permanent structures are typically located close to the shoreline and are hence particularly susceptible to coastal inundation, most notably during the winter months when large wave and water level events are prevalent.

At the beginning of each winter, *bagni* owners organise an artificial dune, or "winter dune", to be constructed in front of their properties, in order to provide temporary protection against these more extreme coastal conditions. This dune is constructed by means of a bulldozer scraping sand from the lower part of the dry beach and depositing it in the upper part as a foredune. Where not enough sand is available from the lower beach, stockpiled sand from summer beach cleaning operations is often used to form the dune. What remains of these dunes at the end of winter is redistributed along the beach profile (Corbau *et al.*, 2009).

This relatively *ad hoc* approach to short-term coastal protection means that aside from the experience of *bagni* owners and bulldozer operators, little is known about the ability of these dunes to withstand different types of storm events. The optimal dune placement location as well as dune dimensions (e.g. height, width and slope) is also unknown. In this study, a new and innovative tool is presented that uses a combination of real-time predictions of coastal risk and numerical modelling to help minimise the risk of coastal inundation in the future.

A NEW TOOL FOR MANAGING COASTAL INUNDATION RISK

As part of the recently-completed MICORE project (www.micore.eu), a set of prototype Early Warning Systems (EWSs) for coastal storm risk have been developed at nine distinct coastal locations across Europe (Ciavola *et al.*, 2011). Each EWS utilises a chain of numerical models to provide real-time predictions (up to three days in advance) of various coastal storm risks specific to that particular site. Coastal storm risk predictions are communicated through the use of Storm Impact Indicators (SIIs), which are a quantification of the coastal zone suited to decision making. Linked to these SIIs are pre-defined threshold levels that trigger various degrees of action by authorities (Van Koningsveld and Mulder, 2004).

A prototype EWS has been operating on the Emilia-Romagna coastline at the site of Lido di Dante/Lido di Classe (Ravenna) since June 2011. This EWS currently provides real-time forecasts of

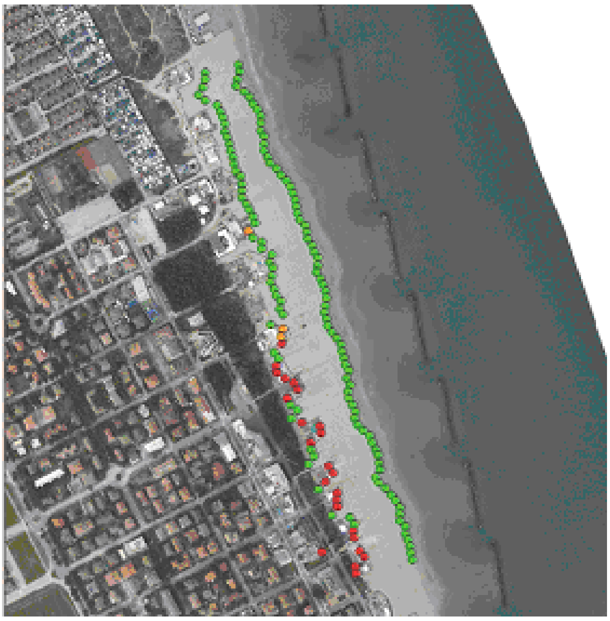

Figure 1 – maximum water line predictions for two test cases at Lido di Classe. Seaward line: Hs = 4 m and water level = 0.5 m. Landward line: Hs = 4 m and water level = 1.25 m. The latter case shows high risk inundation conditions in terms of the BWD (red points)

the so-called Safe Corridor Width (SCW), which is suited to natural dune areas and is a measure of how much dry beach width exists between the dune foot and waterline to allow for safe passage by beach users. Three-day predictions (updated daily) of the SCW for this site are found on-line at geo.regione.emilia-romagna.it/schede/micore.

To incorporate coastal inundation risk into this EWS, a second SII known as the Building-Waterline Distance (BWD) has been designed. The BWD is defined as the seaward distance between any building boundary and the waterline. A predicted BWD of 0 m or less therefore means that the predicted waterline is either touching or inundating existing buildings and hence represents a “High Risk” scenario. Two test cases showing coastal inundation predictions using the BWD at Lido di Classe are presented in Figure 1.

OPTIMISING WINTER DUNE PLACEMENT

The more extreme of the two hypothetical cases (using a scenario of wave heights = 4 m and water levels = 1.25 m above MSL) suggests the possibiliity of coastal inundation (indicated in red) at the southern end of the Lido di Classe test site. With advanced knowledge of this impending hypothetical risk, it may be possible to construct an artificial dune to minimise the risk of inundation in this area.

To extend this concept further, a new piece of software known as DuneMaker has been developed for this study that allows a user to simulate different inundation scenarios based on various dune configurations (see Figure 2). In the DuneMaker software the user is prompted to input a location of the dune crest as well as the height). accompanying dune dimensions (dune width and The software then calculates an artificial dune based on this dune configuration, making sure that the total sand volume remains the same.

Using this new dune configuration, the original predictions can then be rerun to observe whether the hypothetically constructed dune can help to minimise the risk opf inundation. The ease of which a user of the DuneMaker program can calculate artificial dunes means that an optimum dune configuration could be found in terms of inundation risk. Once this configuration is found, a dune could then be constructed.

The results of this study point to a new and innovative way of managing coastal inundation on the Emilia-Romagnia coastine that could then be applied at various other sites worldwide.

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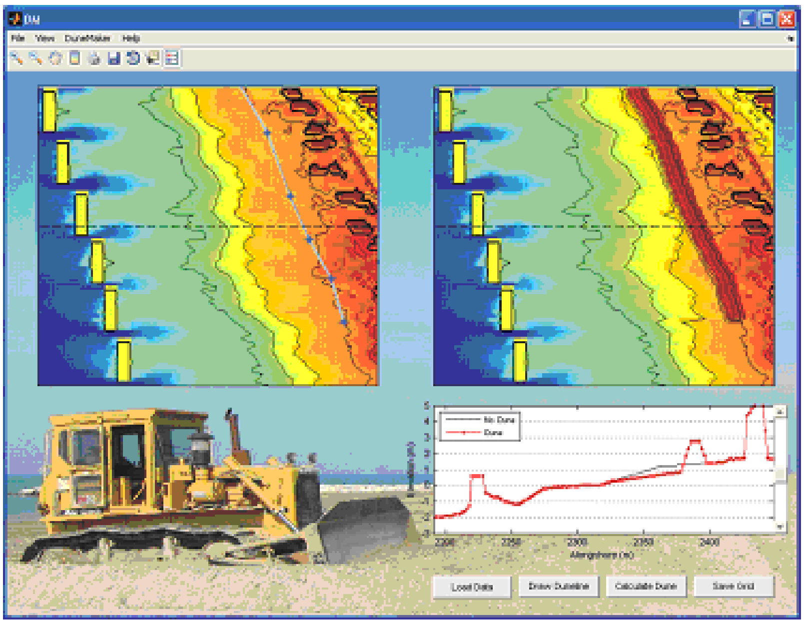

Figure 2 – The DuneMaker software, designed to simulate different scenarios of artificial dune placement to minimise the risk of coastal inundation

ESTIMATING REGIONAL SEA LEVEL TREND WITH MULTIPLE STATION LOCAL TIDE GAUGE DATA

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KEY WORDS: Mean Sea Level, Tide Gauge, Florida Sea Level Change, Regional Sea Level Model.

ABSTRACT

Information about long term mean sea level trends is needed in assessing coastal erosions and projections for coastal system management. Currently regional mean sea level trends and variations are inferred from the analysis of individual local mean sea level tide gauge data that span a long period of time. In this study, we propose a new model to combine various tide gauge data in a region, regardless of their time span, in a single solution to estimate parameters of regional mean sea level changes. The new model consolidates the partial information in local tide gauge measurements into a single data set and accounts for the correlations among the local tide gauge stations thereby enables more realistic uncertainties for the estimated and projected trends. The new formulation also unifies all the local vertical datums as defined by the local tide gauges under the umbrella of single regional vertical datum. To test its effectiveness, the proposed formulation was used to investigate the regional mean sea level variations for the coastal areas of the Florida Panhandle using 26 local tide gauge stations that span approximately 830 years of monthly averages from the Permanent Service for Mean Sea Level repository. The new estimate for the regional trend is 2.14 mm/yr with a ±0.03 mm/yr standard error ($p < 0.00$), which is an order of magnitude improvement over the most recent mean sea level trend estimates and projections for the Florida region.

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SEA-FLOOD HAZARD MAPPING IN EMILIA-ROMAGNA

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KEY WORDS: flood directive, sea flood, coastal hazards, coast management, defence, GIS

INTRODUCTION

The North-Western Adriatic coast is exposed to high sea-flood risk connected to exceptional sea levels caused by storm surges. Storm surges frequently occur along the Emilia-Romagna coastline in autumn and winter, as confirmed by the analysis carried out within EU Cenas (Yu et al. 1994) and Micore (Masina & Ciavola, 2011). Surges are often associated with sea-storms, that contribute to sea-level rise with the “wave set-up”, ranging between 10 and 45 cm along the Emilia-Romagna coast (Decouttere et al. 1997). The impact on the coast, as recorded in the historical storms catalogue produced within the Micore project, involves flooding of the beach, tourist infrastructures and even urban centres (fig. 1) in low-lying areas of the Ravenna and Ferrara provinces (Perini et al. 2011). The catalogue deals with GIS mapping of the impacted areas and with damage analysis, indicating about *15* localities being particularly affected by sea-flooding.

Flood risk management is thus a topical issue for public security and quality of life in coastal low-lying areas. For this reason the European Union approved Directive 2007/60/EC (EFD), which has been transposed into the Italian legislation by means of law decree no. 49/2010. According to this decree, “River Basin District Authorities” are responsible for the drafting of flood hazard maps by June 2013.

The Geological Seismic and Soil Survey (SGSS) of the Emilia-Romagna Region has been involved by the River Basin District Authorities, competent for the regional coastal area, in data management and hazard map development.

METHODS AND RESULTS

In order to build up sea flood hazard maps at a regional scale, as requested by EFD, the SGSS has thus developed a procedure that allows to perform a mapping in a timely and cost effective way.

The method, developed in a GIS environment, is applicable thanks to the availability of all necessary data within the Coast & Marine Information System (Perini et al. 2010). The results have also been compared with results of previous studies already carried out by SGSS in collaboration with local Universities (Armaroli et al. 2007, Zanuttigh et al. 2011).

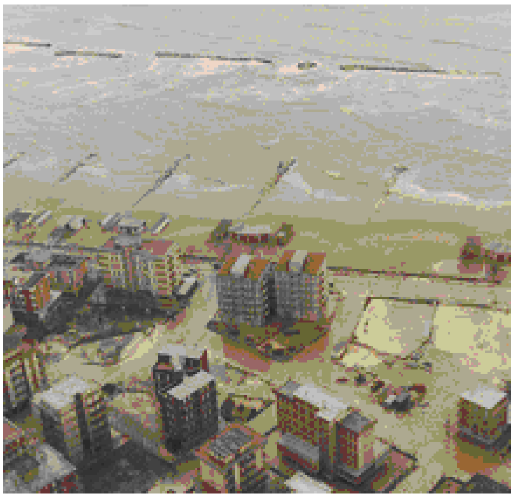

Figure 1 – Valverde (FC) flooded in January 1986

Main data used in the analysis:

- historical maps from the Sea-storm catalogue;
- run up and sea flood survey;
- high resolution coastal DTM, obtained by means of the Lidar technique;
- sea storm parameters: surge (from Masina & Ciavola (2011), astronomical tide (Mosetti et al 1987) and set-up (from Decouttere et al. 1997) for the three different scenarios T1, T10, T100 (tab. 1).

It should be stressed that, since no analysis of the combined return period of the three main sea storm parameters (surge, tide and wave set-up) is available, the worst-case scenarios for T1, T10 and T100 were assumed, considering the simultaneous occurrence of the three effects. This assumption has been compared with real events, which confirmed the validity of the method.

The analysis of flood areas has been GIS processed by intersecting the sea level surface for each scenario (return period of 1, 10 and 100 years), with a high-resolution digital terrain model (LIDAR).

An attenuation factor was introduced to model the dissipation of waves on the beaches and inland flood. This factor takes into account dissipation forces, the distance from the shore-line and the altitude. It was modeled using the maximum run-upand flooding lines observed as a result of real past events. It corresponds to a landward inclination angle of the sea level surface whose co-tangent has a value of 0.002.

The distance from the shore-line has not been considered as the Euclidean one, but it follows shortest paths for the water to reach the different areas (and therefore almost always greater than the Euclidean distance). This analysis was possible thanks to the availability of the *Cost Distance Spatial Analyst* extension from ArcGIS. The altitude value was used as incremental dissipation factor for distance.

Tr (Years)	Surge *	Mean high tide*	Set-up *	Total elevation sea surface
Tr 1	H critica = 0,61	0.40	0.22	1.22 m
Tr 10	H critica = 0,79	0.40	0.30	1.49 m
Tr 100	H critica = 1.02	0.40	0.39	1.81 m

*Tab 1 – Sea level surface values considered in the three different scenarios. *referred to m.s.l.*

The result of the GIS models is a raster matrix in which each cell has a value as a function of the distance from the shoreline and of the depth from the considered sea surface. In the model, only areas below the sea level surface, connected to the shoreline, are included in the calculation and in the maps.

The dissipation is minimal for small distances and high values of depth (high water column) while the maximum is for large distances and shallow depths (low water column).

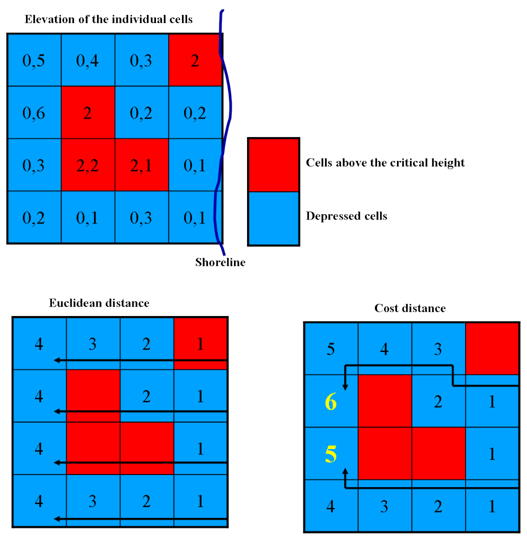

Figure 2 –Applied method scheme

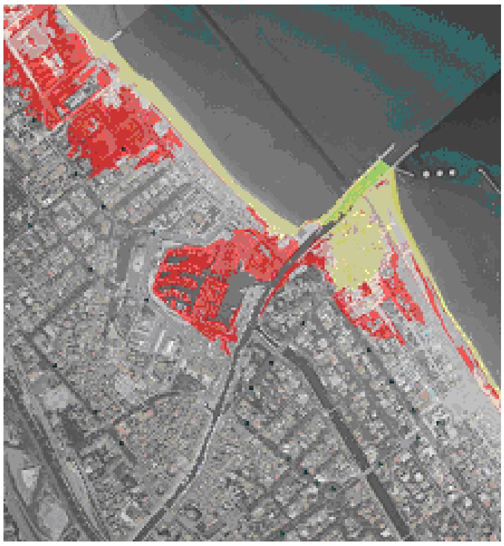

Figure 3 – example of map

CONCLUSION

The proposed simplified method is a response to lack of time and resources and it has already produced a sea flood hazard map prototype of along the entire regional coast. It however required a basic data set, as high resolution DTM and meteo-marine data analysis and background knowledge, especially with regard to the past events. In fact, the comparison of the historical data available in the Sea Storm Impact Catalogue with the results of hydraulic models, processed in restricted testing areas, allowed to validate the procedure.

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A GIS-BASED DECISION SUPPORT SYSTEM FOR MULTICRITERIA COASTAL RISK ASSESSMENT AND MANAGEMENT: THE THESUES APPROACH

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KEY WORDS: coastal risk assessment, decision support systems, GIS, erosion, flooding, multicriteria analysis.

INTRODUCTION

Coastal areas are vital economic hubs in terms of settlement, industry, agriculture, trade and tourism to mention some key sectors. Over the centuries, coastal areas have been globally altered by land reclamation, coastal development, offshore infrastructure, overfishing, pollution and species invasions (Airoldi & Beck 2007)..

THESEUS project (Zanuttigh, 2011) is developing a systematic approach to delivering both a low-risk coast for human use and healthy habitats for evolving coastal zones subject to multiple social and environmental drivers of change Risk assessment is carried out at 8 study sites across Europe within a Source-Pathway-Receptor-Consequence model. This conceptual framework is being developed on a GIS basis and provides coastal managers with a tool for supporting the selection and identification of the appropriate defence strategy to be planned at study sites.

POURPOSES

The paper describes the development of an innovative integrated approach to managing erosion and flood risk, able to support the involved stakeholders in selecting the mitigation measures through a multicriteria response to risk and vulnerability and can cope with the increasing uncertainty caused by climate change.

METHODOLOGY: SPRC APPROACH

The SPRC model (Thorne et al., 2007; FLOODsite, 2009) is a simple linear conceptual model for representing flood systems and processes that lead to a particular flooding consequence. Effectively, the SPRC approach is being used to evaluate how the Sources (waves, tide, storm surge, mean sea level, river discharge, run-off) through the Pathways (coastal defence units) affect the Receptors (inland system) generating economic, social, environmental Consequences.

CESENATICO CASE STUDY

This paper presents a first example application of a risk assessment methodology to Cesenatico, a well-known touristic resort in the North-East of Italy. This site is affected by erosion, flood and suffers also for anthropogenic subsidence since the 70's due to extraction of water for industrial and agricultural use (Preti et al., 2009).

The SPRC model is applied to Cesenatico coastal system.

The Sources of coastal hazard are characterized in terms of wave and climate condition (storm surge, wave set-up, wave run-up) through a probability density function (PDF). The Source characteristics are evaluated for several extreme and future scenarios including the contribution of climate change and sea level rise (Ferreira et al., 2009; Martinelli et al., 2010).

An important drivers for the study area is represented by subsidence able to affect the vulnerability of the area to coastal flooding.

The Pathways are represented by Hydraulic hazard/vulnerability (Fig.1) maps obtained for different return periods by means of a watershed segmentation algorithm based on mathematical morphology operator (Meyer and Beucher, 1990; Soille and Ansoult, 1990).

Environmental, economic and social Receptors were localized and characterized in the study area analyzing the following layers: Land Use, Corine Land Cover, Statistical and Economical data, Ecological and forest map.

The Consequences and damages of flood and erosion scenarios versus the environmental, economical and social receptors are quantified (Fig. 2) using a Damage Function approach (S.N. Jonkma na et al. 2008). In the case of flooding, damage functions are determined using a specified relationship between flood characteristics (usually depth) and the extent of economic damage.

The integrated approach pursued in the Theseus project is achieved by implementing a spatial multicriteria (MCA Malczewski, 2006; Meyer et al., 2009) methodology in order to obtain a cumulative coastal risk maps (Fig 3) under different mitigation and adaptation management scenarios.

THESEUS DSS

The discussed methodology and its application to the case studies is implemented in a GIS-based Decision Support System developed in a Open Source Software framework in order to assist coastal managers and stakeholder in the selection of innovative mitigation and adaptation technologies inside a multicriteria risk and vulnerability approach with particular emphasis to Social, Environmental and Economical aspects.

The tool is built around existing experience, such as CVAT, HAZUS-MH, DIVA, REGIS, Tyndall. The tool includes risk assessment from an engineering, social, economic and ecological perspective and will also combine different mitigation measures.

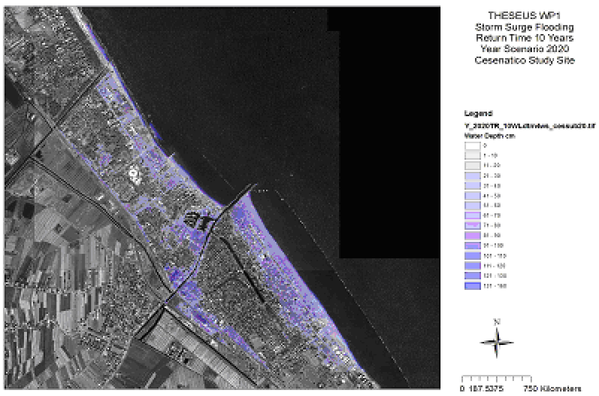

Figure 1 – Storm Surge Flooding Map - Water Depth - Scenario 2020 Return Time 10 Years

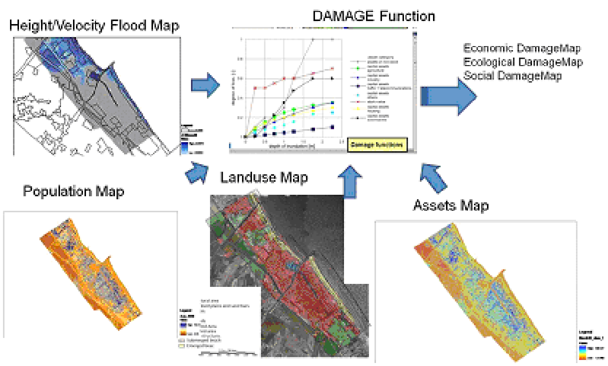

Figure 2 – Consequence Assessment - Damage Function.

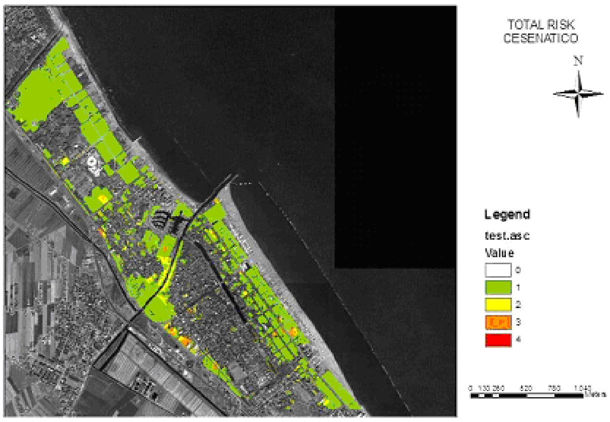

Figure 3 – Multicriteria Risk Assessment

ACKNOWLEDGEMENTS

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ANALYSIS OF DANGEROUS ENGINEERING-GEOLOGICAL COASTAL PROCESSES (ON EXAMPLE RUSSIAN SEA COASTS)

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KEY WORDS: sea shores, tsunami, risk, hazardous processes, damage, abrasion.

Sea coast of Russia are subject to a number of dangerous engineering and geological processes. The most common are abrasion of beaches on the shores of the Black and Baltic seas. And the most formidable - the tsunami on the shores of the Sea of Okhotsk and Sea of Japan.

ABRASION ON THE BLACK SEA COAST

The Imeretin Valley is a central fragment of the large Black Sea platform of the Caucasian coast of Russia; it is located on the coast of the Black Sea between the Mzymta and Psou rivers. Its central and western parts are location of the large sports facilities of the Winter Olympics “Sochi-2014” and Olympic Village. The accommodation of the facilities in the shoreland has aggravated the problem of shoreline protection and preservation of the beach recreation role. It should be noted that apparently already the first settlers faced the necessity to solve the first part of the problem because the active erosions of similar coast forms of the Caucasian Black Sea coast were documented already in the late nineteenth century.

The project was developed without necessary and sufficient geotechnical and ecological justification; the project contains no alternatives; the forecast of probable consequences (risk assessment) was not performed, which makes it impossible to consider the proposed variant as optimum; the efficiency and practicability of the projected combination of artificial unconstrained beaches (not more than 50 m wide) and massive hydrotechnical constructions (augered piles, reinforced concrete raft and slope 15 m wide of permeable packaged units) with the location in the roof part of the alongshore bar of the pleasure embarkment has not been tested by means of hydraulic simulation in the experimental tank; the inclusion of a technogenic component in the shoreline protection system will affect the ecological state of shoreline territories as it completely destroys the fully formed system of shore phyto- and biocenoses as well as destroys their Red Book elements. The proposed variant of shoreline protection destroys the recreation role of the interfluve beaches and esthetically pollutes the landscape costal zone which loses its aesthetic appeal; the adopted system of shoreline protection and its implementation with the procedural violations and without design supervision already at the construction stage has dramatically activated the erosions; the project does not provide for the avenues of retreat, if it turns out that the tendency of negative changes with regard to the shore or the very approach proves to be mistaken. In this case the unsuccessful system of shore fastening causes only the necessity of protection of the very structures; the project contains no information on the guaranteed sources of the required volumes of borrow material for artificial filling - the very possibility of the beach restoration within the period provided by the project remains doubtful.

Figure 1 – In the background – the port under construction (March 2011).

The coast protection by means of formation of artificial unrestricted beaches is performed by way of increase of the alongshore drifts stream by regular artificial filling on the intensively erodible sites. The material used for filling by its size is similar to the drifts of the natural beach and underwater slope of the protected coast. This is the only approach which may stabilize the coastal area with maximum restoration of its original natural environment and ecology of the shoreline interfluve zone.

Unfortunately, the project without duly engineering justification began to be implemented with the gross technological infringements and without designer supervision. As a result, already in the winter stormy period of the year 2010-2011, the low erosion activated on the sector from “Sea port – Constantinosvky Cup” which is evidenced by the necked piles (Fig. 1). As of August 2011, the erosions occupied the area of 320-350 m. The coastline re tracted there to the augered piles fastened by the grillage in front of which, under the project, a beach of 50 m wide should be formed. The seriously delayed filling of gravel - pebble material seems rather like emergency works and not the formation of the artificial beach.

TSUNAMI ON THE FAR EAST COASTS

A terrifying natural phenomenon, tsunami sometimes reaches devastating powerfulness to bring numerous calamities and tremendous material damages. Numerous catastrophic cases described in science literature attest the same. According to OCP-97, the Primorye territory belongs to 6-7 degree areas where T (average frequency period) =1000 years for 6-point magnitudes and T=5000 years for 7-point magnitudes. The Khabarovsk territory is classified in 8-9 point area with T=100-120 years for M=7.5.

The Primorye area is characterized in general by a relatively low seismic activity. This is due on one part to its location in the inside part of the Eurasian (or amour) lithosphere panel at a sufficient distant from seismically active panel's borders. On the other part, a relatively little number of earthquakes instrumentally recorded in Primorye is due to the lack of a comprehensive network of seismic stations in the region. Now, there are only two permanent stations on the Primorye territory: "Vladivostok and "Terney", separated by more than 400 km.

Figure 2 – Moryak-Rybolov Village. The height of the tsunami wave runup on the hydrographic data of 2 meters, by eyewitnesses over - 4 m. Runup length - more than 20 m, the maximum instantaneous level rise over the tidal level more than 2.5 m.

In the North Okhotsk sea area tsunamis happen less frequently being weaker than outside the Eastern shores of Kamchatka and Kurils. Since the beginning of instrumental observations on the North Okhotsk sea shelf there have been reported no earthquakes with a magnitude more than 5.8. There are, however, reliable facts of medium and strong tsunamis in the Nagayev bay. The waves coming into the Okhotsk sea from the South Kamchatka tsunami in 1952, generated by a powerful earthquake with magnitude 8.5, was 2 m high in the Nagayev bay. While in Sakhaline (Aniva gulf) the water rise level as recorded was barely reaching 1 m. In 1960, 28 hours after medium Chilean earthquakes (two shocks of M=8.5) the tsunami reached the North sea of Okhotsk area. A mareograph in the Nagayev bay recorded 5 waves of 2.2 m in height. By its height (2 to 4 m) that tsunami belongs to the strong class with 3 points out of 5. The waves were smaller in different parts of the Sakhalin seaside: from 0.4 to 1.9 m (Ivelskaya, 2004; Koff, 2003, 2005, 2007).

In Khabarovsk territory seaside parts of such communities and towns as Sovetskaya Gavan, Vanino, Oktyabrsky, Zavety Ilyicha and Datta are exposed to tsunami waves which can expand by the rivers Datta, Great Byanko, Muntin, etc. The greatest risk is run by the town of Sovetskaya Gavan which features density of constructions with its brick, slag block and wooden one-two and sometimes two-three storied houses. The seaside mount chains are plateau-like and smoothed altar steps with some tapered and dome-shaped summits. The coastal line from the Datta cape to Red Partisan cape is curved. The beach is intermittent with sectors of 1-10 km. Prevailing coastal depth is 6-8 m.

It would be appropriate to provide for vibration control for facilities to be projected in tsunami risk areas especially in the seismic active fault areas.

Risk assessment of the tsunami was made by the method proposed by G. L. Koff et al (2007). In order to identify and rank environmental factors of seismogenic tsunami waves dangers realization we in 1962-1966 years (Ust-Kamchatsky), in 1994-1995 (Kuril islands - Kunashiri, Iturup, Shikotan), 2002-2004 (Vilyuchinsk) in 2006 (the island of Shikotan), and in 2007-2009 (Primorye, Vladivostok) studied coastal natural factors that determine the realization of the risk of seismogenic tsunami waves (Fig. 2).

As a result, the system of zonal and local risk factors was provided. As the most important, were isolated character of the underwater coastal slope (steep or flat), the presence of underwater shoals and accumulative shallow, exposure to the epicenter of tsunamigenic earthquake (sites located of the angles: 0°, 0-90°, > 90° to the epicenter). Among local risk factors the following are most important: the presence or absence of the beach and (or) the first large marine terrace, the presence or absence of the river valleys cutting through the bay, the degree of the bay openness to the sea area.

Conventionally, bays can be divided into three groups by the degree of tsunami: low (up to 26 points), medium (26-34 points) and high (more than 34 points) risk. The first group in the Primorsky Territory includes Nakhodka Bay, due to its closeness to the intended direction of wave propagation. The second group includes the bay Kozmino Tungus, Popov, Progulochnaya, transparent, Kozina, Litovka. The third group consists of Wrangel Bay, Podosenova, Srednyaya, Gaydamak, Livadia, Anna, Otkrytaya. Determining factors of their high tsunami risk is a steep underwater slope and openness of bays to the proposed direction of propagation of tsunami waves.

For the first time for these areas tsunami risk characterization of coasts is made. It should be noted that the calculated data may be specified using to the results of studying of the nature of the underwater slope of the bays, beach, terraces, etc. The analysis of the materials allowed to identify the most tsunami zone, and to recommend the use of certain sections for the proposed development.

PROTECTION OF THE BALTIC SEA

The Kaliningrad region is one of the territories of the Russian Federation, which is 9 «hot spots» identified by the Helsinki Commission (Helsinki, 1992) as part of the Convention for the Protection of the Marine Environment of the Baltic Sea in the Niemen basin, the Vistula and Curonian bays of the Kaliningrad region.

Due to periodic intensifying storm impacts the Baltic Sea to 10-12 points landslide processes activates on the Curonian and Vistula spits, it leads to substantial losses on the coast of the resort main part. The length of actively destroyed coast is more than 55 miles of its total length of 146 km. Total for 40 years more than 70 hectares of valuable coastal areas was lost due to the storms destruction. Bad shoreline condition endangers further development of the resort. Of particular concern is the safety of the Vistula and Curonian braids that are unique natural complexes, separating the Baltic Sea from the Curonian and Vistula Lagoon. Coastal erosion on the Curonian and Vistula spits dramatically increased. In the Morskoy village in the last 40 years 120-130 meter long strip of coastal territory has been washed away. The only road on the 7th kilometer of the Vistula Spit almost completely washed away.

Despite the measures taken, coast protection measures unable to prevent the destructive processes without the proper building efforts and scientific support.

Bank protection structures of different types, built in the dynamically active zone, are constantly exposed to devastating impact. Over time, they are deformed, broken, and can completely disappear from the scene of their construction. Therefore it is necessary to periodically update the information on their availability and status.

Broad, sandy beaches and coastal dunes (advance dune) created by sand, blown away from the beach by the wind usually form natural defenses of the sandy shores of accumulative coast's. In the non-bound state, or where there is a general deficit of sand in the coastal zone, advance dune looming on the forest land and other lands and applied obvious damage. Therefore, the dunes must be carefully secured by planting plants.

The inventory of beaches and protective structures is necessary for justify the differentiated coast protection. Inventory of the coast and protection structures is based on the results of the coastal zone and the technical condition of buildings survey.

A set of measures to restore and stabilize the coastal zone include:

- Creation of eco-geological and geotechnical foundations of coast protection (scientific and technical support). Objective: To obtain baseline information for the survey works.
- Carrying out development works in the emergency areas and areas of future development. Purpose: building design documentation, project of coast protection, summary estimate of construction cost.
- Construction work on the creation of bank protection works. Purpose: to protect coastal areas from destruction.
- • Monitoring of the geological environment of coastal areas state. Objective: To estimate the efficiency of bank protection works.
- Evaluating the effectiveness of bank protection structures should be viewed in several ways:
- engineering geology (by increasing the degree of stability margin coasts);
- technical (the degree of conformity of the actual protection of bank protection works on the project);
- economic (in terms of minimum cost when comparing the options of activities and a comparison of the costs of engineering protection from potential damage);
- social (in terms of efficient use of the coastal zone);
- ecological (in terms of maintaining and improving the eco-biocenosis).

Evaluating the effectiveness of bank protection structures is performed in view of location of functional areas. These areas include residential buildings, public and business buildings, industrial parks, recreational areas, agricultural areas, corridors of engineering and transport infrastructure, and areas of military and special purpose.

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MONITORING THE IMPACT OF COASTAL STORMS ALONG THE LITTORAL ZONE OF THE GULF OF LIONS, FRANCE

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KEY WORDS: coastal storms, monitoring network, management of coastal hazards.

INTRODUCTION

European coastlines present a wide variability of environments, including natural habitats, large coastal cities protected by offshore structures, low-lying sand dunes, and rocky cliffs. During the last years, extreme hydrometeorological events have highlighted the devastating effects of coastal and marine hazards and evidenced the impossibility to design, fund, and build engineering schemes to protect vulnerable coastal areas across Europe from these extreme events. As it was analysed in the FP7 MICORE Project (Ciavola *et al*, 2011), our ability to predicts the imminent arrival of coastal threats is an essential step for the development of new coastal management system permitting to anticipate and execute the appropriate hazard-reduction measures.

The French coastline of the Gulf of Lions is a low-lying coastal plain. Along this microtidal coastline, where the mean wave climate is moderate, humans have strongly developed infrastructure and urbanised the coastal zone, disregarding the potential impact of extreme events. This results in an increase of coastal vulnerability to extreme storms. Major storm events (1982, 1997 and 2003) have illustrated this phenomenon and caused damage to harbour facilities, coastal tourism infrastructure, and urban infrastructure.

Within the european project MICORE (2008-2011), an analysis of historical storms was perfomed along a part of this coastline to evaluate storm thresholds for morphological impacts and to develop a prototype for Early-Warning System for the reduction of morphological impact due to marine storms. This research permitted to develop tools and knowledge that are currently in use in the monitoring network of coastal storm that is part of the 2007-2013 Coastal studies program of the State-Region contract project in Languedoc-Roussillon. The main objectives of this monitoring network are:

- To improve the knowledge on coastal storms affecting the regional coastal area, as well as the resulting impacts.
- To obtain good quality and homogeneous data along the entire coastline for the validation of morphological models.
- To develop, train and manage an appropriate network including collectivities, governement and research intitutions for a monitoring of the entire regional coastline.
- To obtain pertinent indicators for the management of coastal storms.

STUDY AREA AND METHODOLOGY

The coastal storm monitoring network concerns the entire littoral zone of the Languedoc-Roussillon region. This low lying sandy coast is highly vulnerable and many storm impacts have been observed over recent decades: overwash and breaching of natural sand barriers, beach and dune erosion, as well as damage to coastal infrastructure and facilities. Wave energy is moderate with a mean significant wave height of 0.7 m. Storm waves have significant wave heights over 3 m and can reach 7 m (in 30m water depth). The Hs annual return period is 4.3 m. The wave climate is dominated by SE swell. Waves associated with storms do not exceed 3.5% of occurrences and arrive mainly from ESE (77%), while storms from the S are less frequent (16%). Most important storm events are generated by meteorological conditions associated with a deep barometric depression

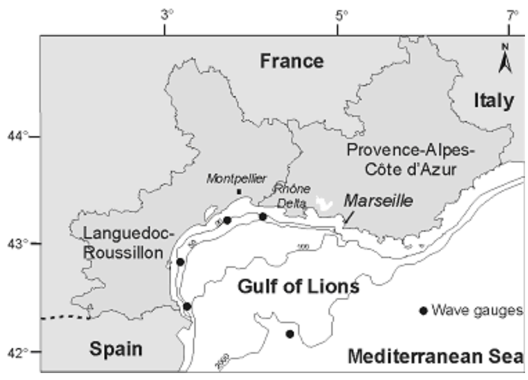

Figure 1 – Localisation of the study area.

near the Bay of Biscay. Major storm events are often associated with coastal marine winds, which generate important storm surges that can reach +0.85 m.

A review and analysis of all historical events and the associated impacts was undertaken in order to assess the thresholds for morphological impacts. As it was observed by Gervais et al. (2012), the most representative indicator for such an analysis is the offshore significant wave high.

An assessment of morphological threshold was done for the entire coastline, taking into account the variability of exposition to the dominant storm wave directions (Balouin *et al*., 2011, Gervais *et al.,* 2012). A monitoring program was defined according to these thresholds in order to ensure the gathering of physical information during/after an event. The 3 defined levels are the following:

- Level 1: for 3 m < Hs < 4 m, coastal morphologies are likely to slightly evoluate, but no major impacts are expected. The monitoring program consists in gathering the physical information available (wave, wind, storm surge, ...) but no field visit are required;
- Level 2: for 4 m < Hs < 5 m (e.g. the annual storm), additionnaly to the level 1 program, field visits are undertaken by the operators of the network to gather information on physical characteristics of the events (local storm surge, waves) as well as the impacts: observation of beach or dune erosion, marine inundation, ...
- Level 3: for Hs > 5 m, major impacts are expected and additional surveys (bathymetry, aerial photos) as well as modeling are undertaken to extrapolate and improve the knowledge on coastal processes generating morphological impacts.

In Order to obtain an homogeneous information, all operators of the network have a field questionnary to fill and are in charge of several observation points they should visit during (if possible) or just after the event.

In order to anticipate the event, an operational model for wave forecasting is used (WW3 model, Prévimer,www.previmer.org). When reaching the defined levels, an automatic email is sent to the operators of the network to anticipate the event, and confirm their availability for a potential field survey. The message sent is not a meteorological alerts that are provided by Meteo-France. They just aim to inform the network that an event is likely to occur (with a given level), and if it is confirmed by the official meteo-France bulletin, operators have to go and survey.

DISCUSSION REMARKS

Along the coast, anticipating the different morphological responses induced by storm events is crucial for managers to evaluate coastal risks and to develop the best measures to mitigate them. The analysis of historical events as well as the development of new experimental and coastal storm prediction levels have been crucial to better understand and anticipate storm impacts. However, to have confidence in these tools, model simulations still need to be validated against real-world events. The monitoring network was implemented in 2011, and was activated during the winter 2011/2012. The monitoring protocol appears to be fully operational and permitted to obtain valuable qualitative and quantitative observations on storm event and their impacts. A storm group in october/november was particularly monitored. The regional network permitted to localise precisely the storm impacts, and analyse their spatial variability. All the participant operators (Region, state, local collectivities, research organisation) have a full access to the entire database, and contribute to feed it.

A notable fact of this initiative lies in the voluntary participation and pooling approach adopted by the partners with no special funding (only the development of common network management tools). The monitoring program developped at a regional level and associating all individual activities is a real improvement in the characterisation of coastal storm and coastal damages. The implementation and the maintaining of such an operationnal network will permit to improve our understanding of coastal threats and to better anticipate and develop mitigation strategies for tomorrow and for the next decades.

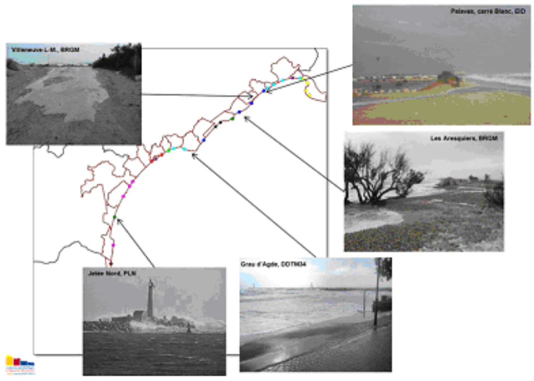

Figure 2 - Example of storm impacts (overtopping) observed during the storm group of October 2011.

ACKNOWLEDGEMENTS

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SUBCOAST: A COLLABORATIVE PROJECT AIMED AT DEVELOPING A GMES-SERVICE FOR MONITORING AND FORECASTING SUBSIDENCE HAZARDS IN COASTAL LOWLAND AREAS AROUND EUROPE

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KEY WORDS: Subsidence, Coastal Lowland Areas, Relative Sea Level Rise, GMES

INTRODUCTION

*Sub*Coast develops a user-centered downstream GMES-service for delivering data and information on extent and impact of subsidence in coastal lowland areas around Europe and demonstrate its viability in various pilot services for a variety of geographical settings and applications.

In order to achieve these goals, *Sub*Coast is been structured around the following topics:

- Deriving indicators of environmental and economic impact made by subsidence by making use of state-of-the-art scenario and impact models.
- Developing a coordinated data provision service for necessary terrestrial and satellite data, and input data streams from GMES Core Services and GMES Service Element Terrafirma and functioning as a portal for *Sub*Coast-services.
- Testing the *Sub*Coast-concept through dedicated pilot services making our approach viable and supportive.
- Demonstrate via a user federation, which holds the most directly involved regional, national and European stakeholders, how the *Sub*Coast-products will be integrated into current user practices and their working environment.
- Build service sustainability by developing a service delivery model which will transform the project into an operational downstream service and includes Service Provision Agreements (SPA) to ensure quality, standards and feedback as input to service improvement.

BACKGROUND

Coastal lowland areas are widely recognised as highly vulnerable to the impacts of climate change, particularly sea-level rise and changes in runoff, as well as being subject to stresses imposed by human modification of catchment and delta plain land use (IPCC, 2007). Utilisation of the coast increased dramatically during the 20th century, a trend that seems certain to continue through the 21st century. It has been estimated that 23% of the world's population lives both within 100 km distance of the coast and <100 m above sea level, and population densities in coastal regions are about three times higher than the global average.

Rates of relative sea-level rise can greatly exceed the global average in many heavily populated coastal lowland areas due to subsidence. Natural subsidence due to autocompaction of sediment under its own weight is enhanced by sub-surface fluid withdrawals and drainage. This increases the potential for inundation, coastal erosion, habitat disruption and salt water intrusion, especially for the most populated cities on these coastal lowland areas. Aside from regional environmental effects of subsidence there are direct costs related to subsidence and soft soil conditions experienced in coastal lowland areas. Failure of constructions, infrastructure and water defence structures bring high maintenance costs with them and add up to substantial financial damages in these areas, estimated to be of the order of billions in for example the Netherlands. Typically, rates of subsidence vary over various spatial scales and depend strongly on local geological conditions and human activity.

Therefore, both from a viewpoint of imminent adverse effects from climate change in coastal lowland areas as from the perspective of a sustainable management of infrastructural assets in these areas, there is a need of:

- Adequate data and information to assess spatial variations in subsidence in coastal lowland areas in relation to sea level rise and its impact on flood risk.
- Adequate data and information to assess geographical and temporal variations in subsidence and its impact on the geomorphological, ecologi cal and hydrological

systems in coastal lowland areas in order to anticipate necessary adaptive measures
- Monitoring of the rate of settlement and movement of water defence structures and engineered constructions in order to detect any significant weaknesses in these structures in time.

OBJECTIVES OF SUBCOAST

SubCoast aims at connecting local, national and european policy requirements, together with existing GMES Services and auxiliary data-streams with a dedicated service for monitoring the extent and impact of subsidence in coastal lowland areas around Europe and globally to a level where sustainable information services can be delivered. Based on the experience of four pilot services,, a product portfolio will be developed which can be delivered by the consortium throughout Europe and eventually worldwide, supporting GMES ambition as a European initiative for Global environmental monitoring.

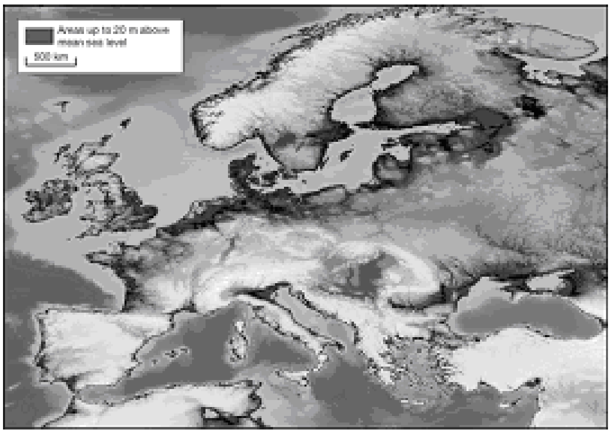

Figure 2 – Pilot areas for service testing in SubCoast.

Central to the SubCoast-project is the development of pilot-services since these will be both the testing environments for the proposed services as well as the deliverers of primary derived output to share with the stakeholders and end-users. The pilot services implement the concept of the SubCoast downstream-service and the appropriate validation procedures for the most important coastal lowland setting around Europe. The main concept is that the different pilot services should have the capability of testing the different functions of the downstream-service and demonstrate its viability for the most important issues related to subsidence in a coastal lowland setting. In SubCoast four pilot areas have been chosen to test the services. Two of these areas are at a regional scale, one on a national scale and one at European scale so as to demonstrate the service capability to various stakeholders operating at various levels. All pilot services actively involve end-users (Table 1).

Pilot	End-users
Rhine-Meuse Delta	• Ministry of Transport, Public Works and Water Management / Rijkswaterstaat
Southern Emilia Romagna	• ARPA Emilia Romagna • Regione Emilia Romagna
Baltic	• Maritime Office in Gdynia • Department of Regional and Spatial Development of Pomorskoie Voivodeship • Coastal Research and Planning Insitute, Klaipeda University
European	• European Environmental Agency (EEA)

Table 1 – Pilot service end users.

PARTNERSHIP AND COLLABORATIONS

Via our partners there is a strong link between ‘Terrafirma’ and SubCoast thus garanteeing that ‘Terrafirma’s’ products will be available for further downstream service development on a European scale. SubCoast will use data from ‘Terrafirma’ to extend our portfolio towards a truly European initiative aimed at delivering data and information on extent and impact of subsidence in coastal lowland areas around Europe.

Other relevant partnerships and collaborations are brought in through partners involved in national and European programmes; e.g.

OneGeology-Europe, the effort to built a digital geological map which is of use in SubCoast’s effort to work on a strategy for integration of subsidence assessments along Europe’s coastal lowlands;

PanGeo, which developes a GMES downstream service providing access to ground stability hazard information in urban areas.

The SubCoast Downstream service integrates leading GMES-services in the field of earth observation and interferometric SAR-analysis with state-of-the-art geoscientific models for coastal lowland areas both on a regional scale as well as on a European scale. Subsidence in these areas is of major interest regarding the imminent issues rising from climate change, such as sea level rise and flooding.

ACKNOWLEDGEMENTS

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STORM INFLUENCE ON OBJECT BURIAL IN SHALLOW WATER

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KEY WORDS: storms, sand, burial

INTRODUCTION

Recent studies on climate change predict a rising sea level. This will result in significant changes to the coasts. Moreover the frequency of storms events is expected to increase.

Improving the knowledge on storm influences on man-made structures will help to develop better suited monitoring stations and shore protection constructions.

This paper presents the effects of two storms on a measuring object deployed on the seafloor in shallow water.

The experimental area has a water depth range between 7 to 12 meters, depending on tides.

Two storms passed the experiment site during a three months experiment directed towards a better understanding of the sand mobility in a highly dynamic environment. The effects caused by the presence of objects on the sea-floor were studied in October and in November 2008.

Storms are uncontrollable and can be destructive. It is not always possible to get on-scene data measurements during storms due to large involved forces.

Having recording instruments deployed on the seafloor and properly working, gave the rare opportunity to observe and analyze the storm impact directly on the sea-floor. It was a chance to study the influence of storms on the sediments surrounding a cylindrical object and how this affects the coverage, as also the visibility of the object. Processes during and after the storm are revealed.

STUDY AREA

The experimental area (Wandelaar region) is located at 12 km distance from the port of Zeebrugge (Fig.1) in the vicinity of the main

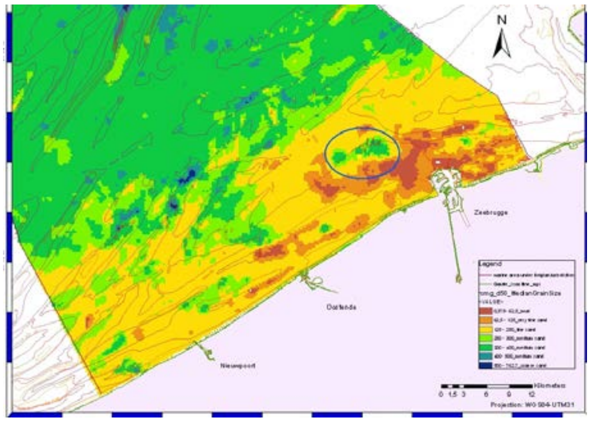

Figure 1: Extract from a grain size map on the Belgian continental shelf. Sandy sediments are in green; the Wandelaar area is contoured in Blue.

navigation channels on the Belgian part of the North Sea.

The Wandelaar region is a sandy shallow water area with a tidal range of 7 to 12 meters. Sediment transport is driven by both tidal currents and waves. Strong rectilinear current ellipses prevail with the main axis oriented in a SW-NE direction.

It is also characterized by the presence of small to large dunes (sensu Ashley, 1990), of up to 2 m in height.

METHODS AND DATA ANALYSIS

The experiment is part of a special research program sponsored by the Belgian Navy and Ghent University. The experiment is also supported by the FWG (Forschungsbereich für Wasserschall und Geophysik of WTD 71). They provided the recording instruments deployed on the seafloor.

Four cylindrical recording objects looking like sea-mines (Fig.2) and called BRMs (Burial Recording Mines) were deployed in September 2008 in the Wandelaar region. They have a length of 1.70 m and a diameter of 0.47 m. The weight in air is 500 kg. They are equipped with three rings of 24 led bridges (“sensor”) equally spaced around the object at 15° which are activated at regular intervals. The sensors consist of an emitter and a receiver and monitor the height of sediment around the BRM (burial) by recording the value “1” if sediment occludes the space between emitter and receiver; otherwise they record “0”. This analysis used data recorded at 15 min intervals.

Figure 2 – BRM, length 1.70m, diameter: 0.47m, weight in air: 500kg

Accelerometers inside the BRMs monitor the movement of the object and allow calculations of Pitch and Roll and the variation in time.

One object was recovered on 15th January 2009. It recorded 10,000 data sets of the sediment height for 104 days between the 25th September 2008 and the 6th January 2009. The burial measurements were analyzed together with sediment info and hydrological and meteorological data sets recorded at different monitoring stations in the immediate vicinity of the Wandelaar.

The hydrological and meteorological data were analyzed to evaluate the two storms affecting the area during the experiment. The threshold necessary to initiate movement of sand grains on the seafloor was calculated. The threshold orbital velocity for sediment motion is used to calculate the corresponding required critical wave height.

The calculated curves were compared with the measured wave height, percentage of sediment volume around the object, and current measurements.

Three curves of critical wave height for the different sediment classes (fine, medium and coarse sand) were calculated (three different critical orbital velocities). These curves were compared with the wave heights measured during the storm (Fig.3a). The calculated and measured curves were combined with the curve of buried volume by the sediment around the object (Fig.3a-3b) in order to unravel a suspected correspondence between BRM burial and forces, and to compare the calculated and the recorded sediment movement.

RESULTS AND DISCUSSION

Two storms, one in October 2008 and one in November 2008 affected the experimental site. Although the first one was less extensive both reveal the same processes.

During both storm events the measured waves were three times higher than required (on basis of the outlined calculations) to initiate sediment movement.

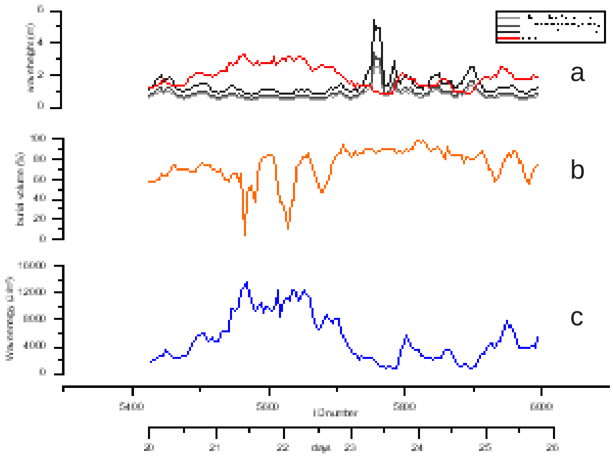

Figure 3 – Storm in November 2008. (a): comparison between measured curve of real wave height (red) and calculated curves of critical wave height (different tone of grey); (b): curve of burial volume; (c): curve of wave energy.

During both storms wave affecting the seafloor caused reduced burial (i.e., sediment coverage) of the BRM. After the storms increased burial of 60% (October) and 80% (November) was observed.

The high storm waves eroded sediment in the vicinity of the BRM and created scour holes at both ends. The storm effects dominated over tidal current effects. Once the scour holes merged to form one, the BRM rests on a small sediment cone. Upon collapse of the cone the BRM rolls into the bigger scour hole. During the sedimentation phase this new deeper hole is filled and causes a higher percentage of buried volume.

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RESEARCH AND EXPLOITATION OF SHELF MARINE SAND DEPOSIT FOR COASTAL RENOURISHMENT: GEODATABASE GUIDELINES FROM EMILIA-ROMAGNA EXPERIENCE.

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KEY WORDS: coastal erosion, sand resources, nourishment, geodatabase, Adriatic sea .

INTRODUCTION

Shorelines and coastal development will be even more vulnerable to hazards in the future. Need for offshore sand for nourishment will increase but volumes for sustainable shore protection are uncertain for many regions. Beach nourishment with sand derived from river or coastal borrow sites has been the preferred most common method of shoreline stabilization method in Italy for several decades. This practice has increased rapidly over the last decade to the point that the search of alternative sources of sand became an issue. Better understanding of the shelf geology can aid our ability to plan for sustainable use of offshore sands (Correggiari, 2011a). Since the '80 the Adriatic shelf has been studied to identify potential sand deposits available for extraction. Information about the geology of Adriatic shelf regions, the character of the seafloor, and samples comprising the seafloor and subbottom have been aquired by ISMAR CNR-Bologna as the result of several national and international projects included the Geological Adriatic Map (1:250000 scale) (Trincardi et al 2001).

SAND DEPOSIT

The Adriatic shelf, particularly offshore Emilia-Romagna and Veneto regions, has been the focus of these studies for the past 25 years in joint ventures with widely varying results. Geophysical studies to locate potential borrow areas, identify sediment quantities, investigate sediment characteristics, and rank candidate sites are usually undertaken in multiple phases. The method draws together local geological information and data to generate the final sand search deliverables. During the late Pleistocene/Holocene relative sea level rise (between ca 18 and 5.5 kyr BP) wide portion of the northern and central Adriatic alluvial plain of the glacial time has been progressively drowned, with concurrent widening of the continental shelf area of the Adriatic.

Across the low-gradient northern shelf, the stepwise, high-amplitude relative sea-level rise favoured the deposition and in-place drowning of different generations of transgressive barrier–lagoon systems. Along the western side of the Adriatic shelf and seaward of the modern shoreline, the late-Holocene mud wedge, a continuous belt of deltaic and shallow-marine deposits, overlies the available transgressive sand deposits. The exploitable trangressive sand bodies comprising old beach deposits, are outcrop only in the axial part of the basin far from the recent muddy sediment (Fig. 1a).

During the last decades the increasing amount of data acquired by ISMAR CNR Bologna provides unique opportunities to summarize knowledge of geology and shelf geomorphology with existing geotechnical and geophysical data that facilitate identification of sand resources. Understanding abbreviates the need to conduct random geophysical and sampling surveys over large expanses of the seabed and is more efficient and economical because only potential deposits are targeted. Some types of offshore sites can be described as linear sand bodies, including remnant shoal features, ebb or flood tidal shoals, drowned barrier islands, oblique sand ridges, longshore bars, trough sand accumulations, and migratory sand spits attached or unattached to tidal inlets.

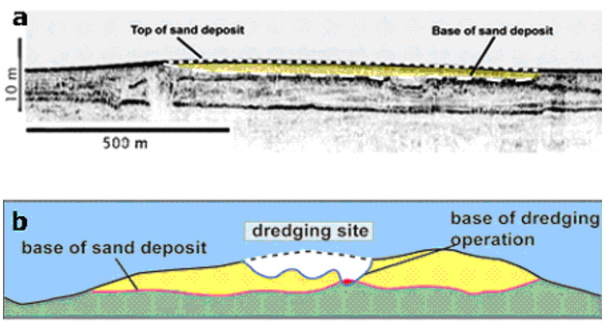

Figure 1 – a) Chirp profile of deposit sand. Top and base line of the sand are in dotted line. b) Model of a dredging site of deposit sand. Dotted line are the removed sand by the dredge. In the example the dredging exceeds the base of the sand

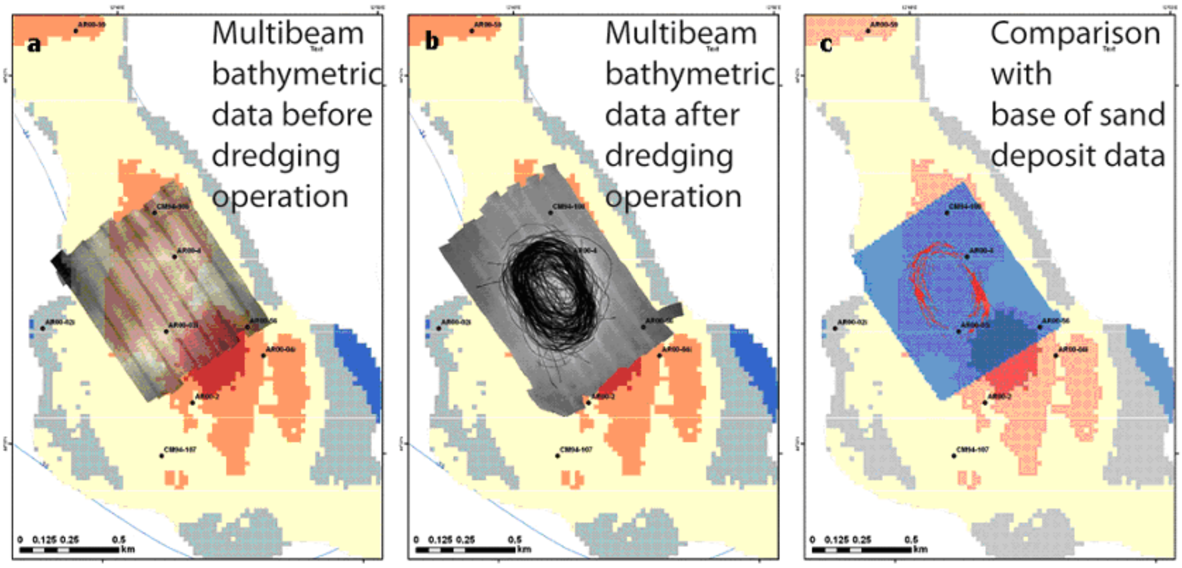

Figure 2 – Example of multibeam bathymetry acquisition before and after dredging operations and the comparison with the base of sand deposit

A GEODATABASE FOR EXPLOITATION STRATEGIES

Geographic Information Systems (GISs) are tools used to gather, transform, manipulate, analyze, and produce information related to Earth's surface. Governments, research institutes, and local authorities that cannot possibly handle the task of manually processing large amounts of geographical data use GIS and geodatabases which are more robust and extendable data models compared to shapefiles and coverages. The sand deposits Geodatabase aims at supporting the regional goverment in managing offshore reservoirs. It represents besides the central repository to effectively, retrieve and analyse geological, geophysical and geognostic data acquired by ISMAR-CNR on the continental shelf of the Emilia Romagna region. The methodological steps for the creation of the Geodatabase include: 1) data collection and analysis, 2) design of the architecture of geographical data model able to define the relationship between spatial (*feature classes*) and non spatial data (*object classes*); 3) population of the geodatabase structure. The data model is represented by a UML diagram that provides suitably modified standard elements for the representation of the *Feature class,* of the *Object class* and the relationship class. The geodatabase architecture has been designed to retrieve the data related to the total volume extracted from each sand reservoir, and consequently to asses the available amount of sand. To perceive this objective a high resolution multibeam bathymetry (0.5 m grid) of the sand deposits was acquired before and after any dredging. The base of the sand deposits, interpreted from geophysical data, and the multi beam bathymetry acquired after dredging were compared with spatial analysis tools in order to highlight the areas where the dredging operations have lapped the base of the sand deposit. The Geodatabase become a simple tool for monitoring and update in real time the volume of sand deposits before and after dredging and to control operations performed in each sand deposit by dredging company checking the volumes actually removed, Fig. 1b, Fig 2 (Correggiari, et al 2011b).

The sand resource in the Adriatic is extremely important and its use can be much better supported by GIS tools that enable engineers and concerned authorities to be aware about the situation and update the fields in the aftermath of several nourishment projects. This tool was designed to provide management with a regional control of the various interventions and to predict scenarios of intervention in the preparation of executive plans. This means that new multibeam bathymetric data are necessary in the future in order to complete the entire database and to make more detailed calculations of sand volumes available.

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DEM OF THE VENETO PLAIN BY ERS2-ENVISAT CROSS-INTERFEROMETRY

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KEY WORDS: DEMs, SAR, cross-interferometry, Veneto plain.

INTRODUCTION

Digital Elevation Models (DEMs) of flat lowlying coastlands are becoming even more important for environmental risk analyses, for example the development of effective plans for flooding protection.

The need of information at high spatial resolution over very large areas, of the order of 100×100 km^2, practically precludes the use of traditional methods (e.g., leveling and DGPS) due to their intrinsic limitation in covering wide zones and reduces the possibility of using Lidar because of its high cost. Starting from the last decade, space-borne radar sensors have been used extensively for this purpose. The most known is the SRTM (Shuttle Radar Topographic Mission) DEM which covers most of the land area between ±60° latitude (Rabus et al., 2003). This DEM was generated using single-pass interferometry and is widely available at 3-arc-seconds. In this work, we present the results obtained for the Veneto plain, Italy, using the space-borne SAR (Synthetic Aperture Radar) cross-interferometry (Wegmüller et al., 2009).

METHODS

Recent dedicated ERS2–ENVISAT tandem missions offer a unique opportunity to apply ERS–ENVISAT cross-interferometry (EET CInSAR) for the generation of precise DEM in relatively flat areas given the short 28 min repeat-pass interval and the 1.5–2.5 km long baseline. Four pairs of images acquired in winter 2007-2008 and 2008-2009 are processed. For each image pair, interferometric processing consisted of co-registration at sub-pixel level, spatially adaptive azimuth and range common band filtering considering the baseline and frequency offset as well as the azimuth spectra effects, generation of the interferograms and removal of topographic phase.

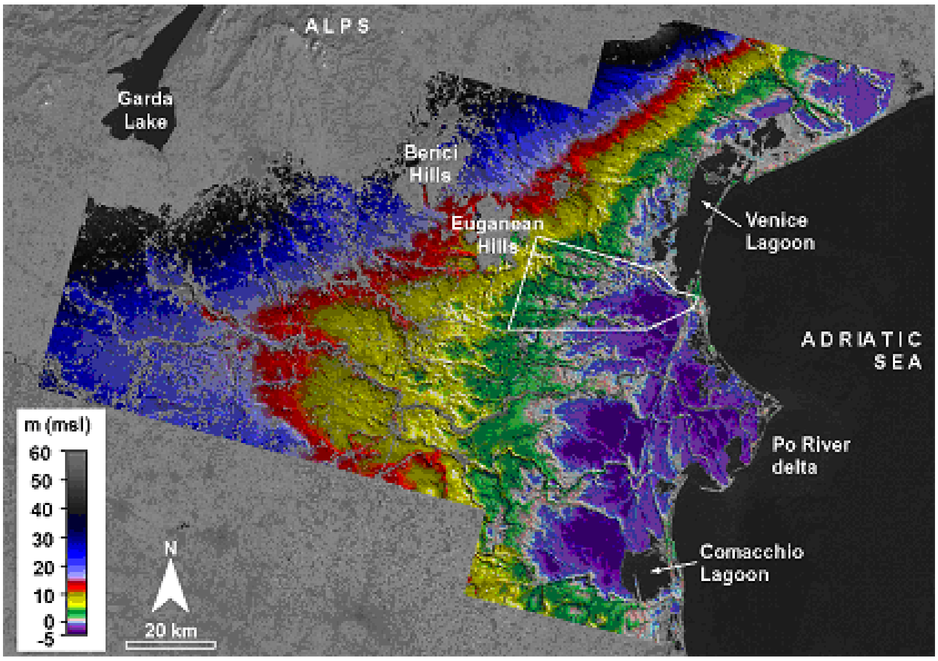

Figure 1 – DEM of the Veneto plain obtained ERS2-ENVISAT cross-interferometry.

All images were finally geocoded to 20×20 m^2 pixel size and shown in cartographic projection. The final DEM is derived by averaging the four DEMs obtained by each pair. Lastly, the DEM was calibrated a-posteriori using a few kinematic DGPS surveys carried out for the purpose.

RESULTS AND DISCUSSION

The investigated area extends from the mouth of the Tagliamento River to the north, that of the Reno River southward, and the Garda Lake 150-km inland from the Adriatic coastline. The elevation ranges between +60 m and -5 m above mean sea level (Fig. 1). The ERS2–ENVISAT DEM reveals impressively the geomorphological features crossing the plain, such as the beach ridges and paleo-river beds elevating above the surrounding lowlying interdistributary areas. However, the DEM coverage achieved was not complete. Decorrelation prevented the application of the technique over water, forests, urban areas, and elevated zones such as the Euganean and Berici Hills.

For the eastern territory of the Adige-Euganeo Water Reclamation Authority, Figure 2 compares the cross-interferometry outcome and the SRTM DEM oversampled to the same 20-m resolution. The picture highlights the significant less noise that characterizes the former with respect to the latter. The EET CInSAR has a significantly higher sensitivity than SRTM and consequently fine structures are better visible. The ERS2–ENVISAT DEM is compared in Figure 2c with the elevation model of a kinematic DGPS survey carried out as of 2002 in a peat farmland at the margin of the Venice Lagoon. It is well visible how cross-interferometry is able to capture the major elevation changes, with the DGPS outcome that is generally located within the ±0.2 m standard deviation characterizing average DEM. Conversely local variations, such as the road embankment at B site, are underestimated.

The DEM is currently under improvement by adding discontinuous localized anthropogenic features, e.g. river embankments, road banks etc., that can not be detected by EET CInSAR. This last step will allow to produce a final outcome that will be effectively used by the river and land reclamation authorities managing the area.

ACKNOWLEDGEMENTS

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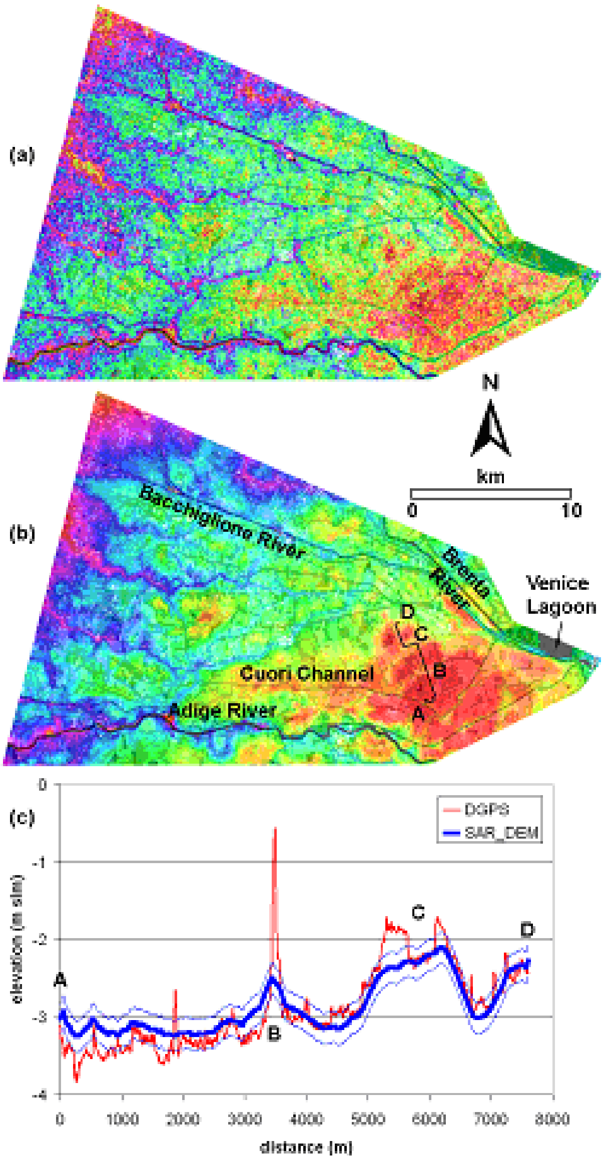

Figure 2 – (a) SRTM DEM and (b) DEM from ERS2-ENVISAT cross-interferometry for the eastern territory of the Adige-Euganeo Water Reclamation Authority. The trace of the area is shown in white in Figure 1. One colour cycle (e.g., from red to red) corredpond to a variation of land elevation equal to 10 m. (c) Comparison of ground elevation along profile A–D of (b) as derived from a kinematic DGPS survey carried out in 2002 and the ERS2-ENVISAT DEM.The thick and thin blue lines represents the average and the standard deviation, respectively.

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A NEW TOOL FOR LITTORALS MANAGEMENT SUPPORT IN EMILIA-ROMAGNA – THE LITTORAL CELLS INFORMATION AND MANAGEMENT SYSTEM (SICELL)

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KEY WORDS: coast, erosion, management, littoral cells, sediments management, climate change adaptation

OUTLINE AND COSTRUCTION PATH OF THE MANAGEMENT SYSTEM TOOL

In the last decades, sediments management became a fundamental aspect in the coastal protection and management programmes of Emilia-Romagna Region. In parallel, it arosed the need for a support tool able to optimised the use of littoral sediments and the sustainable exploitation of sediment resources coming for out of the coastal system (off-shore / inland provenience).

In order to give a response to this need, and catching the opportunity offered by the EU COASTANCE project (www.coastance.eu), the Emilia-Romagna Region developed a specific information system for coast management and protection based on the subdivision of the coastal belt in littoral cells (SICELL).

The tool has been developed, in the cooperation framework with other Mediterrnean partner regions, by a regional work group comprising several structures having specific competences in study, monitoring, programming, managing and interventions realisation on the Emilia-Romagna coastal zone: the Soil and Coast Defense and Land Reclamantion Service, the two coastal Basin Technical Services, the Geological Seismic and Soils Service, the regional agency ARPA Coast and Sea Special Unit.

Basing on several previous studies, direct experiences and specific knwoledge, the 130 km of regional coastal belt have been subdivided in 118 littoral cells and 7 macrocells according with coastal dynamics, sedimentary balance, structures and defence assets, beaches assets and geomorphology. Moreover, according with last decades intervention practices, 14 “significant coastal stretches” (grouping cells within a macrocell) have been defined for management purposes.

The SICELL dataset, on a GIS basis, also integrates data coming from other regional databases (Coast and Sea Information System, nourishments and hard defence works DBs, subsidence rates, topo-bathymetry) re-elaborated and specifically reorganised according with the specific aim of the tool. The period covered by the SICELL dataset goes from year 2000 to year 2011, with updating every six months. Next updating, by the end of 2012, will include data from the now ongoing 5th regional topo-bathymetric and subsidence surveys and the comparative analysis with the previous surveys (4th campaign) dated 2006.

Figure 1 – Coastal arrangement by littoral cells

CONTENTS ANALYSIS APPLICATIONS OF THE LITTORAL CELLS MANAGEMENT SYSTEMS

A littoral cell is defined as a coastal stretch characterised by specific and uniform morphologic and evolution conditions of emerged and submerged beach that distinguish it in respect of nearby stretches. To define its evolution trend in terms of sedimentary balance, a specific indicator named ASPE (Accumulation, Stable, Precarious, Erosion) has been created considering a 6 years cycle observation period.

The SICELL is organised in 4 data sections by each littoral cell:

- Framework information: cell typology, coordinates, location, extension, description, macrocell belonging, ASPE class belonging.
- Evolution state information (useful for ASPE classification): realised interventions, nourishments, sand draws, new hard defence works or maintenance of existing ones, coastline trend, sedimentary balance (topo-bathymetric campaigns comparison).
- Morphology, dynamics, beach asset information: alongshore drift direction, subsidence rate, emerged and submerged beach morphology, beach and back-beach uses.
- Management information: interventions needs

highlighting, presence of constraints (natural protected areas, particular infrastructures, military zone, etc.), suitability as sand withdrawal zone, suitability as nourishments strategic recharge point for down drift stretches (interventions optimisation).

Basing on the SICELL dataset a number of analysis are possible at different scales: local (cells), wide area (macrocell), whole coastal system.

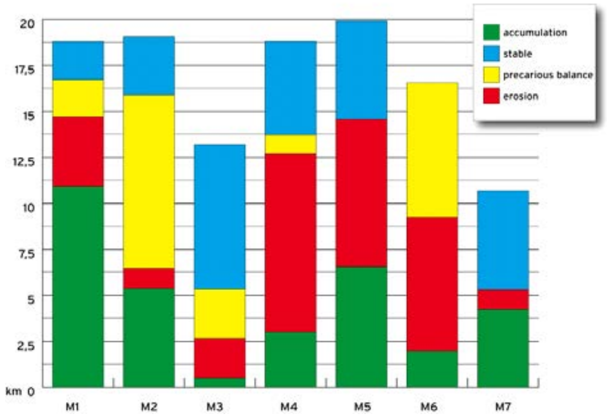

Figure 2 – ASPE classification of the 7 macrocells based on the classification of the 118 cells.

The chart highlights that about 55 km of coastal stretches are in critical conditions, of which 32,9 km in erosion (23,5%) and 22,7 in precarious balance (16%). Percentages are calculated on the total extension of littoral cells system (140 km).

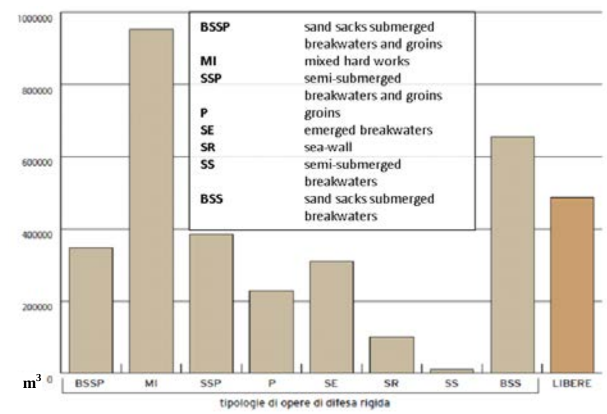

Figure 3 – Sand volumes brought on beaches protected by - and on beaches free from - hard defense works

In the 2000-2006 period, 3 million up to total 3,5 millions of m^3 of sand were brought for nourishment on 45 km of littoral extension, stretches protected by hard defense works (data of the 2007-2011 period confirms this trend).

Other possible kinds of analysis refers to volumes withdrawn by each cell, grouping by cell typology and helps in identifying further cells potentially suitable for sand withdrawals. Thus, 18 cells with accreting beaches, of which 12 already used and 6 potentially suitable for sand withdrawal have been identified, with estimated volumes. As well as 7 cells corresponding to harbour mouths, 5 already used and 2 potentially suitable, and 17 cells corresponding to river and channel mouths, 9 already used and 8 potentially suitable. It must be underlined that the potential suitability of cells is an indication not sufficient by itself to start the exploitation. Specific assesments shall be carried out considering the several aspects of local conditions.

The SICELL finds applications in:

- Littoral accumulations management plans;
- Sediments management of harbour mouths;
- Coastal protection plans and intervention programs;
- Sea storm damages recording (volumes eroded from the beaches, damages to the existing structures).

CONCLUSIONS

The SICELL construction operation has meant the capitalization of knowledge and experiences ripened by several regional structures and the reorganization of existent data with the specific aim of littorals and sediments management.

It supports the systematisation and optimisation of coastal protection interventions, coastal management and littoral sediments dredging and managing programmes and operations.

By its characteristics the SICELL is a tool:

- multi scale, that allows to rapidly switch analyses from local level (Cells), to sector level (Macrocells) and to the whole littoral system
- shared by regional Structures operating within knowledge development, planning, programming, managing, interventions implementation, in coastal protection field
- easy usable by other local stakeholders operating on the coast (Municipalities, Port Authorities, local operators)
- transferable, as a model, in other territorial context, national and European coastal regions.

ACKNOWLEDGEMENTS

We are grateful to the COASTANCE project regional work group.

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COASTAL EROSION ANALYSIS: NEW INDICATORS TO SUPPORT LITTORAL MANAGEMENT IN THE EMILIA-ROMAGNA REGION

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KEY WORDS: coastal indicator, evolutionary trend,erosion, management, integrated analysis, protection procedure performance.

INTRODUCTION

The Emilia-Romagna coast is a narrow strip of low sandy beach 130 km long.

A significant part of this littoral is artificially protected by the erosion that started to affect the beaches in the second half of the 20th century. In order to study the beach dynamic processes and the effects of protection structures, since 1983 Arpa Emilia-Romagna periodically surveys the regional coast through monitoring networks (Preti et al., 2008).

This paper presents new indicators which describe the evolutionary trends of the Emilia-Romagna coastal system in a simple way, starting from the whole set of data collected by Arpa.

The basic criterion of this indicators is the integrated analysis of all available information about:

- beach volume changes,
- subsidence,
- nourishment volume,
- withdrawl volume,
- coastline trend,
- hard structures state.

An integrated analysis is fundamental for the correct study of an artificial coast such as the Emilia-Romagna littoral, where changes in beach volume or in coastline features can result both from natural processes and from artificial procedures. Information about hard coastal structures are important too. They change the morphological features of the beach and their presence along littoral has made the coastal system even more complex. For this reason, the analysis through indicators is referred to elementary territorial units called ‘cells’ (length range 0,05-10 km) characterised by homogeneous dynamics and features that are different from the adjacent littoral stretches (Preti et al., 2008).

The indicators have been defined and tested on the data set resulting from the last two available surveys of 2000 and 2006. We will apply them also to the 2012 survey still in progress.

THE ASPE INDICATOR

This indicator is a fundamental analysis tool of the Littoral Cells Information and Management System (SICELL) of the Emilia-Romagna Region developed in the EU Coastance project (Regione Emilia-Romagna, 2011).

It describes the evolutionary state of the coast in terms of erosion, stability and accumulation trends. ASPE considers all the data set above and shows the real state of the beaches if protection procedures had not been carried out. ASPE provides four classes (Fig.1) starting from a sand volume variation threshold of 30 m^3/m referred to six years (the period between the last two available regional coastal surveys of 2000 and 2006) and taking into account the coastline trend too. In addition, to distinguish cells in accumulation and erosion, ASPE recognizes littoral stretches naturally stable from those where a precariuos balance is maintained by protection works.

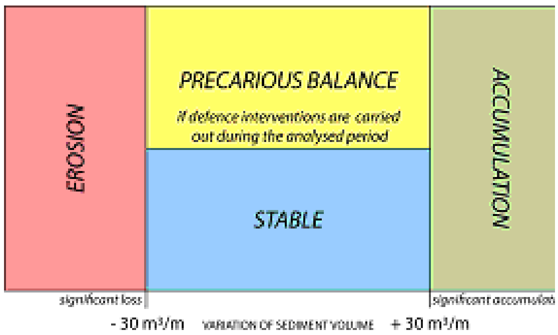

Figure 1 – The 4 ASPE classes.

THE ASE INDICATOR

Like the ASPE indicator, ASE describes the evolutionary state of the coast in terms of trend to erosion, stability and accumulation but, unlike the first one, the aim of this indicator is to assess the state of the regional littoral produced by the mitigation works. For this reason ASE does not take neither sand nourishment volumes nor hard structures presence into account (Arpa ER, 2012). The indicator provides three classes showed in Figure 2.

The concept expressed by this indicator looks like those of the coastline fluctuation, but the main difference is that ASE is based on data volume, so it can be machted with ASPE. The indicator provides some preliminar information about the general effect produced by the regional coastal policies, that are evaluated through the following indicator.

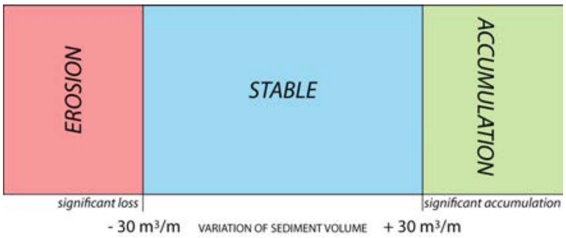

Figure 2 – The three ASE classes.

'THE EVALUATION OF EFFECTS PRODUCED BY DEFENCE PROCEDURES' INDICATOR

This indicator evaluates the effectiveness of defence policy on the Emilia-Romagna coast in order to find suggests for improvements (Arpa ER, 2012).

The indicator is applied only to those beaches where defence works have been carried out in the investigated period. By using this indicator it is possible to realise, for example, if the nourishment volume used is enough to assure the beach balance, or if a new hard structure had a good performance.

This evaluation is based on the comparison between ASPE and ASE, namely matching the beach state without protection procedures with the beach state resulting from defence measures. The indicator foresees three possible behaviours to defence works (Fig. 3):

- an improvement of the beach state;
- no changes in the beach state;
- a worsening in the beach state.

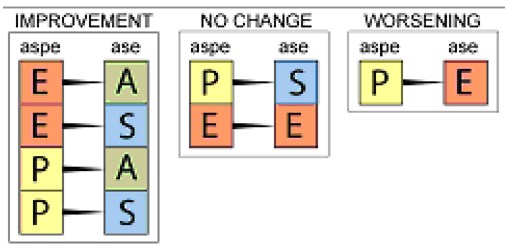

Figure 3 – The three possible situations led by defence works.

STATE OF THE COAST AND DEFENCE SYSTEM PERFORMANCES

On the basis of the last available coastal survey (2006) compared with the previous one carried out in 2000, ASPE analysis shows that 48% of the regional coast is in critical conditions: 33 km are in erosion and 23 km are in precarious balance (Fig. 4). But on the other hand, as shown by ASE indicator, thanks to the Emilia-Romagna regional defence policy mainly orientated towards nourishment, only 15% of the beaches are still in erosion. Focusing analysis on cells where interventions have been carried out during the six years investigated, the data show that nourishment has produced a general beach improvement. Only in a few cases no changes are noticed. Finally, the three indicators can be used as supporting tools for the management system of the regional coast, because they are able first to define where defence works are needed, then to evaluate the coastal defence system performance and finally to suggest improvements for the coastal protection.

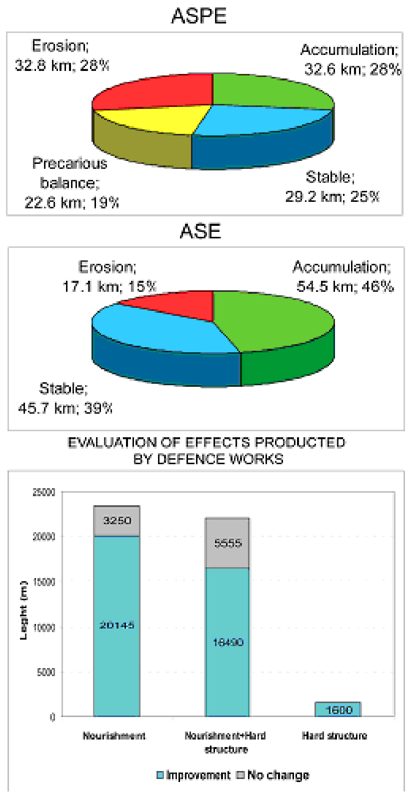

Figure 4 – The three possible situations led by defence works.

ACKNOWLEDGEMENTS

We are grateful to the Soil an Coast Defence and Land Reclamation Service, to the Coastal Basin Technical Services and to the Geological Seismic and Soils Services of the Emilia-Romagna Region that contributed to the definition of the ASPE indicator. Thanks are also due to the Monitoring and Environmental Reporting Unit of Arpa Emilia-Romagna.

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A SIMPLIFIED METHODOLOGY FOR THE EXTIMATION OF WAVE RUNUP ON ARMOURED RUBBLE SLOPES FOR VULNERABILITY ASSESSMENT

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KEY WORDS: rocky armour, coastal protection.

INTRODUCTION

The Emilia-Romagna coastline is exposed to the negative effect of marine storms and, in particular, to the erosive effect of high water levels due to the combination of storm surges and spring high tides (Armaroli et al., 2011). The regional coastline is characterised by the presence of different environments such as natural areas with dunes, urbanised zones protected or non-protected by defences, river mouths, coastal lagoons and marshes. More than 30 km of the coastline are eroding while there are sectors that are stable and/or in accretion (Calabrese et al., 2010). About the 60% of the coast is protected by hard defences (Perini et al., 2008) that have many different configurations and orientations with respect to the shore.

The effect of marine storms on the coast and the interaction between waves, surges and defence structures is a crucial point in order to understand how a storm will affect the shore. The Geological Survey of the Emilia Romagna region has produced, in cooperation with the University of Ferrara, a vulnerability mapping of the whole coastal area considering the effect of significant storms occurring at the same time as high water levels (surge + tide, see http://cm.regione.emilia-romagna.it/ambiente/geologia/cartografia/webgis-banchedati/sistema-informativo-mare-costa). The vulnerability assessment was done for unprotected and protected areas following the methodology of Armaroli et al. (2007) and Armaroli et al. (2009). The zones protected by rubble mound slopes were firstly excluded from the analysis. The present study describes the simplified methodology applied to calculate the runup elevation on rocky armoured slopes, located on the coast near Volano and the Reno river mouth in the Ferrara province (blue dots in Figure 1), to evaluate the vulnerability from flooding of the low lying areas placed behind them.

METHODS

The armoured slopes are locally made of sand and/or earth embankments covered by geotextile and by a single layer of natural irregular limestone rocks. To assess the runup elevation several information were used. The elevation and slope of the embankment were extracted from a 2008 Lidar flight along 15 profiles spaced 500 m (same methodology applied for the vulnerability assessment of the whole coastline, see for example Armaroli et al., 2007). The water depth at the toe of the structures and the slope of the seabed in front of the embankment was derived from a bathymetric survey carried out in 2006 by the Emilia-Romagna Region (ARPA, 2008). The information of the deep water wave height and period, that define the stormy conditions, were derived from the literature (Table 1; Idroser, 1996).

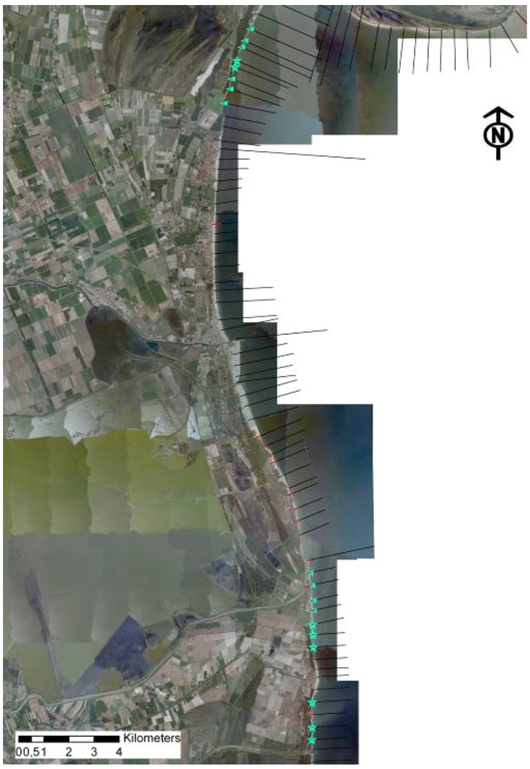

Figure 1 – Study Areas, OrtoAGEA 2008 flight.

Two different formulas were compared to calculate the runup: EurOtop (http://www.overtopping-manual.com/) and Coastal Engineering Manual.

Moreover the results obtained with the empirical formulas were compared to S-Beach model runs (Larson and Kraus, 1989) using the same data used for the simplified computation. The last comparison was done along three profiles representative of the mean conditions of the two areas.

Return period	T1	T10	T100
Hs (m)	3.3	4.7	5.9
Ts (s)	7.7	8.9	9.9
Surge (m)	0.85	1.039	1.28

Table 1 – Deep water wave conditions and surge levels for the 1-in-1, 1-in-10 and 1-in-100 return periods.

The maximum water level for each scenario calculated as runup elevation plus surge level plus high tide for each return period was used to define if the study area is vulnerable to extreme events or can be considered less exposed to marine storms. The definition of "vulnerable" and "non vulnerable" was done through the direct comparison between the maximum water level and the freeboard elevation of the rocky armoured slope. If the maximum water level is below the freeboard of the slope, the section is considered "safe" from flooding and consequently less vulnerable ("profile intersection"). If the water is below the freeboard but reaches an elevation that is very close to the crest of the slope (≤20 cm from the crest) the effect of the scenario on the profile is defined as "high probability of overtopping". Finally, if the maximum water level is higher than the freeboard, the effect is defined as "overtopping and flooding".

RESULTS AND DISCUSSION

The comparison between the two formulas with the S-Beach model results revealed that the CEM formula underpredicts the runup elevation. The consequences of the three scenarios using the EurOtop formula are listed in Table 2. It is clear that there are areas that are vulnerable even to the T1 event, that is not considered as an exceptional storm. This means that there are stretches of coast that are protected by structures that are no more capable of preventing inundation and damages to the low-lying areas placed behind them. On the contrary, there are profiles that are safe even from the T100 event, meaning that the coastal protections are very effective. These sections are located close to the Reno river mouth and have high freeboard elevation (around 4 m).

Return period	T1	T10	T100
Profile intersection	53%	27%	20%
High probability of overtopping	0%	13%	0%
Overtopping and flooding	47%	60%	80%

Table 2 – percentages of the effects of each scenario on the study sites (15 profiles).

CONCLUSIONS

The importance to define a simplified method to evaluate the runup elevation on coastal structures is crucial for management purposes. The rapid and simple calculation described above gives to coastal managers a tool to understand how the defences react to extreme events without the need to run numerical models that require expert competences and a considerable amount of time to setup the grids and to calibrate the code.

The present study reveals that there are defences that are still effective as coastal protections while others may need maintenance and/or to be reconstructed according to different standards. Moreover, it is fundamental to know which are the protections that are able to defend the coast and to prevent flooding in the perspective of global climate change and the consequent sea level rise.

ACKNOWLEDGEMENTS

We are grateful to Prof. Diego Vicinanza for the precious suggestions and to Ing. Massimo Tondello and Ing. Silvia Bellotto for the productive discussions. Thanks also to Prof. Paolo Ciavola and to Paolo Luciani.

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EVIDENCE OF SEA-STORMS IMPACTS ON THE PHREATIC COASTAL AQUIFER: THE CASE OF CESENATICO

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KEY WORDS: phreatic coastal aquifer; piezometric level; electrical conductivity; sea-storm; wave height.

INTRODUCTION

In the coastal area of Emilia-Romagna Region the unconfined aquifer is characterized by the proximity of fresh waters of continental and meteoric origin and the sea water.

The dynamics of these groundwaters are rather complex (Post V.E .A 2005) and any change in the interface between fresh and saline waters (F/S interface) could have negative effects on the delicate coastal ecosystems.

In this paper we present the first results of the piezometers monitoring at Cesenatico's beach area that highlights the possible influences of the sea-storm on the water quality and water table of the phreatic coastal aquifer.

METHODS AND RESULTS

In the study area the coastal unconfined aquifer is an outcropping sandy strip, parallel to the shoreline, consisting of strand plain deposits, with a thickness of about 8 meters and an inland extension of approximately 1 km (Bonzi et al. 2010). The piezometer analysed is located in Cesenatico (*Ex Nuit area*) at a distance of 100 meters from the shoreline and it is 8 meters deep; and filters the entire thickness of the aquifer.

The piezometer was equipped with a probe with sensors, placed 4.5 meters depth from ground level – corresponding to the F/S interface -, for the monitoring of electrical conductivity, temperature and position of the water table.

The measures, started in June 2011, are hourly, and are currently in progress. The data on wave height are referred to the Nausicaa buoy (http://www.arpa.emr.it/sim/?mare/boa), situated in front of Cesenatico where the seabed is 10 meters depth. Wave height data are collected every 30 minutes, from the ARPA (regional environmental protection agency) monitoring network.

In the monitoring period (1 August 2011-20 October 2011) there were two episodes of major sea-storm (September 20, 2011 and 6-9 October 2011) with a maximum wave height of 1.79 meters registered on 20 September 2011, with a sea level of 0.52 recorded by tide gauge at Porto Corsini; in association with the storms event, weak precipitation occurred. Figure 1 shows the data log of the piezometer during these particular events.

The values of EC and the groundwater level both underwent a temporary decrease due to the action of neighboring well-points (Esca and Venturini, 2006) that extracted salty waters from the bottom of the aquifer, from September 8 and for all period considered. For that reason, the F/S interface dropped down and the probe were then located within the fresher water.

During the storm events (20 Sept. and 6 Oct.) this trend was interrupted by a relative rise of groundwater level and by a even more marked rise of the EC.

That caused the occurrence of a strong hydraulic gradient due to a lowering of about one meter of the water table due to the well-points (from -0.5 to about -1.5 m m.s.l.) and a sea level rising more than 0.5 m m. s. l.

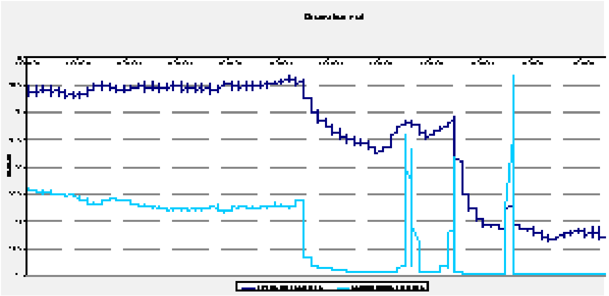

Figure 1: water table position (dark blue line) and EC value (light blue line) at the probe, from 1 August to 20 October.

The impact of sea-storm is particularly evident by comparing the groundwater data with the trend of the wave height.

With regard to the water table level, we observe that, throughout the course of the storm of September 20, it rise rapidly of about 40 cm and continues to rise more slowly (20 cm) during the next 48 hours. For the next hours it's remained constant, except for some minor increases still connected to the secondary peaks of the wave height (figure 2).

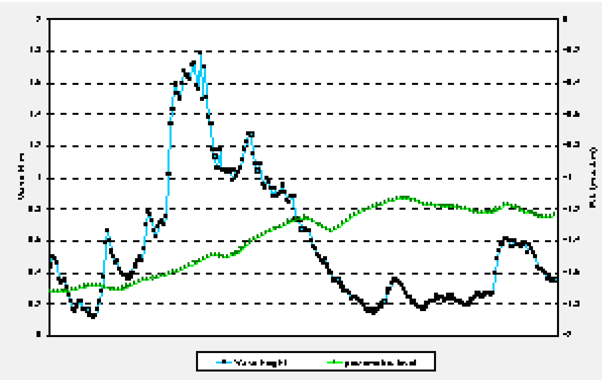

Figure 2: comparison between the Nausicaa buoy data (wave-heght) and piezometric level, (from 19 to 23 September 2011).

Considering the electrical conductivity, it can be noted, comparing the EC log and the wave height about the event of 20 September 2011, that during the peak of sea-storm does not have variations in the value of EC, probably because of the probe position, while a significant increase of conductivity values from 0.82 mS / cm to 25.75 mS / cm (), takes place in a period of 48 hours, in correspondence of the higher position of the water table (Figure 3).

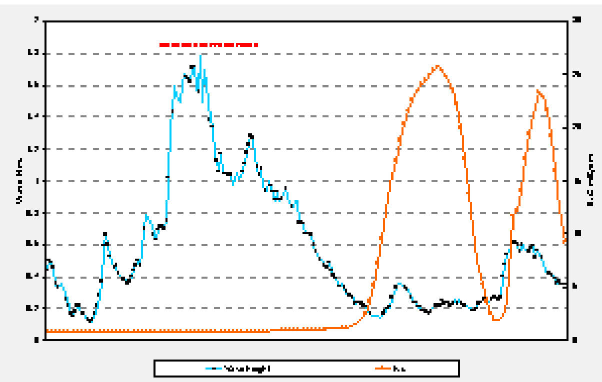

Figure 3: comparison between the Nausicaa buoy data (wave height) and EC, (from 19 to 23 September 2011).

CONCLUSION

Continuous monitoring of the Cesenatico La Nuit piezometer has showed a direct response of unconfined aquifer to sea-storm events, especially the wave and then the set-up on the shore. The rising of the water table is concomitant with increase of the wave height and is influenced by the increased hydraulic load by the sea. An important mass transfer of marine water must be considered because of a strong increase of the EC values and the stability of the groundwater level after the main pulse of the sea-storm.

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PAST, PRESENT, AND EXPECTED HYDRO-MORPHOLOGIC EVOLUTION OF THE BAHIA DE SAMBOROMBON (ARGENTINA) BY REMOTE SENSING DATA

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KEY WORDS: remote sensing, coastal hazard, hydro-geomorphology, SLR, Rio de La Plata.

INTRODUCTION

Hydro-geomorphologic setting of coastal areas is the result of complex interactions between marine and continental processes. Lowland morphologies make coastlands the zones at highest hydrogeological risk because of flooding, land subsidence, and saltwater contamination (e.g., Pousa et al. 2007). As many studies have predicted a significant increase of eustacy, sea level rise (SLR) is the most relevant problem affecting coastal lowlands.

The wetland of the Samborombon Bay (Argentina) is a Ramsar natural reserve affected to periodic floods due to rainfall, runoff, tidal fluctuations, and storm surges. In this work, we show preliminary results of a project aimed at understanding the effect of expected SLR scenarios on the hydro-morphologic setting of the Samborombon Bay. In particular, the outcomes of the first step of the research, i.e., the remote sensing analysis, are illustrated.

GENERAL SETTING

The Samborombon Bay stretches along 180 km of coastline on the outer estuary of the Rio de la Plata (Fig. 1). The bay is characterized by microtidal regime where marine water penetrates into the Rio de la Plata mouth. The coastland consists of salt marshes and wetlands whose width varies from 100 m to 15 km, in the northern and southern sectors, respectively. The coastal plain is formed by Pleistocene and Holocene sediments. Loess deposits occur in the western plain and shell ridges are located parallel to the coastline. Coastal sector shell ridges gradually thin and pass to small isolated outcrops of aeolian sandy layers to the south. Fluvial deposits are restricted to the plains crossed by of the rivers flowing into the bay.

From the hydrologic point of view, the bay forms the eastern boundary of the depressed area of the Salado River. The coastal plain is characterized by a very mild slope and extremely low morphogenetic potential that makes runoff difficult. In order to mitigate the effect of frequent prolonged flooding occurring in wet periods, a regional drainage network was constructed. Soils and groundwater are highly salinized. Freshwater reserves are scarce and occur only in lenses located inside shell ridges and thin sandy layers: their availability is strictly connected to the amount of local rainfalls, which are their only recharge.

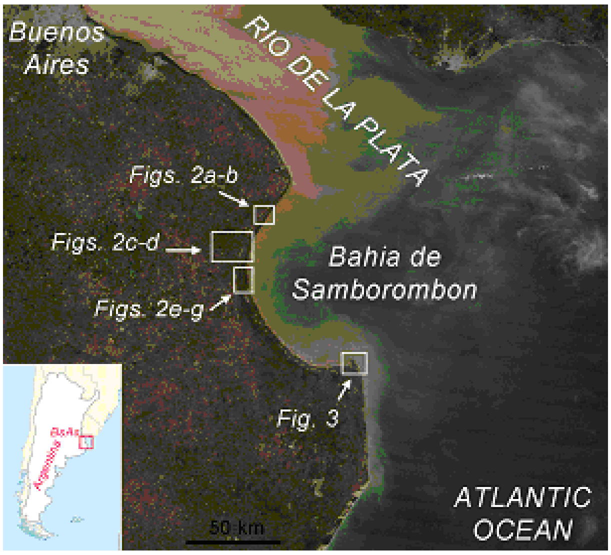

Figure 1 – The Samborombon Bay (Image courtesy of MODIS *Rapid Response Project at NASA/GSFC).*

1972-2011 MORPHOLOGIC EVOLUTION

Satellite images acquired with the same tidal levels were selected and compared to perform the morphological analysis. The available dataset considers the period between 1972 to 2011. In the northern sector, along the coastline no significant morphological modifications in the marshland occurred over the last three decades. However, since the '990 the ancient shell ridges have been seriously damaged by excavation for mining purpose (Figs.

2a-b). In the central sector, the construction of the Ancillary canal of the Salado River in 1987 (Figs. 2c-d) accelerated the water and sediment discharges into the bay leading to morphologic changes along the coastline (Figs. 2e-g). In the southern coastal plain tidal creek network maintained its shape and extension, whereas a small retreat of the coastline was detected along the southern bay margin (Ajo River mouth). Significant morphologic changes occurred in the Punta Rasa spit (Figs. 3a-b).

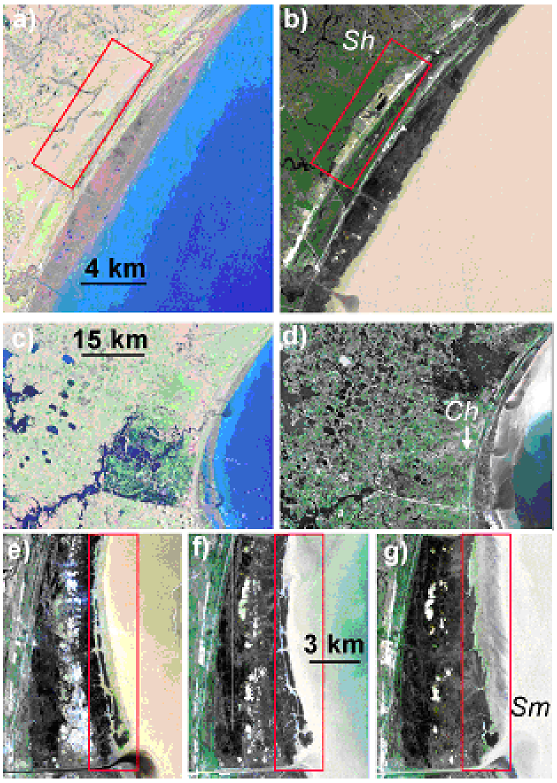

Figure 2 – Examples of man-induced morphologic evolution detected by Landsat images a) 09.1987, b) 09.2009, c) 01.1986, d) 09.2001, e) 09.1987, f) 10.1996, g) 09.2009. Sh: Shell excavation, Ch: ancillary canal. Sm: salt marsh aggrading.

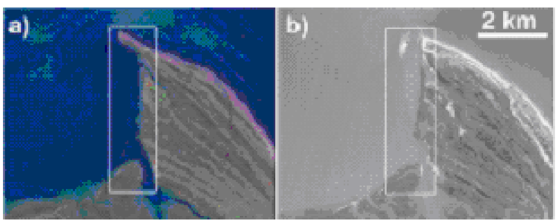

Figure 3 – Examples of natural morphologic evolution detected by comparing a) the Landsat image, 01.1986 with b) the INPE CBEC image, 08.2009.

EXPECTED HYDRO-MORPHOLOGIC SETTING OF THE COASTAL PLAIN IN 2100

SLR is expected to affect the Samborombon coastland in two main ways: permanent changes of the hydro-morphologic setting and the temporary extreme flooding events due to the 'sudestadas' (a strong occasional south-eastern wind). The former is related to the long-term water level rise, yielding progressive permanent coastline retreat, lowland flooding, groundwater and soil salinizations. The latter is triggered by anomalous 3-4 m storm surges due to 3-5 day long meteo-marine events whose effects seriously impacts on built-up areas and human activities.

Taking into account SLR scenarios of 12, 50, and 300 cm resulting from the past sea level rise in Buenos Aires, the IPCC mid-term scenario, and the 5-year return period of 'sudestadas', respectively, the flooding extent during an astronomic mean high tide at the end of the 2100 has been simulated. To do this, the digital elevation model (DEM) obtained by the Shuttle Radar Topography Mission (SRTM), ad hoc calibrated/validated for the study area, has been used.

Results clearly show that the tidal flats and marshes are expected to be permanently submerged (Fig. 4). The extent of the affected areas significantly varies according to the latitude, with the worst situation expected in the southern zones, where the sea could encroach up to 30 km inland. According to this prediction, a serious reduction in the volume of freshwater reserves is expected with a significant decrease of the thickness or freshwater lenses. In the southern sector, SLR will be able to contaminate the whole fresh groundwater lens located in the sandy ridges.

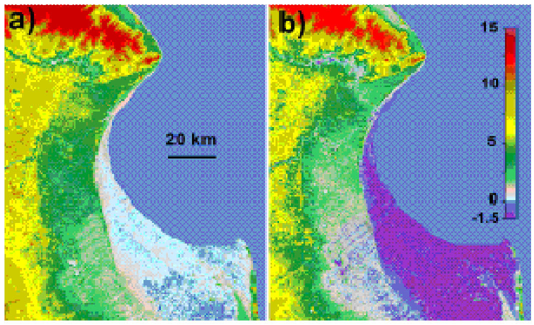

Figure 4 – a) DEM of the present setting; b) simulation of 50 cm SLR with 1m high tide at the end of 2100.

ACKNOWLEDGEMENTS

Research supported by the CNR-CONICET, Programme 2011-2012, Project "Fresh- saltwaters in high-value coastlands: from the hydrogeophysical /geochemical characterization of the present interactions to the modeling quantification of the expected effects of climate changes". Landsat images: USGS's EROS Center. SRTM: USGS/ NASA and CIAT. CBEC: INPE.

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CHARACTERIZING THE SALTWATER EFFECT ON SOIL PRODUCTIVITY BY WORLDVIEW-2 IMAGES. THE SOUTHERN MARGIN OF THE VENICE LAGOON, ITALY

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KEY WORDS: remote sensing, saltwater contamination, soil productivity, Venice.

INTRODUCTION

Salt accumulation in coastal soils is strongly affected by water dynamics in unsaturated and saturated zones. Rainfall and irrigation promote salt leaching contrasting the effect of upward flux from saline groundwater. Salinization degree and soil productivity depend by the final equilibrium between these two contrasting processes. This dynamic has been investigated in a farmland close to the Venice Lagoon, Italy. Indeed, the Venice watershed includes a very precarious coastal environment subject to both natural and anthropogenic changes with a significant and economically important fraction of the coastal farmland presently below mean sea level. In the hydrogeological context of the Venice coastland, a large risk of saltwater contamination characterizes the southernmost area because of the geomorphological setting of the coastal plain.

Within the framework of the GEORISK Project funded by the University of Padova, a 25-ha basin cultivated with continuous maize was chosen to evaluate the effects of saltwater contamination on soil quality and crop production.

MATERIALS AND METHODS

The study area (Fig. 1) is located in Ca' Bianca, approximately 5 km from the Adriatic Sea and right at the southern margin of the Venice Lagoon. The ground elevation ranges between 2 and 3 m below the mean sea level.

On 2010 the basin was sampled in 120 points up to 1.2 m depth. Soil salinity (EC 1:2) and the main physical-chemical properties (e.g. texture, organic carbon, cation exchange capacity, exchangeable cations) were measured. Maps of the apparent electrical conductivity (EC_a) at three different investigation depths (0 - 0.75 m; 0 -1.50 m; 0 - 6.00 m) were also obtained in April 2010, April 2011 and September 2011 with a CMD electromagnetic conductivity meter (GF Instruments) associated to a DGPS.

Physiological crop parameters, in particular in situ leaf reflectance (SpectraScan, Photo Research) and leaf ions content were monitored across the study area in 2010 and 2011. NDVI maps were obtained in three dates per crop season by proximal sensing using an active spectral radiometer (Crop Circle, Holland Scientific).

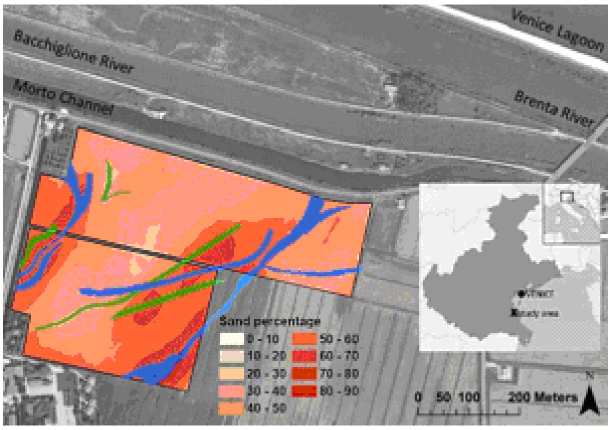

Figure 1 – The study area with the distribution of the topsoil sand content and the trace of the paleochannels (well- and poorly-preserved in blue and green, respectively).

Moreover, two WorldView-2 (WV-2) multispectral images were planned and acquired at the end of July 2010 and the beginning of July 2011. WV-2 provides 2 m resolution, 8-bands multispectral imagery between blue and near-infrared (400 - 1040 nm). After radiometric and atmospheric correction, vegetation indices (VIs) were derived from the spectral bands (Poss et al., 2006). A supervised classifica tion method, Spectral Angle Mapper (SAM) (Kruse et al., 1993), was also applied to WV-2 scenes for mapping the yield variability. SAM maps were generated on the basis of 4 spectral regions of various crop status extracted directly from images for the known ground targets.

Finally, maps of the crop yield were obtained at the end of the growing seasons by a yield mapping system mounted on a combine harvester.

RESULTS AND DISCUSSION

The various analyses described above were used to draw thematic maps. The maps show that soil is characterized by a high areal and depth heterogeneity (Scudiero et al., 2011) both due to the geomorphological setting of the area: the southern margin of the Venice Lagoon is crossed by ancient river beds (paleochannels, Fig. 1) where sand content prevails (Rizzetto et al., 2003). Due to the high permeability facilitating the horizontal groundwater fluxes, paleochannels hydraulically connect the farmland with the Venice Lagoon and the major rivers (Teatini et al., 2011).

The field surveys demonstrated that soil salinity was the main factor affecting the crop production in the study area. Nevertheless, maize was also apparently affected by water stress in some zones of the study site, where the sand content in the top layer (0-45 cm) was higher than 75% (i.e. in some portions within the paleochannels).

Although the maize yield in 2010 was significantly lower than in 2011, the spatial distribution of high- vs low-yield zones remained unchanged in the two years confirming the strong impact of the soil conditions (Fig. 1 and Fig. 2a) on the productivity (Fig. 2b).

VIs and SAM maps obtained from WV-2 images, as an indirect measure of plant vigour and abundance, allowed to highlight the zones of high and low production. VIs identifies the areas of low maize yield, providing a possible tool for the farmers in order to optimize the management practices. However, VIs were not able to distinguish between the different kinds of crop stress. The SAM classification clearly identifies the presence of weeds if clustered in a vast zone, but it is not able to discriminate between salinity stress and water stress. More research is needed to evaluate SAM technique and improve the results for deriving yield and crop information.

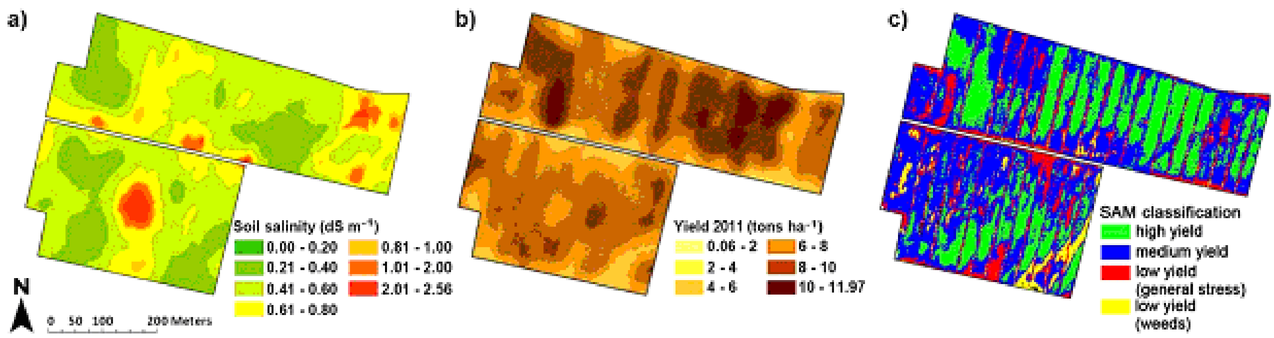

Figure 2 – a) topsoil (0-45 cm) salinity ($EC_{1:2}$); b) maize yield and c) 4-class supervised SAM classification in 2011. Regions of interest based on ground truths.

ACKNOWLEDGEMENTS

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CORRELATION BETWEEN HYDROCHEMICAL FACIES AND DEPOSITIONAL ENVIRONMENTS IN A SALINIZED LOWLAND COASTAL AQUIFER (FERRARA, IT).

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KEY WORDS: groundwater, salinity, deltaic and strand plain deposits, redox processes.

INTRODUCTION

The increasing demand of freshwater in coastal areas has intensified the research on saltwater intrusion in coastal aquifers (Custodio, 2010; Post and Abarca, 2009). However, land-use activities can lead to a relevant deterioration of coastal water resources and ecosystems (Lambrakis and Kallergis, 2001; Antonellini et al., 2008). In addition, in lowland sedimentary areas the problem of saltwater intrusion is greatly enhanced by land reclamation which forces seawater to intrude the coastal aquifers (Gattacceca et al., 2009). In order to understand the hydrogeochemical processes occurring within a groundwater system is also necessary to define the contribution of water-sediment interaction (Gaofeng et al. 2010) and to relate the groundwater quality to the sediment through which it passes. Thus, in this study we compared the depositional environments and the groundwater hydrofacies to delineate possible water/sediments interaction mechanisms.

STUDY AREA

The study area is the coastal aquifer of Comacchio (Ferrara, Italy), in the southeaster part of the Po River Plain. The Holocene geomorphic evolution of the area has been controlled by continental (Würmian) and marine deposition (post Würmian transgression) in a coastal environment of the Po Plain (Amorosi et al., 1999; Bondesan et al., 1995). Above the Pleistocene alluvional-plain deposits, the Flandrian transgressive phase (18–5.5 kyear) deposited back-barrier fine-grained deposits and transgressive barrier sands. Today the alternation of highs and lows in the topography corresponds to different coastlines and to different stages in the evolution of the Po Delta.

In this coastal aquifer four piezometers located along a flow line were selected to monitor the groundwater quality. These four piezometers are part of the regional monitoring network of the coastal aquifer, developed by the Geological Survey of the Emilia Romagna Region (Bonzi et al., 2010). The selected piezometers are aligned along fore-stepping direction of Holocene Po Delta system. The sedimentary sequence is characterized by transgressive bay and barrier deposits at the base and prograding sandy deltaic lobes and strand plains at the top; locally, coastal plain fine deposits overlay sand bodies making the aquifer semi-confined.

MATERIAL AND METHODS

All piezometers of the regional monitoring network have 5 cm inner diameter and are fully screened. In two boreholes, P33 and P34, core samples were collected every meter or when a change in stratigraphy was recognized. Samples were stored in a cool box at 4 °C and immediately transported in laboratory for sediment analysis.

Groundwater samples were collected every meter from the four piezometers, by using an 800L straddle packers system (Solinst, Canada). The samples were collected via low-flow technique using an inertial pump, after measuring the groundwater static level and purging the well. Then, the collected groundwater samples were filtered through 0.22 μm Dionex polypropylene filters, stored in a cool box at 4 °C and immediately transported in laboratory for analysis. Major anions and cations in groundwater were analysed using an isocratic dual pump ion chromatography ICS-1000 Dionex.

RESULTS AND DISCUSSION

The results from groundwater characterization show that the salinization is very high, with most of the samples exceeding the actual Adriatic sea salinity (≈35-38‰) with peaks of 60-70‰. These brines have been found within fine sediment layers associated with back barrier, salt-marsh and lagoonal environments. In fact, in this kind of environments salinity can be increased by evaporation processes. Once these sediments are covered by other layers and become saturated with water, the salt can be leached by dissolution processes. This is well testified for P33. Moreover, the large amount of organic matter that can accumulate in lagoonal, marsh and swamp environments, as well as in distal delta fronts and prodelta deposits lead to very reduced conditions, with sulphate reduction within the aquifer, here represented along the transect by piezometer P33 and P34. These piezometers are also characterized by a clayey plug on the top of the sedimentary sequence.

On the other hand, outcropping dune ridges and beaches correspond to recharge areas, with lower salinity with respect to the previous environments. The chronic deficit of organic carbon sources maintain these environments in nitrate and manganese reducing conditions. Here extreme reducing condition are never found (see P3 and P8 along the transect). The piezometer P8 shows both the above discussed environments along its profile. The upper part corresponds to the ancient sandy delta lobes and the lower part to the prodelta sediments. Another complicating factor is that the aquifer is stressed by a complex drainage system with many canals and ditches forming the land reclamation network. This stress creates steep vertical head gradient causing a mix of groundwater from different depositional environments. Despite of this, the horizontal fine layers greatly diminish the vertical permeability and act as a barrier to the complete mixing.

CONCLUSIONS

The study correlates the hydrochemical facies and depositional environments in the salinized coastal aquifer of Ferrara (IT). Given the structural features of this aquifer and the paleogeography of the region, saline and hyperhaline water are associated with fine sediment of back barrier, salt-marsh and lagoonal environments, relic of Holocene transgression; while brackish and fresh waters are associated with relict dune-beach systems. Organic rich fine sediment and peat layers, which are characteristic of palaeo-marsh depositional environment, contribute to sulphate reduction.

Salt accumulated in the sediment can be leached by dissolution processes and transported from the bottom to the top of the aquifer by a steep vertical head gradient that has been measured in these sediments and causes a mix of groundwater from different depositional environments.

Recognizing all these factors enhances the understanding of the salinization dynamics within shallow coastal aquifers.

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HIGH RESOLUTION SHALLOW WATER SEISMIC: A TOOL TO UNDERSTAND COASTAL LATE HOLOCENE EVOLUTION

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KEY WORDS: coastal evolution, late holocene, high resolution seismic, Adriatic.

INTRODUCTION

Natural and anthropogenic changes in coastal regions significantly affect both property and life. Scientific understanding of the mechanisms causing coastal change provides guidance for an appropriate societal response. The coastal intersection of land, sea, and air is a highly dynamic region that evolves in time and in space over a wide range of scales due to a variety of physical processes. Coastal geology encompasses both the geomorphology (the shape) of the landforms and the nature of the ancient strata that underlie our outcrop in the region. Knowledge of the geology is needed not only for understanding the controls acting on the coastal processes, but also for characterizing the processes themselves. Traditionally, only changes in bathymetric contours are used in order to decipher the shoreface changes and the storage of sediment input, but a high resolution seismic acquisition will also improve our understanding of the geologic controls to modern beach behavior and coastal evolution. Very high-resolution seismic data (Chirp Sonar profiles) was acquired along the microtidal wave-dominated littoral zone of the Emilia Romagna for a better understanding of beach evolution and to correlate surficial geology onland with evidences in unit architecture in the shallow water deposit.

DATA AND METHODS DESCRIPTION

The CHIRP sub-bottom profiler, used for acquisition, operates around a central frequency that is swept electronically across a range of frequencies from 2 and 7 kHz and improves resolution compare to other subbottom systems. The instrument is composed by a topside Benthos DSP-662 CHIRP III (DSP + Transceiver) connected with 2 transducers mounted on side of a boat. The geophysical survey was carried out in May 2010 within a jont project betwen Regione ER - Servizio Geologico, Sismico e dei Suoli and ISMAR-CNR - Bologna. Approximately 210 km of data were recorded in 4 area offshore Volano river, Reno river, Fiumi Uniti river and Savio river from 2 to 8 metre water depth. Geologic framework mapping in these shallow-water environments has provided valuable data used to:

- define modern sediment distribution and thickness
- determine underlying stratigraphic and structural controls on shoreline behavior
- enable onshore-to-offshore geologic mapping within the coastal zone when coupled with subaerial investigation techniques

LAND-SEA CORRELATION

The new Chirp sonar profiles allow the geologic recontruction with correlation on land (cfr.. Foglio 205 Comacchio della Carta Geologica d'Italia 1:50.000), and offshore (cfr. Carta Geologica dei Mari Italiani, Ravenna NL33-10). The data acquired in the unkown submerged littoral zone permit the correlation of the Po delta lobes Roman (Po Primaro) and Renaissance (Po di Volano) in age with ther correlative clinoforms offshore.

In the northern sector it's possible to recognize a building phase of delta lobes during the Roman period which ended with an abrupt discontinuity, in the Fifth Century, (limit AES8/AES8a nella Carta Geologica d'Italia 1:50.000), a subsequent erosional phase with the disruption of delta front and the progradation of a new northern distributary channel (Po di Volano). Offshore the gas prone Roman delta deposit are easly recognized laying ontop transgressive deposits and late holocene highstand units. The progradation of Volano delta lobe, VI al XVI century, is correlate on land with the sand littoral ridges and offshore with the downlapping geometry of seismic reflectors. Nearshore is recorded the most recent hystory of Volano delta front with erosional processes that are visible in beach section (fig. 1 and 3).

The recent evolution of Reno river mouth and its shift drawn in the cartographic record (1911 coastline in fig.2) is evident in the surficial seismic facies (old channels and erosional surfaces) acquired in one of the Chirp Sonar survey.

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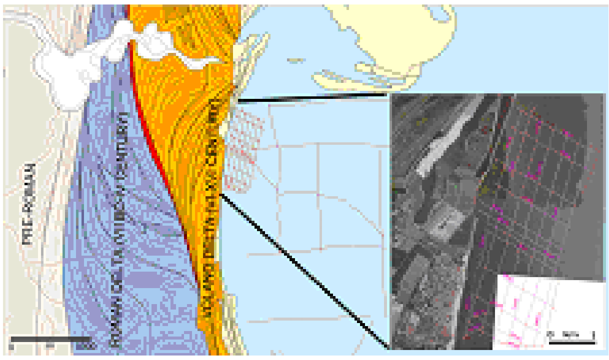

Figure 1 – Location of Chirp Sonar profiles in the historical evolution framework of the southern sector of the Po delta

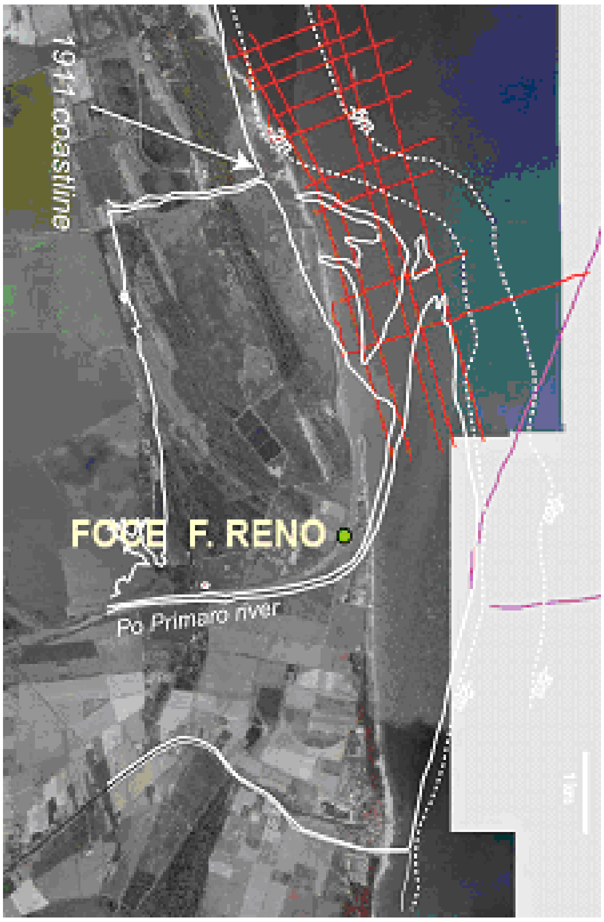

Figure 2 – Location of Chirp sonar profiles offshore Reno river mouth, in white the 1911 coastline and the

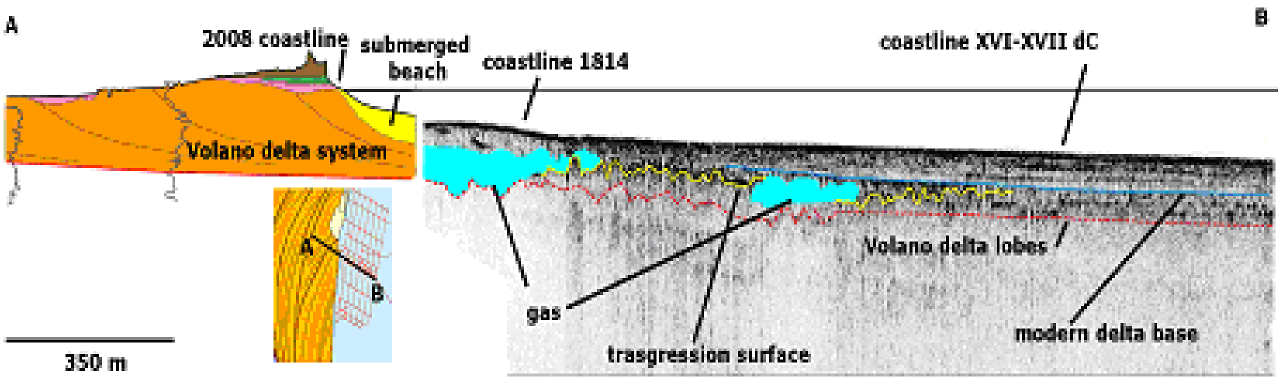

Figure 3 – Schematic section with chirp sonar profile acquired offshore Volano delta

MORPHOBATHYMETRIC AND SEISMIC REFLECTION SURVEY OF THE VALLI DI COMACCHIO COASTAL LAGOON (NE ITALY).

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KEY WORDS: Valli di Comacchio, coastal lagoons, Holocene evolution, ultra-shallow geophysical survey.

INTRODUCTION

The Valli di Comacchio coastal lagoons, in the NE Italy, are shallow, brackish water environments, formed around the tenth Century as a consequence of subsidence in the S sector of the Po River Delta, between Comacchio and the Reno River (Bondesan, 1986). Presently, the hydrodynamics is controlled by the tidal cycle and by the inflow of freshwater from several rivers and channels.

We present a geological study of these lagoons, which includes acquisition and processing of morphobathymetric and seismic reflection data in an extremely shallow water environment.

Seismostratigraphic data were integrated by available stratigraphic information and by a series of Cone Penetration Tests (CPTu).

Combined data analysis enabled us to:

a) define the present-day morphology and depositional environment of the lagoon;
b) describe variation of reflectivity at the water-bottom interface;
c) reconstruct the recent (late Pleistocene- Holocene) geo-history of this complex transitional environment, identifying the main seismostratigraphic unit;

METHODS AND RESULTS

Bathymetric data were aquired using a Datasonics PSA900, 200 kHz echosounder.

Seismic reflection profiles were collected using a Benthos ChirpIII system, with 4 transducers mounted on board of a small catamaran towed by the boat. Data were processed using SeisPrho (Gasperini and Stanghellini, 2009).

The tidal excursion was measured during the survey, and the depth soundings were positioned with an accuracy of ± 1 m using a DGPS receiver.

Morphology of the lagoons is extremely flat, if we exclude artificial dams and channels created and abandoned during the centuries.

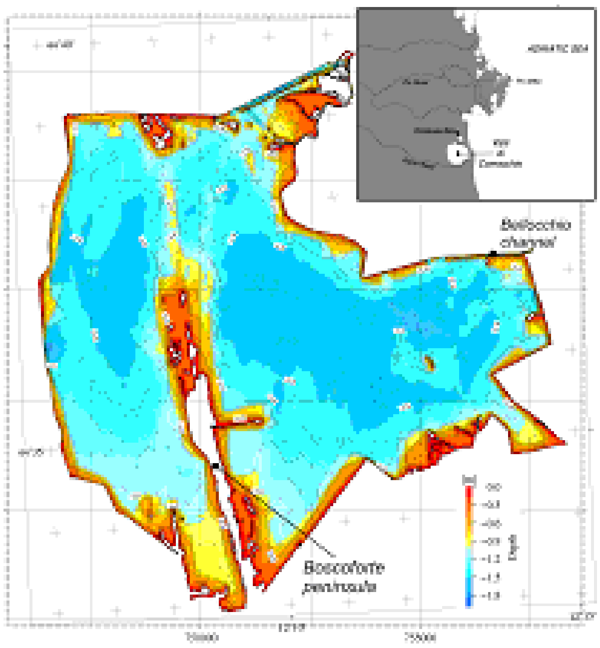

Figure 1 – Morphobathymetric map of the Valli di Comacchio coastal lagoon.

However, the signature of natural reliefs, such as sand bars or dunes is still locally visible. An example is the submerged part of the Boscoforte peninsula, that cuts into two part the lagoons and develops under the water with a series of ridges that reach the northern shore of the lagoon and create a physical separation between its eastern and western sectors (Fig.1). The acquisition of the entire echosounder sweep at each sounding point, rather than a simple depth estimate, gave us the opportunity to calculate the bottom reflectivity. We used the method developed in Gasperini (2005) to compile the map displayed in Fig. 2 (left), that shows different patterns, E and W of the Boscoforte peninsula.

Since these variations are coherent in wide sectors of the lagoon, we can deduce that they are mainly related to the mean grain size of the bottom sediments, as verified in Gasperini (2005), that appears higher in the E sector; this could be due to the fact that water (and sediment) inputs are localized mainly in the W sector of the lagoon. Moreover, the E part of the lagoons, located closer

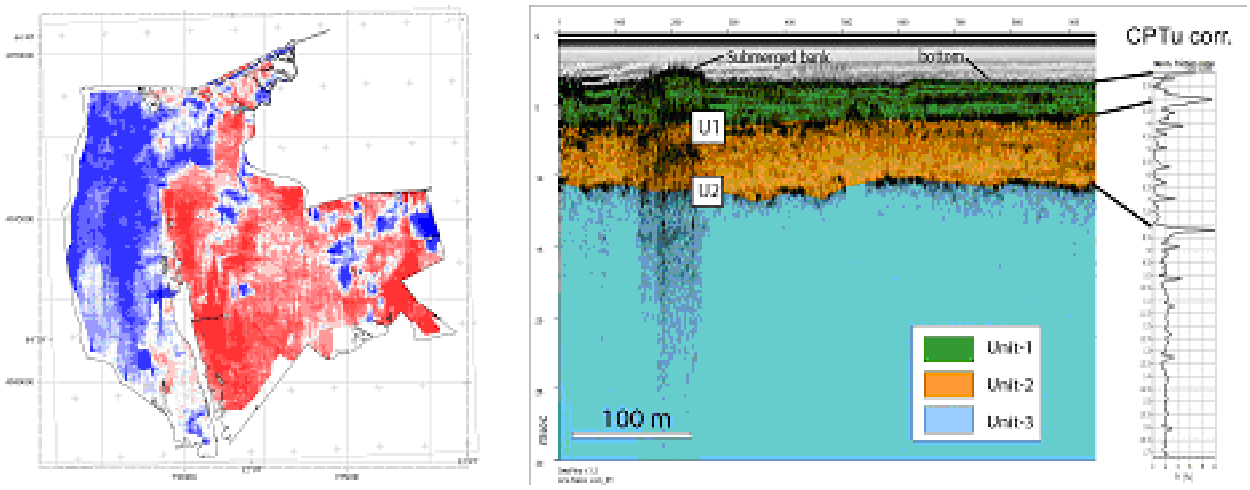

Figure 2 – Left: bottom reflectivity map of the Valli di Comacchio lagoons. Reflectivity is normalized and displayed using a color palette ranging from red (high values) to blue (low values). Right: seismic reflection profile COM_09 collected in the SE part of the lagoon, showing main seismostratigraphic units.

to the Adriatic shoreline are more prone to the aeolian sediment inputs, partially sheltered by the presence of the Boscoforte peninsula.

Seismostratigraphic interpretation, correlated with CPTu results, enable us to describe the main stratigraphic units recognize into the valley (Fig.2 right):

Unit-1, made of fine-grained lagoon deposits correspond to the recentmost deposits characterizing the present-day lagoon, mostly constituted by bioturbated mud.

Unit-2, made of alternating sand, mud and silt deposits, with complex internal geometries, may indicate a relatively high-energy of the depositional environment. The thickness of this unit is rather constant (5-6 m assuming an average P-wave velocity of 1600-1700 m/sec).

Unit-3 is made of fine grained deposits; the absence of internal reflectors indicate that it's made of very homogeneous mud, probably of marine origin. This is also confirmed by the low values of strength recorder by penetrometric test.

We correlate Unit-2 and –3 with the progradational stacking pattern of the Po Delta, and the marine prodelta deposits, respectively, that start to develop after the last episode of sealevel rise (Amorosi et al., 2002; Correggiari et al., 2005).

We found that, not to mention their naturalistic and economic interest, transitional enviroments such as the Valli di Comacchio, are important geological case studies for several reasons. First, due to constant subsidence, sedimentation is relatively continuous in time and space, resulting in more reliable chronostratigraphic records and regional correlations. Second, acquisition of geophysical data, that support geological interpretation, is carried out more quickly and at a lower cost. Finally, the overall quality of high-resolution subsurface images is improved by the presence of water, that enhances coupling between signal sources and substratum.

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CPTu test were carried out by Ing. Sacchetto, of the SPG company (Adria, RO, Italy).

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SICILY (ITALY): PRELIMINARY STUDIES TOWARDS THE INTEGRATED COASTAL ZONE MANAGEMENT

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KEY WORDS: coastal erosion, policy, beach, GIS, Sicily, ICZM, indicators, risk, management, climate change.

ABSTRACT

The Sicilian coast, stretching for 1.565 km (including small islands), is highly important for both recreational reasons and economic value. However, some of these landscapes are under threat from shoreline erosion. Indeed, 252 km (out of 750 km) of beaches are currently experiencing recurring or persistent shoreline erosion that is the result of dynamic natural processes associated with the consequences of bad land uses, in conflict with coastal environment stability. In order to preserve coastal dynamic natural processes, whilst providing a framework for a sustainable use, development and management, proactive planning and effective management strategies are required.

The Coastal Erosion Risk Plan, defined coastal PAI (Piano di Assetto Idrogeologico), is the first experience for Sicily region to lay the foundation for homogeneous studies of the coast dynamics.

Within Coastal PAI, an overall wide database has been realized, assessing the magnitude of coastal erosion in Sicily. This study uses a simple analytical methodology detecting and monitoring the trend of coastal evolution by comparing historical aerial photographs with recent images. The main analysis of the coastlines has been made using a GIS tool that allows the monitoring of erosion by creating and measuring equidistant transects (ca. every 100 metres) between the old and the recent digitalized coastlines.

A general analysis of the results, based on the data worked from 2004 to 2010, shows a predominance of eroded areas in the coast of north-eastern and southern of Sicily. The erosion's mean tax is comprised between 1 and 10 m/ year. Most areas considered to be at erosion risk are linked to different conditions:

a) coastal exposure to frequently extreme storm events;
b) some kinds of river hydraulic structures intercepting sediment transported by longshore drift;
c) some erosion control works in adjacent beaches;
d) human pressures along coastal strip;
e) seaports and structures trapping or redirecting sediments;
f) destruction of coastal dune systems;
g) some river water regulation works;
h) coastal urbanization.

The coastal PAI consists of a General Report (containing methodology, objectives and implementing rules ensuring an adequate regulation to avoid and/or minimise increasing development pressures in erosion prone areas) and 26 Plans corresponding to each of coastal sediment cell of Sicily that include:

- a detecting and mapping of areas subject to sediment fluctuations (erosion or accretion);
- assessment, analysis and documentation of the severity of shoreline erosion generating an associated risk class (from 1 to 4);
- a description of the local causes determining coastal erosion;
- a map of the existing protection works and maritime buildings and structures;
- a meteo-marine analysis;
- a description of protected natural areas;

The Analysis of the coast vulnerability, erosive phenomena, and the survey of the critical areas that put at risk population and cultural heritage represent a basic system for monitoring the coastal erosion and providing a projections of the impacts of climate change, whic is essential for the protection and management of Sicily coast and its communities.

In this report the Sicily coastal erosion data are mainly showed, and, in addition, a first group of environmental, economic and social indicators, recommended by EU Working Group, according with ICZM advices, has been calculated and mapped.

This is the first attempt by the Regional Administration of selecting and implementing a set of revealing "Indicators for Sustainable Development", consistent with the policies principles and criteria established in the European Union ICZM Recommendation (2002) that will be completed in the next phases.

ACKNOWLEDGEMENTS

We are grateful to all the temporary personnel employed in the PAI for their commitment, particularly to Task force PODIS who developed the methodology and realized the coastal erosion project.

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BENTHIC FORAMINIFERA AS A POWERFUL TOOL FOR THE COASTAL MARINE SYSTEM MANAGEMENT

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KEY WORDS: Benthic foraminifera, Bioindicators, Pollution, Marine System Management.

Coastal areas have traditionally been places of human settlement, with the accompanying development of cities, industries and other human-related activities possibly having an impact on the aquatic ecosystems. These impacts may take the form of pollution from industrial, domestic, agricultural, or mining activities; dredging or spoil dumping; salinization; sedimentation from land clearance, forestry, or road building; and the introduction of alien plants or animal species. All of these impacts can cause major ecological changes, thus assessing their effects on a regular basis becomes of paramount importance when it comes to providing an insight into the ecosystem health. Due to the high temporal and spatial variability of coastal areas, the evaluation of these impacts remains a difficult issue to investigate.

Notwithstanding, biological indicators (also called bioindicators) can be used as proxies to provide an indication of environmental conditions and, thus, within coastal marine management programs. The increasing importance of bioindicators is also encouraged within the European Union's Water Framework Directive. The directive aims to achieve a good ecological status in all European water bodies and requires the assessment of the ecological status of a system to be accomplished primarily utilizing biological indicators. Among the wide range of bioindicators, benthic foraminifera represent one of the main biotic components of marine ecosystems and are widely used for biological monitoring (Frontalini & Coccioni, 2011). Since foraminifera have short life and reproductive cycles, they react quite quickly to both short and long-term changes in marine and transitional-marine environments (Coccioni, 2000; Frontalini & Coccioni, 2008; Coccioni et al., 2009; Frontalini et al., 2009, 2010, 2011). Furthermore, many foraminiferal taxa secrete a carbonate shell which can be preserved in the fossil record and used for monitoring environmental changes over long time periods. They are generally small, highly diversified and abundant compared to other hard-shelled taxa and they are also easy to collect, providing a highly reliable database for statistical analysis even when only small sample volumes are available. Many studies from different environmental settings focused on the response of benthic foraminifera to various forms of pollution such as sewage outfalls, oil spills, trace elements and pollution related to paper and pulp mills and thermal activity.

The interest in benthic foraminifera has partly been driven by government policies and programs, which are aimed at developing suitable, non-invasive bioindicators of marine environmental quality. Although many issues are still open and are a matter of debate, foraminifera have been proven to be successful candidates as part of an integrated monitoring program and can be used within coastal marine management programs in all marine environments.

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THE TERRITORIAL SYSTEM ANALYSIS, A BASIC TOOL FOR THE INTEGRATED COASTAL ZONE MANAGEMENT PLAN OF THE SELE COASTAL AREA (SOUTHERN ITALY)

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KEY WORDS: Sele plain, coastal zone, ICZM, naturality, natural hazard, human pressure.

INTRODUCTION

The Italian coastline, stretching for approximately eight thousands of kilometers, is characterized by an incredible mixture of natural resources, social, economic and cultural heritages that are intimately linked to the coast. As in many other countries, even in Southern Italy, these resources are threatened both by natural and anthropogenic pressures that influence their availability and quality.

The coastal zone facing the Gulf of Salerno, the Sele Plain, is one of the widest alluvial coastal plains of Southern Italy (Fig.1). The historical and recent maps and the aerial photographies (Tab.1) allowed to carry out a preliminary investigation of the relation between the increase of human activities and the evolution of the coastal system.

Figure 1 – Location map of investigated area.

The topographic maps of 1870 and 1908 of Istituto Geografico Militare Italiano (IGMI) show that the coastal zone was still a natural land.

Date	Data source	Scale
1870	IGMI Topograghic Map	1:50,000
1908	IGMI Topograghic Map	1:50,000
1944	Aerial-photo	1:18,000
1954	Aerial-photo	1:39,000
1975	CASMEZ Topograghic Map	1:5,000
1984	Aerial-photo	1:26,000
1998	Campania Region Technical Map	1:5,000
2004	Ortho-photo Map	1:5,000

Table 1 – Data sources used to study the territorial sistem evolution.

After 1944, the expansion of urban zones and the thickening of the road network became significant and consequently the human activities, started to exert a significant influence upon the natural evolution of the area (Alberico et al., 2011).

At present, the Sele Plain shows a high degree of fragmentation, because of the land-use for industries, agriculture, fishing and tourism have occurred without regulations (Fig.2).

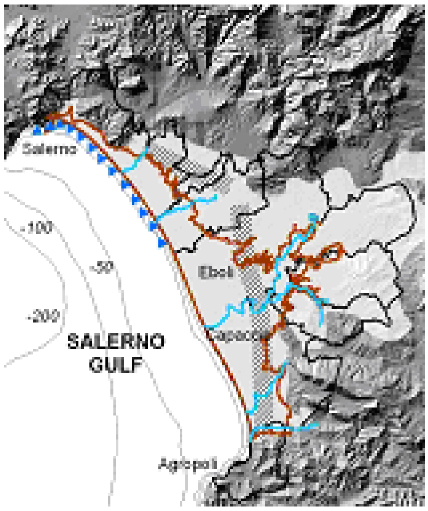

Figure 2 – Ecosystem fragmentation overview. The light gray area indicates high fragmentation, the dashed area corresponds to a multiple fragmentation, the blu triangles indicate the coastal fragmentation. From Piano Territoriale of Salerno Province (http://www.provincia.salerno.it/ptcp/), modified.

This state of art, in fact, was partly due to the lack of a defined national laws on this topic, as the one adopted in the United States in 1972, the Coastal Management Act, the first official document on Integrated Coastal Zone Management (ICZM).

The Italian peninsula counts fifteen coastal regions: among them nine have environmental management tools extended to the entire territory, six have a specific coastal defence plan and only the Emilia Romagna and Marche Regions have an approved plan for ICZM.

Basing on the recent seventh protocol on ICZM defined by the European Union (2010/631/UE) we identified, for the ten municipalities of the Sele coastal zone (Fig.1), the most important natural and anthropic features necessary to implement an ICZM plan.

THE TERRITORIAL SYSTEM ANALYSIS

The implementation of an integrated costal zone management needs to know the natural and antrophic features of environment in order to assess the state of the coastal zone and consequently promote a sustainable development of coastal and marine areas. In this preliminary study, we collect and orgnanized into a geo-database (ArcGis framework) a great quantity of environmental data, of the Sele coastal plain, published in scientific works, by Local Authority deputed to the territorial management. The availability of a well organized database and the potentiality of the spatial analysis (Connolly and Cummins, 2002; Smith et al., 2012) allowed us to evaluate for the Sele coastal plain:

- the naturality;
- the natural hazard;
- the antropogenic pressure.

Aiming at defining the degree of naturality of Sele costal plain and the promotion of its preservation, all the documents (e.g. reports, maps) published by the Local and National Authorities were considered. This analysis let us to rank the territory into different classes of naturality attributing a different weight to the land use classes, the presence of the protected zones, the fluvial and transversal corridors the fragmentation zones.

For the natural hazard assessment, scientific literature, reports of Local Authorities were considered to identify the main natural hazard affecting the study area: coastal erosion, marine inundation, river inundation, seismicity and water table vulnerability. This analysis deal with the assessment of two type of indexes: a) simple index (ranging between 0-1) for each natural hazard listed above, ranking the study area into different classes, b) synthethic index, able to explain the dangerousness characterizing the study area at municipality scale.

For the analysis of human pressure we evaluated the effect on the territory of different sources of perturbation: urban areas, intensive cultivation, agricultural crops, industrial districts, and population density. With the same methodology used for the hazard assessment we rank the territory in different classes of human activity intensity.

The synthetic indexes described above (known as “*indicators*”) were fundamental in our territorial system analysis because they give a simplified view of a more complex phenomenon. Their importance is globally recognized by many authors which report the necessity of acquiring a complete indicators set in evaluating the ICZM implementation (Henocque, 2003 and Pickaver, 2004). The preliminary analysis of spatial distribution of synthetic indexes showed that Salerno and Battipaglia municipalities are characterized by the highest human pressure due to population presence together with large industrial areas.

These municipalities represent two “*hot-spots*” in the Sele coastal plain that still shows a good degree of naturality and that should be preserved by means of an integrated management strategy to ensure a sustainable development in the next future.

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THE SEA USE GEODATABASE OF EMILIA-ROMAGNA REGION

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KEY WORDS: sea use, marine spatial planning, ICZM, Coastal Information system, Marine information system.

INTRODUCTION

Within the last decade our view of marine environment has undergone a radical transformation as man's impact on the sea has become clearer and public awareness has been heightened. The impacts on seas and coasts are driven by human activities such as fishing and aquaculture, land-based activities such as fertiliser and pesticide use in agriculture, chemical pollution from industries and shipping, and the exploitation of oil, gas and other resources. Further negative factors include the introduction of alien species, marine litter, noise, urbanisation and tourism, and the destruction of habitats for ports and off-shore structures (EEA, 2010). For that reason is important to increase the knowledge about the extent and distribution of different use of the sea in order to promote the sustainable use of marine goods and services, according to the Integrated Coastal Zone Management Protocol in the Mediterranean and the Roadmap for Maritime Spatial Planning. For this purpose the SGSS of Emilia-Romagna has developed the Coast and Marine Information System (Perini et. al., 2010) that has recently been updated with a *Sea-use geo-database.*

MARINE AREA DESCRIPTION

The Emilia-Romagna region is located in the North East of Italy and the coastal area extends from the Po river delta to the south border of the region (Gabicce headland), and has a total shore length of about 130 km. Southward the modern Po delta the coastline is a long arcuate flat and sandy coast interrupted by minor Apennines rivers and by the jetties of several harbours. In some parts the beach is over 200 metres wide, while in other parts it is completely eroded and has been replaced by sea-walls. The portion of Adriatic Sea facing the coast of Emilia-Romagna, between the Po delta and Cattolica and from the shoreline to the limit of Italian-Croatia territorial waters (Italian Platform ~65 km) is approximately 567.000 ha wide; is characterized by a uniform morphology, with a low axial gradient (0.02 °) and a depth maximum of 60 m in the south-eastern portions. The seabed Holocene sedimentary coverage is characterized by littoral sand and by a prodelta mud wedge which merges into the shelf muddy deposits. They are exposed or buried by a very thin recent silty coverage. Sandy deposits are exploited as underwater caves for shore replenishment by the Local Government.

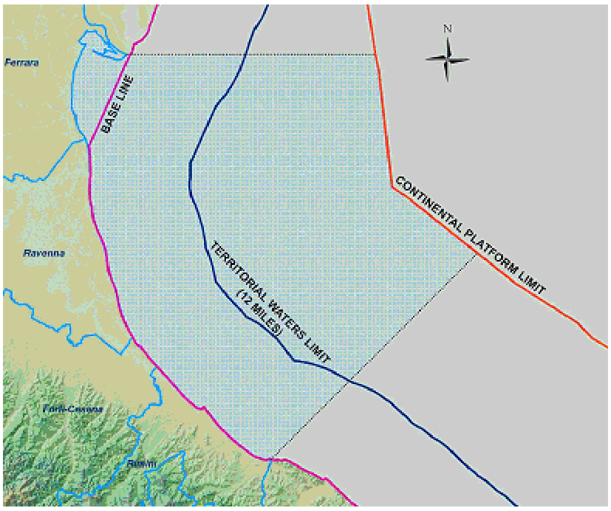

Figure 1 – Emilia-Romagna coastal and marine area

THE SEA-USE GEODATABASE

The representation of coastal and marine feature and the three-dimensional nature of water column represent a challenge for traditional geographic information systems; for this reason the SGSS is trying to readapt data type to the marine application in order to represent its dynamicity (volumetric and temporal). Despite this the first step for a correct GIS representation remain the identification of major thematic groups and the initial set of feature classes within these groups. The Coast and Marine Information System already contain several database which extend to the sea area (tab.1) and we are now working for collecting and organizing further data concerning the sea use, in particular the human impact and the human activity (fishery, tourism and recreation, shipping, defence, environmental protection etc..). We are taking contact with other Institution in order to implement the sea-use geo-database with information about the ecologic and bio-chemical status of the sea.

As a result the embryonic structure, with the data now available, can be schematically represent in table 1. The sea use map of Emilia-Romagna Region is partially represented in figure 2.

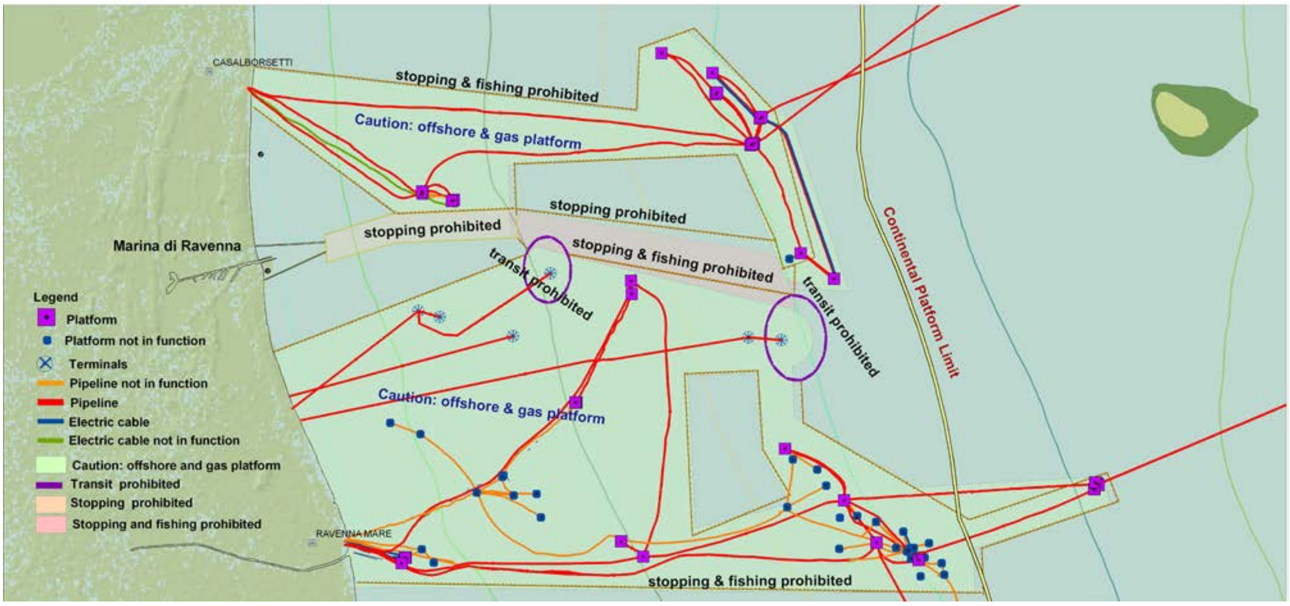

Figure 2 – Particular of the sea-use map (restriction areas, platforms and pipelines)

SEA USE GEODATABASE				
Bounda-ries	Physical characteristics		Human Use	
Territorial waters	Marine geology	Sea Temperature	Traffic separation zone	Marine protected area
Regional marine area	Seafloor classifica-tion	Wind speed/ direction	Anchor-ages	Restriction and warning
International waters limit Italy-Croatia	Type of seabed	Current velocity	Port and harbour	
	Sediment	tide	Light structures	Reclamation area
	Bathy-metry	Wave exposure	Gas Platform	Electric line
Ecology protection zone	Topogra-phy	Buoy	Pipeline	Sewer pipes
Coastal waters		Circula-tion	Aquacultu-re	Coastal defences
		Run-up	Cables	Underwater sandy caves
			Infrastructure	

Table 1 – The sea-use geodatabase at February 2012.

Any information considered is further subdivided on the basis of the sea sector involved (surface, water column, seabed and seabed background), of the coastal areas involved (lagoon, shore, wetland) and with respect to the distance of the coastal zone (onshore, offshore).

The SGSS sea-use geodatabase will be used to support the IPA-project Shape (http://www.shape-ipaproject.eu) whose aim is the development of a multilevel and cross-sector governance system, based on an holistic approach and on an integrated management of the natural resources, risk's prevention and conflicts resolution among uses and users of the Adriatic coast and sea.

It will be implemented in order to reach the project objectives of a Gis Atlas creation (WP5) to support the implementation of the Integrated Coastal Zone Management (WP3) and the Maritime Spatial Planning in the Adriatic region (WP4).

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RECONSTRUCTION OF THE LATE QUATERNARY ENVIRONMENTAL EVOLUTION OF A COASTAL AREA AND IMPLICATIONS FOR ITS PRESENT DAY ENVIRONMENTAL HAZARD: THE GORO CASE HISTORY FROM THE PO DELTA REGION

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KEY WORDS: Benthic foraminifera, Paleoecology, Sedimentology, Geochemistry, Stratigraphy, Pollution, Italy.

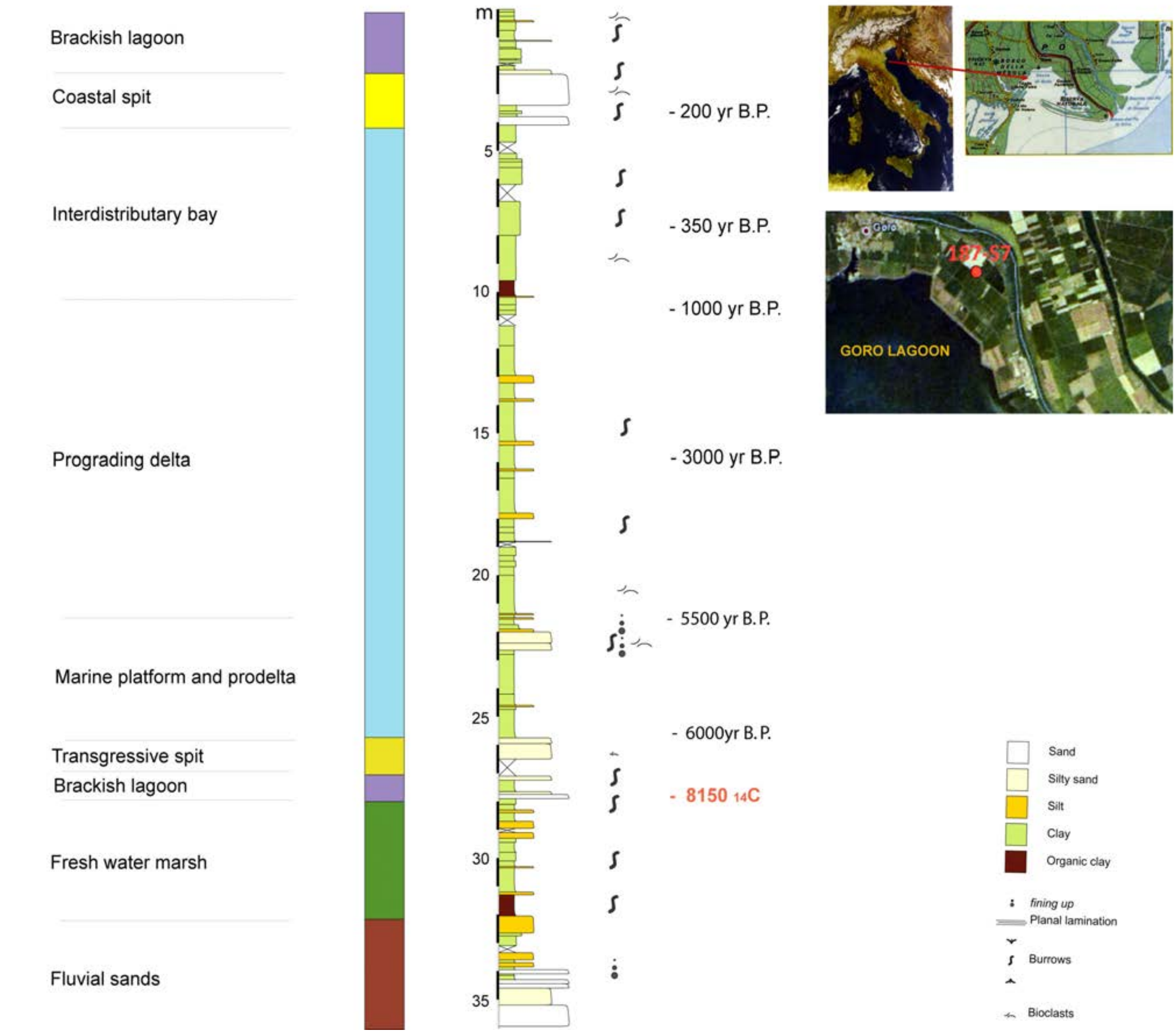
Ecological, geochemical and sedimentological research are essential for assessing and mitigating the human perturbation of present-day environmental equilibria. However, only the analysis of the stratigraphic record can support the comparison with the natural pre-anthropical values and provide the historical perspective needed for evaluating the contemporary environmental trends. The fragile Po Delta area shows a great variety of environments, inscribed to the UNESCO world heritage list and often rich in biodiversity, but subject to a growing degree of human alteration and environmental risks. At the southern edge of the Po Delta lobe, the shallow-water Goro interdistributary bay is a schizohaline biotope. The lagoon-bay area is renowned for mollusc production, but is subject to major environmental problems, such as organic and inorganic pollution, eutrophication, and the development of severely dysoxic bottom condition.

The environmental evolution of the area through Holocene times was provided by the integrated sedimentological, palaeontological, and geochemical study, and by ^{14}C dating of a continuous core (187S7) drilled in the area by the Regione Emilia Romagna. The lower portion of the core records continental (fluvial) environment associated to the last glacial low-stand. The upper ca 32 m of the core record the transgressive-regressive post-glacial evolution of the area, developed through the last 7 000 yr. Fresh water marsh mud graded into brackish lagoon deposits, capped by a ravinement surface, and by a thin level of transgressive barrier sands, with foraminiferal assemblages dominated by *Ammonia* (e.g. *A. papillosa*) and miliolids. At about 21 m, open marine clays record the maximum transgression, dated at about 5500 yr B.P. The marine muds contain diversified benthic foraminiferal assemblages and some planktonic forms, such as *Globigerina*. The regressive succession, formed by prodelta muds, grades into interdistributary bay deposits and records the progradation of several generations of laterally shifting delta lobes. Sedimentary rates were very elevated, locally exceeding 4 m per century of partially compacted sediments. The growing ecological influence of the distributary channel mouth is recorded by the transition toward schizohaline associations, again dominated by *Ammonia*, particularly by *A. beccari*. The modern delta lobe progradation was triggered by the digging of an artificial canal by the Venice Republic (1604). The lateral growth of a sand spit eventually enclosed the lagoon area, during the XIX century, and the benthic foraminiferal community became dominated by oligotypic association of opportunistic species, such as *Ammonia parkinsoniana*. The younger sediments of the Goro bay record a growing degree of ecological alteration, related to both the pollutant influx from mainland and the strong impact of the mollusc production in the lagoon area.

In the modern environment, abundant P and N nutrients are provided by the polluted continental fresh water influx, whereas the concentration of Co, Cr, Pb, V, and of other metals is often dangerously high, well above the legal limits. The stressed environmental condition is also recorded by an extremely high percentage of severely deformed benthic foraminifers, sometimes exceeding 80% of the total population, as documented by our determinations, for instance during the 2005 summer. The natural background of the geochemical values derives from the samples predating the half of the XX century. These samples record much lower heavy metal levels and a sharply reduced percentage of deformed foraminifer tests than the modern ones (normally less than 5%), documenting the extent of the human activity impact. However, the Cr concentration is high in prehistoric samples, often above the modern legal limit, due to the important contribution of ophiolitic rocks to the Po river sedimentary load. Eutrophic conditions were developed also under natural condition, but at reduced levels than the contemporary ones.

ACKNOWLEDGEMENTS

We are grateful to Renzo Tassinari for helping the geochemical analysis.


Brackish lagoon
Coastal spit
Interdistributary bay
Prograding delta
Marine platform and prodelta
Transgressive spit
Brackish lagoon
Fresh water marsh
Fluvial sands
m
5
10
15
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35
- 200 yr B.P.
- 350 yr B.P.
- 1000 yr B.P.
- 3000 yr B.P.
- 5500 yr B.P.
- 6000yr B.P.
- 8150 14C
GORO LAGOON
Sand
Silty sand
Silt
Clay
Organic clay
fining up
Planal lamination
Burrows
Bioclasts

SURFACE CIRCULATION PATTERNS IN THE GULF OF CALIFORNIA DERIVED FROM PASSIVE REMOTE SENSING IMAGERY

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KEY WORDS: Feature tracking, field vector, surface current, Gulf of California.

INTRODUCTION

Ocean surface currents play influence in the distribution of suspended and dissolved material, so the study of the ocean circulation as a dispersal mechanism is a relevant topic in Oceanology. The first estimations of the surface circulation in the Gulf of California (GC) were based on reports of drifting ships, and later estimated from hydrographic data, lagrangian measurements, and more recently interpreting satellite images and the development of numerical models (Lavín & Marinone, 2003).

The general objectives of this work were:

- To examine the potential of estimating surface velocities in the GC using a feature tracking method applied to sea surface temperature images.
- To use ocean color images in order to infer mesoscale structures.

METHODOLOGY

For this purpose a maximum cross-correlation algorithm (Emery et al., 1985; García & Robinson, 1989; Mattews & Emery, 2009) was applied to pairs of sub-images corresponding to common regions in sequential scenes. This procedure allowed inferring displacement speeds of such sub-images. To implement this algorithm a database of 360 images of sea surface temperature (http://ourocean.jpl.nasa.gov) was compiled. The temperature values correspond to daily data (2009-2010) from 6 satellites, interpolated at 1 km spatial to eliminate cloud cover (Chao et al., 2009).

Daily precipitation data (TRMM) was analysed in the watersheds draining into the GC (2004-2008), locating the river mouths activated by runoff processes on specific periods. This spatial and temporal demarcation determined the selection of MODIS-Aqua bands level 1B, which applies algorithms to detect the total suspended matter (TSM) to be used as tracer of the surface circulation. QuikScat wind data and drifter buoys trajectories were used as complementary information. The global process was assembled in four modules (Fig. 1).

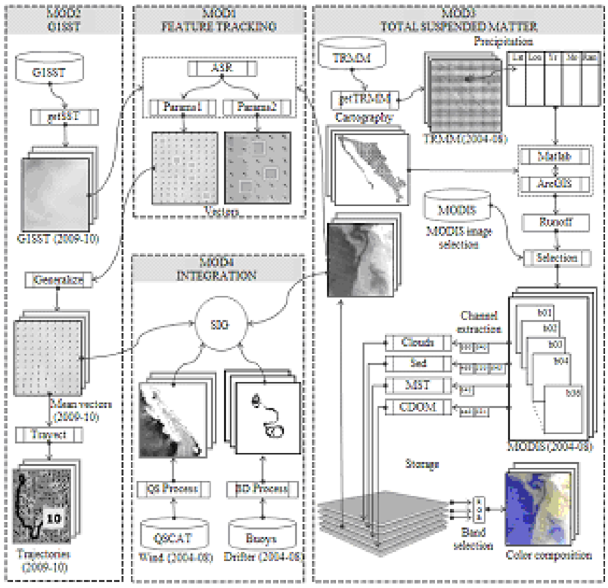

Figure 1 – Conceptual diagram showing the four modules for the general process.

RESULTS

As a result of the feature tracking algorithm an average of ~18,000 vectors for each pair of scenes of surface temperature were obtained. Based on these data, monthly averages of direction and speed by geographic location were calculated, generating a spatially dense grid in order to trace trajectories of advective transport. The traced trajectories reproduced some circulation patterns described with numerical models, and speeds are of the same order of magnitude (Fig. 2). Compared with displacements of drifting buoys, estimated speeds with this method were ~30% lower. The obtained vector fields can be incorporated as the initial state of numerical models, as well as the simulation of particle surface advective transport.

Structures detected with MODIS images were most evident during periods of increased runoff from the drainage basins, revealing TSM plumes that reach extensions up to 44,000 km^2, filaments crossing the Gulf from East to West, as well as cyclonic and anticyclonic gyres on the order of 10 to 100 km in diameter. These observations were supported with data of trajectories of drift buoys tracked by satellite.

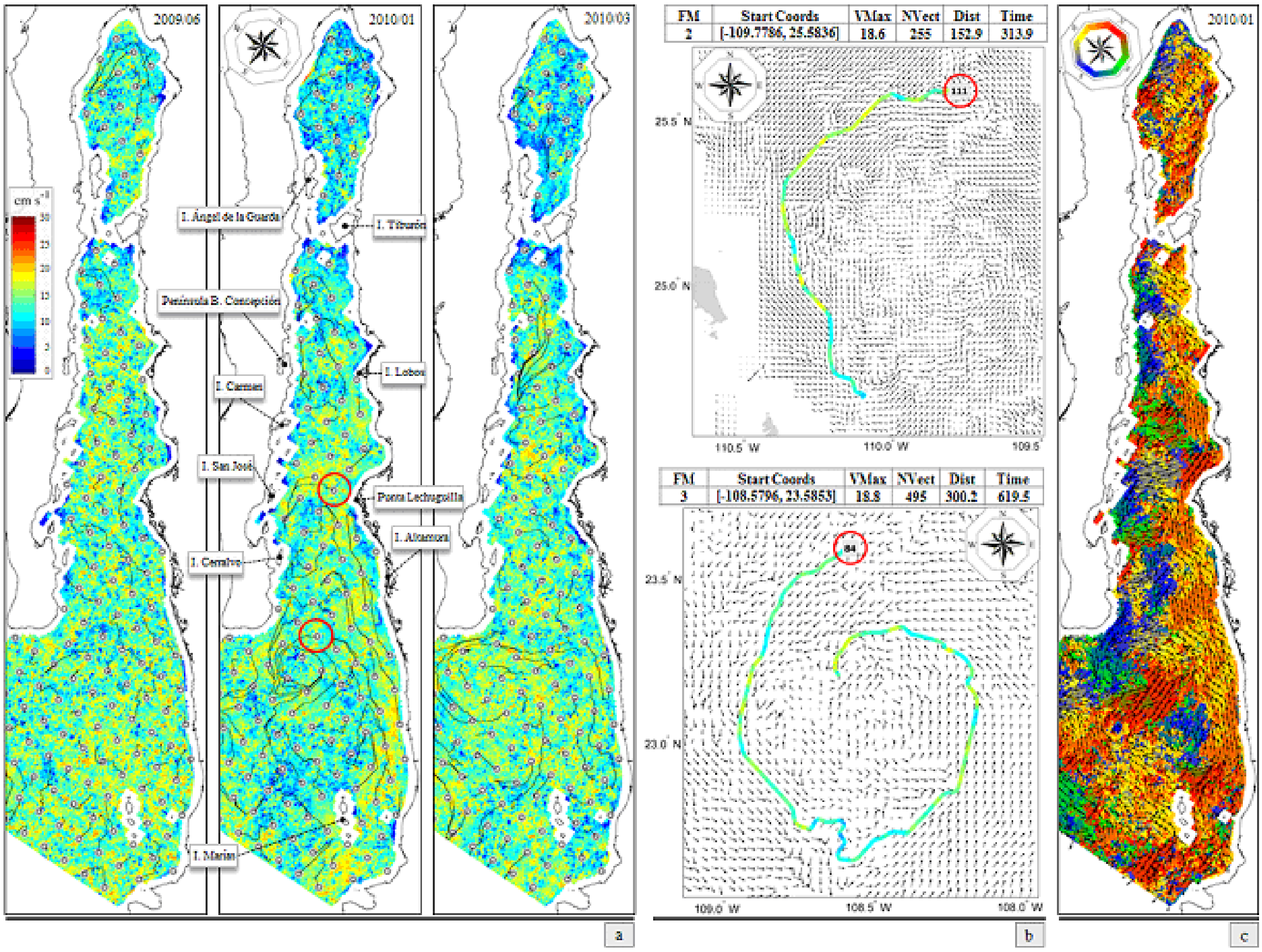

Figure 2 – (a) Trajectory samples derived from monthly average field vector, (b) Sample of derived filed vectors, and (c) direction map for January of 2010.

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SPATIAL INFORMATION SYSTEM AND MULTI-TEMPORAL IMAGE DATA FOR MAPPING AND ANALYZING CHANGES OF COASTAL AREAS

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KEY WORDS: multitemporal data, orthophotomap, analysis of change, coastal area, spatial information system

Digital photogrammetry and teledetection solutions applied under the project and combined with the spatial information system made it possible to utilize data originating from various sources and dating back to different periods. Research works made use of archival and up-to-date aerial images, satellite images, orthophotomaps, digital terrain models and their derivatives. Multitemporal data served for mapping and monitoring intermediate conditions of the shore zone of the Słowiński National Park without a need for a direct interference in the environment.

The main objective of research was to determine the dynamics and volume of sea shore changes along the Slowinski National Park coast in the period of 1951-2004, and to assess the tendencies of shore development in that area.

Within the project framework, examinations concerning the Baltic Sea shore within the Park limits in 1951-2004 were conducted, aimed at the determination and analysis of those sea shore elements, which describe both its condition in particular years, and the development dynamics. The examination subjects included the following:

- Reconstructing the location of dune base and water lines in relation to six consecutive annual data sets: 1951, 1964, 1975, 1984, 1995, and 2004.
- Determining the size and rate of shoreline changes in particular periods;
- Determining areas, which undergo morphodynamic processes of erosion and accumulation, and determining the size of areas that are exposed to changes;
- Determining shore areas of an oscillating nature and characterized by unidirectional changes;
- Performing the dynamic classification of shore and assessing tendencies of shore development;
- Determining the beach width and the beach width factor (BDF) in successive years.

For each of the six annual data sets, the following were determined: front dune base line, water line (the so-called shoreline), and the beach width. The location of the dune base line, which reflects the course of the shoreline in a given year was reconstructed based on stereoscopic study of images from each annual set. The water line was reconstructed based on orthophotomaps.

The reconstruction of dune base line locations in successive years made it possible to determine the scalar sum (∑S) and vector sum (∑V) of dune base line changes for the examined shore section. Those sums enable determination of the dynamics of changes and shore development tendencies, respectively. On the basis of calculated vector and scalar sum values, five classes of shore dynamics and development tendencies were identified. Also spatial distribution of particular classes was defined.

Research based on the analysis of multitemporal aerial images of the Slowinski National Park from 1951-2004 made it possible to reconstruct the intermediate conditions of the Baltic Sea shoreline and determine the volume and rate of changes in the location of dune base line in the examined period of 53 years, and to find out tendencies of shore development and dynamics.

Both within the whole examined period of several dozen years 1951-2004, and in subsequent time intervals, a considerable diversification of areas was noticed as regards extent and rate of changes in dune base line locations. The limits of those changes ranged from 120 to -90 m, and their velocity from 0 to 11 m/year, save that the middle and west parts of the examined coast section were subjected to definitely more intense shore transformations.

Within the whole examined area, the changeability of the shoreline course has an oscillating nature, in which one can observe accumulation and erosion processes taking place alternately. Unidirectional changes in the period of 1951-2004 occurred only within 10% of the examined shore section length.

On the basis of dynamic shore classification for the Park section in 1951-2004 it was found out that half of the examined section was of an accumulative nature, while more than 1/3 displayed erosional tendencies. Dynamic balance existed within only 14% of the examined shore area.

The examined shore is marked by a high and considerable dynamics of changes. Almost half of the shore, in particular the middle coast of the Park (1/3 of the examined section) shows big changes, in excess of 2 m/year. No sections of stable shore occur within the Park, while low dynamics of changes concerns as little as 60 m of the examined shore.

PREDICTION AND PREVENTION OF INTEGRATED RISK IN THE BASIN OF THE RIO MANNU (FLUMINIMAGGIORE, SOUTH-WESTERN SARDINIA)

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KEY WORDS: coastal erosion, flooding, integrated hazard, integrated risk, landslide, overlay mapping, Sardinia.

INTRODUCTION

This paper shows the results of a study aimed at prediction and prevention of integrated risk connected to hydraulic, landslide and coastal processes in the basin of the Rio Mannu (Fluminimaggiore, South-Western Sardinia).

The analysis of thematic data collection, conducted in a GIS environment through different elaborations of arithmetic overlay mapping, has led to perform a map of the integrated hazard phenomena connected to flooding, landslides and coastal phenomena, resulting from the integration of the geo-environmental factors that play a role in susceptibility to these hazards.

The integrated risk map, produced by the superposition of the hazard conditions with the vulnerability of the territory, is the fundamental support for planning prediction and prevention actions. This map, in fact, identifies areas in which to concentrate the activities of "Alert" and focus the environmental monitoring activities.

THE AREA EXAMINED

The area investigated is located almost entirely in the territory of Fluminimaggiore (south-west Sardinia) (Figure 1) and includes the drainage basin of the Rio Mannu river, about 120 km^2 in area, and the stretch of coastline adjacent to its mouth (Portixeddu - St. Nicholas), of about 4.5 km length. The area has mainly character hilly - mountainous with maximum altitude at Punta Nestru (1,084 m). Only the valley of the Rio Mannu opens gradually approaching the coast with flat morphology.

The major urban site is the village of Fluminimaggiore, located along the Rio Mannu river, at an average altitude of 80 m above sea level, while the coastal conurbation Portixeddu - St. Nicholas is poorly built and inhabited.

GEO-ENVIRONMENTAL HAZARD

Along the Rio Mannu of Fluminimaggiore have been identified conditions of hydraulic danger related to the flow of the river, in particular, at the valley part, near the center of Fluminimaggiore, and near the mouth, in particular in correspondence of the hydraulic section of the bridge along the way Buggerru - Portixeddu. Conditions of geological hazard related to phenomena of landslide have been identified in correspondence of the metalimestones, metargillites and metasandstones (Cambro-Ordovician). The portion of coast examined, however, has a strong evolutionary trend of the shore line; the magnitude of displacement in the time of the shore line was estimated by observation of the aerial images, starting from 1977 until 2008.

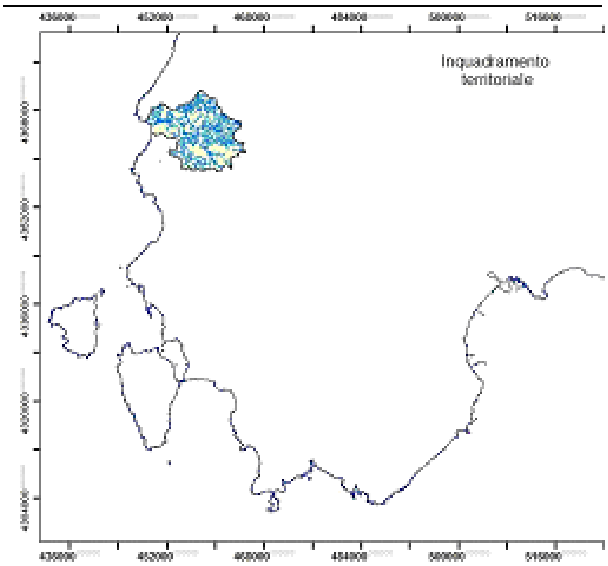

Figure 1 – Map of the Rio Mannu river basin.

METHODOLOGY OF RISK ASSESSMENT

The integrated hazard assessment in the basin of the Riu Mannu, was conducted, first, by analysis of the specific hazards of each of the three adverse events considered related to phenomena of landslides, flooding and coastal erosion. Through the overlay of data in raster form obtained by synthesis processing relating to particular hazards described above, after a reclassification, it was possible to identify the magnitude and spatial distribution of the integrated hazard.

The integrated risk assessment, according to the same logical process, is derived from the overlay process of data in raster format of the integrated hazard and vulnerability indicators.

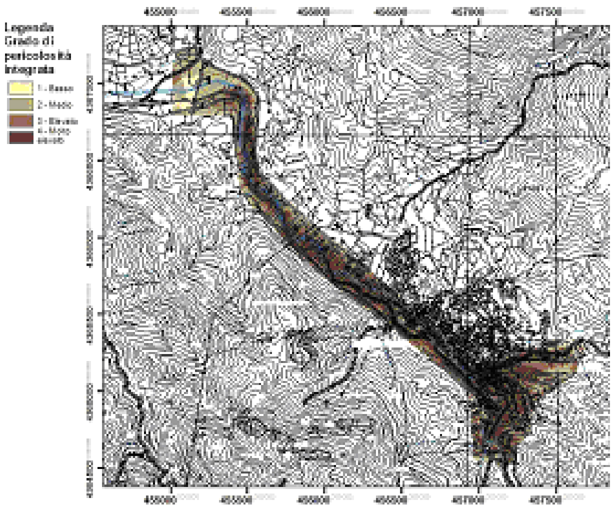

Figure 2 – Map of the integrated hazard (particular of the territory of Fluminimaggiore)

RESULTS

The works of synthesis resulting from the application of overlay methods in the basin of the Rio Mannu and along the coastal strip in front of the mouth permit recognition of areas and levels of exposure in relation to distinct physical phenomena and processes typical in coastal and continental (erosion superficial and landslides, floods, coastal erosion).

The integrated risk map shows the areas, and the intensity, in which the synergistic action of natural phenomena is considered particularly important, as in large parts of the Rio Mannu river where, in particular, the limits of the flood areas, and the effects of slope instability, also incorporate contexts with a high index of population density This methodological approach may be crucial in planning and land use and activities in the prediction and prevention of geo-environmental risk.

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CLIMATE CHANGE ACTIONS INTEGRATING WITH CHILD LED DISASTER RISK REDUCTION

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KEY WORDS Community,Children,Vulnerabilty Mitigation,Risk Reductionduction,Preparedness,Contingency planning,School Safety,Early Warning,Disaster Drill.

INTRODUCTION: CHILDREN AND DISASTERS.

The dangerous tidal wave came up at 100 feet height at midnight on 17th November 1977 and inundated hundreds of villages killing thousands of people and 80 percent of the dead were children. In fact the people died without an understanding about what was happening as they were in a deep sleep. By that time the tidal wave inundated their houses with 250 kilometers wind velocity and the gale of cyclone made them panic. All the women died in one of the villages named "Ramakhandam" whereas 80 percent of the male population survived as they were able to swim. At Malgayalanka village the same situation aroused and the male people found themselves in the dilemma weather or not to rescue the children as they are obstacles for swimming. Finally they had decided to leave the children in the water in order to save their lives at least. All the family members kissed their children goodbye, left them abruptly in the water and started swimming to save their own lives.

How are Children vulnerable to Disasters? Let us learn lessons from earlier disasters and make efforts to build a safer environment for Children. 1002 students died in the 2001 Bhuj Earthquake. 1884 school buildings- collapsed loss of 5950 classrooms, 11761 school buildings suffered major to minor damages.

Kumbakonam fire tragedy …… A deadly fire raged through Lord Krishna School killed 93 children, all below the age of 11 years. Let us learn lessons from earlier tragedies & make our schools a safer place for children.

ACTORS INVOLVED:

- 28,412 children and 36,116 adults from 25 disaster prone villages and 25 vulnerable schools.
- District education Department
- District Fire department
- Mandal Revenue Office
- Mandal development office
- District Fisheries office
- 150 Teachers from 25 vulnerable Schools
- State disaster management authority
- District women and child welfare department

Children practising the Rope Bridge Construction

- **CAPACITY BUILDING OF SCHOOL GOING CHILDREN**

Development and Disaster preparedness

- Disaster history of each vulnerable village
- Emergency medical care
- Emergency rescue
- Relief camp management
- Contingency plan development
- Training skills
- Children's participation and Child protection

METHODOLOGY:

CADME has been using a training manual for the training purposes. The trainings in each school are tailor made to address vulnerability of that particular school. The training focuses on peace time issues or emergencies like harms of pesticides and how to protect from it, types of fire and their response, responding to any accidents or children falling etc.

To help in better information transaction we have placed a drop in box in each school so that students or club members are using it to ask doubts or clarification and to give their suggestions. These children are an asset to the village community too as they have basic knowledge on disaster preparedness. The emphasis is on clarity on concepts, role of each member in the group and on horizontal training or information dissemination to children in school and in their villages. The clubs are now involved in risk mapping keeping in mind the both natural and man made hazards

Importance is given on the need for horizontal transfer of knowledge so as to cover many children. To reach out to other children in the school, the trained children perform disaster drills in their own schools every quarter and also during the school assembly or any special school programs, on disaster preparedness. The trained children with the support of the teachers organise training to other students to organize disaster preparedness drills and also help them in increasing their knowledge on disasters by organizing quiz and essay writing competitions.

School going Child is explaining about chest bandage

CONCLUSION

This intervention can be replicated in other villages involving the trained children and Task force groups. District officials and other stakeholders of disaster management are quite impressed of this intervention and started replicating it in other vulnerable villages and schools.

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We are grateful to Fisher folk communities of Pathapali, Balusuthippa, Magasanithippa and 240 communities of Coastal Andhra Pradesh of India and 480 Task Force Groups of 480 vulnerable villages and 1750 School going children

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National Disaster Management Authority of India,Save the Children,OXFAM India,Plan International.

International Strategy for Disaster Reduction

2003 United Nations Sasakawa Award for Disaster Reduction

Certificate of Distinction

Presented to

Mada Gurudutt Prasad (CADME)

Andhra Pradesh, India

In appreciation for his outstanding contribution to developing a global culture of prevention, thereby furthering the goals of the International Strategy for Disaster Reduction.

Jan Egeland
Under-Secretary-General for Humanitarian Affairs
United Nations

Bonn, 16 October 2003

ANTICIPATING SEAWATER INTRUSION IN URBAN COSTAL AREAS BY MEANS OF GEOPHYSICAL EXPLORING, HYDROCHEMICAL ANALYSIS AND ANALYTICAL MODELLING.

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KEY WORDS: Seawater Intrusion, Electrical Resistivity Tomography, Hydrochemistry, Pumping optimization, Coastal Urban Areas.

INTRODUCTION

Intensive pumping in urban coastal areas is a common threat to water resources quality by means of seawater intrusion. In those areas where subsurface water resources are not usually used for human supply or irrigation, intensive pumping is associated to other activities like lowering water table, necessary to build up underground structures and foundations. This activity also increases the likelihood of soil settlement which affects buildings stability and corrosion of concrete structures by groundwater salinity. Under these circumstances, the awareness of a certain municipality (Calonge, NE Spain) about the potential effects of groundwater withdrawal upon foundations has derived in an integrated approach to anticipate seawater intrusion related to urban development. Electrical resistivity tomography (ERT) geophysics and hydrochemical data permit a comprehensive knowledge of the geology and hydrogeology of the area necessary to determine the management tools in coastal aquifers. Strack's (1976) analytical solution that determines the interface location provides an additional insight to this management question as it estimates the critical pumping rate to prevent seawater intrusion.

METHODOLOGY

To assess the geological structure and the magnitude of saltwater intrusion of the aquifer, a geoelectrical survey was conducted in the vicinity of "Sant Antoni de Calonge", where several two-dimensional ERTs profiles have been taken. The logs from several geotechnical boreholes, as well as some geological surveys were also used for the finer interpretation of the results of ERTs. In addition to ERT and geotechnical boreholes, hydrochemical study of the groundwater is specially addressed to the elements or compounds that are salt-water mixture indicators. An analytical solution of the steady state sharp-interface saltwater intrusion model is also used in this study. The proposed procedure by Cheng et al. (2000) which is based in Strack's method consists in rating two distances, x_S and x_G, namely the stagnation point and toe of a salt water wedge respectively, and measured from the coastline to determine if the well pumping will cause saltwater affectation (Fig. 1). Therefore, for pumping cases, the toe responds by shifting inland until it finds a new equilibrium position. If we compare the two distances, when $x_S > x_G$, the system is in steady conditions and x_G show the toe location. Therefore the pumping rate could be increased without contaminating the well until de toe reaches the stagnation point. At the same time, we can get an idea if the well is near or far to salinization. Otherwise, if $x_S < x_G$ the system is in unsteady conditions and the well is contaminated by saltwater. Thus, when $x_S = x_G$, this point defines the maximum allowable saltwater intrusion limit and the maximum pumping rate for a given condition.

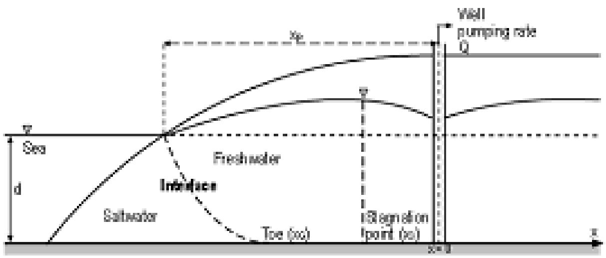

Figure 1 – Cross-section of a coastal unconfined aquifer pumped by one well (modified from Strack, 1976).

RESULTS AND DISCUSSION

The salinity differences in 18 water samples permit to differentiate several hydrochemical facies. These facies correspond to the geomorphological units that were developed in the study area: alluvial plain, coastal marsh and offshore bar. Piper diagram (Fig. 2) shows this distribution. Bicarbonate facies with a slightly tendency to move to higher concentrations of chlorine and sulfates can be observed in the alluvial plain and coastal marsh. In the offshore bar the dominant facies are sodium-chloride but of lower EC values respect to the marsh area. The wells located in this area have a local groundwater recharge, which provides them low hydrochemical salinity and it is not related to mixing processes with the sea water. Generally, the wells don't show saltwater intrusion evidences except in the case of intensive pumping. Then, an important mixing is detected in the well that might be more severe in the area between the well and the sea. Thus, some samples from the offshore bar (C06 and C12) and a sample from the marsh area (C13) present chloride-sodium facies, the later with lower EC values than usual for the marsh area.

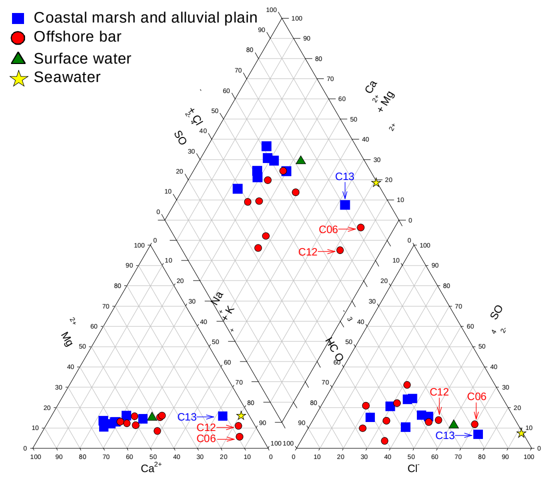

Figure 2 – Piper-Hill diagram of ground water samples.

24 resistivity lines were conducted across the studied area, and the most representative, is represented in Fig. 3a. The inverse model of this profile, carried out along the coastal line, shows a highly heterogeneity of the area under investigation. Low resistivity anomalies (0,25 – 3 Ωm) have been interpreted as a saline water zone. In this case, resistivity variations are due to lithology differences, so lower values (dark blue) correspond to clay-rich layers and the values between 1 and 3 Ωm match with sandy-clayey layers affected by saltwater intrusion. High resistivity values (red and purple) have been associated to granite bedrock, which is suggested at depths of 7 up to 54 m. Therefore resistivity tomography imaging shows erosion topography of the basement. The geological cross section in Fig. 3b, reconstructed by means of information obtained from both the ERT profile and geotechnical boreholes, illustrates this geological structure. The discontinuous character of the low resistivity layer has been interpreted as an effect of the morphology of the basement surface which has suffered the erosion of streams in granite materials. The pre-quaternary valleys are filled by sand and clay, and it is in these materials, together with the most altered granite, where the salinity intrusion interface can advance preferably in an intensive pumping situation. Thus, the geological structure evidences that the geometry of the basement plays a very important role in the intrusion phenomenon.

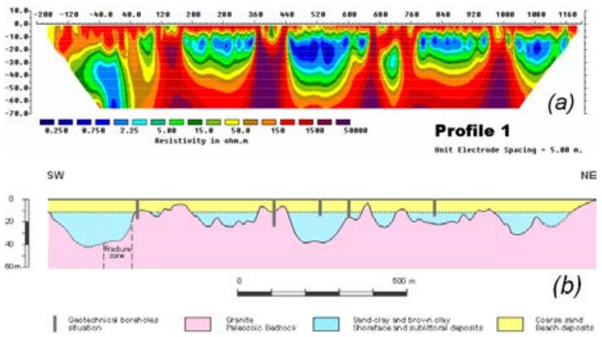

Figure 3 – Profile of ERT (a) and geological cross section interpretation (b).

With Strack's analytical solution the maximum pumping rate is obtained to avoid an episode of saltwater intrusion. This analytical solution is applied in new constructions of the study area where is necessary decreasing the piezometric level to building basement floors. These new constructions are located above an old valley defined with ERT prospecting and consequently susceptible to cause an episode of saltwater intrusion. The well used to lower piezometric level in the construction of basement floors is located at 1000 m from coastline. With Strack's method, 219,8 m^3/day is the safe pumping rate before saltwater intrusion becomes a problem for the stagnation point of this well.

CONCLUSIONS

Saltwater intrusion, commonly associated with extensive groundwater extraction, is an important problem for coastal regions. Geophysical techniques offer a suitable method for determining the location of the freshwater/saltwater interface since costs are reduced and results are good. However it is strongly recommended to supplement geophysical data with other methods like hydrochemical or geotechnical boreholes. In a coastal aquifer management the main objective is to maximize the total pumping rate subject to the constraint of no intrusion of the saltwater front into the wells. To achieve this aim it is necessary to have a comprehensive knowledge of the geology and hydrogeology of the study area. Afterwards, Strack single-potential solution offers a good method to determine approximate maximum pumping rates to limit saltwater to a prespecified distance from the coastline.

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THE LOWER PLAIN OF THE VOLTURNO RIVER (SOUTHERN ITALY): EVOLUTION OF THE LANDSCAPE IN HISTORICAL PERIOD

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KEY WORDS: coastal lagoon, delta, Volturno River, historical cartography, GIS.

INTRODUCTION

The coastal plains are one of most natural fragile environments on which a large number of factors which influence their evolution have been concentrated.

The dynamics of coastal processes, including the hydrological links between catchment areas and the coast, have therefore been greatly influenced by human activities.

In particular, during the last 150 years, land reclamation of the delta plain region and massive anthropogenic alteration of rivers, such as dam construction, embankments, legal and illegal river-bed excavation have been combined to make the environmental management of the fragile coastal area difficult.

To understand the complexity of spatial and temporal relations of territorial phenomena, analysis of maps and aerial photos (current and historical) is essential. For a detailed spatial analysis it is necessary to develop a large number of geospatial and alphanumerical data, whose manipulation and interpretation is facilitated by the use of GIS.

STUDY AREA

The lower plain of the Volturno River exhibits a gently sloping morphology with two sub-triangular depressed area close to the coast, in the left and right of the Volturno River; in these areas, the plain is characterized by the presence of partly reclaimed ponds and brackish lagoons.

The hydrographical system is characterized by a dense network of drainage canals: the Savone stream, the Agnena Channel and Regi Lagni that are artificially embanked.

A recent study by Pacifico (2011) outlined the Holocene and Recent evolution of the Volturno delta-coastal sector. The author attributes about 9 ky B.P. (Holocene sedimentation) to the establishment of marshy/lagoon systems that originally developed in the southern part of the Volturno river delta system. This swampy environment, represents the initial expression of the transition from a pure continental system to the first transgressive phase, in a sub aerial context probably during a moist and warm period. The final transgressive process is, instead, documented by the transition from a freshwater to widespread, brackish, lagoon environments, areas in direct connection with the open sea and areas in which the lagoon was more sheltered. The formation of beaches, bars and dune systems, sheltered inner lagoon areas, and wide brackish stains occurred about 6.5 ky B.P. (Pacifico, 2011). In this context there is also the Patria Lake that was an integral part of the lagoon-wetland area of the Volturno River delta system (Sacchi *et al.*, submitted).

The progressive reduction of the lagoon environments is attributed at 5.5 ky B.P. At this time the beach systems continued to developed to the north, while long dune cordons rimmed the brackish areas of the southern part, where a beach-coastal dune system developed on a sandy bar, enclosing the lagoon setting now represented by the Patria Lake. In fact, about 4.5 ky B.P., the coastal system shows a clear forestepping pattern in which the lagoon sediments moved towards south in relation to the present river position, and locally little patchy marsh were concentrated (Pacifico, 2011).

The location of the inner continental shelf and associated coastline has been relatively stable and was accompanied by the development of a significant prograding sequence during this period.

METHODS

An extensive cartographic documentation (geodetic and pre-geodedic), author pictures and aerial photos have been used in order to carry out space-time analysis on the main morphological changes occurred in the coastal area between Massico Mount and Patria Lake. The cartographic sources cover a period of about 400 years, since the 1620; they have been acquired in raster format and georeferenced, when possible, through the GCP (Ground Control Points) technique and then analyzed. The historical maps and aerial photos have been managed with GIS (Geographic Information System) using the software Intergraph Geomedia Pro 6.1 and georeferenced in the reference system Gauss-Boaga, East Zone.

The calculations made were overlapping in order to compare and understand the morphological and anthropic changes that have occurred over time.

RECENT LANDSCAPE EVOLUTION

The lower plain of the Volturno River area was subject to ponding and swamping.

These problems have led to a long series of reclamation works started to the end of the sixteenth century.

The historical maps available for the Campania coastal zone back to the period between 1620 and 1711, and even though not georeferenced, have provided important information on the general setting and features of the Campania coastal zone between the mouth of the Monte Massico and Patria Lake outlet.

Since the 1797 it is observed that the northern part of Patria Lake lagoon has been subject to significant changes in its shape and extent over time.

The Clanio River inlet of Patria Lake was diverted directly into the Tyrrhenian Sea. As a consequence, the extent of the former lagoon area of Patria Lake progressively shrunk during the last three centuries to the present-day size. Most of the marshy areas were reclaimed from 1811 until the early 1900s. Such interventions, intentionally designed and realized as land-works were achieved by earth accumulation by flooding. By this system part of the river waters were diverted and canalized without the prevention of the natural river dynamics in the other parts of the alluvial plain. The system aimed at elevating the land surface by filling the marshy areas with alluvial sediments. The system was based on a canal diversion network, with the water being drawn directly from the river bottom, and flowing into the sedimentation tanks. Such canals branched into other diversion canals reaching the inner parts of the sedimentation tanks.

The reconstruction of the drainage network has uncovered some problems recently, such as waterlogging in some road areas after heavy rainfall, being related to the building on the track of the ancient drainage canals, or on sites of oxbow lakes of the Volturno river. In fact, geomorphological systems are not often considered by managers and decision-makers, who usually consider their management action on short spatial scale (1-5 years). Moreover, they tend to view the river system as stable and accept its current condition as natural and permanent.

Among the morphological changes of the landscape induced by land reclamation, the river mouth variation is perhaps the most striking.

In the right of the Volturno River, Regia Agnena and Savone, whose lower section were known as “Acque delle Bagnane” and “Alveo della Piana”, have undergone significant changes since the Bourbon times. In the *Carta dei Dintorni di Napoli e Caserta* (1876) we can see the great reclamation works carried out in 1832 on the lower section of the “Acque dell’Agnena” by the realization of long interconnected straight channels that take water from the Savone to the Agnena.

Between the Agnena Canal and Regi Lagni mouths extends the delta plain of the Volturno River, whose structure and late Holocene evolution trends seem to follow those of the major Tyrrhenian deltas, for which a wave dominated delta model was proposed.

The GIS based comparison of georeferenced cartography from historical sources has allowed us to record the peak of progradation of the Volturno delta system during the 1800’s, after which it began to evolve from cuspate (Wright and Coleman, 1973) to arcuate in a strongly asymmetric form. The eroded sediments of the cuspate delta apex were gradually stored by longshore transport along the lee-side, so the shoreline has become parallel.

In particular, the Volturno river delta from 1800 to 1907 has been subjected to a continuous progradation. In the *Carta Austriaca del Regno di Napoli* (1822), the Volturno River has a wide delta mouth, indicated by the name “Bocche del Volturno” that is separated from “Isolotto dell’Incogna” in two branches. In the *Carta dei Contorni di Napoli* (1845), the Volturno delta cusp is anastomosed into two parts with the right branch blocked by the formation of a tombolo cluster. The entire coast in the left area of the Volturno mouth seems to be more developed, with a beach slightly wider than the one of the previous cartographic document shown. In Topographic map of Italy - 1887, produced by the IGM, the Volturno River delta is represented to its fullest extent. It is again divided into two branches with the presence of more sandy deposits in the middle of the stream, the destruction of tombolo cluster on right bank and the formation of sand spit on the left bank.

From 1907 to 1954 the shoreline close to the mouth area has suffered erosion phenomena with a rate of about 2 m per year, while in the left mouth area subjected to a less conspicuous retreat (about 1m a year). From 1954 to 1982 the backward trend has been continued with values between 1 and 6 m/year in the right mouth area and 1 to 19 m/year in left area. This “asymmetric retreat” is partly due to massive urbanization and building of defensive works on the right side which have “hardened” the coast; conversely, the establishment of the natural reserve on the other side has left the coastal area exposed to the erosion process. In Campania Regional Technical Planning Map (1987), the consequences of the erosion, with the complete rectification of the coastline, the destruction of the Volturno River delta peak and the location of the ancient lighthouse in the sea, appear evident.

DISCUSSION

The analysis of the historical cartography of the period between 1500 and 1700 and the comparison with recent maps up to the present, provide a sufficiently exhaustive picture of the evolutionary trend of the studied littoral.

The shoreline is characterized by a continuous progradation with decreasing values from 100 m at 10 m per century, proceeding from southeast to northwest. The highest progradation speed (15 m per year) is recorded in the period 1809-1907. In recent decades there has been a process of cusp mouth the Volturno river rectification. This has occurred in relation to the decreased of load river sediments after the human interventions in the catchment area and the excessive urbanization and the coastal builiding works that have stiffened coastline.

CONCLUSIVE REMARKS

This study provides an evolutionary framework of a coastal area of a considerable interest from both the scientific socio point of view that of -economic development and highlights the importance of an interdisciplinary approach to land management.

The structure of the lower Volturno Plain and the related coastal system has undergone considerable natural and anthropic changes in the last two centuries following:

- reclamation works that have generated benefits by creating of new land for agricolture, livestock and a more healthy environment; never the less, because of an unsound management over time, they have contributed to the deterioration of the environmental quality of the entire Domitia coast;
- changes in the course of the Volturno River, as a result of natural and anthropogenic factors, that have led to dynamic phenomena of coastal sedimentary alteration and the onset of erosion process;
- coastal erosion. To protect the coastal beaches from this phenomenon many coastal defenses have been built. These structures, were often made under emergency conditions and have entrenched the coast, without solving the problem of erosion.

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GEOLOGICAL MAPPING OF THE ITALIAN SEAFLOOR: THE ADRIATIC PROJECT

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KEY WORDS: Adriatic sea geological maps. Late Quaternary

GEOLOGICAL MAPS OF THE ADRIATIC SEA SCALE 1:250,000

As part of the CARG project, considering the importance of the geological knowledge of the Italian continental platform and of the main geological structures of seabeds, the Geological Survey of Italy has launched a project of marine geological mapping of the Adriatic sea:

- NL -33-10 - Ravenna and the definition of methodologies and criteria for the realization of the marine geological mapping at 1:250,000 scale, to which it refers, published in the Booklets, Series III, No. 8, of SGI entitled " Geological Map of the Italian seas at the scale 1:250.000. Guide to mapping;
- NL-33-7-Venice;
- NK-33-1/2- Ancona (which includes, between the meridians 13° and 15°, the eastern half of the sheet NK-33-1 and the western half of Sheet NK 33-2);
- NK-33-5 - Pescara;
- NK-33-6 - Vieste;
- NK-33-8 / 9 - Bari (which includes, between the meridians of 15° and 17°, the eastern half of the NK-sheet 33-8 and western half of the NK-Sheet 33-9).

The geological Maps of the Adriatic sea is the first cartographic project giving a synthetic representation of the distribution of the seafloor sediment (Seafloor Chart) and the tectonic and stratigraphic characteristics of the Adriatic Sea (Subcrop Chart). The six geological maps together with their explanatory notes contain the late Quaternary deposits representing the principal phases of the last glacial cycle: 1. HST High stand system tract (last ca. 5.000 years) 2. TST Trasgressive System Tract (25.000-18.000 years) 3. LST Low Stand System Tract (18.000-5.000 years) 4. FST Fallings System Tract (125.000-25.000 years). The six geological chart of the subcrop contain the structural map at the base of the time interval Pliocene to Quaternary, where all the tectonic features, that are referred to this relevant isochronopach, are displayed. Inside each sheet, seismic reflection profiles crossing the area and stratigraphic sketches are presented, showing the long time geological evolution and the tectonic context of the Adriatic Sea. If available, seismicity over the area and the relation with the mapped active tectonic structures is also presented.

Figure 1 –.Location of Adriatic Geological Maps

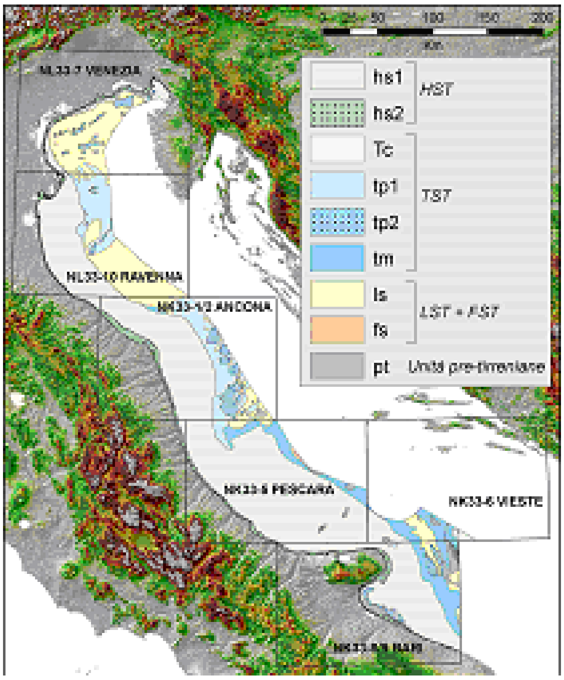


Figure 2 –.Seafloor chart in the Adriatic basin with system tracts legend.

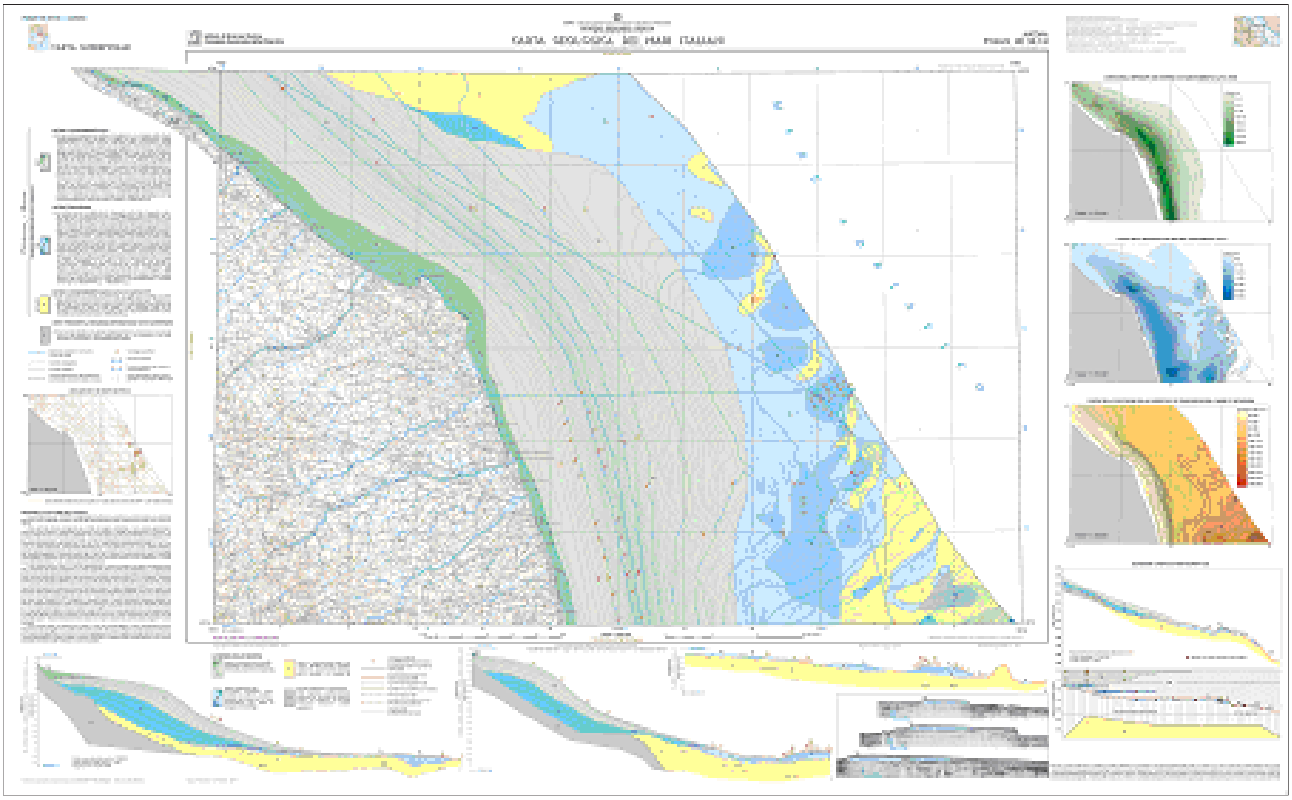
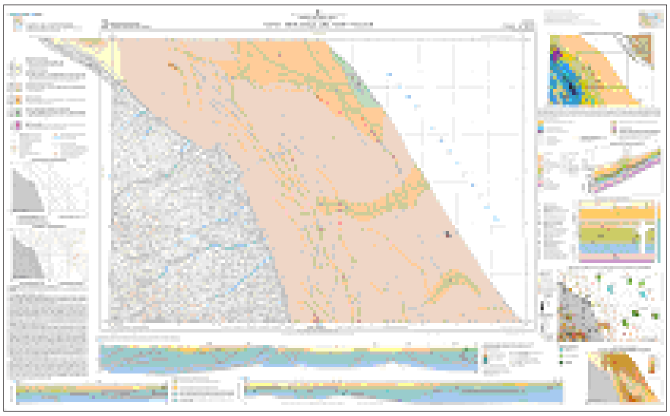


Figure 3 – Example of seafloor chart NK-33-1/2- Ancona



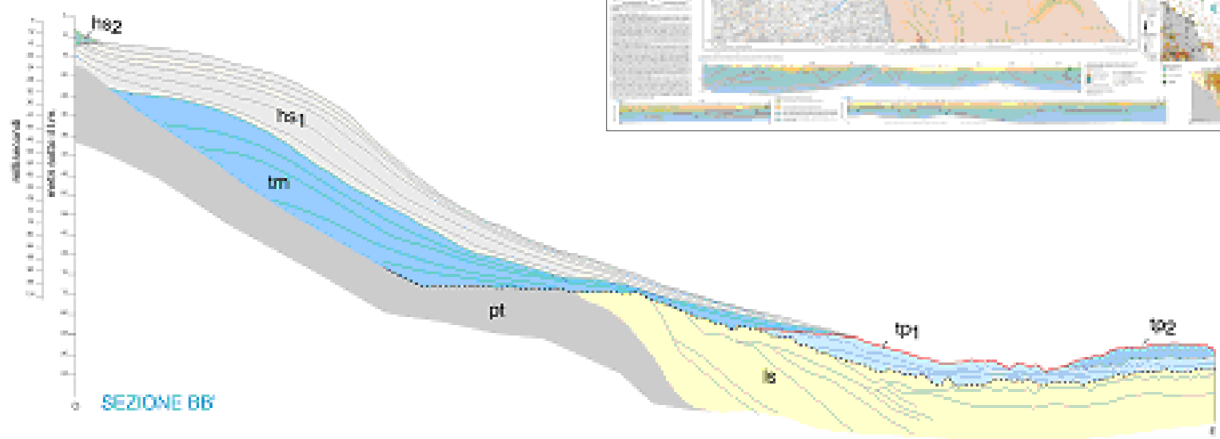


Figure 4 Example of a geologic section of Ancona chart

Gruppo di lavoro: L. Angeletti, A. Asioli, G. Bortoluzzi, E. Campiani, A. Cattaneo, A. Fabbri, F. Foglini, A. Gallerani, F. Gamberi, M. Ligi, D. Minisini, D. Penitenti, A. Piva, A. Remia, D. Ridente, M. Rovere, M. Roveri, M. Taviani, G. Verdicchio.

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The six Adriatic Maps are interactively available at ISPRA web page: http://www.isprambiente.gov.it/Media/carg/index_marine.html

RECOVERY OF DREDGED SEDIMENTS OF THE PORT OF RAVENNA AND SILICON EXTRACTION – THE SEDI.PORT.SIL. PROJECT

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KEY WORDS: SEDI.PORT.SIL; silicon extraction; soil-washing; landfarming; dredged sediment, MGS.

INTRODUCTION

The total amount of sediment dredged in Europe reaches approximately 200 million cubic meters per year (SEDNET, 2011). Polluted sediments are usually sent to landfills, with all issues and environmental risks associated to the management of wastes. It is clear that the sustainability of this process should be improved.

The SEDI.PORT.SIL. project (Recovery of dredged SEDIments of the PORT of Ravenna and SIlicon extraction) has been conceived to demonstrate an integrated approach for the sustainable management of sediments dredged from ports, and specially from the Port of Ravenna (11 million of m^3 will be dredged in the next 3 years) (Ravenna Port Authority, 2011).

Specific objectives are to demonstrate the efficiency of a physical, chemical and biological treatment processes for the decontamination of polluted sediment and associated water and to test the efficiency and the productivity of the extraction of metallurgic grade silicon (MGS) through a plasma treatment on sediments.

MED Ingegneria is the Coordinating beneficiary of the project started in September 2010 (end foresees in February 2013), financed by the European Commission through Life + founds. Other associated beneficiaries are the universities of Bologna and Ferrara, Diemme Enologia S.p.A, the Institute for Environmental Protection and Research (ISPRA), Management authority for the Parks and Biodiversity - Po Delta, GeoEcoMar (Romanian Institute of Geo-ecology) and CRSA MED Ingegneria srl.

SOIL-WASHING TREATMENT THROUGH PROTOTYPE

During february 2011 a sampling campaing was carried out and more than $30m^3$ of sediments were collected in port areas characterised by different level of pollution (red, yellow and green, according to Dlgs 152/06, Annex 5, Table 1 limits) and a pre-treatment characterisation was done.

These analysis and preliminary laboratory tests on sampled sediments were used to collect baseline data for the design and development of the sediment treatment prototype realized by DIEMME. The prototype was designed for grain size separation and progressive washing of Ravenna port sediment, meanwhile concentrating the contaminants into the finest fraction (Figure 1). The Ravenna sediments sample based on their contamination were originally subdivided into green, yellow and red classes (TESTs) and have been treated separately trough the prototype with 3 different cycles. Coarse and sandy fraction was recovered clean and not contaminated, the silt-clay finest fraction presented a high hydrocarbons concentration and was processed through landfarming. Wastewater did not present critical issues, except for chlorides level that resulted above the Italian Regulation limit.

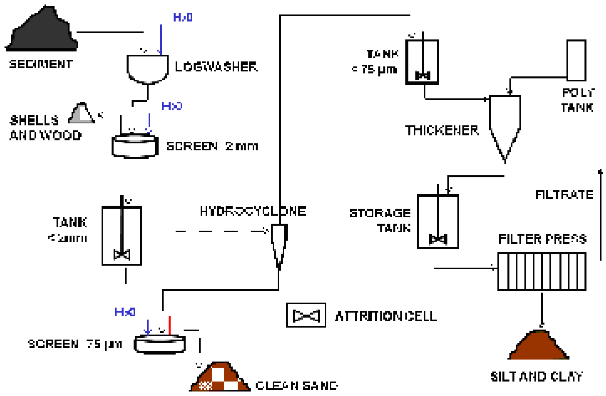

Figure 1 – Scheme of DIEMME prototype pilot plant.

LANDFARMING APPLICATION

Landfarming, also known as land treatment or land application, is an above-ground remediation technology for soils that reduces concentrations of petroleum constituents through biodegradation (EPA, 2004); selected bacterial strains that use organic contaminants as carbon source to reduce concentrations of petroleum constituents through biodegradation.

The treatment has been carried out on 9 different samples (3 treatment cycles for 3 different pollution classes), in plastic boxes where the sieved and dry sediment has been inoculated at the beginning of experiment and manually mixed daily. Periodically (7, 15, 21, 51 and 86 days of treatment, Table 1), a sub-sample has been collected in order to assess the degradation and the nutrient contents. At step 4th a further sieving has been done in order to increment the oxygen distribution and to improve degradation rates.

Process step	Sampling date	Process time (days)
Step 1 (T0)	30/08/2011	0
Step 2 (T1)	06/09/2011	7
Step 3 (T2)	14/09/2011	15
Step 4 (T3)	20/09/2011	21
Step 5 (T4)	20/10/2011	51
Step 6 (T5)	24/11/2011	86

Table 1 – Landafming process steps detail.

Silty fraction presented high level of organics (C>12 and PCB only in RED test), coming from the original sediment. During the sieving and the following filterpress process, an effect of physical concentration has been produced by the separation of unpolluted fraction. The addition of landfarming treatment permitted to reduce the hydrocarbons contents; the difference in degradation rates of the 3 tests depends to initial concentration and composition of TPHs, reaching significant percentages: RED: -60%; YELLOW: -67%; GREEN: -45%.

THERMAL TREATMENT THROUGH PLASMA TORCH

A part of the dredged sediment have been used as raw material in a demonstrative action for the extraction of metallurgic silicon through a plasma torch at the University of Bologna, DIEM department.

A total amount of 23 tests with green, yellow and red sediment samples have been performed. Operating parameters analysed are: treatment time, distance between crucible and nozzle exit of the plasma torch, percentage of carbon added to the sediment for the carbon-thermal reduction (Colombo, 2010). In addition, fusion tests are going to be done for each granulometrical class (sand, silt, clay).

Preliminary results demonstrate that the Ravenna sediments, due to the considerable natural SiO_2 content (ranging from 43,5 to 53% in all the granulometrical classes), represents a real chance of extracting silicon from dredged sediment; SEM-EDAX analysis carried out at CRSA MED Ingegneria laboratories demonstrated that some areas of the plasma output have nearly 90% of Si.

At the same time, leaching tests and geotechnical characterisation is going to be executed, in order to demonstrate that the silicon production wastes could be re-used as secondary raw material in engineering works.

PROJECT REPEATABILITY AND FURTHER ACTIVITIES

The treatment procedures on Ravenna sediments are going to be tested on different dredged sediments. The area chosen is the Port of Midia, on the Black Sea coast, Romania. The different context (historical, natural, sedimentological and legislative) allows us to analyse the strengthens and weakness of the project, in order to improve it and make it suitable for different applications in Europe. Two sampling campaigns have been done and sediments collected were sent to Italy, in order to test soil-washing and plasma torch techniques and to carried out required pre- and post-treatment analysis.

For both the Italian and Romanian case study, the project foresees the design of the treatment plant at industrial scale; moreover, a master plan will be drawn up, in order to evaluate and quantify all potential reuses of decontaminated materials, socio-economic benefits and potential new sources of sediment. The business plan will undertake an economical analysis of the new plants and it will set a strategic plan for its optimal exploitation.

CONCLUSION

The physical-chemical-biological treatments tested within the SEDI.PORT.SIL. project showed a significant reduction of the concentration of pollutants on dredged sediments and that a relevant amount of them could be reused after treatment.

The thermal process application is not exclusively function of the particle size of the sediment; also the silty-clay fraction in the SEDI.PORT.SIL. view become an important sources of silicon. The MGS extracted may actually make the entire industrial process economically sustainable.

ACKNOWLEDGEMENTS

The project SEDI.PORT.SIL is financed by the European Commission through Life + Environment Policy and Governance 2009 program and co-financed by the Port Authority of Ravenna.

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SUBSIDENCE IN COASTAL LOWLANDS- INTEGRAL ASSESSMENT FRAMEWORK (EU-FP7-SUBCOAST)

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Keywords: *Subsidence, Assessment framework, Awareness raising, Sealevel rise, Flood Vulnerability, Pilot Delta River Po*

Subsidence in coastal lowlands can have the same or even much higher yearly rates as Sea Level Rise related to climate change (~ 6 mm/year). However, it seems to be a hidden driver for increasing flood risk in deltas, coastal areas and river basins.

Within the EU-project FP7- SubCoast an integrated assessment framework has been applied in 3 pilot regions. The focus is on flood-related risks and information from earth observations as enabling information for analysis and decision-making (see figure).

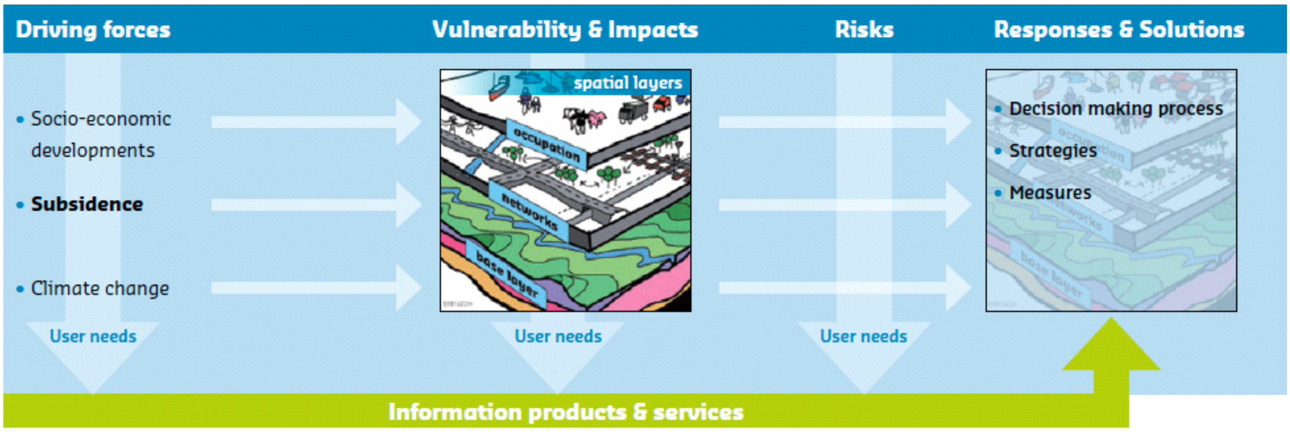
Future scenarios for socio-economic developments and the rates of subsidence and sea level rise have been used for the impact and risk assessment. For the risk assessment, a "3-spatial layer" approach is used, in which respectively the base, network and occupation layer will have different impacts and risks, related to level of investments, varying damage figures and risk of lives. The main aspect of the project is to improve information services for responsible authorities and stakeholders, which should lead to better decision making on adaptive measures.

This paper will first introduce the integrated assessment framework and will show results of a stakeholder workshop in the pilot region Southern Emilia-Romagna (Italy).

Combining with other pilot regions (Rhine-Meuse and Baltic) the stakeholder consultation has shown the need for a structure like the integrated assessment framework based on different future scenarios and good governance for the adaptive response to subsidence and Sea Level Rise.

Governance from municipality level, to regional and national level is needed to prevent local societies (private and public assets, critical infrastructure and natural resources) for future disaster related to subsidence.

Responsible authorities have to consider strategies and take decisions about adaptive, cost-effective measures over longer time scales than they normally do. Raising awareness is needed and can be stimulated by good geographical information on all level of threads based on observations and future scenario based of forecast modeling.



Integrated Assessment Framework by Deltares as a guideline to inventory user needs in order to develop information products for decision-making

GEOPHYSICAL TECHNIQUES FOR PROTECTION AND MANAGEMENT OF MARINE HABITAT: EXAMPLE FROM THE CAMPANIA OFFSHORE, EASTERN TYRRHENIAN SEA.

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KEY WORDS: marine geophysics; habitat mapping; coastal zone management; benthic features; seafloor morphology.

INTRODUCTION

The Water Framework Directive published by the European Commission on 23 October 2000, aims to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and ground waters. Similarly, in the United States, the Manguson-Stevens Fishery Conservation and Management Act requires that all 'essential fish habitat' should be identified and protected. Policies such as these explicitly recognize the link between fauna, flora and physical features, and require appropriate strategies for classifying aquatic habitats and assessing their relative importance or condition.

Marine geophysical techniques provide basis to support to the development of strategies for protection and characterization of natural ecosystems, in regards of human activity, and sustainable management of tourism in areas with high environmental value. For this aim it is important knowing the types, locations, and condition of ecosystems as they are distributed across seascapes (fig.1).

Based on aforementioned directives we started to classify seabed off the Campania Region using available bathymetric, backscatter and sedimentologic data that allowed to identify topography and bedform features. This approach allows the following applications:

strategies for monitoring, management and protection of Marine Protected Areas.

- Assessment and conservation of marine biodiversity.
- Understanding of how particular human activities are undertaken in relation to marine habitats.
- Policy for Managing the Impact of Fishing on Sensitive Benthic Areas.
- Management of marine tourism by creating submarine environmental paths and identifying underwater archaeological areas.

MARINE LANDSCAPES AND HABITATS

The Marine Landscape concept aims to describe the marine environment with respect to its main geophysical features, in terms of both the seabed and water column. It focuses also on the formation and consequences of spatial heterogeneity and dynamics in natural and human dominated environments and how spatial pattern controls ecological processes. Moreover, the strong ecological relationship between the physical environment and the character of biological communities allows the use of Marine Landscapes as *surrogates* for marine communities.

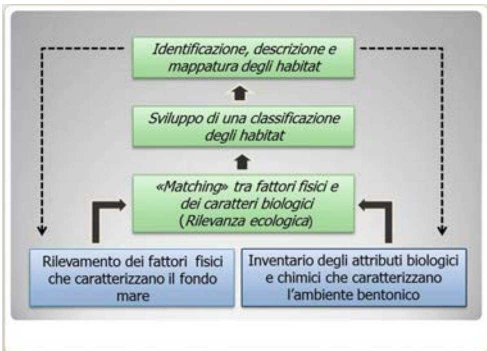

Figure 1 – Scheme showing procedure for benthic habitat classification and mapping. Modified from Olenin, 2006.

Whilst the habitat mapping approach is most suited to detailed (fine-scale) classification of the seabed, marine landscapes allow classification of the marine environment at an ecological relevant scale. The two approaches are hierarchical related to each other even if many habitat types can occur in several landscape types.

Currently the Marine Landscape concept is applied for management purposes both in Europe and USA. The general deterioration of the marine environment have resulted in the wide recognition that an ecosystem based approach to the management of marine environment is necessary for promoting a future sustainable development.

There are various initiatives and legal requirements, such as the implementation of EU directives (EC Habitats Directive, EU Water

Framework Directive, EU INSPIRE Directive and the EU Marine Strategy Directive), the identification of marine protected areas (MPAs) and the assessment of the ecological coherence and representativity of existing MPA networks, e.g. the Natura 2000, that endorse the current needs for broad-scale information. In particular the Regione Campania (Southern Italy) has issued "Standards and strategic directions for the protection, management and development of the *regional geodiversity* and places of special geological interest.

Various acoustic systems and combinations of systems can be employed to facilitate the production of habitat maps, but to connect biological communities with physical parameters it is important to obtain adequate ground truth information, in order to optimize the interpretation of the sonar images. The present study employs CNR Research Vessels equipped with Multibeam echosounder (MBES) and Side-scan sonar systems to provide high-resolution bathymetry maps and backscatter images of the surveyed area, coupled with underwater grab sampling, video systems and multiparametric probe to provide ground truth data. Both acoustic and ground truth data will be used to construct thematic maps and models depicting type and distribution of marine habitat across the study sites.

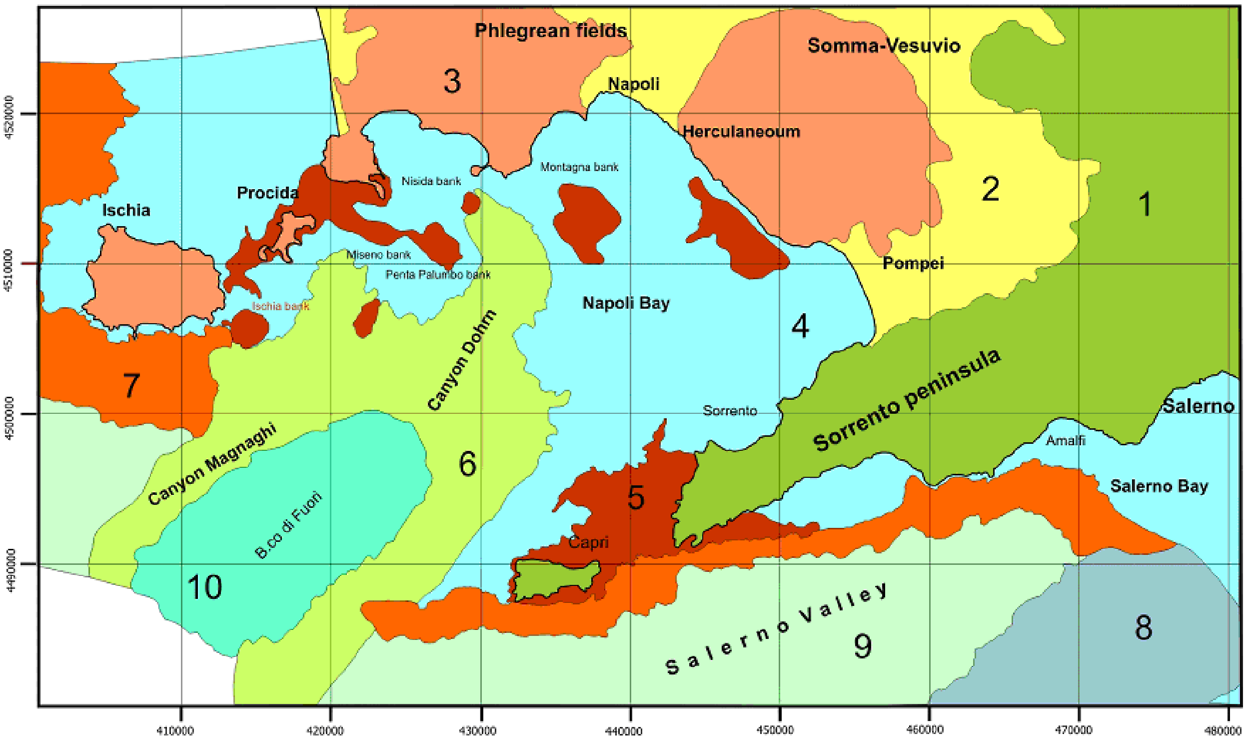

Figure 2 – Marine and coastal landscape of Campania region (modified from Violante, 2009). 1. Rocky coast with limestones. 2. Volcanic rocky coast. 3. Alluvial plain. 4.Continental shelf with soft bottom. 5. Continental shelf with mixed hard bottom. 6. Canyon with soft and rocky bottoms. 7.Steep slope with soft and rocky bottom. 8. Gentle slope with soft bottom. 9. Deep basin with soft bottom. 10.Seamaunt with mixed hard, rocky and soft bottom.

THE CAMPANIA REGION

Marine landscapes off Campania region (fig. 2) are dominated by geologically young structures and sedimentary processes. This mid-latitude sea area is composed of three main basins namely Volturno Bay, Naples Bay and Salerno Bay and by a number of minor basins. It develops along the eastern margin of the Tyrrhenian sea across the boundary between the Apennine chain and the Tyrrhenian extensional area where Quaternary tectonics deeply controlled the physiographic setting. Sedimentary processes related to dynamics of Volturno and Sele rivers contributed to shape the seascape off the Volturno and Sele plains respectively. In the Naples Bay the occurrence of some of the most active volcanoes,

the Phlegrean Fields and Somma-Vesuvius, significantly influenced marine and coastal habitats and landscapes.

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THE CENTRAL EUROPE PROJECT TRANSENERGY – TRANSBOUNDARY GEOTHERMAL ENERGY RESOURCES OF SLOVENIA, AUSTRIA, HUNGARY AND SLOVAKIA

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KEY WORDS: thermal water, geothermal energy, hydrogeology, transboundary aquifers, water management, Pannonian basin, Vienna basin, Styrian basin, Danube basin.

INTRODUCTION

Worldwide there is a growing need for sustainable energy – not only because of the negative climatic affects of the man-made emission of carbon-dioxide but also due to the restricted reserves of fossil combustible materials. A significant component of the energy mix of the future could be geothermal energy, a renewable energy which is stored as heat beneath the earth's surface (fig 1).

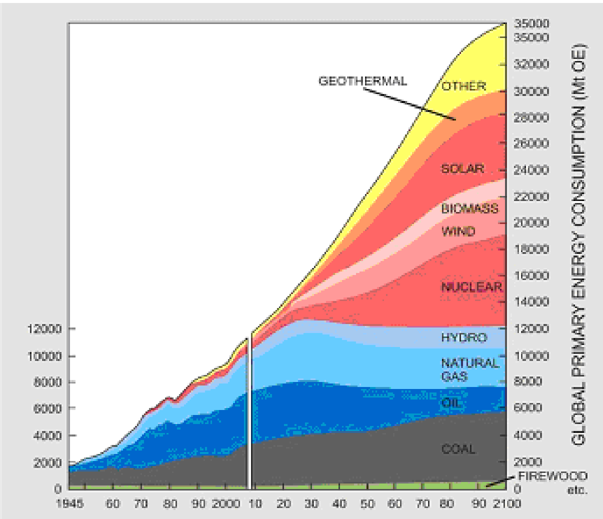

Figure 1 – Energy spectrum 1945 to 2100 after W. E. Schollnberger (2006)

In the Pannonian basin and its surrounding there are met good conditions for the production of geothermal energy due to the occurrence of deep aquifers and the elevated heat flow rate (Lenkey et al., 2002). But these natural resources are limited and a sophisticated water management is necessary to avoid overexploitation and conflicts among users. This is especially true to the national borders because the hydrothermal systems are strongly linked with favourable geological settings which don't end at the state boundaries. In this region the international water management is a challenge.

The project TRANSENERGY – Transboundary Geothermal Energy Resources of Slovenia, Austria, Hungary and Slovakia (it is implemented through the CENTRAL EUROPE programme and co-financed by the ERDF) deals with transboundary thermal water management from the geosciences' point of few. Four national geological surveys are partners in TRANSENERGY project: MÁFI (Geological Institute of Hungary), GeoZS (Geological Survey of Slovenia), GBA (Geological Survey of Austria) and ŠGÚDŠ (State Geological Institute of Dionyz Stur, Slovakia). The project started in April 2010 and it will deliver its services in March 2013.

PROJECT AREA AND THE CHALLENGE OF THERMAL WATER MANAGEMENT

The project area comprises the north-western part of the Pannonian basin and the adjacent Vienna and Styrian basin (red line in fig. 2). In this region Hungary, Slovakia, Austria and Slovenia border on each other. In this region famous ancient thermal springs and spas exist, for instance in Hévís in Hungary and Baden in Lower Austria. Due to the favourable geological conditions the number of thermal water utilisations (district heating, bathing resorts etc.) is constantly expanding.

The thermal water aquifers consist of Tertiary sediments or thick Palaeozoic or Mesozoic carbonates. In the project area the thermal water occurrences can be roughly divided into two types (transitions are possible): Stagnant thermal aquifers with high mineralized water can be distinguished from thermal convection systems with relatively young and low mineralized water. In the Vienna basin, for instance, such waters are described by G. Wessely (1983). For both types of thermal waters specific problems related to the application and water management can be observed: The low mineralized circulating thermal waters normally don't reach temperatures much higher than 50°C. Furthermore, in most instances their natural discharge is already in use which implicates the risk of overexploitation in the case of an additional thermal water catchment. The stagnant thermal waters are more interesting for energy production as they reach significant higher temperatures, but overexploitation is also here a problem, even if this risk is better manageable than in the mentioned convection systems. Moreover, due to the high dissolved content of the stagnant thermal waters there is the risk of environmental pollution. Therefore the reinjection of such waters is necessary – only small amounts used for balneological treatments are excluded from reinjection.

Figure 2 – Scheme of functionality operation.

THE PROJECT'S SUPPORTING TOOLS

The project TRANSENERGY will deliver multilingual tools supporting a sustainable transboundary thermal water management. These tools comprise a profound geoscientific evaluation of the thermal water resources of the project area, in which particular attention is paid to the pilot areas (fig. 2). These tools are based on geological, hydrogeological and geothermal models. Moreover, the project will deliver an overview on the actual legal framework on the use of thermal waters in the participating countries and the EU level and it will deliver a strategy paper with recommendations for an improved sustainable thermal water management in the project area. In these activities representatives of the national water management and mining authorities, land use planners, consultants and investors are involved by the project partners. After their completion in March 2013 all TRANSENERGY services (multilingual maps, databases, reports etc.) will be provided to the public by the project website (http://transenergy-eu.geologie.ac.at).

TRANSENERGY TEAM:

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TRANSENERGY WEBSITE:

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GLOBAL GROUNDWATER MAPS – THE WORLD-WIDE HYDROGEOLOGICAL MAPPING AND ASSESSMENT PROGRAMME (WHYMAP)

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KEY WORDS: hydrogeological map, WHYMAP, groundwater, global overview, groundwater resources world-wide.

THE WHYMAP PROGRAMME

WHYMAP (Worldwide Hydrogeological Mapping and Assessment Programme), a joint programme of UNESCO (United Nations Educational, Scientific and Cultural Organization), CGMW (Commission for the Geological Map of the World), IAH (International Association of Hydrogeologists), IAEA (International Atomic Energy Agency) and BGR (Federal Institute for Geosciences and Natural Resources, Germany), was established in 1999 as a contribution to management of the earth's water resources, especially groundwater. The International Groundwater Resources Assessment Centre (IGRAC) and the Global Runoff Data Centre (GRDC) as well as other scientific organisations, universities and regional centres are contributing to the WHYMAP network.

WHYMAP collects, compiles and collates groundwater-related hydrogeological information, at continental and global scales, to aid global discussion of water issues by making underground water resources more visible. It aims to raise awareness for this 'hidden resource' and help improving the often still weak understanding of the complexity of groundwater systems. To achieve this WHYMAP synthesizes the very large amount of hydrogeological mapping undertaken at regional and national level.

THE WHYMAP-GIS AND THE DERIVED MAPS

In order to allow the integration of large amounts of data of very different origin and to ensure flexibility and reproducibility of the products, one main focus of WHYMAP was the establishment of a geoinformation system (GIS) in which global groundwater maps and related vector and raster data are stored and processed. The design and creation of the GIS had to meet different requirements: the data structure had to prove useful for both the handling and processing of the digital data as well as for the representation of cartographic aspects for the output of high-quality thematic maps.

In its final form the WHYMAP-GIS is supposed to contain a number of thematic layers providing information on quantity, quality and vulnerability of groundwater resources of the world.

By combining this WHYMAP data with complementary information such as precipitation, surface water courses and their discharge or population data, important correlations and interdependencies can be visualised. This helps to understand the function of aquifers within the global water cycle, provide insight into potential pressures and point out the role of groundwater as a major source for drinking water-supply, agricultural irrigation and industrial production. The latest global map compiled by WHYMAP focuses on interaction of groundwater and surfaces water resources by comparing the river and groundwater basins of the world, which requires representing a three-dimensional reality on two-dimensional paper (see fig. 1).

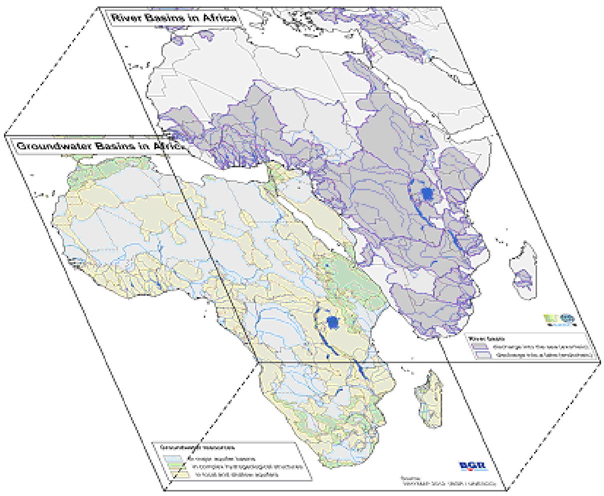

Figure 1 – Comparison of surface water drainage basins and underlying groundwater basins in Africa.

WHYMAP also serves as an entry gate for more detailed, national and regional hydrogeological map information all over the world. An internet based map application is available which combines the presentation of WHYMAP data with an information system on national, regional and continental hydrogeological maps. This 'World-wide Hydrogeological Mapping Information System (WHYMIS)' offers users searching for more detailed hydrogeological information a direct link to national web sites as well as existing printed maps, together with a set of metadata; it also serves as an archive function, in particular capturing maps of less developed countries that are all too often lost or not available to interested map users.

The WHYMAP data is also provided via WMS and Google Earth.

All WHYMAP products are derived from the WHYMAP-GIS, e.g. a number of global groundwater maps (see fig. 2), that has been released so far:

- A first small scale overview at the scale of 1 : 100 000 000 published in the 1st World Water Development Report in 2003.
- A global groundwater resources map at the scale of 1 : 50 000 000 compiled for the 32nd International Geological Congress in Florence in 2004.
- A special edition focusing on transboundary aquifer systems for 4th World Water Forum in Mexico City in 2006.
- An educational wall map of 'Groundwter Resources of the World' at the scale of 1 : 25 000 000 published as a contribution to the International Year of Planet Earth in 2008.
- A global map comparing 'River and Groundwater Basins of the World' at the scale of 1 : 50 000 000 released at the 6th World Water Forum in Marseille in 2012.

WHYMAP products and services are accessible via the programme web site www.whymap.org.

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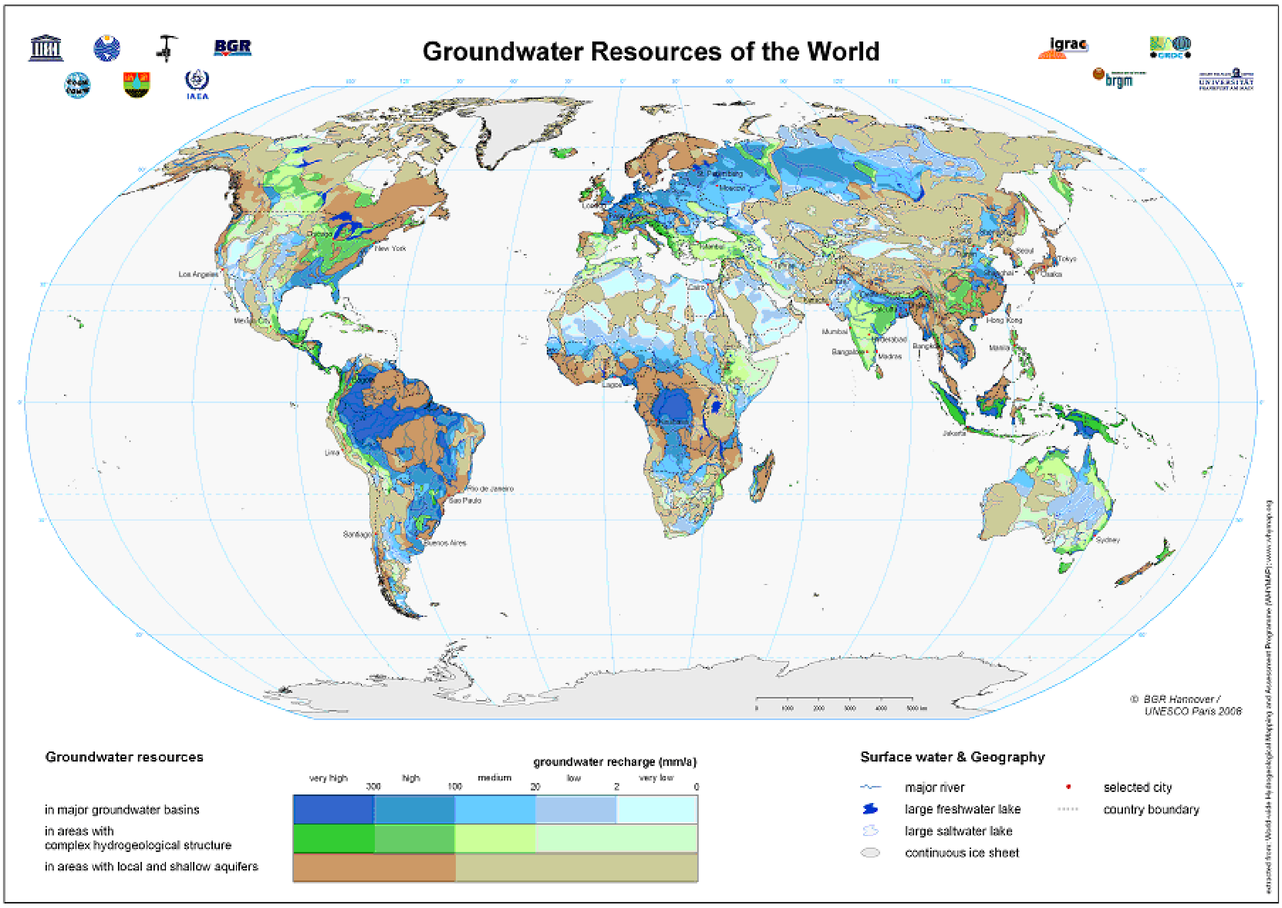

Figure 2 – Simplified groundwater resources map of the world.

APPLICATION OF STABLE ISOTOPES (^{18}O, ^{2}H) TO INVESTIGATE THE GROUNDWATER RECHARGE MECHANISM IN THE SANA'A BASIN, YEMEN

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Keywords: *isotopic study (^{18}O, ^{2}H), Groundwater recharge, Sana'a basin, Yemen*

ABSTRACT

In the present study, the environmental stable isotopes deuterium (^{2}H) and oxygen-18 (^{18}O) were applied to investigate the recharge mechanisms within the Sana'a basin. The results of this work provide some important insights into the dynamics of aquifer recharge in the study area. A comparison of the stable isotopic signatures of groundwater, spring water and rainwater samples indicates that the groundwater in the basin was recharged from rain occurs under cooler and wetter environment with greater intensity and duration as the currently climate conditions. The isotopic composition of the rainwater, groundwater and spring water samples are not identical. The ground- and spring water samples are more depleted in the heavier isotopes ^{18}O and D than the rainwater samples. The δ-values ^{18}O and D for the samples collected from the alluvium and sandstone aquifer plot along or close to GMWL and SMWL indicating to recharge from non- evaporated meteoric water, whereas the samples collected from the alluvium and limestone aquifer plot below the both meteoric water lines which indicate to evaporation process before recharge.

1 RESULTS AND DISCUSSION

1.1 STABLE ISOTOPES COMPOSITION OF RAINWATER

An establishing a MWL for the Sana'a basin is a one of the most important part of this work. The Oxygen and hydrogen isotopic composition of rainwater samples varies in a wide range; $\delta^{18}O$ changes from -8.03 to +4.50‰ while δD varies from -53.60 to +41.90‰ with an average to be -0.21 and +7.02‰, respectively. The d-excess values range from 0.00 to 22.40‰ with a mean of +8.68‰. The **Sana'a Meteoric Water Line (SMWL)** was defined by the final dataset of 52 rainwater samples collected from the Sana'a basin. This line is shown in (Figure 1) and defined by the (equation 1):

$$\delta^{2}H = 7.4*\delta^{18}O + 8.6‰ \ (R^2 = 0.95) \qquad \textbf{(eq.1)}$$

this line shows more or less similarity with the LMWL for Yemen Highland's defined by the (equation 2) (Al-ameri, 2011) and plots approximately along the GMWL indicates that the precipitations fall in the Sana'a region is probably little affected by evaporation (primary and secondary)

$$\delta D = 7.1 \times \delta^{18}O + 7.01‰ \qquad \textbf{(eq.2)}$$

Generally, the stable isotope composition in rainwater falls in Yemen is primarily affected by the **altitude and temperature**. Thus, the rainwater samples collected from Yemen Highland with lower temperature (such as theSana'a basin) are more depleted in $\delta^{18}O$ and δD than values reported for the coastal stations (higher temperature) which were more enriched in heavy stable isotopes. Other parameters affect the isotopes compositions of Yemen's rainwater are the air humidity and rain amount. Actually, the temperature, rain amount and the humidity are altitude function. The increase in the altitude is associated with decrease in the temperature and increase in the rainfall amount, consequently a decrease in the humidity. Unfortunately, no rain amount and humidity data were available at the time of the storm event. The available data obtained from the nearest meteorological stations cannot be considered suitable for reliable interpretations because of the small-scale variations of the amounts of precipitation and the data were not representative for the sampling stations (Al-ameri, 2011).

1.2 STABLE ISOTOPES COMPOSITION OF SPRING AND GROUNDWATER

Stable isotopes oxygen-18 and deuterium compositions of water samples collected from 24 deep wells and 13 springs located in the Sana'a basin in October 2009 can provide useful information on the recharge sources of groundwater. The data were used to determine the recharge origin and mixing process of the groundwater in the differences aquifer systems. The relation between $\delta^{18}O$ and δD for spring and groundwater samples in the study area is shown in (Figure 2). The oxygen and hydrogen isotopic compositions of groundwater's samples collected from the deep wells range from -4.20 to – 1.25‰ and from -24.39 to -5.3‰ with an average of -2.61 and -12.49‰, respectively. The d-excess value ranges from +1.53 to +11.6‰ with an average of +12.30.

The samples collected from springs are divided in tow groups according to their ^{18}O and D isotopes composition: one group plots along the GMWL and SMWL; the other group plots above the GMWL and LMWL. This is could be because of re-evaporation of precipitation from local surface water in low-humidity regions, as in the Sana'a region, creates vapour masses with isotopic contents that plot above the local meteoric water line (Clark & Fritz, 1997). Values for δ^{18}O and δD range from -3.05 to -0.45‰ and from -13.17 to -0.13‰ with an average to be -2.13 and -6.1‰, respectively. The d-excess was calculated to be +3.50 as minimum +and 15.70‰ maximum with an average of +10.96‰. The difference between the isotopic values of water samples collected from wells and the samples collected from the springs could be due to: a) a temperature effect; the samples of springs are colderthan the well samples due to the contact with the colder air temperature; b) most of the springs are fed by several springs of higher recharge altitude compared with that of the groundwater; c) pathways and residence time of spring water is shorter.

Figure 2 shows that the groundwater samples collected from the volcanic and the limestone aquifers plot below the SMWL and GMWL and exhibit the lowest d-excess values compared with the samples collected from the sandstone and the alluvium aquifer indicating relatively higher evaporation before recharge (groundwater in the volcanic and the limestone aquifer origins from evaporated meteoric water). The values for δ^{18}O and δD range between -1.3 and -3.35‰ and -5.3 and -20.5‰ in the volcanic aquifer and -1.25 and -4.20‰ and -8.5‰ and -24.4 in the limestone aquifer, with d-values of 4.9 and 1.5‰, respectively. In contrast, the samples collected from the sandstone and the alluvium aquifers are more depleted in the heavy stable isotope δ^{18}O and δD and show d-excess values to be 11.6‰ in the samples of the alluvium aquifer and 12.3‰ in the sandstone aquifer. These values are near the d-excess of GWML (10‰) indicating that they are little affected by evaporation before recharge.

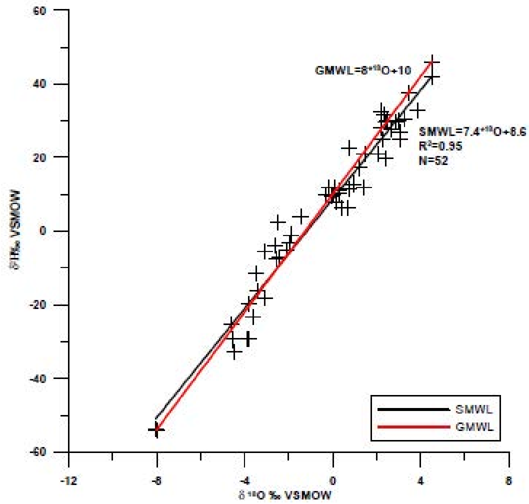

Figure 1: δ^{18}O vs. δD in rainwater samples collected from the Sana'a basin

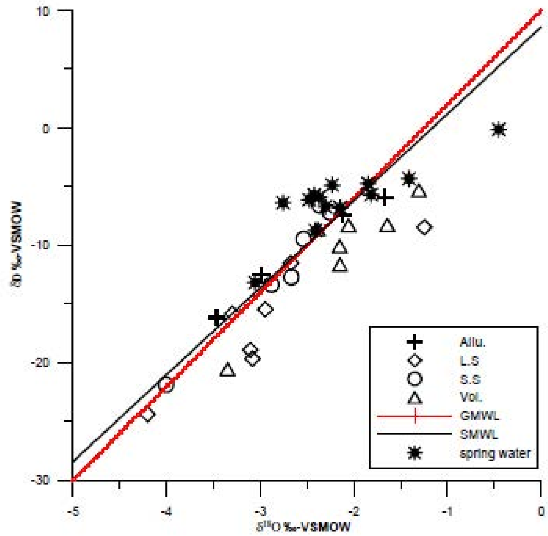

Figure 2: δ^{18}O vs. δD of spring and groundwater - Sana'a basin

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MAPPING SALINIZATION IN THE COASTAL AQUIFER OF RAVENNA (ITALY)

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KEY WORDS: Coastal aquifer, salt-water intrusion, subsidence, drainage, biodiversity, hydrology.

INTRODUCTION

The groundwater of the shallow coastal aquifer of Ravenna (Italy) is strongly contaminated by salt. The salinization has strongly increased in the last decades and it is threatening the ecosystems of the wetlands, the pine forests, and the dunes of the Park of the Po Delta (Antonellini et al. 2008, Antonellini and Mollema 2010). The coastal aquifer (Fig. 1) is a closed system and water recharge can only occur via infiltration of the rainfall and excess irrigation water in the dune areas and where sandy deposits are exposed at the surface. The limited rainfall, strong evaporation rate, sea level rise, and land subsidence have limited the amount of freshwater infiltrating into the aquifer (Mollema et al. 2012). The groundwater salinization is caused by two processes: (1) salt-water intrusion from the sea boundary, because of the strong hydraulic gradients landwards and (2) upwelling of Holocene brackish and salty water from the bottom of the aquifer where the water table is below sea level. The driver for both groundwater salinization processes is land subsidence and drainage. The physical law (Ghijben-Herzberg) clearly states that for each unit decrease in water table elevation with respect to sea level, there is a 30 times unit rise in the interface between salt-water and freshwater. In the low lying coastal plain of Ravenna, all human activities (agriculture, urbanization, etc.) are possible thanks to the drainage of the Land Reclamation Authority. The pumping machines of the land reclamation authority need to pump more water to sea in order to keep the land dry as land subsidence keeps raising the water table with respect to the topography. This drainage brings salt-water into the groundwater.

METHODS

The monitoring of the salinization of the Ravenna coastal aquifer started in 2003 using a network of shallow piezometers (20 piezometers at a depth ranging from 4 to 20 meters) that belonged to the Ravenna municipality. Antonellini et al. (2008) already reported the initial results of the study. During the last three years it was possible to add to this network, 36 piezometers (depth 18 to 27 meters) that were drilled in continuous coring plus three piezometers equipped with minifilters. An additional 73 auger holes were drilled mostly for calibration of the 87 Vertivcal Electrical Soundings (VES) along nine profiles normal to the coast. Water samples for full hydrochemistry analysis (see Mollema et al. this volume) were recovered by means of straddle-packers multi level samplers and water level, electrical conducibility as well as temperature were measured with continuous multiparametric logging in the piezometers and in the surface waters. The results of the monitoring campaign were integrated in ArcGIS and maps of watertable, water quality (freshwater, brackish water, and salt-water) as well as maps of isosalinity contours for selected values of salinity were produced. Areas of active sea-water intrusion were identified on the basis of the flow vectors maps. In this paper we define a water with less than 3 g/l salinity as freshwater; this because of the importance of this threshold for the ecosystems (Antonellini & Mollema 2010) and the advanced state of degradation of the aquifer. According to Stuyfzand (1989), most of the water in the Ravenna coastal aquifer would be classified as brackish.

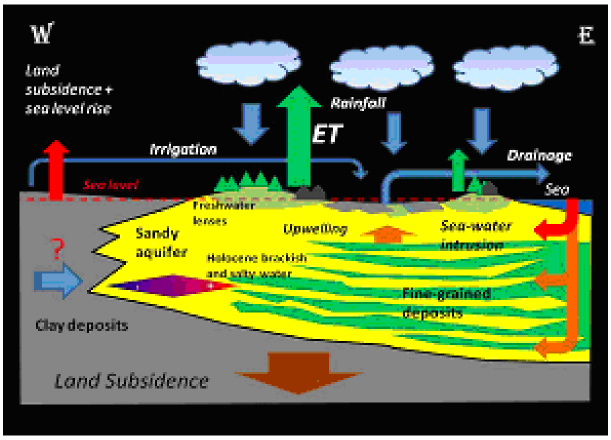

Figure 1 – Coastal aquifer processes.

RESULTS

The water table in both monitoring periods is mostly below sea level (Fig. 2a), which shows that the aquifer is in unstable hydrodynamic conditions; these conditions allow for active ingression of sea-water from the east and the upwelling of the salty brackish Holocene waters from the bottom of the aquifer. The quality of the water at the top of the aquifer (Fig. 2b) shows that most freshwater is located in the paleodunes (*Classe* and *San Vitale* forests), the beach dunes, and in the areas where the freshwater carried by the rivers and canals can seep into the aquifer. The water at the bottom of the aquifer is mostly salty and brackish (Fig. 2c) except for the northern area below the paleodunes of the *San Vitale* pine forest. The 3 g/l salinity threshold depth (Fig. 2d) shows how the freshwater in the aquifer is distributed in bubbles floating on top of brackish/salt-water; the thickness of these bubbles is rather small (1-5 m) and they form only where the rainfall can infiltrate in the aquifer where it is not confined by layers of alluvial clay. The groundwater flow in the aquifer is mostly from the sea landwards and it is controlled by the drainage of the pumping machines (Figs. 2e and 2f).

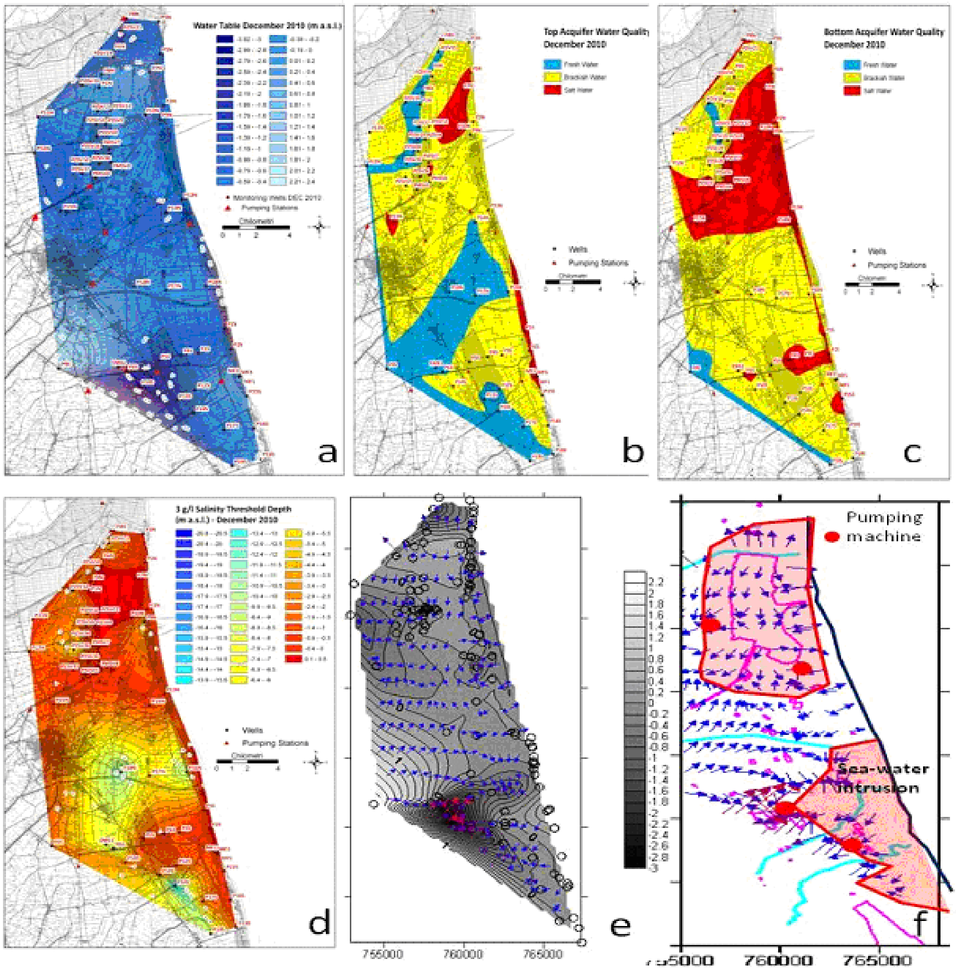

Figure 2 – Maps of the unconfined coastal aquifer of Ravenna. (a) Water table map in December 2010. (b) Water quality at the top of the aquifer showing the areal extent of freshwater, brackish water and salt-water in December 2010. (c) Same as in (b) but for the bottom of the unconfined aquifer. (d) Depth of the isobaths of the 3 g/l iso-salinity contours. (e) Water table depth and flow vectors field in December 2010. (f) Flow vector field and areas of active groundwater salinization (pink) in december 2010. The red dots represent the location of the pumping machines and that control the flow in most of the shallow aquifer.

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PO RIVER DEEP AQUIFERS IN EASTERN EMILIA-ROMAGNA ALLUVIAL PLAIN : GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERIZATION.

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KEY WORDS: Po river aquifers, geological maps, chemical and isotopic characterization of groundwater in deep Po river aquifers.

INTRODUCTION

A large amount of geological and hydro geological data was analyzed to improve geological and chemical information on Po river deep aquifers in eastern Emilia-Romagna alluvial plain. Geological data mainly consists of geological cross-sections available on the Emilia-Romagna Geological Survey website (http://ambiente.regione.emilia-romagna.it/geologia/), hydro geological data results from groundwater monitoring networks available on the Emilia-Romagna Environmental Agency website (www.arpa.emr.it).

CHARACTERIZATION AND MAPPING OF PO RIVER DEEP AQUIFERS IN ESTEREN EMILIA-ROMAGNA ALLUVIAL PLAIN

Aquifers in the Emilia-Romagna alluvial plain consist of gravel bodies in the southern part, along the Apennine border, and sandy bodies in the northern part of the plain. Gravels bodies characterize the alluvial fans of Apenninic rivers, sands are typical of both Apenninic rivers and Po river. Apenninic river alluvial fans are the main and most used aquifers in Emilia-Romagna Region (Regione Emilia-Romagna, 2004).

A distinction between Apenninic and Po river aquifers was suggested for the upper part of the geological succession (Late Pleistocene and upper part of Meddle Pleistocene, almost two hundred meters underground) in the Emilia-Romagna Water Protection Plan (Regione Emilia-Romagna, 2010), but it is not yet available for the lowest part of the succession (central part of Meddle Pleistocene, almost four hundred meters underground, Regione Emilia-Romagna & ENI-AGIP, 1998).

Different sets of information are used to identify Apennine or Po river sandy aquifers in the deepest part of the plain: sandy body thickness (generally more than ten meters for Po aquifers) and their lateral extension (at least for some kilometres), sand petrographic analysis and the paleogeographic context.

Available information enabled us to identify Po river sandy aquifers in many geological cross sections. These aquifers constitute very large sandy bodies of deltaic nature (Carta Geologica d'Italia, foglio n. 202, 203, 204, 222 and 223).

In the geological sections that have been analysed every Po river aquifer was assigned to different hydro stratigraphic units used in the Po Plain (Regione Emilia-Romagna & ENI-AGIP, 1998; Regione Lombardia & ENI, 2002).

A single map for Po river aquifers of different ages was developed by correlating data between all geological sections. A map for unit A3, A4, and B was developed and included aquifer boundary and sand top isobaths (example in fig. 1).

It was observed that over time Po river coarse sedimentation shifted from south to north in the Emilia-Romagna plain, up to a total shift of a few tens of kilometres. Displacement is due to tectonic activity in buried thrust of the Po Valley and along the Apennines chain, which produced a northward migration of the most depressed section of the plain where the Po river coarse sedimentation was located.

At the same time, the sections of the plain that were previously occupied by Po sedimentation where now occupied by Apenninic river sedimentation, which means that Apenninic sedimentation and Po river sedimentation can be found in the same portion of the plain.

HYDROGEOLOGICAL FEATURES OF PO RIVER DEEP AQUIFERS IN ESTEREN EMILIA-ROMAGNA ALLUVIAL PLAIN

After geological reconstruction and mapping, as above mentioned, it was possible to associate every Emilia-Romagna groundwater monitoring well to Po river or Apenninic provenience, and to assign them to their own stratigraphic units. This operation was possible only for groundwater whose filter positions were known.

Only wells with a single filtered stratigraphic unit were utilised to assign chemical and isotopic information to Po river deep aquifers.

Total available data base included 45 wells.

Geochemical data enabled us to observe that these aquifers are frequently characterized by sodium-bicarbonate groundwater, while the Apenninic aquifers are characterized by calcium -bicarbonate groundwater (Regione Emilia-Romagna & ENI-AGIP, 1998; Pilla et . al., 2006).

Oxygen isotope values are typical of Alps recharge of groundwater and confirm the Po river provenience of these aquifers (ARPA Regione Emilia-Romagna, in press; Longinelli and Selmo, 2003).

Preliminary evaluations allows to recognize the existence of palaeowaters in both Apennine derived and Po-Alps derived aquifers.

Chemical and isotopica data of selected groundwaters in the studied area have been compared with piezometric levels and with local withdrawal data. A relatively higher hydraulic head was observed in the Po plain aquifers with respect to the ones hosted in Apenninic derived conoids. This is probably also due to the intense groundwater withdrawal in towns located along the boundary between the Apenninic chain and the plain area.

Gradient in piezometric level due to groundwater withdrawal could induce groundwater flows through different sector of the aquifers, monitoring activities are currently carried out to verify this phenomena.

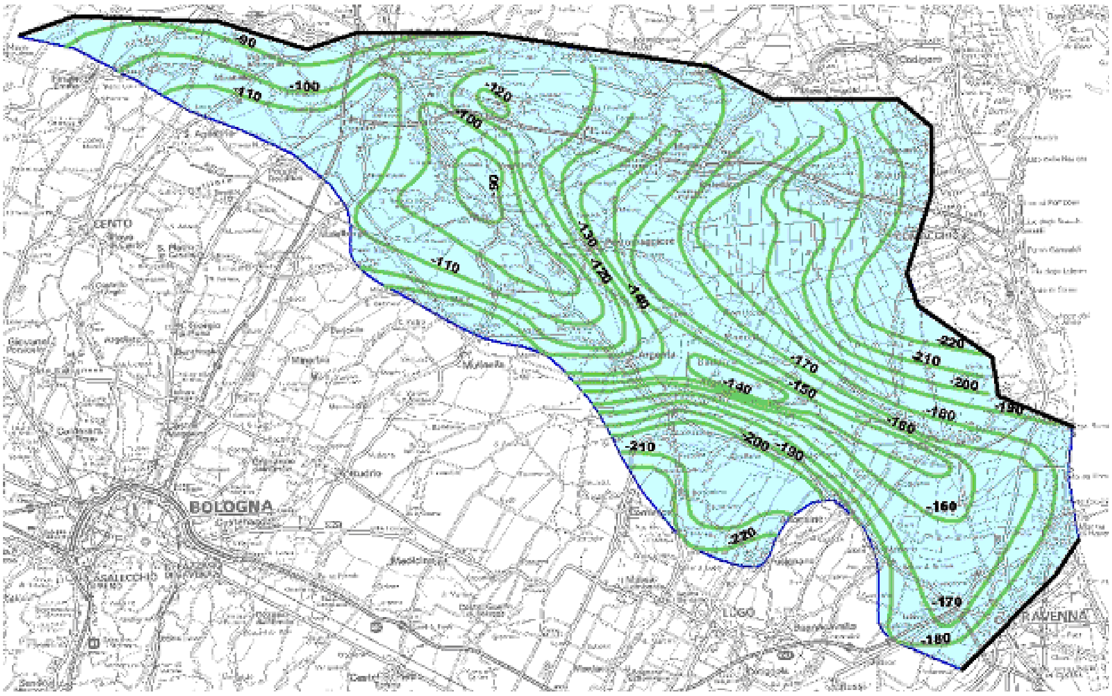

Figure 1 – Geological map of Po river aquifer A3. Boundary (blue line) and isobaths of the top sea level (green lines). Black lines show the boundaries of the study area.

CONCLUSION

Subsurface reconstruction from interpretation of many geological cross-sections have enabled to map deep Po river aquifers in the eastern part of the Emilia-Romagna alluvial plain.

This map has allowed us to assign the specific kind of aquifer (Po river or Apenneine river provenience) and its age to different groundwater monitoring wells.

Chemical and isotopic data fit to geological information and allowed us to better characterize Po river deep aquifers.

New knowledge on these aquifers could be utilized for further in-depth scientific investigations and for ground water management.

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HYDROGEOLOGY AND HYDROGEOCHEMESTRY OF THE MOLA PLAIN FRACTURED AQUIFER (ELBA ISLAND, ITALY)

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KEY WORDS: Hydrogeological conceptual model, Resistivity tomographies, Heavy metal, Step Drawdown Test, Costant Rate Test.

INTRODUCTION

Elba Island (Italy) is one of the numerous coastal areas where the need of drinking water is critical. This project is for study the potential of one of Elba Island aquifers for increasing its exploitation. This fractured aquifer lies under the Quaternary deposits in the Mola coastal plain, an East-West oriented depression, sized 2.5x1.5 km. We carried out the geological survey and the hydrogeological characterization of the whole southeastern sector of Elba Island, in order to define the recharge area of this deep aquifer, and its possible connection with the seawater.

The geological characteristics of this island are linked to its complex tectonic pile of nappes and to the well-known Fe-rich ores, also to the well-exposed interactions between Neogene magmatic intrusions and tectonics.

METHODS

The first phase of this work concerned the realization of geological map, and, after conceptualizing and designing step, the implementation of a geographical database. Several geological cross-sections were drawn in both North-South and East-West directions, in order to infer the subsurface geological structure.

We carried out also both structural geological survey and geomechanical survey to evaluate the main joints system of rock mass, which should bring the most part of groundwater flow.

In order to better conceptualize the geological model of Mola plain, we performed a geophysical survey by realizing 11 resistivity tomographies that were coupled with aerial photos interpretation and stratigraphic logs information. This leaded us to define the relationships among the main hydrostructures of Mola plain and infer the hydrogeological conceptual model (Figure 1). The shallower hydrostructure is mainly composed by recent fine sediments (the superficial aquiclude) that have a thickness ranging from 5 to 25 m in the central-eastern part of plain. This deposit lies on a thick layer of hornfels (the aquifer), in which fractures increase close to the contact zone with the below monzogranitic pluton (the bedrock). This condition increases the hydraulic conductivity of the deep aquifer. Differential GPS measures of every geological, hydrogeological and hydrogeochemical features were implemented in the geo database, together with the census of water wells and piezometers structural characteristics. In summer time (the more intensive exploitation period for the aquifer) we sampled the deep groundwater in more than 30 points for quantitative chemical analysis; during the field survey we performed also the main chemical-physical parameters of groundwater.

Few moths later, in December 2011 we carried out both Step Drawdown Test (SDT) and Costant Rate Test (CRT) in some Mola plain wells.

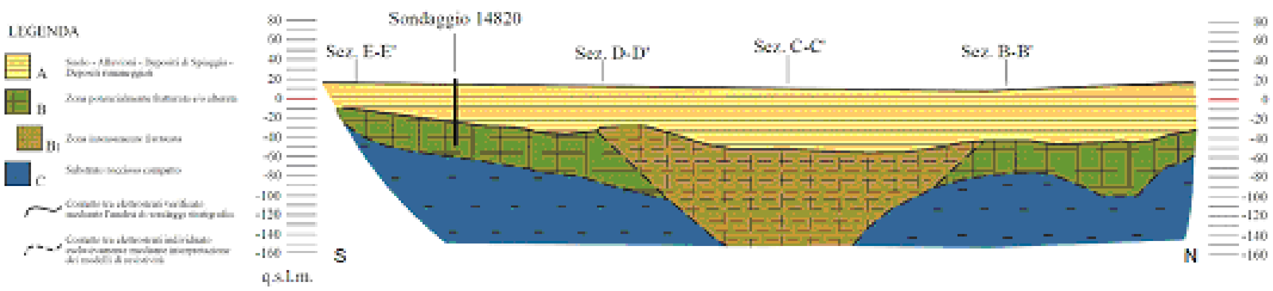

Figure 1 – Example of reconstruction of hydrostratigraphic structures of Mola plain by inferring electrostratigrahic cross sections achieved by resistivity tomographies.

During the pumping tests we continuously monitoring the groundwater levels by digital devices (Schlumberger Micro-Diver and CTD-Diver, together with Baro-Diver utilized for atmospheric pressure compensation). This was made for estimating the aquifer hydrodynamics parameters (Figure 2).

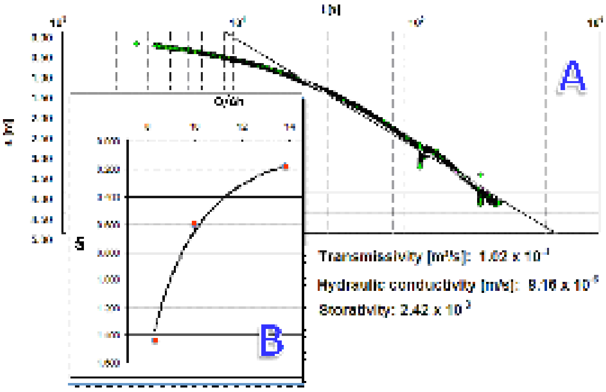

Figure 2 – A) Drawdown inferring of CRT by Cooper & Jacob method; B) Specific discharge (Q/Δh) vs drawdown (Δh)

RESULTS

Groundwater samples do not clearly belong to a particular geochemical facies, even if Calcium Sulfate facies prevails (Figure 3).

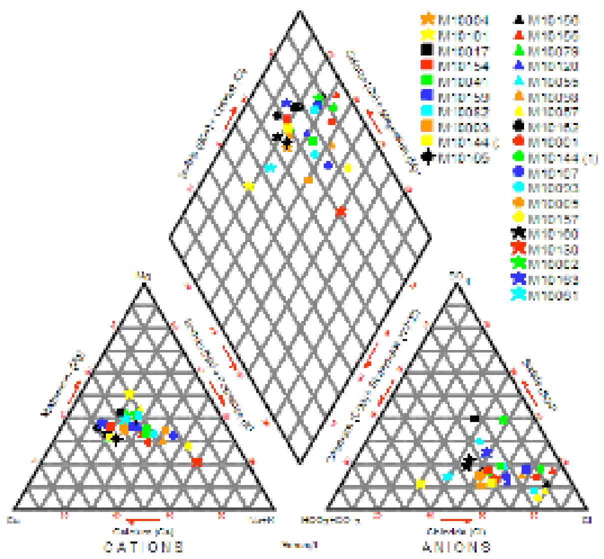

Figure 3 – Analysis of geochemical facies of well samples from Mola plain deep aquifer and other surrounding deep wells (field survey in July 2011)

Major Cations and Anions analysis points out high concentrations of Chlorides moving from West to East in the sampled wells, with 14 values in control points over the acceptable limits for drinking waters (D.Legs. 31/2001). Bicarbonates concentrations in the northern zone are higher than the others, since the dissolution of Ca and Mg carbonates frequently constituting the rocks of this sector. Generally all Cations shows similar evolution trends in terms of increasing and decreasing moving from North to South, while from West to East the variability is higher. Moreover we found elevate concentrations of sulfates (higher than the law limit equal to 250 mg/L; D.lgs. 152/06).

We performed the characterization of aquifer by carrying out the pumping test and observing the aquifer's response (drawdown) in both pumping and observation wells. Cooper-Jacob method (1946) best fits the aquifer test results of CRT, because the changing of measured hydraulic heads are very lower than the thick of the aquifer (Figure 2.A). Following Celico (1998), Q/Δh vs Δh graph highlights that the Mola plain deep aquifer is confined with large decreasing of hydraulic head (Figure 2.B). Once we stopped the CRT we measured how the aquifer restored its initial conditions. The interpretation of these data confirmed the mean parameters found during the drawdown test.

CONCLUSIONS

Analysis of heavy metals pointed out that As, B, Fe, and Mn major concentrations are mainly located in the western part of Mola plain. These high values might be related to the local environmental conditions and geological framework. We must to notice that the few B values higher than the law limit come from wells close to the aqueduct, so a mixing of water is plausible. Moreover, chemical-physical parameters seem to confirm the interpretation of hydrogeochemical facies.

This study highlights the non-relationships between Mola plain deep groundwater and the seawater. Hydrogeological and hydrogeochemical aquifer estimated parameters, together with the geometrical three-dimensional reconstruction of subsurface geology, will be the basis of the groundwater flow numerical modeling, that is under construction.

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SIMPLIFIED METHOD TO EVALUATE THE GROUNDWATER BALANCE OF A HYDROGEOLOGICAL BASIN BY MEANS OF A CALIBRATED 3D MATHEMATICAL MODEL: THE EXAMPLE OF THE TARO RIVER HYDROGEOLOGICAL BASIN (WESTERN EMILIA-ROMAGNA REGION, NORTHERN ITALY)

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KEY WORDS: water budget, monitoring network, net infiltration, aquifer recharge coefficients, 3D modelling.

INTRODUCTION

The Taro River Hydrogeological Basin (TRHB) is a small water bearing stack of fan-delta and alluvial fan depositional systems included in the Quaternary Po River Basin and located in the Western Emilia-Romagna Region of Italy, between the margin of the Northern Apennines and the Po River. The thickness of the fresh water bearing part of TRHB ranges from a few meters to more than seven hundred meters. Almost 90 Mm^3 of groundwater and 50 Mm^3 of stream water are yearly subtracted from the TRHB to sustain economic activities and drinking water demand of Parma Province population. A 3D mathematical model of TRHB has been built to evaluate the long-term sustainability of this consumption. The subsurface 3D finite element model is coupled via Cauchy type boundary conditions to a 1D finite element model of the Taro and Po rivers. This model of TRHB has been directly calibrated under transient-state conditions, simulating groundwater seepage and stream flows in the period between May 20th 2005 and October 31st 2006.

WATER BALANCE EVALUATION AND DERIVATION OF THE RECHARGE COEFFICIENTS

The following table shows the numerical water budget of the TRHB computed by the 3D mathematic model for the hydrologic year spanning from October 1st 2005 to September 30th 2006 inclusive.

Water volumes entering the hydrogeological basin (Mm^3)		
Recharge from rainfall	**A**	29.94
Recharge from the Taro River	**B**	39.98
Recharge from the Baganza River	**C**	11.58
Recharge from the Taro River Minor Tributaries of the southern margin	**D**	32.40
TOTAL (Mm^3)	**E**	**113.90**
Water volumes leaving the hydrogeological basin (Mm^3)		
Leakage towards the Po River	**F**	-13.23
Pumping from breeding wells and industrial wells pumping less than 10 cubic meters per day		-4.96
Pumping from irrigation wells **(CALIBRATED DATUM)**		-43.35
Pumping from wells of the public aqueduct		-17.00
Pumping from industrial wells (pumping more than 100,000 cubic meters per year)		-22.11
TOTAL (Mm^3)		**-100.65**
Water volume stored into the hydrogeological basin (Mm^3)		**13.25**

Recording the annual rainfall on the hydrogeological basin and on the mountain watersheds of the Taro River, the Baganza River and the Taro River Minor Tributaries of the southern margin, some recharge and leakage coefficients can be derived from the previous water budget as in the table below:

Autumn – Winter rainfall (Mm^3) on the		
Hydrogeological basin	**G**	148.52
Taro River mountain watershed	**H**	999.29
Baganza River mountain watershed	**I**	131.95
Taro River Minor Tributaries southern watersheds	**L**	108.12
DERIVED COEFFICIENTS		
Net infiltration coeff. (A/G)		**0.202**
Recharge from Taro R. coeff. (B/H)		**0.040**
Recharge from Baganza R. coeff. (C/I)		**0.088**
Recharge from Minor Southern Tributaries coeff. (D/L)		**0.300**
Leakage to Po R. coeff. (F/E)		**- 0.116**

Only the Autumn – Winter rainfall is considered useful in the coefficients calculation.

Inverting the process, by means of the calculated coefficients it's now possible to evaluate the numerical water budget of the TRHB for the following hydrologic years without running the original mathematic model. In this way we can save the time and money needed to prepare the time varying boundary conditions used by the model to run.

To support the validity of the proposed method, a specific monitoring network, comprising 21 selected piezometers (0.038 per km^2), has been set up. It records the variations of the groundwater level in the TRHB at the end of every hydrologic year. The Figure 1 shows the comparison between the water budget variations obtained by means of the derived recharge and leakage coefficients and the piezometric variations recorded until October 1st 2011.

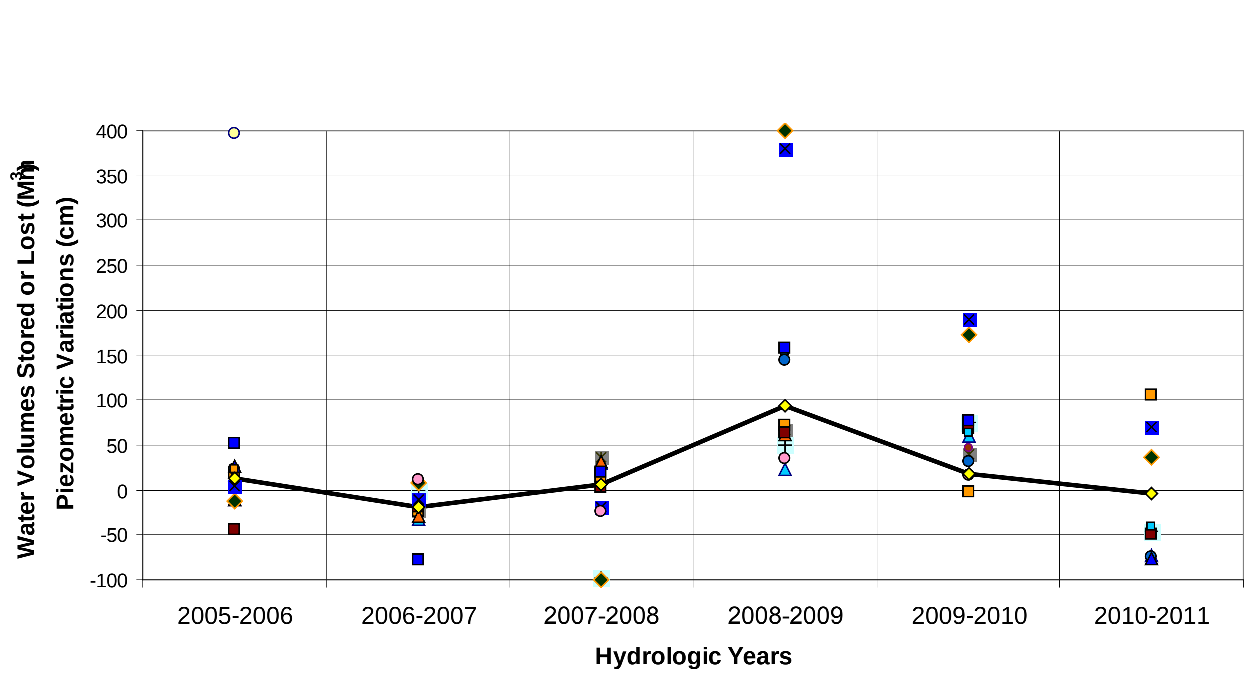

Figure 1 – Water budget variations (black line) obtained by means of the derived recharge and leakage coefficients, compared with the piezometric variations recorded in the 21 piezometers of the monitoring network.

CONCLUSIONS

The availability of a detailed and calibrated model of a hydrogeologic basin enables the evaluation of its water budget for a particular hydrologic year, even without running the original mathematic model. This is possible by means of the exposed method of the recharge and leakage coefficients derived from the recordings of the annual rainfall. This method can be validated by monitoring the annual variations of the groundwater level in the hydrogeological basin on a piezometric network specifically designed for this target.

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RIVER WATER QUALITY AND PROTECTION IN ZONE OF CORRIDOR X IN SERBIA

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KEY WORDS: water quality class, BOD_5, water saprobity, water protection, Corridor X.

STUDY AREA

As part of the scientific project "Danube-Morava Corridor (Corridor X) as the Main Axis of Regional Development and Integration of Serbia with the Environment in the South East Europe" few years ago, we analyzed also surface water quality state of the Corridor X through Serbia (border with Croatia–Sava valley-Belgrade metropolitan area–Velika- and Južna Morava valleys-the border with Macedonia). In the Corridor X area is concentrated most of the population of Serbia, as well as major industrial facilities, so water from rivers and their alluvial plains was used for water supply. Therefore, the exploration of the river water quality in this zone is of great importance and it will be again analyzed with data from 2010.

Figure 1 - Location of Corridor X in Serbia

SURFACE WATER QUALITY

The surface water quality was analyzed at 33 gauging station according to physical, chemical and biological characteristics of water, using the data of the Republic Hydrometeorological Service of Serbia The most significant parameters were taken into consideration: the total evaporation residue (mg/l), biological oxygen demand BOD_5 (mg O_2/l) and water saprobity (Table 1).

Observing gauging stations, higher values of total evaporation residue (which does not exceed 1000 mg/l) were registered at 12 profiles, so the water, according to this indicator is classified into II class. BOD_5 values of purest surface waters amounts less than 2 mg O_2/l, and it was registered only at Sremska Mitrovica profile in the Corridor X zone. At the other profiles, different BOD_5 have been registered: class II (17 stations), class III (11 stations), class IV (3 stations) and at profile Vrbas II in Danube-Tisa-Danube canal, exceeded the maximum permissible concentration (Milanović et al, 2011).

In Corridor X zone, there was not registered I or II water quality class at any profile. At 7 profiles (21.2%) water is in transition from II to III quality class, at 8 profiles (24.24%) water belongs to III quality class, at 10 profiles (30.3%) water is in transition from III to IV quality class, at 5 profiles (15.15%) water belongs to class IV, while the water at 3 profiles cannot be classified into any class. Conclusion is that none of 33 gauging stations has a better class than the required or appropriate.

In comparison to 2002 (Miljanović et al, 2004), when the prior research was done, water quality state has been improved to 6 measurement profiles - from IV to III/IV class (3 profiles on Južna Morava River), from III to IV class (Danube-Tisa-Danube canal at Novi Sad), from III to II/III class (Jerma River) and from „out of class" to class IV (Krivaja River). In 9 gauging stations the situation has remained unchanged: Velika Morava river (3 profiles), Veternica, Južna Morava, Nišava, Veliki Lug and D-T-D canal (profiles Vrbas I and Vrbas II). For the other 18 gauging stations the river water quality pointed to pollution increase- from the III to intermediate III/IV water quality class (the Danube at Novi Sad, Nišava River at Niš, Jablanica-, Pusta-, Toplica-, Crnica- and Resava River); from the II to the II/III water quality class at all 4 gauging stations in Sava River; from the III to the IV class in Velika Morava River at Bagrdan and from the II to III water quality class in Danube at Zemun and Smederevo, and Vlasina River. Topčiderska River is out of class. The causes of river water pollution increase is mainly an increase of BOD_5, the activity of the largest commercial and industrial centers, located nearby these rivers and decreasing of river discharge in low water level period, especially in the smaller streams.

River	Gauging station	Total evaporation residue	BOD_5	Saprobic index	Required class	Actual class
Gaberska	Mrtvina	II	III	β-mezosaprobna	-	II/III
Sava	Jamena	I	II	β-mezosaprobna	II	II/III
Sava	Sremska Mitrovica	I	I	β-mezosaprobna	II	II/III
Sava	Šabac	I	II	β-mezosaprobna	II	II/III
Sava	Ostružnica	I	II	β-mezosaprobna	II	II/III
Jerma	Trnski Odorovci	I	II	β-mezosaprobna	II	II/III
Nišava	Dimitrovgrad	I	II	β-mezosaprobna	II	II/III
DTD canal	Novi Sad	II	III	β-mezosaprobna	IIa	III
Velika Morava	Varvarin	I	II	β-mezosaprobna	IIa	III/IV
Vetrenica	Leskovac	I	II	-	IIb	III
Dunav	Novi Sad	I	III	β-mezosaprobna	II	III/IV
DTD canal	Vrbas I	II	III	β-mezosaprobna	IIb	III
Jablanica	Pečenjevce	II	III	-	IIb	III/IV
Vlasina	Vlasotince	I	II	-	IIa	III
Dunav	Zemun	I	II	β-mezosaprobna	II	III
Dunav	Smederevo	I	II	β-mezosaprobna	II	III
Južna Morava	Grdelica	I	II	β-mezosaprobna	IIb	III
Južna Morava	Aleksinac	I	II	β-mezosaprobna	IIa	III/IV
Južna Morava	Mojsinje	I	II	β-mezosaprobna	IIa	III/IV
Nišava	Bela Palanka	I	II	β-mezosaprobna	IIa	III
Nišava	Niš	I	III	-	IIb	III/IV
Pusta	Brestovac (ili Pukovac)	II	III	-	-	III/IV
Resava	Svilajnac	II	II	β-mezosaprobna	III	III/IV
Toplica	Doljevac	II	III	-	IIb	III/IV
Crnica	Paraćin	II	II	-	IIa	III/IV
Velika Morava	Bagrdan	I	II	β-mezosaprobna	IIa	IV
Velika Morava	Velika Plana	I	IV	β-mezosaprobna	IIa	IV
Velika Morava	Trnovče	I	III	β-mezosaprobna	IIa	IV
Velika Morava	Ljubičevski most	I	III	β-mezosaprobna	IIa	IV
Krivaja	Srbobran	II	IV	β-mezosaprobna	IIb	IV
Topčiderska River	Rakovica	II	III	-	-	(VK)
Veliki Lug	Mladenovac	II	IV	-	IV	(VK)
DTD canal	Vrbas II	II	VK	β-mezosaprobna	IIb	(VK)

Figure 2 - River water quality in Corridor X zone X in 2010.

PROTECTION OF RIVER WATER QUALITY

In the Corridor X area a small percentage of the territory is protected. Considering the water quality state and its importance, it is necessary to implement measures for their protection, which include the purification of polluted water. According to the Spatial Plan of Serbia from 2010 it is necessary to reserve areas for filtration belts construction on polluted rivers in the areas of pollution. The big problem is also the lack of system for wastewater treatment. They are presented in small number in Serbia, and it is in plan to construct them in future.

Long-term program goal is to keep most of the rivers in the Corridor X area within the I, IIa and IIb water quality class, or reclassify them to these classes, in case they are now in the worst condition. Exceptions are several small rivers in which area are located big urban and industrial centers (Lug River downstream Mladenovac and Lepenica River downstream of Kragujevac, which should belong to the III or III/IV class). From a regulatory point of view new Water Act of the Republic of Serbia, which is in action from 2011, is important because it contains a series of regulations on limit values of hazardous substances and pollutants emission. Unfortunately, new deadlines for improving water quality and reaching allowed values can be determined after defining current state of water quality.

ACKNOWLEDGEMENTS

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RESOURCES AND HEALING PROPERTIES OF SULPHUR-HYDROGEN MINERAL WATERS OF SERBIA

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KEY WORDS: sulphur-hydrogen, mineral waters, resources, healing, Serbia

Hydrogen-sulphide has been used for balneological purposes only recently. By completing this study, the carried out research has pointed to a significant number of occurrences containing hydrogen-sulphide on the territory of Serbia. The obtained data have pointed out that nowadays hydrogen-sulphide is being used intensively for healing purposes. Hydrogen sulphide (H_2S) is a gas which can be organic- biochemical and inorganic-chemical in origin. The organic origin is related to the decomposition process of organic matters and micro organisms containing sulphur. The inorganic origin is related to chemical reactions at high pressure and temperature.

On the territory of Serbia, there are about 50 occurrences containing hydrogen-sulphide. Out of the overall number of occurrences, the presence of hydrogen-sulphide is recorded only in traces with some of them while the recorded concentration with some other occurrences is even to 19 mg/l. Territorially, occurrences with hydrogen sulphide were formed within varied rock formations and differ significantly according to their quantitative and qualitative properties. The regions without any data on the existence of occurrences with hydrogen-sulphide are located north of the Danube River, i.e. in the area of the Pannonian Basin as well as in the farthest east of Serbia.

A position map of sulphur-hydrogen mineral waters on the territory of Serbia is represented in Figure 1.

No	Location	No	Location
1	Malo Laole	27	Mlaela-Veluće
2	Palanački kiseljak	28	Bogutovačka Banja
3	Suvi Do (Žagubica)	29	Jošanička Banja
4	Šarbanovačka banja	30	Lukovska Banja
5	Banja Jošanica	31	Kuršumlijska Banja
6	Lepterija (Soko Banja)	32	Novopazarska Banja
7	Ribarska Banja	33	Banja Vuča
8	Kulinska Banja	34	Banjska
9	Suva Česma	35	Lužane
10	Pločnik-barutana	36	Klokot Banja
11	Tularska Banja	37	Slankamen
12	Vranjska Banja	38	Jakovo
13	Bujanovačka Banja	39	Bogatić
14	Višnjička Banja	40	Kupinovo (Tp)
15	Obrenovac "Kasarna"	41	Kupinovo (1/H)
16	Obrenovačka Banja	42	Dublje
17	Banja Ljig	43	Banja Badanja
18	Brdani	44	Banja Koviljača
19	Žaočani	45	Radaljska Banja
20	Banja Slatina	46	Planinica
21	Vršinci	47	Ovčar Banja
22	Vitanovac	48	Kotrađa
23	Mataruška Banja	49	Kremna
24	Vrnjačka Banja (Snežnik)	50	Lopatnička banja
25	Vrnjačka Banja (Slatina)	51	Rajčinovića Banja (t)
26	Vrnjačka Banja (Jezero)	52	Pećka banja

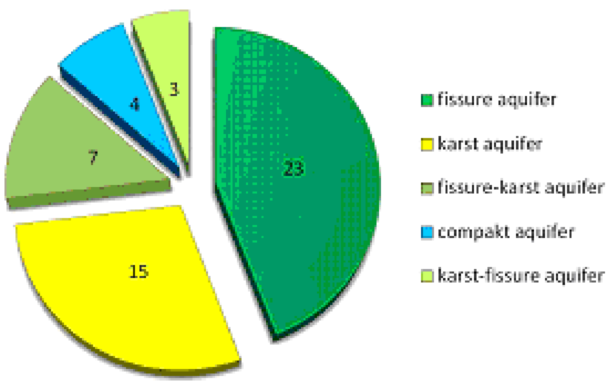

Figure 1 – Position map of sulphur-hydrogen mineral waters on the territory of Serbia

The majority of occurrences have been recorded within rocks with fissure porosity represented by metamorphosed Palaeozoic shale, a volcanogenic complex and ultramafic rocks. A karst aquifer has been formed within Cretaceous, Triassic, and Sarmatian limestone where 15 occurrences have been recorded. Fissure-karst and karst-fissure aquifers have been formed within low metamorphosed shale and diabase-horn slate formations depending on the distribution of limestone sediments. A compact aquifer is recorded within alluvial sediments represented by sands of varied grain size. Overall reserves of sulphur-hydrogen mineral waters on the territory of Serbia amount about 400 l/s. Based on the chemical composition analysis of the most significant occurrences with hydrogen-sulphide on the territory of Serbia, it can be stated that a hydro carbonate groundwater type (HCO_3) prevails. The presence of carbonate (CO_3), sulphate (SO_4) and chloride (Cl) ions, as prevailing ones, is recorded only with a few occurrences, in the anion composition. A sodium- calcium water type (Na+K) prevails in the cation composition.

Groundwaters rich in sulphide and hydrogen-sulphide are used in the healing of wide range of diseases, from skin infections, respiratory problems to skin inflamed processes. These waters are also used for treatment of liver and gastro-intestinal tract as well as in case of respiratory problems when inhalation therapy is applied. On the basis of given balneological values of examined waters it can be concluded that, on the territory of Serbia hydrogen–sulphide is used in healing of the following diseases :

- Joint and other kinds of rheumatism and sciatica,
- Skin diseases (especially psoriasis)
- Diseases of central nervous system
- Orthopaedic diseases
- Gynaecological diseases
- Problems with liver and gastro-intestinal tract,
- Respiratory problems,
- Arthritis problems,
- Post-traumatic and postoperative disorder,
- Detoxification of organism.

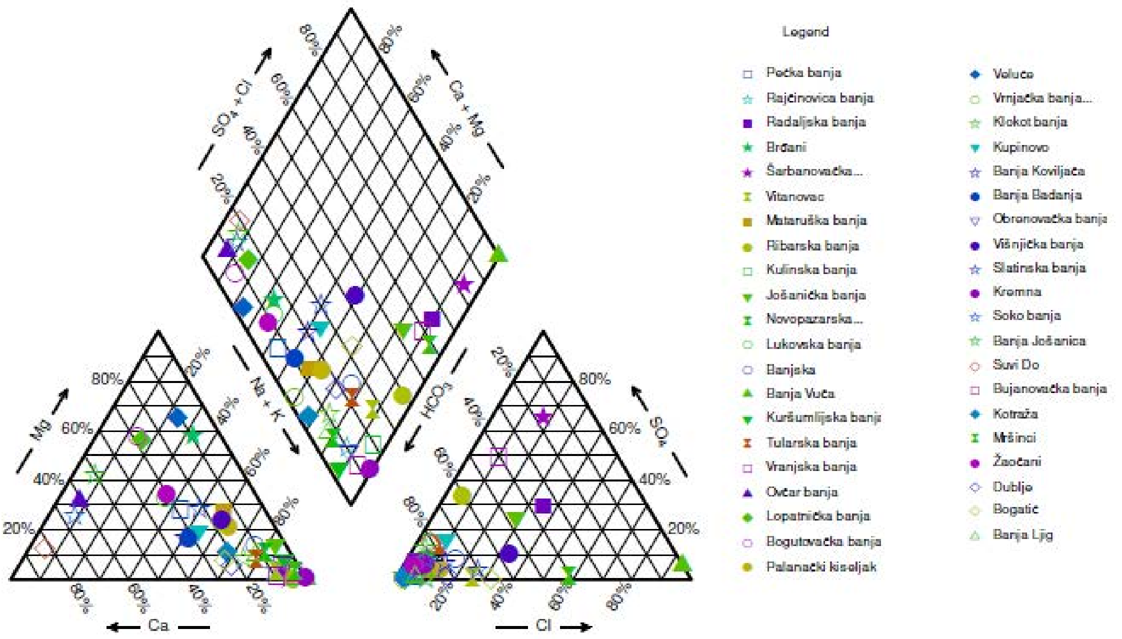

Figure 2- Piper trilinear diagram of sulphur-hydrogen mineral waters (the most significant occurrences) on the territory of Serbia

The mineralization of sulphur-hydrogen mineral waters ranges from 0.3 g/l (Banja Vuča Spa, Ribarska Banja Spa, Žagubica) to 5.9 g/l (Slankamen). The yield of the examined occurrence ranges from about 1l/s to occurrences with the capacity of 60 l/s (Bogatić). The temperature of sulphur hydrogen waters ranges

from 8^0C (Kremna) to 75^0C (Bogatić). Piper trilinear diagram of sulphur-hydrogen mineral waters (the most significant occurrences) on the territory of Serbia is represented in Figure 2.

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A PROPOSAL TO INTEGRATE THE ANALYSIS OF TREND CONCENTRATION OF CONTAMINATION IN WELLS IN GROUNDWATER VULNERABILITY ASSESSMENT

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KEY WORDS: groundwater vulnerability, trend analysis, statistical methods.

INTROD UCTION

Nitrate is an abundant contaminant of groundwater. Determining areas where groundwater is at high-risk of nitrate contamination and which factors mainly influence its presence represents an important step in managing and protecting both groundwater and human health. Given its chemical stability in water, high mobility, and the wide range of sources, nitrate clearly represents a natural choice as an effective indicator for the protection of groundwater to surface contamination. In some areas, the frequency with which nitrate concentration has been monitored in groundwater, and the long time series of data, would allow to perform historical analysis of contamination trend. Thus, determining the trend occurring in a specific area would allow to determine if groundwater management plans adopted in the area were effective, to evaluate the reliability of the groundwater monitoring network and to give an important support in locating the main hazardous areas. To cope with this problem European Community has issued two main Directives with the aim to prevent and reduce nitrate water pollution, obliging Member States to design nitrate vulnerable zones (91/976/EC), and more recently to provide measures and methods to protect groundwater against pollution and deterioration (2006/118/EC).

METHODS

Analysis of nitrate concentration trend in a porous aquifer in the river Po plain, a wide area identified by European Community as a nitrate vulnerable zone, has been done. Ten different type of trends has been identified and classified by assigning a specific rank according to their indication of different degree of relative hazard. The spatial distribution of these trends (determined for a number of wells, used as Training Points, TPs) has been related to "unique conditions" identified as singular spatial combinations of factors, representing both potential sources of nitrate and parameters influencing its movement to groundwater. This simulation has been done using an alternative Weight of Evidence (WofE) method. Then, the obtained distribution has been compared and merged with the specific vulnerability map of the area using the classical WofE approach (Bonham-Carter et al 1989).

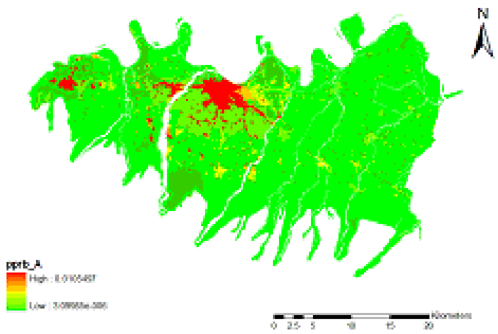

Figure 1 – Posterior probability for Map B.

RESULTS

The alternative WofE method analysis requires the use of a new parameter: the time factor. A classification was realized based on trends of nitrate concentrations, and this classification was used to create the first map.

- Posterior probability map, based on trends of nitrate concentrations in wells (Map A). 22 TPs having the most critical trends were used as TPs, to create this map.
- Posterior probability map, achieved by the average weights calculated from the study of trends and concentrations in wells (Map B) (Fig.1).

This map was created using TPs achieved by a process of elaboration, called ranking, which consists in attribution of a mathematical value for each class of both trends and concentrations. For each TP, it's calculated the average of the numerical values achieved for the two classifications. The average value is then used to realize the map. 18 wells with higher weights were selected and used as TPs to elaborate the map.

- Posterior probability map, achieved from the study of concentrations (Map C).

This map was realized using classical WofE method; training points are 19 wells with values higher then the average concentration (20.12 mg/l).

- Posterior probability map, considering Map A and Map C (Map D) (Fig. 2)

This map was realized using a simple average, performed on each pixel of two previously developed maps: the posterior probability map of trends (A) and the posterior probability map of concentrations (C).

For every pixel of the mask, it was performed the following operation: D=(A+C)/2; this means that values of pixels of the output map are the mean of posterior probability parameters of respective pixels of the two input maps.

After these phase, the last step was the comparison between Map B and Map D. The spatial agreement between the two maps was calculated by performing a simple pixel-pixel comparison. Comparison shows a very good agreement between the two maps.

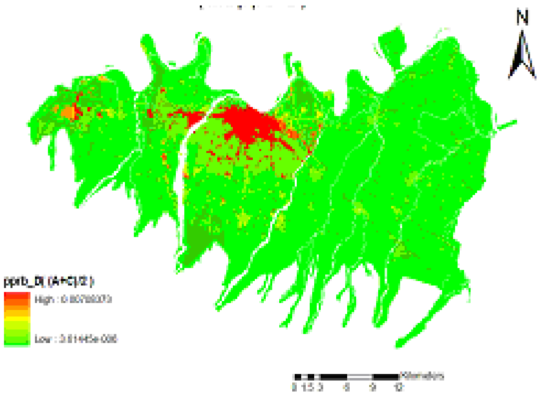

Figure 2 – Posterior probability values obtained for Map D

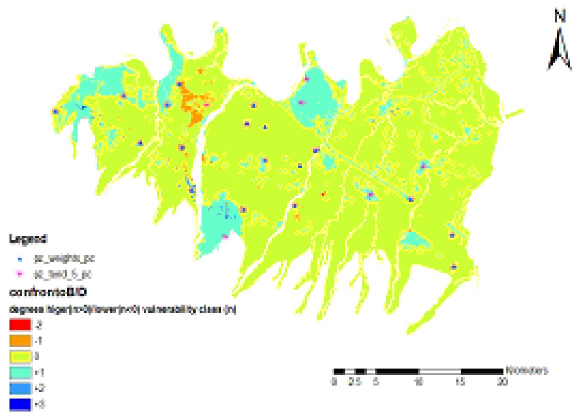

Figure 3 – Comparison between Map B and D

CONCLUSION

The identification of areas where groundwater is characterized by upward concentration trend of contaminants is required by EC laws. Even when specific vulnerability maps correctly represent the present status of groundwater contamination, they could not be able to identify areas characterized by upward trend and therefore could not be a useful tool for preventing further deterioration of groundwater quality;

In this context spatial statistical approaches represent useful tools because they allow to keep into account the time factor in groundwater vulnerability assessment. Two different approaches have been used to evaluate their general performance. The agreement between the two is good and indicates a high potential to use the described approaches to better understand the cause-effect relationship between concentration trends and variations of potential predictors.

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ANTHROPOGENIC INFLUENCES ON A KARST ISLAND, THE BLATO AQUIFER ON THE ISLAND OF KORČULA, CROATIA.

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KEY WORDS: Karst aquifer, diffuse pollution, arable soil, land-use, climate change.

INTRODUCTION

The Blato aquifer on the island of Korčula has two major threats to the quality of its potable water a) salt water intrusion and b) agricultural diffuse groundwater pollution. To assess the possible impact of land-use change on groundwater a detailed study of both the aquifer and soil cover in this unique karst system were carried out. The soil geochemistry was used to determine the present state of the soil cover and the soil profile related to agricultural practices and their changes during the past one hundred years. The studied catchment is located in the most western part of the island Korčula, about 1,3 km away from the sea. The Blatsko polje covers about 3 km^2, and the area of hydrogeological catchment is 28,4 km^2. The area is mostly covered by antropogenic soils, rendzinas, terra rossa, and brown soils on limestones. During the past, waters often flooded larger parts of polje during autumn-winter period, sometimes even covered parts of polje for several years. At that time, polje was used to grow short period crops like millet, or as pastures. Terraces on surrounding hills were used to grow olives, vineyards and figs. Melioration of Polje begun at 1912, when the 2000m tunnel was created from the lowest point of the Polje to the Bristva cove at the northern part of the island. After the hydromelioration was complete, vineyards were gradually relocated to Polje.. Intensive farming is detected as a potential source of pollution of soils, surface and underground water. The most often pollution comes from nitrates and pesticides, but also from accumulation of heavy metals. The abstraction wells are located in an agricultural area, so special care is needed in application of fertilizers, pesticides, herbicides and fungicides.

HYDROGEOLOGY AND CLIMATE CHANGE

The hydrogeological and hydrological investigations were performed in the test area Blatsko polje on the island of Korčula with the purpose of determination of the recent climate changes/variations. The Blatsko polje aquifer extracted by few pit wells is currently used for public water supply of the nearby settlements, representing their only water source with some 60 L/s during the summer time. Water quality is good, but in extreme hydrological conditions after few consecutive dry years, seawater intrusions in aquifer happen. Detail hydrogeological mapping and tracer test enabled delineation of the catchment area (Terzić et al., 2008), which is in this karst terrain quite different than the topographic water divide (Fig. X). Climatic models (Aladin, Promes, RegCM3) suggested slight trend of annual precipitation decrease and quite significant increase of air temperature. Such predictions were put in simple water balance models (Turc, Langbein; modified for GIS by Horvat & Rubinić, 2006). Results were very troublesome: there will be a significant water deficit in the aquifer because the amount of effective infiltration in this sensitive karst aquifer will be up to 30% lower (RegCM3), or even 47% lower (Aladin) – until the year 2100. The water supply will, therefore, possibly have to be faced with this scenario and extracted groundwater quantities will have to be decreased. Since this is coastal karst groundwater system, the seawater intrusions will also be probable with the drop of groundwater level, and water quality will deteriorate as well. New sources for potable water will have to be secured.

TOPSOIL GEOCHEMISTRY OF THE CATCHMENT

Thirty five shallow soil profiles within the Blato chatchment were sampled and analysed for total and mobile fractions of elements do determine their liable (mobile) fraction which could influence the water quality. Also to assess possible anthropogenic influences, enrichment factors were calculated using Sc as a normalising element. Cobalt, Cr, Ni, La, Ba and Zn reflect the geogenic background when normalized to Sc. The distribution and abundance of Cu reflects that it is probably the only heavy metal that has affected the area of the Polje. Copper can be supplied to the aquifer during storm flooding from the contributing catchment, both in its dissolved form and bound to eroded topsoil particles. Compared to the forest and machia soil the Cu/Sc ratio of the arable soils contain three to five times more Cu. The amount of Cu bound to the carbonate phase (0.11 mol dm-3 CH3COOH extraction, 1 st step of the BCR sequential procedure) of vineyard soil was up to 22% of total Cu. The uncultivated slope soils contain Cu in the range from 22 to 45 mg/kg with a mean concentration of 38.7 mg/kg while the vineyard soil Cu concentrations range from 120-450 mg/kg. The content of Cu in topsoils from Dalmatia range from 6 to 923 mg/kg with an average of 67 mg/kg. These forest soils contain Pb and Zn slightly enriched compared to the arable soils. Although considered as a micronutrient studies have shown that Cu residues originating from fungicide application reduce soil microbial biomass, and in the orchard where residues averaged between 180-338 mg/kg Cu has resulted in an elimination of earthworms. Use in Europe has lead to high levels in the soil (200-500 mg/kg in France and similar concentration rages have been determine for Croatian vineyard soils. Copper is an essential element and required by all organisms. However, elevated concentrations of Cu in soils are toxic and may result in a range of effects including reduced biological activity and subsequent loss of fertility.

When all social, economic and political factors are taken into account, task seems impossible. There is a trend in the last decade to enable abandoned arable lands, and to expand production of grapes and olives. If the predicted climate changes occur, with same precipitation and higher temperatures, wine makers will gradually have to consider grape and vine adaptation issues like variety shifts or water management on the terraces surrounding polje. To induce sustainable farming, and at the same time reduce risks for future water quality, further education of farmers has to be provided. One of the curtail changes should be the abandonment of Cu based fungicides. With reasonable discussion and presented facts, farmers were easily persuaded to change current land use practices. Reallocation of vegetables around the water wells, and planting fruit trees instead drastically reduced the amount of nitrates in the water. In the spirit of that success, further measures should be taken, to educate farmers even more (e.g. how to more efficiently use fertilizers or fungicides), and insure water quality in the more distant future.

ACKNOWLEDGEMENTS

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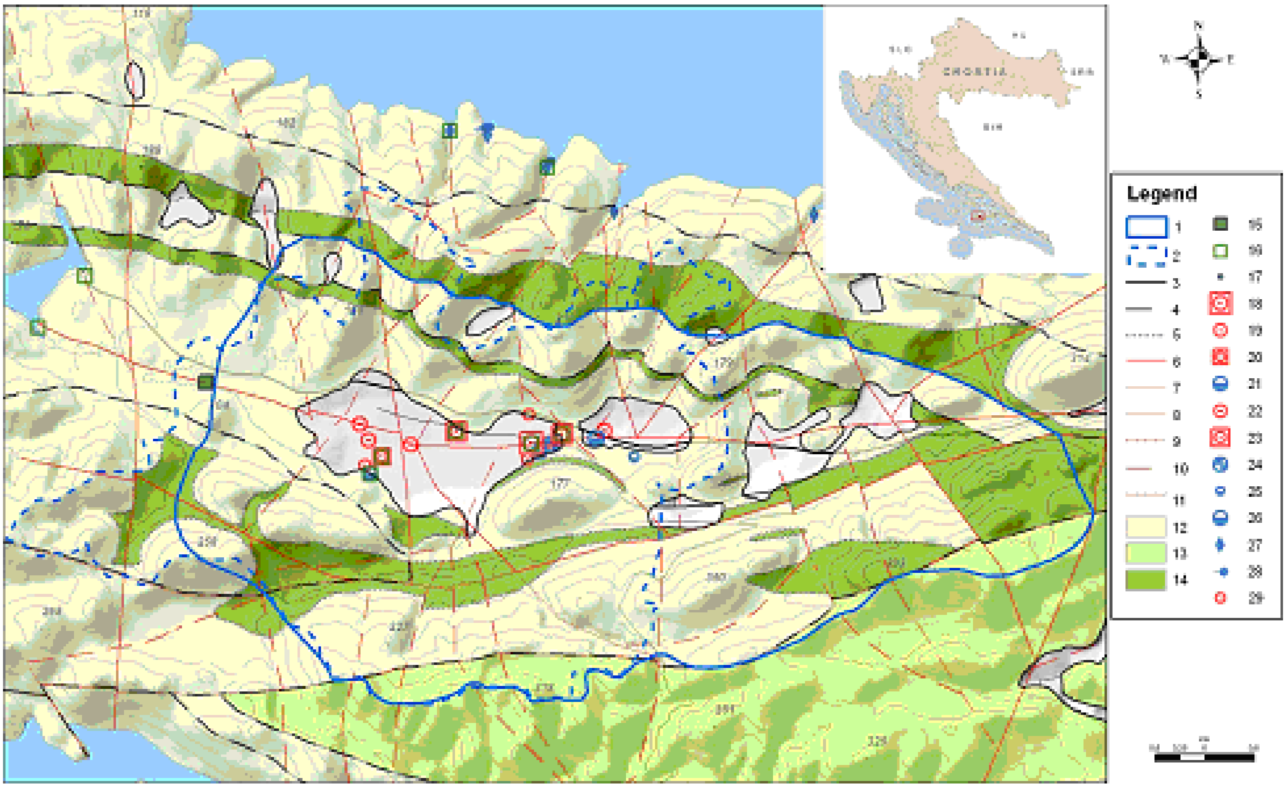

Figure 1 – Hydrogeological map of the Blatsko polje catchment area. Legend: 1-hydrogeological catchment; 2-topographical catchment; 3 to 11- geological and tectonic lines; 12 to 14-hydrogeologically classified rock masses; 15 to 29- hydrogeological objects, wells, springs, extraction sites and main pollutants.

GIS BASED HYDROCHEMICAL ANALYSIS TOOLS (QUIMET)

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KEYWORDS: GIS, geospatial database, hydrogeochemical analysis

INTRODUCTION

Nowadays many factors cause deterioration in groundwater quality. Chief among them are the expansion of irrigation activities, industrialization, and urbanization (Vazquez-Suñè et al, 2005).

Given the complexity involved in evaluating the influence of these factors for ensuring the compliance with standard regulatory guidelines (e.g., the Water Frame Directive), sustainable management is mandatory. This requires continuous monitoring of a number of hydrochemical parameters and subsequent interpretation. This interpretation consists in determining characteristics such as the origin and processes that control the chemical composition of groundwater, and its spatiotemporal distribution.

In practice, this interpretation task, may face several difficulties: i) dealing with a large amount of data, collected among many years; and ii) integrating data from different sources, gathered with different data access techniques and eventually different formats (Carrera-Hernández and Gaskin, 2008). Moreover, the scarcity of comprehensive tools for the systematic management of spatial-temporal dependent hydrochemical data further complicates their interpretation.

To overcome these difficulties a software platform (QUIMET) was developed. QUIMET is a GIS-based toolbox composed by a set of tools that arrange all the available data into a coherent and logical structure and provide support for its proper management, analysis and interpretation of hydro-geochemical data.

The presented work forms part of a wider on-going framework developed to facilitate detailed hydrogeological modelling studies of sedimentary media with hydrogeological and geological GIS–based analysis tools. The latter are described in Velasco et al. (submitted).

THE QUIMET SOFTWARE PLATFORM

QUIMET is composed of a geospatial database plus a set of tools specially designed for graphical and statistical analysis of hydrochemical parameters. All of this integrated in a friendly graphical user interface (GUI). It coordinates its activities with several external software (ArcGIS, Microsoft Excel) and has been programmed using Visual Basic Programming Language. A sketch of the graphical interface is shown in Figure 1.

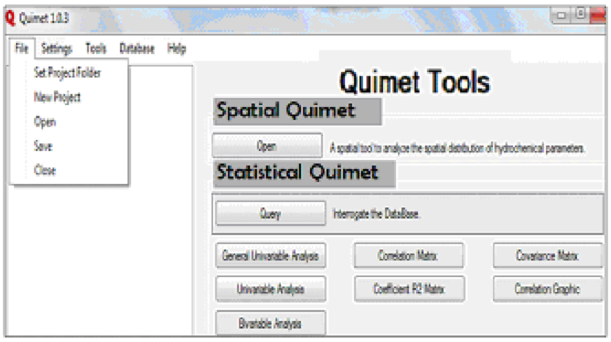

Figure 1 – The GUI of QUIMET software platform.

The geospatial database represents geospatial information based on the Personal geodatabase structure provided by the ArcGIS (ESRI) concept. Its structure facilitates: 1) data standardization and harmonization; 2) the storage and management of large amount of spatial features and time-dependent data; and 3) the creation and the execution of simple queries. This database has been designed to include information about hydrogeology, geology and chemistry. Regarding the latter, the database enables one to include organic and inorganic chemical records, as well as other relevant measured parameters (temperature, Eh, PH, etc). Further information about existing normative and laboratory detection limits can also easily be included.

This set of analysis tools is separated in two main modules: 1) Spatial QUIMET and 2) Statistical QUIMET (Fig.1).

Spatial QUIMET tools were developed as an extension to the ESRI's ArcMap environment, which is part of the ArcGIS version 9.3 software package. They were created with ArcObjects, which is a developer kit for ArcGIS, based on Component Object Model (COM), and programmed in Visual Basic using the Visual Studio (Microsoft) environment. These analysis instruments cover a wide range of methodologies and calculations used for querying, interpreting and comparing groundwater quality parameters. They include, among others, chemical time-series analysis, Ionic Balance calculation, correlation of two chemical parameters plots, and calculation of various common in practice diagrams (Wilcox, Schöeller-Berkaloff, Piper, Stiff) to which the spatial components are added. This allows the generation of maps of the spatial distribution of several hydrochemical parameters and of the aforementioned specific hydrochemical diagrams. Figure 2 shows some of the functions of this module.

Statistical QUIMET tools enable the user to perform a complete statistical analysis of the data, including descriptive statistic analysis (calculation of mean, median, variance, etc), generation of correlation matrix of several components, calculation of correlation graphics, bivariate analysis, etc. The dating of this procedure is on-going. The results from both modules can be exported to external software platforms for further analysis.

CONCLUSIONS

The QUIMET software platform offers a user friendly GIS environment with a great variety of automatic tools developed for the management and analysis of hydrochemical data to facilitate interpretation and visualization in thematic maps. It also provides the automatic generation of common hydrochemical diagrams, easily including evolutions in time and space. Moreover, QUIMET comprises a database that allows straightforward maintenance and incorporation of new features and data. In addition, the possibility of querying and visualizing the stored information in a GIS environment allows the user to integrate the obtained hydrochemical information data with other relevant information such as geological, hydrological, etc. This is useful for providing the user with a consistent image of the aquifer behaviour under study.

The application of this software in various study sites is needed for the validation of the provided results.

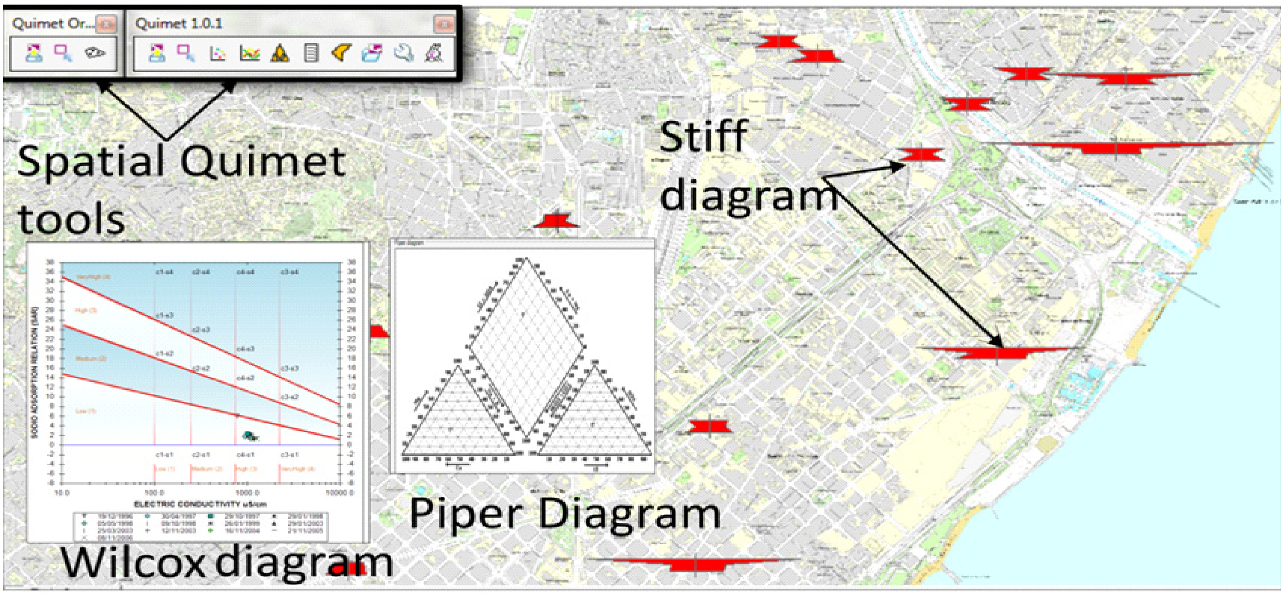

Figure 2 –Quimet spatial Toolbars in ArcGIS. Piper, SAR, and Stiff diagrams projected on map.

ACKNOWLEDGEMENTS

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WEB MAP SERVICE FOR INORGANIC BACKGROUND VALUES OF GROUNDWATER IN GERMANY

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KEY WORDS: Groundwater quality, groundwater background values, probability plots, European water framework directive.

INTRODUCTION

One of the main objectives of the EC Water Framework Directive (EC-WFD) is the achievement of a good qualitative status of groundwater bodies. Hence, the derivation of groundwater background values is required to detect significant point source contamination or to identify whole groundwater bodies at risk of failing to meet the required water quality standards.

In cases where the required water quality standards are not being met, it is important to know, if exceedances are of anthropogenic or natural origin, because counter measures have only to be taken in the first case.

To fulfil the above requirements of the EC-WFD, the Geological Surveys of Germany initiated the working group "Groundwater Background Values" that gathered available groundwater analyses and evaluated the background values for a total of 40 parameters within the different hydrogeochemical units (WAGNER et al. 2011a). The results have been made available on the internet as Web Map Service (WMS) at: http://www.bgr.de/Service/grundwasser/.

METHODS

The main objective of the project was a nationwide compilation of aquifer specific groundwater background values on the basis of about 52,700 groundwater analyses from all over Germany. The groundwater data were provided in 2005 and originate from measurements between 1980 and 2005. For the investigation only naturally occurring inorganic parameters were taken into account.

The dataset comprises physicochemical parameters (total hardness, specific electrical conductivity, pH-value), the major elements calcium (Ca), chloride (Cl), hydrogen carbonate (HCO_3), potassium (K), magnesium (Mg), sodium (Na), sulphate (SO_4), and a large set of minor and trace elements (silver (Ag), aluminium (Al), arsenic (As), boron (B), barium (Ba), bismuth (Bi), bromine (Br), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), fluoride (F), iron (Fe), mercury (Hg), lithium (Li), manganese (Mn), molybdenum (Mo), ammonium (NH4), nickel (Ni), lead (Pb), phosphate (PO_4), antimony (Sb), selenium (Se), silicate (SiO_2), tin (Sn), strontium (Sr), thallium (Tl), uranium (U), vanadium (V), zinc (Zn)).

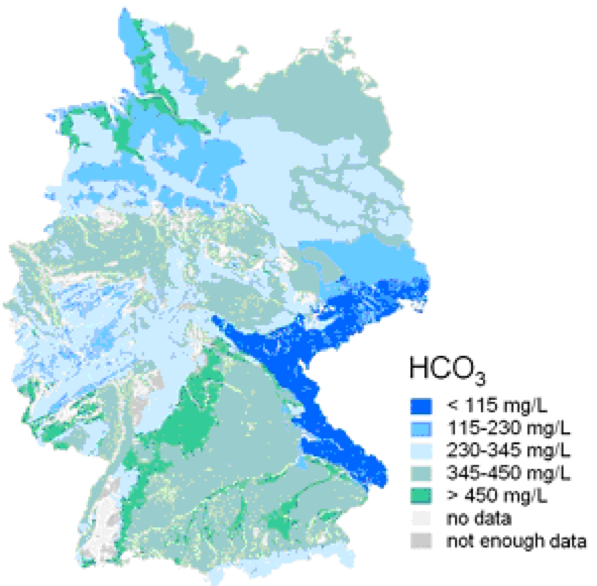

Figure 1 – Map of groundwater background values (90%-percentile) of the upper aquifer in Germany for the example of hydrogen carbonate.

For the statistical evaluation, the working group aggregated the about 1100 hydrogeological units from the Hydrogeological Map of Germany 1:200 000 (BGR 2010) into hydrogeochemical units (HCU). HCUs are defined as hydrogeological units with typical distributions of hydrochemical properties and are grouped according to the ten hydrogeological regions of Germany.

A total of 186 HCUs were defined, of which 110 units contained sufficient (at least ten) samples to perform the statistical analysis. The evaluated units cover about 97% of the extent of Germany. Before statistical analysis, all samples had to be assigned to the appropriate HCUs. The statistical evaluation of each parameter was performed semi-automatically using probability plots (WALTER 2008). This method allows the identification of different populations within datasets. Thus, anomalies can easily be identified and separated from the normal background population. These anomalies could be caused by anthropogenic influences, but also by local natural phenomena such as ore mineralization, coastal and inland salinization, or acidification of crystalline rock regions. However, it is not possible to separate the ubiquitous diffuse component from long term atmospheric and agricultural inputs (e.g. fertilization, soil melioration, traffic related inputs), if these impacts have already been integrated into the normal population. The statistical parameters (mean, standard deviation, percentiles) of the normal distribution can be derived from the probability plot. In this study the parameter specific background values were defined as the 90%-percentile.

DATA PRESENTATION AS WEB MAP SERVICE

The results of the project 'Groundwater Background Values' are accessible to the public as a WMS. An English version is also available online (WAGNER et al. 2011b). In figure 1, the distribution of background values for hydrogen carbonate are shown as an example. The results can be viewed with WMS-capable programs or via an internet application. This way every user can access the background values, display maps and investigate the values in the database via info-queries. Through the WMS-technology it is also possible to combine the maps with any other spatial information available to the user.

CONCLUSIONS AND OUTLOOK

Compared to previous studies, the statistical evaluation of groundwater quality in Germany presented here is the most detailed approach so far. However, this investigation has to be regarded as a macro-scale approach, giving an overview at a nationwide scale.

The maps of parameter-specific background values of the different HCUs are an ideal basis to answer many questions related to groundwater quality. They can be used as a tool to evaluate groundwater analyses in their regional context. Through the knowledge of typical regional distributions of parameter values, exceedances of threshold values can be investigated and local geogenic or anthropogenic anomalies can be identified. Additionally, the data can be used for the evaluation of the qualitative status of groundwater bodies as required by the EC-WFD. The direct access to the data via internet offers great comfort for the users.

There are still gaps in the maps with respect to full coverage, especially concerning trace elements, which have not been measured systematically by all water authorities in Germany. Due to the requirements of the EC-WFD in some federal states trace element measurement programs of groundwater have been launched in the meantime. Therefore it is planned to extend the WMS presented here with respect to the trace elements in order to produce nationwide maps for all parameters investigated. Results of this extended investigation are expected until end of 2012.

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SUSTAINABLE WATER SUPPLY AND RESOURCES MANAGEMENT A CASE STUDY FROM THE TOWN OF HABABAH, AMRAN GOVERNORATE, YEMEN

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KEY WORDS: Water resources, Water supply, Sustainable, Hababah town, Cisterns, Yemen.

ABSTRACT

This paper presents alternative solutions for local communities that find other option for water supply in arid areas to reach sustainable use of water. Hababah town is a part of the District of Thula, one of the twenty districts of the Governorate of Amran. Hababah is suffering from water supply due to the fact that water supply from the public network comes once a month for a few hours. The main thrust of this area is to promote the water supply and management thereby contributing significantly in a sustainable manner and towards poverty reduction. Communities are starting to repair and maintain their previous traditional cisterns and constructing new cisterns in cooperation with the local population and charity men without any support or supervision from the Government or local council. More than fifteen cisterns have been rebuilt and rehabilitated for the sustainable use of water resources. Sustainable use of water has contributed to reduce poverty and improve the bad conditions of the water supply in the area where the poor people are now able to obtain water easily and cheaply. More than seven villages around Hababah town are now relying for water from cisterns. Each year, more than 70,000 cubic meters of water cisterns are being used. More than 1,700 families and 13,000 inhabitants are dependent on water cisterns.

INTRODUCTION

Yemen faces immense water challenges, such as scarcity of water, low rainfall rate per year. The Yemen Government has identified the water sector as one of the key priorities for government policy. Yemen has been vulnerable to the effect of the climate change. Topographical variations of Yemen give rise to a wide range of climatic conditions. In general, the climate of Yemen can be classified as semi-arid to arid. Averages annual rainfall is 130 millimeters in the western coastal plain Tihama and 127 millimeters in the southern coastal plain Aden. The highest mountainous areas of southern Yemen receive from 520 to 760 millimeters of rain a year (AREA, 2005). Amran Governorate is located north of the capital Sana'a around 40 km and contains twenty districts (Figure 1). Between November and January, temperatures in these mountain areas can drop down to 0 °C particularly in Amran Governorate. Humidity is very high, on the coastal plains up to more than 80%, whereas it goes down toward the high land where it reaches its minimum rate in the desert areas to be around 15%. The hottest season in Amran Governorate is from May to July, and the coldest season is between November and January, with maximum and minimum monthly temperatures in May 33 °C and December 4 °C, respectively. The average monthly humidity in Amran ranges between 35 % in July and 52 % in May. Thula district is one of the Amran Governorate, it is contains six towns, one of these town is Hababah. It is located north west of Sana'a around 40 km.

Figure 1 – Map of Amran Governorate, red circle is Thula district.

Table 1: Demographic indicators in Hababah and their villages, Thula district, Amran Governorate (Census 2004)

	Nr. Families	Male	Female	Total (M + F)
Hababah	1174	4333	4232	8565
Al Saidah	108	357	352	709
Watar	108	379	390	769
Bait Behr	44	122	129	251
Al Mahla	131	665	553	1218
Bait Hebah	61	226	230	456
Khoshar	82	390	357	747
Al Rawnah	86	293	282	575

The public water network started in Hababah in the year 1980. This made the people trust the public network for a period of time. As a result communities neglected their traditional cisterns.

and cisterns. The phenomenon of purchasing water from vendors is appearing in Hababah. Vendors bring drinking water from Hawshan village about 10 km to the east from Hababah. The water in Hawshan village based on dug and dug/bore wells.

For the past ten years the public network in Hababah has provided water only one day every two months for a few hours from Shibam city, around 20 km from Hababah. The municipal water utility of Shibam is often unable to guarantee the basic service of water supply and unable to provide people with a continuous drinking water supply due to the growing population and the increasing water demand. The number of hours supply available seems insufficient. The local people believe that water vendors or cisterns could deliver water more reliably than governmental supply. Therefore, rehabilitation the traditional cisterns around Hababah not only to manage the water, but also to help poor families who can not afford to buy water from private water providers. This paper presents the role of community participation on sustainable water supply and resources management and shows how they have helped to improve the conditions in poor rural areas and protected the resource for future generations.

THE GEOLOGICAL BACKGROUND

The surrounding mountain of Hababah from south and west are Cretaceous Tawilah sandstone whereas Hababah city is located on Jurassic limestone which is part of Amran group that considered to be the oldest sedimentary formation in the region (SAWAS, 1996). The underlying Amran group consists mainly of fossiliferous carbonate (shallow-water limestone and marls) of upper Jurassic with total thickness between 410 and 520 m (Al-Thour, 1997). The Amran limestone is generally considered to be a poor and semi-confined aquifer. Well yields range from 3 to 6 l/s (Rybakov, 2004).

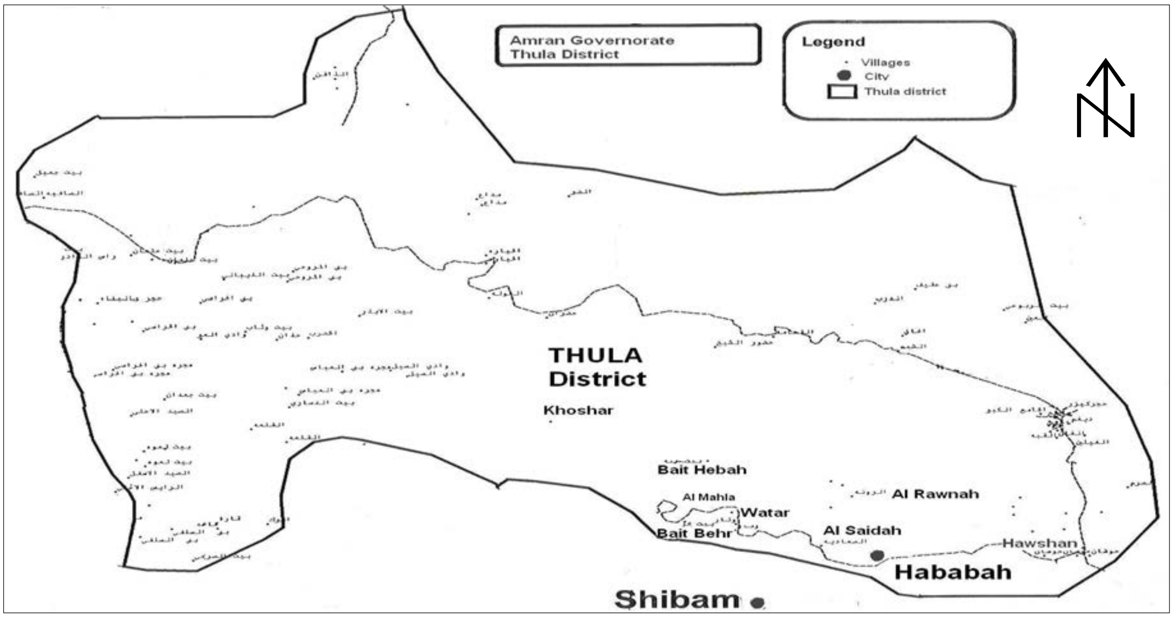

Figure 2 – Map of Thula district and Hababah city

OWARD SUSTAINABLE USED

Historically, the region is known for their traditional domestic and drinking cisterns. For centuries, local people in this region have carefully adapted to their local environment and needs. Increasing water demand and lack of access to water resources enable local people to come back to traditional cisterns and undertake activities and responsibilities for the conservation and management of natural resources independent without any support or supervision from the Government. Around two third of the population has no access to water supply in Hababah due to the public network is covering only

30 %. Therefore, the people depended on water vendors and cisterns. The phenomenon of purchasing water from vendors is appearing in Hababah. Vendors bring drinking water from Hawshan village about 10 km to the east from Hababah. The water in Hawshan village based on dug and dug/bore wells.

The repairing cisterns start on 2005 because of the public water supply not sufficient and the cost of water tank truck. The cisterns in Hababah town more than 15 and most of them old and need for rehabilitate (Table 2). The supporting of funding to maintain previous traditional cisterns and built new one come from charity men and local people without any assistance from the Government or local council. Local authorities who are responsible for providing water supply such as General Authority for Rural Water Supply Projects (GARWSP) and National Water Resources Authority (NWRA) are absent in the region. Social Development Fund (SDF) which is support by World Bank built one cistern in Hababah. The cost of this cistern was fife times of other cisterns which fund by charity men. This cistern also has defect in design and construction.

The first stage was repairing Shabar (1) and Shabar (2) which are based on spring water and will be used for drinking water for northern Hababah (Figure 3). Al Hajarn, Mahdi and Al Dalae cisterns are the oldest in Hababah town. These cisterns are cleaned two times per year during runoff and provide the inner town. The second stage was repair Al Safa (1) cistern which is the biggest in the town. The two spring waters in the western part of the town are Al Qasr and Al Sannaf cisterns which have been rehabilitated at the third stage. The last stage which was under construction and rebuild for Al Safa (2), Hejar Al Sood and Al Harawah cisterns. The domestic cisterns filled by rain water during the flooding season and used predominant sources for animals and washing clothes.

Table 2: Names of the cisterns in Hababah town, Amran Governorate

Names of the cisterns	Area (m2)	Capacity (cm3)	Location	Purposes
Al Hajarn	1540	10010	Old city	Domestic use
Al Dalae	176	1414	Old city	Domestic use
Shabar 1	774	3870	Northern part	Spring-Drinking
Shabar 2	100	300	Northern part	Spring-Drinking
Mahdi	200	1400	Eastern part	Domestic use
Al Safa 1	5200	41600	Northern part	Domestic use
Al Safa 2	4200	29400	Northern part	Domestic use
Al Qasr	375	1875	Western part	Spring-Drinking
Al Sannaf	510	2805	Western part	Spring-Drinking
Al Harawah	800	4000	Southern part	Domestic use
Hejar Al Sood	512	4096	Southern part	Domestic use

Total capacities for all cisterns are 70,000 cubic meters. Two third of the capacity of fifteen cisterns water have been used each year. More than 1,700 families and 13,000 inhabitants are dependent on water cisterns. The task of water transportation is mainly done by women and children.

CONCLUSIONS

The community improved sustainable water use and introduced this approach for other villages using traditional cisterns. The repair of cisterns in Hababah not only improves the management of water, but also helps poor families who can afford to purchasing water. The local people understood the concept of the rebuild the cisterns. It is perfect solution for rural areas that cannot access for public network services. It promotes and create a strong motivation for future generations how to find alternatives for water resources.

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Figure 3: Cisterns in Hababah town, Amran Governorate

MONITORING OF THE UNCONFINED AND CONFINED AQUIFERS CLOSE TO THE RIGHT-HAND RIVER BANK OF THE PO RIVER IN THE REGGIO EMILIA AREA

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KEY WORDS: Po river, riverbanks, unconfined aquifer, confined aquifer, hydraulic monitoring

INTRODUCTION

We focus on the analysis of the relationships between the groundwater system and the Po river in a selected area in the presence of recharge also due to rainfall. Recent geological investigations performed within a national program for the seismic study of the Po river embankment allow to confirm the geological model of the area. Hydraulic monitoring results support the underlying conceptual picture of the geological system.

Hydraulic monitoring stations are distributed within the Reggio Emilia and Ferrara districts, along sections normal to main river bed and covering a few kilometers. This work is mainly devoted to the presentation of some preliminary results related to the area of Reggio Emilia.

GEOLOGICAL-HYDROGEOLOGICAL SETTING

The deep aquifer system is hosted within a thick upper Pleistocene sandy layer which derives from a high energy fluvial environment, related to a past fluvial-glacial climatic age of the Po River. The bottom boundary of these Würmian sands can reach a depth of more than 50 m. The shallow aquifer is hosted within alternated sequences of sediments of fine and coarse Holocene materials for a thickness between 7 to 12 m near the top, deposited by a meandered fluvial system, similar to the present (Bondesan et al. 1974, Servizio Geologico d'Italia - Regione Emilia-Romagna, in press).

The conceptual hydrogeological model relies on the occurence of two different aquifers (named A0 and A1) of mainly sandy Pleistocene-Holocene deposits of the regional multilevel aquifer (Regione Emilia-Romagna & ENI-AGIP, 1998, Severi et al. 2002). These are in direct hydraulic contact with the main surface waters.

AVAILABLE DATA

The monitoring period under investigation is comprised between April and December 2011. Monitoring stations comprise piezometers equipped with downhole transducers measuring hydraulic pressure, electric conductivity and temperature. Data are collected at hourly intervals and continuously sent through a GSM system to a web-controlled server.

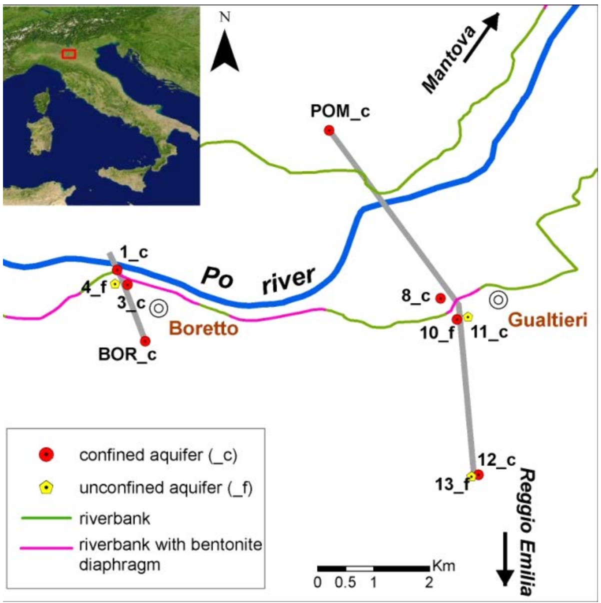

Figure 1 – Geographic setting of the study area.

Two kinds of piezometers are installed: type "c" is typically filtered along the 10-50 m depth interval to intercept the first confined aquifer starting from the topographic surface (A1); while type "f" is filtered at about 2-10 m deep to intercept the water table (unconfined aquifer – A0).

The confined aquifer is investigated in three locations: i) between the Po river and the right-hand embankment; (ii) in the external right embankment footstep; and (iii) at a distance of about 3 km from the right embankment.

The unconfined aquifer is investigated at two locations, beside piezometers "c": (i) in the external right embankment footstep and (ii) at a distance of about 3 km from the right embankment. The river level is monitored at a hourly rate through 4 hydrometers. Hydraulic modelling results providing predictions of the river stage are available.

Here, we illustrate data collected along two sections within the Reggio Emilia area (Figure 1), where data related to a monitoring station located at a distance of about 2 km at the left-hand side of the Po river are also available (POM_c).

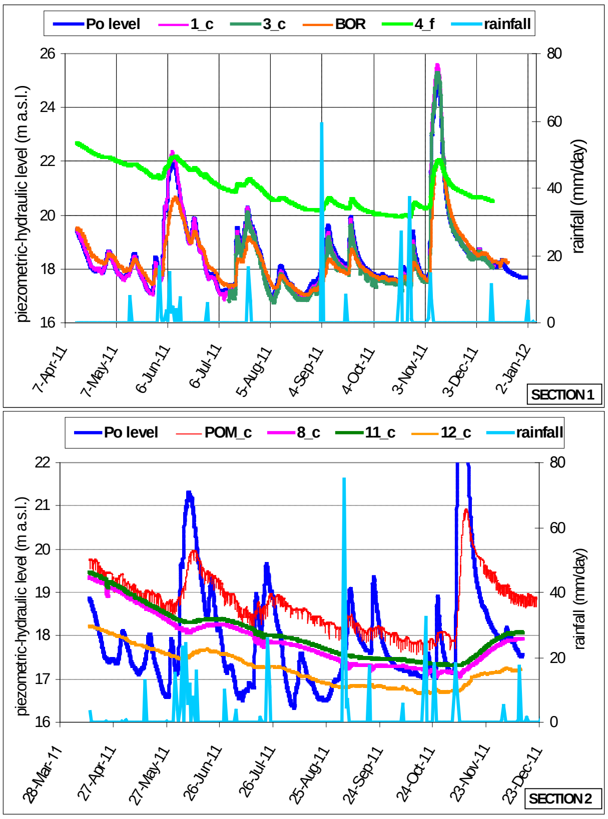

Figure 2 – Monitoring results of groundwater level and water level in the Po river. Precipitations are also reported.

CONCLUDING RESULTS

Monitoring results (Fig. 2) reveal that the confined aquifer is typically characterized by a piezometric level which is about 1-2 m lower than that of the unconfined aquifer. This scenario is reversed during significant flooding events (e.g. the November flood). These data area consistent with previous observations (Regione Emilia-Romagna, 2007).

The river drains the unconfined aquifer. Even if the unconfined aquifer level is higher respect to the river level most of the times, it follows river trend. During floods this relationship is inverted.

The piezometric levels of the confined aquifer are influenced by the river up to a distance of about 2 km. Piezometric level of the confined aquifer closely match those monitored within the Po river at locations close to the river. The piezometric level of the confined aquifer can be influenced by local effects, such as riverbank bentonite diaphragm (11_c), coverage litology (8_c), and groundwater wells (POM_c). If the riverbank is protected with bentonite diaphragm, the river influence is strongly reduced both in the unconfined and in the confined aquifer, even though the diaphragm does not reach the bottom of the aquifer.

Electric conductivity and water temperature show significant trend for the comprehension of the interaction of aquifers with river and rainfall.

The electric conductivity in the confined aquifer strongly decreases in the proximity of the river during flood events. This is an important indication of the occurence of river-aquifer mass exchanges (Colombani et al, 2007). The electric conductivity in the unconfined aquifer displays sharp peaks during some heavy rainfall events, probably due to the dissolution of salts located in the soils.

The temperature of the confined aquifer is not influenced by the seasonal variations and by the effect of floods. It displays a relatively constant value of about 14.5° C. The unconfined aquifer has a 2°C temperature gradient from spring to autumn. Temperature data allow identifyng the confined/unconfined nature of an aquifer system. Note that the temperature values typical of unconfined conditions can be recorded within deep piezometers (c) due to the occurrence of sandy sediments above the aquifer that do not provide a complete insulation of the system from athmosferic effects.

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HYDROLOGICAL INFORMATION SYSTEM OF GEORGIAN WATER RECOURCES

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Key words: *water resources; management; water supply; GIS; Georgia*

At the beginning of the twenty-first century, the Earth, with its diverse and abundant life forms, including over seven billion humans, is facing a serious water crisis. We are all dependent on water. We need it every day, in so many ways. We need it to stay healthy, we need it for growing food, for transportation, irrigation and industry.

In the whole world, and in Georgia as well, arises the necessity of exact estimation of the amount of water resources in order to arrange the efficient fresh water management and supply system and its proper use.

The problems of organization and presentation of spatial information successfully realized by means of GIS technologies arranging the collection, storage and automatic processing of data.

The territory of Georgia comprises 69,7 thousand square kilometers. The population is 4,4 million. Georgia is rich in available water resources, but due to their non-uniform distribution over the territory, in a number of regions there appears a significant imbalance between the amount and use of water resources. Fresh water resources are the major natural resources of Georgia. The calculation and the management of the available water resources of Georgia is very important not only for the republic, but also for entire South Caucasus. In this connection, it is necessary to transition to a system of controlled (managed) water consumption considering the rational use of water resources.

As the pilot- project was selected the basin of the river Aragvi, which is characterized by the wide variety of natural conditions and the formation of the river run-off. Besides this, the basin of the river Aragvi is the main source of the water supply of Tbilisi.

For realizing of project was used software GIS - ArcView. The basis of GIS was the three-dimensional electronic map of Georgia (1: 50 000). In the implementation the project were used the following layers of the above-mentioned map: river, lake, reservoir, springs, channels, the populated areas, districts, roads, hydrological stations.

The database of GIS of the proposed project contains the whole data information about water and water demand, which were existed in various departments and published in the literary sources (monograph, article, atlases, statistical handbooks and other).

The data bases in the space of GIS provide an opportunity to identify the resource potential of the basin of Aragvi river, manage it and carry out monitoring.

The results of work could be used for creation of a cadastre of the water resources of Georgia.

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NUMERICAL SIMULATION OF COASTAL GROUNDWATER RESOURCES OF GENOA MUNICIPALITY

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KEY WORDS: groundwater resources, Modflow, freshwater-saltwater interaction,

PREFACE

Human activities have been always influenced by availability of water. Both the necessary amount and the usage of the resource have changed over time. Liguria Region has identified as a primary resource for drinking water the aquifers contained in the end of the floodplains of major rivers of the Tyrrhenian coast and of the Apennine slope. These aquifers are considered significant and therefore these are already subject to environmental quality monitoring under the meaning of Legislative Decree 152/06 and Legislative Decree no. 30/09.

The preservation and planning of groundwater resources are based on the knowledge of the quantitative status of the regional aquifer: for these reasons ARPAL started to gather information and data in order to deepen the knowledge and to develop mathematical models of the main aquifers.

A mathematical model of groundwater flow is a dynamic tool allowing to evaluate the impact of changing external conditions, like extraction, exceptional meteorological periods, interaction between surficial water bodies and the seawater (salt water intrusion) on the availability of the resource.

The quantification of underground water resources through continuous measurement of the watertable, together with the mathematical modelisation of the aquifer behavior under different conditions will result in an advanced decision-support tool for the management, the planning and preservation of underground water.

The use of predictive models is of great interest in order to assess the sustainability of current and future uses, including the hypothesis of exceptional drought.

The first aquifer to be modelised was the low Polcevera flood plain. This aquifer is located in the central-western urban area of Genoa and it extends about 8 km^2 upwards from the mouth of the river. Groundwater use has decreased after a period of heavy use, but this aquifer is still a strategic drinking-water supply for the city of Genoa.

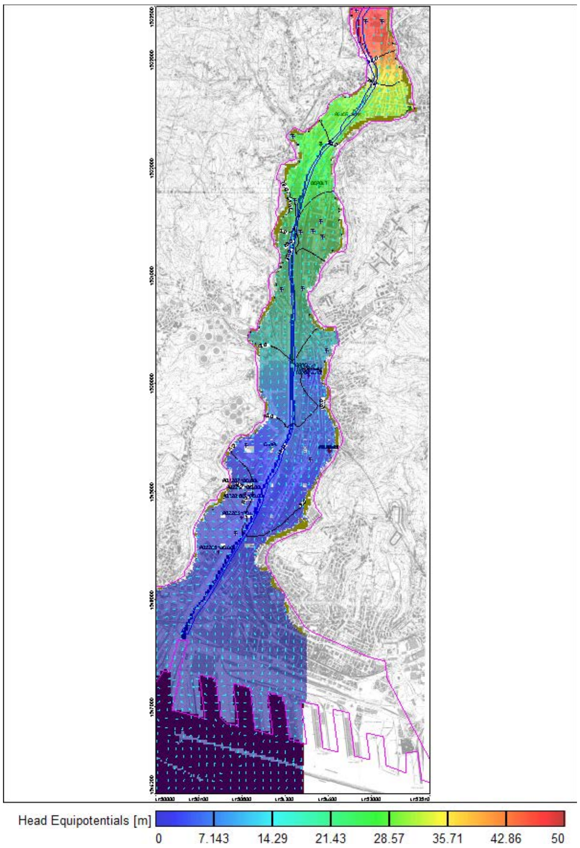

Figure 1 - The study area located in the central-western city of Genoa

METHODOLOGY

All the existing stratigraphic surveys were acquired, and 17 new piezometers were drilled: 5 of these piezometers were also equipped with remote datalogger (measuring frequency: 1 sample per hour). Using all the available data and information, a mathematical model was developed with Visual Modflow. The aquifer was simulated as a single layer. The hydrogeological property variability was modeled on the whole layer. The river, the sea level and the piezometric head in the inlet sections were established as boundary conditions. The model takes into account also the pumping and rainfall rate as external conditions.

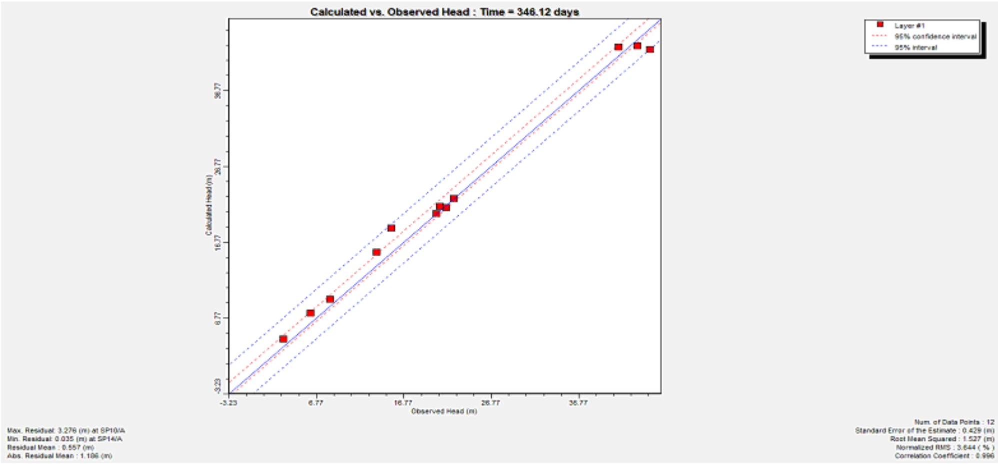

Figura 2 – Calculated vs. Observed Head plot

The sea represents the downstream limit of the model. Each sea cell was considered as a constant-head cell at 0 meter above sea-level. In second model the saltwater intrusion was modelled by SEAWAT module.

The simulation was performed during one year in order to take into account the seasonal variation of the boundary conditions. The initial watertable condition is the output of a previous simplified model. The simulation was performed in transient, because the equilibrium condition is never reached within the different stress periods.

The calibration of the model was performed using the automatic procedure WinPest code minimizing the residual between the groundwater level observed and calculated. The model calibration allows to evaluate the resource availability as external conditions change.

RESULT OF3 THE STUDY

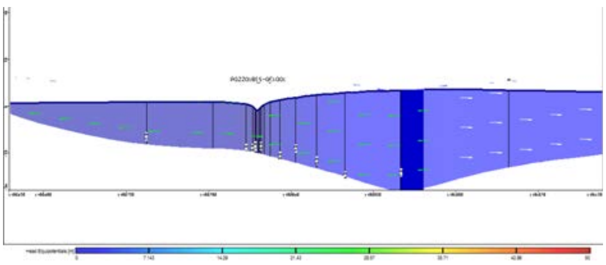

Figura 3 – Drawdown near pumping well and recharge near river.

The relationship between rainfall and groundwater level was established by many watertable acquisition surveys and by remote watertable continuous acquisition. The developed model suggests that the groundwater level are strictly correlated with the rainfall rate.

This behavior has been reproduced during the simulation performing numeric value of boundary condition cells. We raise the hydraulic head, in according to observed data, during each stress period considered. A strictly correlation between calculated values and real values was observed over each stress period - as example see figure 2 (stress period 7, 346 days from simulation start).

Modflow can calculate the watertable as well as evaluate the water budget of the model.

The model suggest the following results:

1) *the rainfall rate is strictly correlated on short period (days) with groundwater and river levels;*
2) *the Polcevera river can drain or recharge the aquifer, but overall mass budget suggest that the river is the main inflow of the aquifer;*
3) *during the dry season the river goes dry, therefore in one stress period (about summer season) the river condition was switched off;*
4) *the main outflows are the sea boundary and the pumping wells;*
5) *during a long-lasting dry season, if pumping rate were increased the aquifer budget became negative and quantitative status, (sensu Legislative Decree no. 30/09), could get lower.*
6) *The model can be used in planning water resources to establish sustainable extraction rate.*
7) *The transport code can be used to predict the fate of pollutants in groundwater bodies.*

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SPRINGS AS MAIN GROUNDWATER DEPENDENT ECOSYSTEMS

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KEY WORDS: Biodiversity, springs, northern Apennines, diatoms, benthic algae, cyanobacteria, water mites, copepods, ostracods, hydrochemistry, SAL springs.

WATER RESOURCES

Springs are peculiar habitats. They are areas were groundwater comes to daylight. Several springs (in particular the perennial ones) show virtually constant water temperature all over the year. Many of the morphological, physical, and chemical characteristics (e.g., hydrological stability) of the spring habitat are determined by the hydrogeological features of the parent aquifer (Van der Kamp 1995). The environmental (physico-chemical) stability of permanent sources can allow the colonization by rare organisms or taxa which are of special interest for biogeographic reasons.

EBERs (Exploring the Biodiversity of Emilia-Romagna springs) is a three-years-lasting (2011-2013) Project fostered and funded by the Geological Service of the Emilia-Romagna Region. Its main goal is an exploratory investigation on the biota of selected springs of the Emilia-Romagna Region. It is characterized by a multidisciplinary approach with the aim of spring-habitat characterization and advancement to disseminate an improved awareness of the role of this resource in the territorial and thematic planning.

The reasons for spring habitat peculiarity and biodiversity richness are complex (e.g., marked heterogeneity of characteristics, complex microhabitat mosaic structure, ecotonal environment –transition from surface to groundwater, and from aquatic to terrestrial habitats). Springs are however imperilled by direct (especially water exploitation and tapping) and indirect anthropogenic impacts.

Sixteen springs were considered for the EBERs Project (Fig.1), selected on the basis of the following criteria:

- Location in different types of nature preserves, in particular in Sites of Community (E.U.) Importance;
- Occurrence of deep-seated gravitational deformations in slopes (DGPV);
- Representativeness of the ecomorphological spring types occurring in the study region: rheocrenic, limnocrenic, helocrenic, hygropetric springs and sources with special physico-chemical characteristics (e.g., SAL –springs associated limestones- springs);
- Availability of medium-term data series (temperature, discharges, algae nutrients, trace elements and heavy metals);
- Location of the aquifers within the main geo-lithological types of the Emilia-Romagna Apennines;
- Location in the different altitudinal belts and with permanent hydraulic regime;
- springs in natural or near-natural conditions.

Field work was so far carried out in the summer of 2011. Some physical and chemical variables (pH, conductivity, temperature, redox potential, dissolved oxygen) were measured directly in the field with multi-probes. Water samples were collected for comprehensive chemical analyses (major ions, nutrients including phosphorus fractions, trace elements and heavy metals; Jacopo Gabrieli, IDPA-CNR, University of Venice). As regards the biota, special attention was devoted to the photoautotrophs that were assessed also in the field. In particular the following were collected:

- Bryophytes characterizing the springs and its immediate surroundings (Daniel Spitale, Museo delle Scienze, Trento);
- Diatom microalgae that can provide useful and interesting information on water quality (Marco Cantonati and Nicola Angeli, Museo delle Scienze, Trento). Detailed analyses were carried out also on the other benthic algae including cyanobacteria that form macroscopic structures and colourings (M. Cantonati, Museo delle Scienze, Trento). A specific part of the study dealt with SAL-springs' algae (Eugen Rott, University of Innsbruck, Austria) in two petrifying springs, the sole spring type indicated as priority habitat by the European Union Habitat Directive (92/43/CEE).

Further, in each spring zoobenthos samples were collected (overall management of invertebrate samples Reinhard Gerecke, University of Tübingen, Germany) to gain information also on the animal component of these environments. Special attention will be devoted to some groups, such as water mites (R. Gerecke, University of Tübingen), the group that includes the highest number of species exclusive to springs (so-called crenobionts). Microcrustaceans such as ostracods (Giampaolo Rossetti, University of Parma) and copepods (Fabio Stoch, University of l'Aquila) are analysed as well, since they are particularly well suited to evaluate the relations between spring and aquifer.

The contribution of the Emilia Romagna Geological Survey and University of Bologna is aimed at defining the spring geological hydrostructure, and to the classification of groundwater flow system that discharges next to the outcropping area by using a hydrological-exhaustion-based method (Gardini et al., 2008) to identify the drainage basin and to foster the territorial conservation of the capturing structures.

Only an integrated hydrogeological-ecological approach allows to lay the foundations for conservation actions and for the monitoring of springs, understood not as simple points of aquifer-system discharge but as complex GDEs (groundwater dependent ecosystem).

With this contribution our aim is to illustrate the first results of the ongoing analyses on the samples collected in the 16 springs.

ACKNOWLEDGEMENTS

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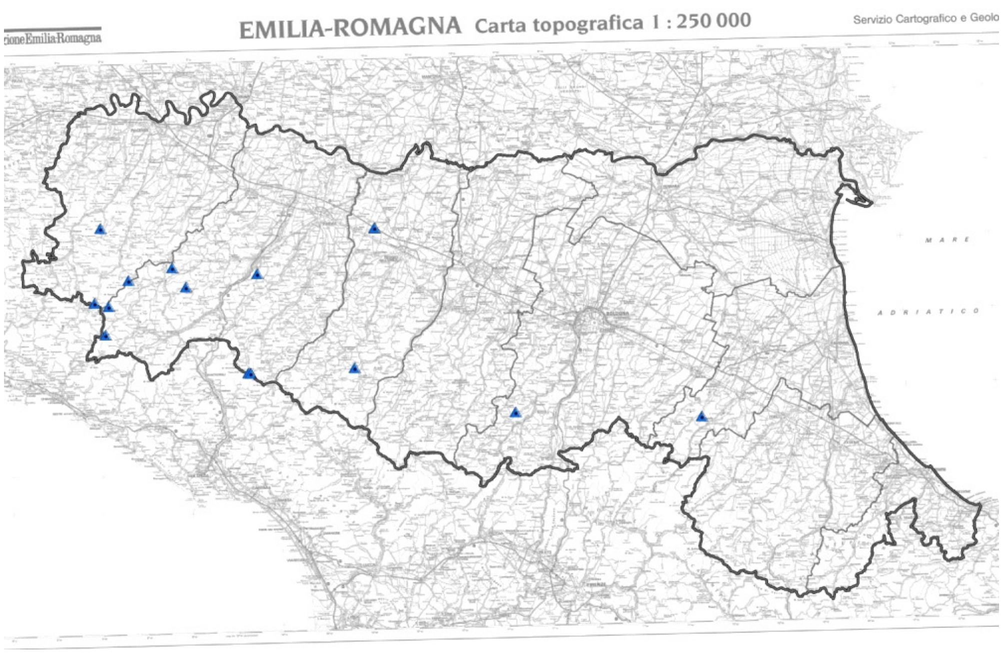

Figure 1 . Location of the sampled sources

MODELING GROUNDWATER RESOURCES: YAGMOD, YET ANOTHER GROUNDWATER FLOW MODEL.

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KEY WORDS: water resources, groundwater, arid regions, aquifer recharge, mathematical modelling.

INTRODUCTION

Modeling groundwater flow and transport in alluvial aquifers is quite common and a great number of effective and validated codes is already available. In principle they can consider complex chemical and physical processes, such as variable saturation, interactions with the porous matrix, variable fluid density, heat transport and complex hydrostratigraphic structures, which control hydraulic conductivity and, therefore, the flow field and solute transport. Since codes that fully consider both kinds of complexity require a large and rarely available data set, an original code YAGMod is proposed to solve specific problems.

DEVELOPING A NEW CODE

YAGMod, developed in FORTRAN90, solves the 2D or 3D hydraulic forward problem. Numerical solution of the steady-state balance equation in porous media, which describes the 2D or 3D groundwater flux, is found using the finite difference scheme method. Space is discretized with a grid of cells, which are rectangular in the horizontal plane (Δx and Δy *spacing* are assumed to be constant values for all the grid), but could be vertically distorted. A short list of some characteristics, that are not common to other software packages, is given below. Different types of source terms and boundary conditions are considered: in particular, it is possible to simulate variable sources, like draining systems, river/aquifer interactions and recharging fractures, with a more general formulation than that used in other software packages. Moreover, YAGMod models the effects that the water head drawdown below the top of the screened interval of a water well can have on discharge.The cells saturated thickness is taken into account when calculating hydraulic transmissivity, during the simulation. Finally, an original approach is implemented to simulate the drying of shallow discrete cells. YAGMod has been validated by comparison of its results with those obtained with Modflow (Harbaugh,2005).

APPLICATION

YAGMod has been applied to the alluvial aquifer of the Ged Deeble (GD) basin, which supplies water for the city of Hargeisa (Somaliland, Fig. 1). The water production of well fields, after the drop due to the civil war, raised again from 6,000m^3/day in the first years of the millennium up to 10,400m^3/day at the beginning of 2010.

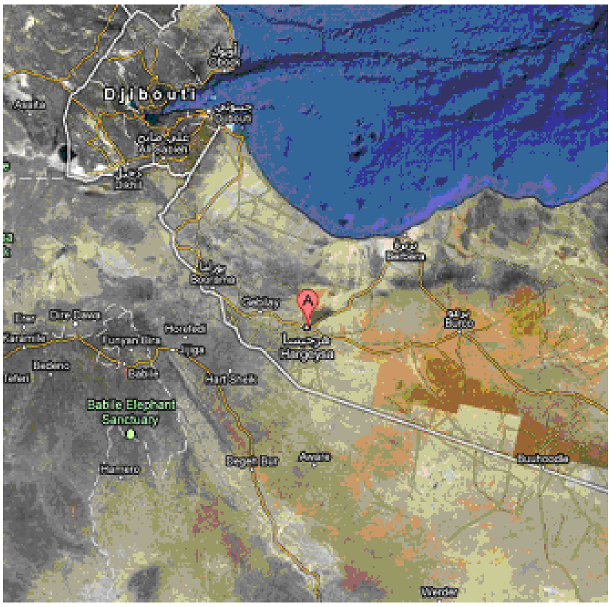

Fig.1 Map localization of the city of Hargeisa, Somaliland (Google Maps)

This trend reflects in the variation of the water table depth with time. An EU project (Buggiani & Petrucci, 2007) allowed to perform some exploration activities from 2003 to 2007, including: a detailed geological and geoelectrical survey, a series of pumping tests, a monitoring activity prolonged for two years. The data permit a first reconstruction of the basin shape, of the hydrological structure and of the mechanisms of the aquifer recharge. The aquifer consists of unconsolidated sediments deposited in lacustrine or fluvial environments and is bounded by a Precambrian crystalline bedrock.

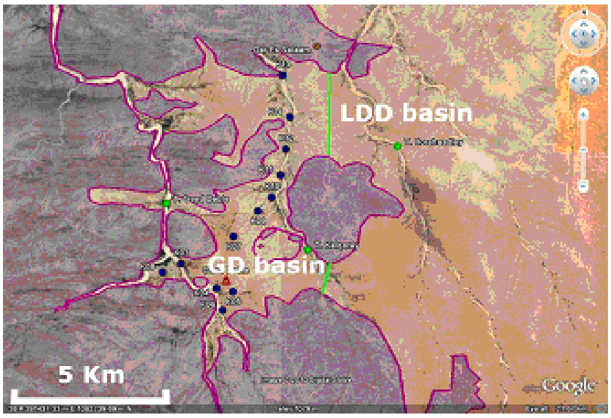

Fig.2 Ged Deeble basin: wells are indicated on the map as blue dot. (Google Maps)

From a structural point of view, the basin is the result of the intense tectonic activity of the thrusts that gave birth to the Gulf of Aden rift: it was probably formed by two major tectonic trenches, E-W oriented, connected by a long fracture with N-S alignment. The GD basin is connected to the Laas Dhuurre-Damal (LDD) basin through a wide outlet, at the N-E edge (Fig. 2). The mathematical model considers a 2D hydraulic flow approximation, pseudo-steady conditions corresponding to the average annual flow, no-flow boundary conditions in correspondence of the crystalline bedrock and Robin boundary conditions at the edge connecting the GD basin with the widespread and thick LDD basin. Different conductance values are used for outflow or inflow Robin boundary conditions, to take into account the effect of the geometry of the two basins. The model calibration was quite difficult for the big uncertainties on the old data, and therefore a sensitivity analysis has been conducted. From the hydrogeological point of view, there is a division of the basin in two sections, separated by an area of low permeability (Table 1: hydraulic conductivity values, Fig.3: Distribution of hydraulic conductivities in the model); the recharge in the upstream sector has been modeled as related to an underground fracture-fault network, whereas in the downstream sector recharge is mainly given by the water flux that enters from the LDD basin.

Zone	Hydraulic Conductivity (m/s)
K1	$5.0 \cdot 10^{-4}$
K2	$4.0 \cdot 10^{-4}$
K3	$3.5 \cdot 10^{-4}$
K4	$5.0 \cdot 10^{-5}$
K5	$1.0 \cdot 10^{-5}$

Table 1: Hydraulic conductivity values used in the model

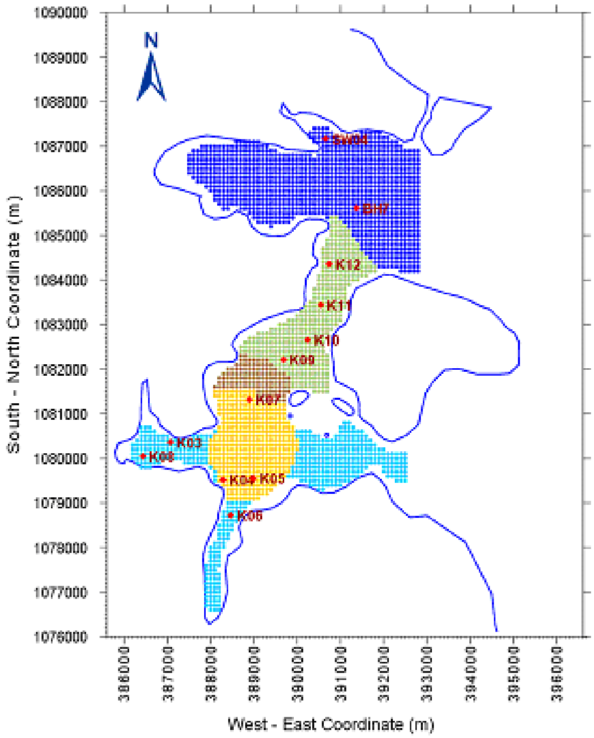

Fig. 3 The Ged Deeble discrete domain. Different colors correspond to different hydraulic conductivity values.

Different exploitation scenarios has been examined and the model outcomes show that the GD basin cannot sustainably satisfy the future water demand of the city.

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GROUNDWATER MODELLING: EMILIA-ROMAGNA RESOURCES PLANNING AND MANAGING SUPPORT TOOLS

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KEY WORDS: groundwater, model, water budget, reservoir, flux, aquifer, land subsidence

EMILIA-ROMAGNA GROUNDWATER FLOW MODEL

Most of Emilia-Romagna groundwaters (northern Italy) belongs to a large alluvial plain of about 12,000 km2 limited by the northern Apennine margin to the south, the Po river to the north and the Adriatic Sea to the east (Fig. 1).

In the southern belt, the Apennine alluvial fans are characterized by the presence of both free aquifers, where the main charge from Apennine rivers and rain occurs, and confined systems, these latter laterally connected to the formers following the SW-NE direction. Further north, lowland plain mainly consists of confined aquifers, the origin of which is both alpine and apenninic.

Since 1976 a regional monitoring network of this complex system has been established and it is now the main source of knowledge of this area in terms of hydraulic head and chemical parameters (Emilia-Romagna, 2010).

The importance of the preservation and protection of these resources is strictly connected to the intensity of groundwaters exploitation: withdrawals for various uses amount to about 700 million cubic meters per year (average over 2002-2006) and the 70 % of these comes from the alluvial fans border. Aqueduct withdrawals from the alluvial fans belt amount to 260 million cubic meters.

Location	Soil layer	RMSE ($W\ m^{-1}\ K^{-1}$)
6727/90/17	Ap	0.25
	Sd	0.09
6728/90/22	Ap	0.22
	Sw	0.37

Figure 1 – Hydrogeological contest of Emilia-Romagna plain.

Thus, the Emilia-Romagna government has supported its water planning tools with the development of mathematical modelling of the whole alluvial groundwater system. The three-dimensional and unsteady state flow model, which has been firstly developed in 2003 and then updated in subsequent years (last calibration update on 2006), has been used as a basis for several other more detailed analysis, some of which are the subject of this notice.

LOCAL GROUNDWATER BODIES AND FLOW

In order to define a quantitative pattern of groundwater flow, the modeled water budget has been applied all over the Emilia-Romagna plain in terms of water balance and exchange of fluid between parts of the system. The analysis was realized for some aquifer subsystems, as defined in Emilia-Romagna (2010) according to 2000/60/EC Directive. These subsystems give evidence of planning initiatives, resource management and monitoring organization. Water bodies, also defined in the third dimension, have been projected on the model allowing its division in terms of reservoir volumes in order to compute the water budget of each of them in space and time.

As an example, one result is shown in Fig. 2, where the main items of the hydrogeological balance and the terms of water exchange between the bodies are arranged to give the pattern of groundwater flow. The flow rates (in m^3/s) are given as average of 5 years of available simulations.

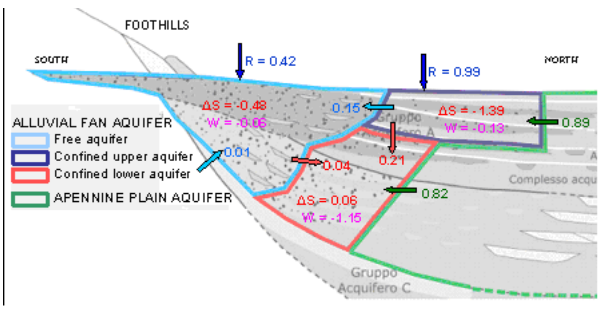

Figure 2 – Groundwater budget analysis (R: recharge; W: withdrawals; ΔS: storage change).

The analysis has been extended to the main fans of the regional aquifer and has allowed to verify the possibility of using the regional flow model to evaluate the flow dynamics of hydrological subsystems to a level of greater detail. These assessments can be used directly to obtain quantitative information about the status of water bodies.

COASTAL AREAS LAND SUBSIDENCE

To improve the understanding of cause-effect relationships between groundwater withdrawals and land subsidence, the flow simulation model was used in conjunction with a vertical soil compaction simulator. The compaction simulator has been formerly used in another application context at a more detailed scale (Chahoud et al, 2010), while here has been applied to a band of about 20 km parallel to the coastline for a surface of approximately 2,400 km^2 and it has been possible to estimate the land subsidence rate between 2002 and 2006, which is the period of the available measures (Bonsignore, 2008).

The interpretation of the results of model simulations has required the joint assessment of the following aspects that, together or individually, may affect the calculated value of soil compaction: distribution of the compressibility coefficients, natural land subsidence and gas exploitation.

To get a better analysis of the results, two different approaches have been adopted. At first, the coastal zone has been further divided into three other areas considering the following criteria:

- Zone 1: no gas exploitation;
- Zone 2: gas and groundwater exploitation;
- Zone 3: as zone 2, but with a very limited contribution of groundwater withdrawals (Fig.3).

These more detailed areas may also be distinguished for a different behaviour of natural subsidence (Carminati et al., 2003), but the approach adopted has been shown to have enough flexibility of use and accuracy, since it was possible to reproduce the phenomenon for almost 90% with respect to the available observations. Where the accuracy has been lesser, the possible causes of underestimate or overestimate have been verified.

The second approach has investigated some more specific situations (local case study areas), where the possible contributions to land subsidence due to groundwater withdrawals (as derived form the flow model and from the available extensometric observations) to gas production (as described in Gambolati, 1998) and to natural mechanism are compared.

CONCLUSIONS

The technology here employed is the result of almost 10 years of development, so that these models can now be employed as a systematic service, also in terms of forecasting purposes, but it is important to update models over time (model management) to achieve and maintain this kind of results. These tools can be used for different purposes: designing, planning, management and even for water emergencies, and can be adapted to specific situations through the construction of appropriate scenarios and / or predictions.

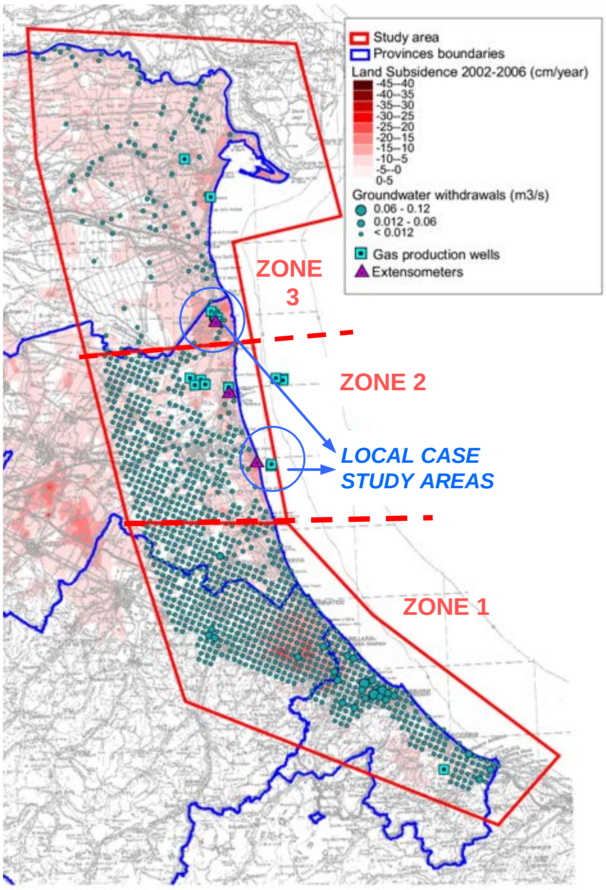

Figure 3 – Land subsidence model analysis by zone.

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NUMERICAL MODELLING TOOLS FOR WATER CRISIS PREDICTION AND MANAGEMENT

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KEY WORDS: water crisis, numerical modelling, forecast, groundwater, simulation

THE STUDY AREA

This work refers to the area of the three Provinces of Ravenna, Forlì-Cesena and Rimini, in the eastern part of Emilia-Romagna Region (North Italy) where in the last ten years several situations of water crisis (2003, 2007 and 2011) occurred due to prolonged drought periods.

Local drinking water annual needs, corresponding to more than 100 million cubic meters (Romagna Acque, 2012), are satisfied by both surface water and groundwater. The main surface source is Ridracoli dam with a capacity of 33 million cubic meters, while the major groundwater reservoir is the alluvial fan of the Marecchia River (withdrawals of about 25 million cubic meters per year) located near Rimini. Further sources are distributed on the territory of the three provinces as shown in Fig. 1.

Figure 1 – study area and main surface (blue) an groundwater (red) sources.

The amount of water available from all these sources may be seriously affected by extended dry periods. Available data on local water consumptions show that in such situations, it is necessary to make a greater use of groundwater sources. As a consequence, the evaluation of the groundwater quantiative state and of the sustainability of withdrawals become a strategic element in the water crisis management.

In this context, Arpa Emilia-Romagna has developed modelling tools and assessing procedures in order to predict and then to support the management of a possible water crisis. These tools are constantly made available to the decision makers that have to manage such ordinary and emergency situations.

LONG-RANGE FORECASTING AND DAM INFLOW PREDICTION

Specific tools for monitoring observed and forecasted aggregated precipitation over different areas of our region have been developed at ARPA-SIMC. In Fig. 2 is shown an example of one of these graphical tools that allows to quickly compare, for a given area, the current accumulated precipitation with climatology distribution or with previous years.

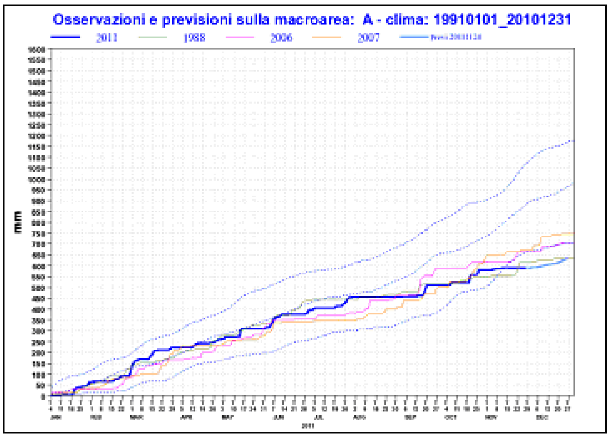

Figure 2 – Evolution of the total rainfall accumulated from the beginning of each year.

This example refers to the areal average rainfall mesured over the Romagna mountain region (macroarea A, Fig. 1). Colored curves in Fig. 2 refer to past dry years and the blue one refers to 2011. Starting from the last observed value, the blue curve is prolonged with a forecast (cyan curve) resulting from the calibration of the ensemble mean total precipitation from the monthly forecast system of the European Center for Medium-range Weather Forecast (ECMWF, 2012), available twice per week. Dashed lines represent the climatology of the total accumulated rainfall taken as a reference. Upper line is 95° percentile, middle line is the 50° percentile, bottom line is the 5° percentile of the climatology observed over that area between 1991-2010.

The next step of the evaluation tool is shown in the Fig. 3 where the quantitative estimation of the inflow predicted into the Ridracoli dam is reported, given the precipitation forecast 1 month ahead.

The precipitation estimate, resulting from the ensemble mean calculations, is then converted in dam inflow using a monthly statistical regression based on the last 10 years of observed precipitation over the basin and inflow measured at the dam, in order to compute seasonal dependent run-off coefficients. The inflow interval for each week is empirically obtained applying two different run-off coefficient. The first one usually corresponds to the current month, while the second one corresponds to the previous month, accounting for uncertainty in the estimate of the water saturation of the ground.

Finally, the predicted monthly inflow volumes are decremented by the monthly expected consumption in order to estimate the future level of the water in the dam.

Weeks	Forecast/ Prediction		Climatology values	
	A [mm]	VOL [Mm^3]	A [mm]	VOL [Mm^3]
28/11/11 04/12/11	3	0.1 – 0.3	19	1.9
05/12/11 11/12/11	10	0.2 – 0.5	12	1.4
12/12/11 18/12/11	9	0.2 – 0.6	12	1.4
19/12/11 25/12/11	20	0.4 – 0.9	24	2.2
monthly values	42	0.9 – 2.3	67	6.8

Figure 3 – Forecasted precipitation and predicted volumes of water inflow into the Ridracoli dam. The examlpe refers to the last very dry autumn (2011) with extremely dry soil and limited run-off compared with climatological values (right columns) based on 1991-2010 climatologies.

GROUNDWATER QUANTITATIVE STATE EVALUATION AND MODELLING SCENARIOS

Groundwater withdrawals for urban purposes from Marecchia alluvial fan corresponds, on average, to 75 % of the total groundwater withdrawals for urban needs in the whole Romagna area, and to 25 % of the total drinking water demand.

The groundwater quantitative state of Marecchia alluvial fan is monitored through a groundwater flow model that is constantly updated and verified on the basis of piezometric level measurements available from a dedicated network.

All evaluations are carried out through model water budget calculations. Variations on storage volumes of water resource within the system are computed and cumulated starting from the reference critical point set equal to the minimum of the piezometric levels of 2007. In this way, a measure of distance from that critical situation is provided.

Six model simulation runs are performed combining four different natural recharging possibilities (main percentiles based on historical data) with three levels of system exploitation. All results are synthesized in Fig. 4 where colored bands from orange to blue are associated to a poor or good evolution of groundwater quantitative state. This graph allows to evaluate the current state of groundwater availability resulting from the last model update (orange line). At the same time, comparison with past year curves could be done.

Moreover, forward simulation runs allow to predict groundwater quantitative state after 2-4 months, depending on seasonal forecast simulations (Pavan et al., 2008) and on expected drinking water needs for the same period (green lines).

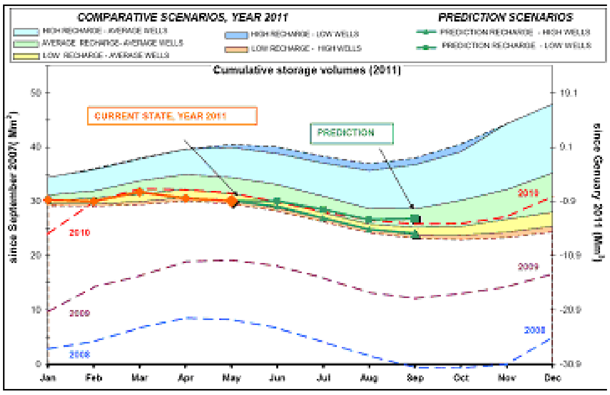

Figure 4 – Evaluation of groundwater quantitative state by model budget analysis. In this example the model is updated on May 2011 and the prediction is for four months ahead.

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EXTENT OF ARSENIC CONTAMINATION IN THE GROUNDWATER OF THUWAL AND BISHNUPUR DISTRICTS OF MANIPUR (INDIA)

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KEY WORDS: Groundwater, Manipur India Arsenic contamination.

ABSTRACT

Groundwater plays an important role in shaping the economic and social health of urban and rural population throughout the globe, but the distribution of good quality groundwater is quite uneven. In many parts of the world, especially in the South and South-East Asian nations, many fold higher concentrations of various elements (e.g; arsenic, fluoride and selenium etc.) than their respective WHO permissible limits have been reported. A systematic study has thus been undertaken to assess the ground water quality of Thoubal and Bishnupur district of Manipur. For this 26 water samples were collected and analyzed for various elements, including arsenic. More than 45 % of collected water samples show arsenic concentration well above the permissible limit prescribed by WHO for drinking water. The highest concentration of arsenic (535 µg/L) was registered from Ngangkha Lawai Mamang Leikai area of Bishnupur district which is fifty fold of the WHO limit for arsenic and tenfold of Indian permissible limit.

INTRODUCTION

The access of safe drinking water is one of the prime necessities for the survival of mankind. However, in many regions of the world, especially in undeveloped and under-developed countries, this primary requirement is not fulfilled and a significantly large population is forced to drink contaminated water, which ultimately causes many waterborne diseases (Fewtrell et al., 2005). Apart from anthropogenic sources, many inorganic and organic pollutants from natural sources are also contaminating the groundwater. As in case of India, it is well established that pollutants such as Arsenic (Farooq et al., 2010, 2012; Berg et al., 2008), Fluoride (Hema et al., 2005) and Selenium (Bajaj et. al., 2011) etc., are contaminating the groundwater due to natural causes, on intra-basin and inter-basin scale. Though, a lot of research has been done on the problem of arsenic contamination in different basins of India but still many basin are left unexplored. India being a vast country with different hydrogeological and geological conditions, the outcome of one basin cannot be interpolated for the other basin, thus, there seems a need to investigate every single basin individually. The study has therefore been taken with an aim to investigate the extent of arsenic contamination in parts of Imphal valley region of Manipur.

STUDY AREA

Manipur (North Eastern state of India) is high structurally deformed province, consisting of younger sediment of quaternary age (Singh L. D. 2007). It is located between N: 23°50 - 25°42 and E: 92°58 - 94°45 longitude in the extreme eastern parts of the country. The total surface area of the state is 22,327 sq. km, of which around 90% is covered by hills and the remaining 10% consists of central oval shaped valley surrounded by hills from all sides.

Barak River Basin and the Manipur River Basin are two major river basins within the State of Manipur. The rivers draining both the basins originate from the surrounding northern hilly region, thus are comparatively young while in valley area they shows some degree of maturity.

METHOD OF STUDY

To investigate the extent of arsenic contamination, 26 water samples were collected on a random basis. Out of the 26 sampled wells, 21 were actively used domestic wells (tube wells/hand pumps), 2 river water samples, 1 spring water and 1 pond water sample. Collection of all the water samples involved collection of: (1) filtered samples (0.45 µm cellulose nitrate filter) for analyses of major anions; and (2) filtered (0.45 µm cellulose nitrate filter) and acidified (with 5 mL 14 M ultrapure HNO_3/L) samples for major cation and trace element analyses. All samples were tightly sealed and stored at low temperature until further analyses. Analysis for all major (cations) and trace elements was done by ICP-OES (Perkin-Elmer, France). Sulfate (SO_4^{2-}) concentrations were measured by spectrophotometer (Shimadzu UV-Visible spectrophotometer 160), alkalinity by titration and chloride (Cl^-) by Expandable Ionanalyzer 940A with a combination electrode Orion ionplus 9817 BN. Tube wells were operated at least 15 minutes before collection of samples, to flash out the stagnant water inside the tube and to get the water representing the aquifer.

RESULT AND DISCUSSION

The summary of the geochemical analyses of the groundwater samples is presented in Table 1. All the water samples show weakly alkaline character and the pH ranges between 7.2 - 8.9.

Table 1- Geochemical data of water samples.

	Tube well water	Other waters*
pH	7.2 - 8.8	7.9 - 8.9
Na^+	17.9 - 211	4.06 -16.6
K^+	0.68 - 24.3	0.84 -8.32
Ca^{++}	16.4 - 93.3	2.22-18.2
Mg^{++}	10.7 - 46.3	0.9 - 11.4
Cl^-	4.38 - 296	7.12 - 22.2
SO_4^{--}	19.9 - 47.8	25.6 - 34.7
HCO_3^{--}	190 - 560	90 - 120
As (total)	Bdl - 535	Bdl

**Other waters include samples from river, pond and spring. All major ion concentrations in mg/L, Arsenic concentrations in µg/L.*

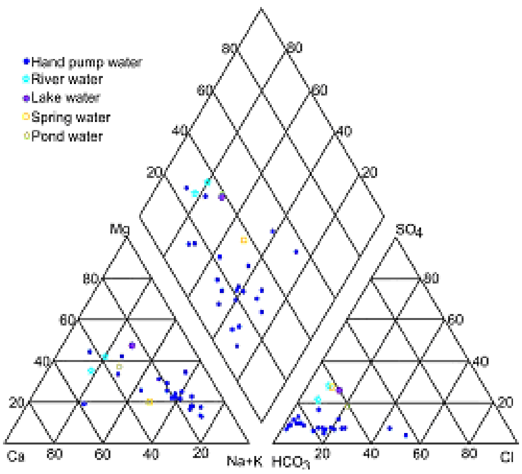

Figure 1 - Piper diagram showing the geochemical characteristics of water samples.

The major ions composition, plotted on piper diagram (Fig. 1), clearly differentiates the tube well water from the surface water. Tube well water is mainly of Na-HCO_3 type while the surface water (including river, lake, pond and spring) is Ca-Mg-HCO_3 type. In all water samples SO_4^{2-} concentrations are quite high (tube well: av. conc. 27.1 mg/L and surface water: av. conc. 30.5 mg/L) compared to other arsenic affected areas (Eiche et al. 2008; Smedley and Kinniburgh 2002), where they are frequently well below detection limit. This indicates that the arsenic mobilization in the study area is not controlled by the reduction mechanism, as proposed for arsenic mobilization in Bengal Delta (Bhattacharya et al. 1997).

All surface water samples falls within the safe limit of arsenic in drinking water and arsenic concentration in these samples remained below detection limit (Bdl). However, in 57% of tube well water samples the arsenic concentration well above the WHO permissible limit of 10µg/L of arsenic was registered.

The presence of arsenic free water on the surface and contaminated groundwater at deeper levels indicates the existence and operation of arsenic release mechanism within the aquifer sediments. Further studies on larger scale to evaluate the extent of arsenic problem and to estimate the affected population is required. Use of surface water for drinking purposes is suggested, until the long term solution for providing safe drinking water can be put in place.

ACKNOWLEDGEMENTS

We are grateful to Dr. Bhuvanchandra, Dr. Inoba Singh and Mr. Holland for providing the local help to conduct the research work.

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A CARBONATE AQUIFER HOSTING A DECREASING HYDROTHERMAL SYSTEM: THE VITERBO CASE, CENTRAL ITALY

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KEY WORDS: Viterbo, hydrothermal system, carbonate aquifer, aquitard, discharge, sustainable yield, temperature.

In north-western Latium region, affected by volcanic activity of the Cimino (1.3 – 0.9 Ma) and Vicano (0.8 – 0.150 Ma) during Pleistocene, the deep carbonate aquifer consisting of the Mesozoic - Cenozoic Tuscan Nappe of the Mt. Razzano – Vetralla structural high with a N–S trend has been recognized in the underground of Viterbo area. This aquifer is separated by the overthrusted Late Cretaceous - Eocene Tolfa Flysch aquitard with The hydrothermal system is fed by a circuit of groundwater derived from the carbonate aquifer of the Mesozoic - Cenozoic Umbria - Marche Succession in the central Apennine (the mountains of Amelia, Spoleto, Rieti and Sabini Mountains). This groundwater emerges in the Narni gorge of Amelia Mountains, 34 km ENE of Viterbo, forming a linear spring along the River Nera with an overall discharge of 13.5 m3/sec and a temperature of 15°C and mix with groundwater of the shallow Pleistocene sandy-gravelly aquifer at the gorge outlet (Fig. 2). The spring water is of sulphate-alkaline-earth type and shows a value of least permeability from the middle-late the strontium isotopic ratio 87Sr/ 86Sr (0.70816) Pleistocene shallow volcanic aquifer that hosts cold bicarbonate- alkaline-earth waters.

The Mt. Razzano – Vetralla structural high includes an uplifted block and a lowered block which together form an hydrostructure completely isolated by the Tolfa Flysch aquitard (Fig. 1). Sulphate alkaline earth hot waters hosted in the carbonate aquifer flow upward through the permeable cataclastic belts of three transversal normal faults, which cut across the hydrostructure, and emerge at surface forming several springs (40° - 62°C) through an area of about 24 km2. Furthermore several wells drilled in '50s and '60s, which intercepted the thermal waters, have an overall actual discharge of 32.3 L/sec. The total discharge of the springs, estimated as 76.55 L/sec in 1984, decreased to 36.7 L/sec in 2010: in particular the discharge of the most famous spring (Bullicame) was 30 L/sec in 1855 and 10 L/sec in 2010, showing a loss of 20 L/sec (67 percent) in 155 years. Thus the total actual discharge due to springs and wells is 69 L/sec. The temperature values have also decreased by at least 2°C over an overall period of 100 years.

A volume of 114 million cubic metres of travertines (3.9 million from the Case Castiglione Unit and 110 million from the Bullicame Unit; Fig.1) is the result of the deposition of CaCO3 by a giant volume of thermal waters that flowed at surface for a long span of time. The travertines of the Case Castiglione Unit and the dome - shaped travertines of the Bullicame Unit lacking thermal waters suggest that several emergences have been completely extinguished, thus confirming that the overall discharge of thermal waters has been decreasing over time.practically identical to that of thermal waters (0.70750 - 0.70850).

Travertine material recognized at the base of the Vicano District pyroclastic rocks dated at 0.420 Ma in the wells and the palaeegeographic setting of the Viterbo province area between the Tyrrhenian Sea and the central Umbria - Marche Apennine, including the marine shallow water basins of Tarquinia and Tevere, suggest that the hydrological cycles of cold waters and thermal waters have been active since at least 0.420 Ma and very probably contemporaneously with the Cimino Volcanic District. Cold waters emerged forming several springs along the coast lines of the Tevere Basin, whereas thermal waters emerged with several springs in Viterbo area.

Decreasing discharge of the thermal emergences is related to: (1) a decrease of the thermal waters' temperature over time; (2) a decrease of the permeability of the cataclastic belts of the transversal normal faults; (3) a very long period of activity in the hydrothermal system and (4) the possible consumption of permanent reserves of the carbonate aquifer, that have not been suitably renewed, due to several climatic variations which occurred during Pleistocene. Thus the 69 L/sec overall discharge, corresponding to the actual balance of the hydrothermal system, should be referred to as the sustainable yield which should not be exceeded.

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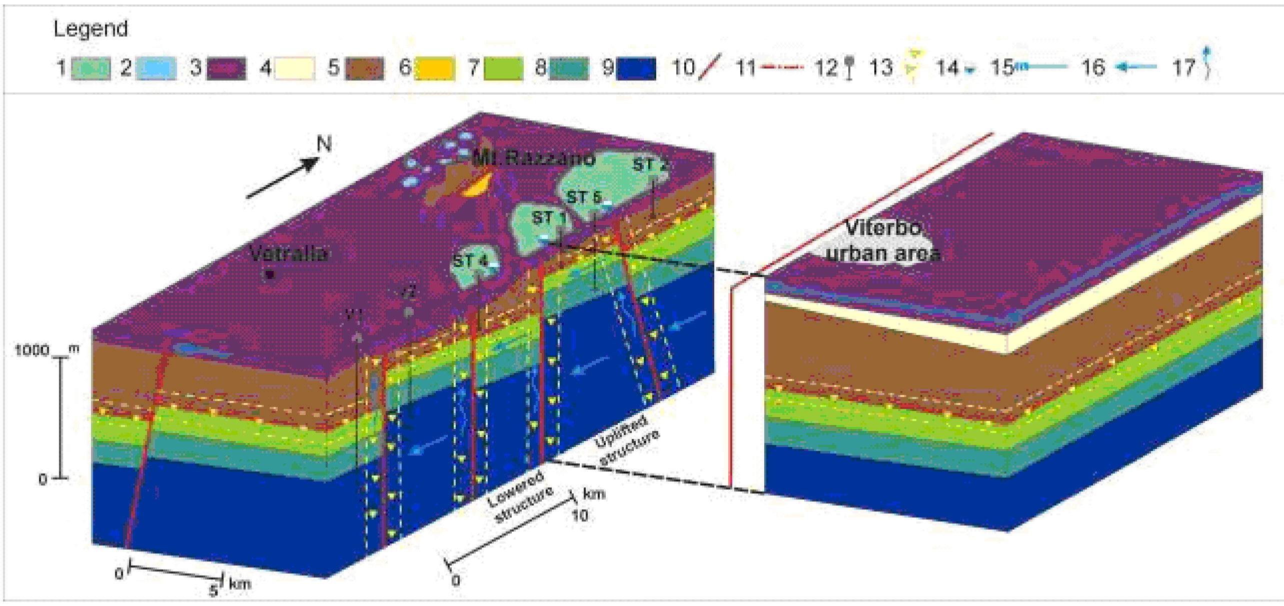

Figure1 - Block diagram showing the stratigraphic - structural and hydrogeological settings of the Viterbo hydrothermal system. Legend: 1, travertines of the Bullicane Unit (Holocene); 2, travertines of the Case Castiglione Unit (Holocene); 3, volcanic aquifer (middle - late Pleistocene); 4, clays (aquitard with least permeability; Early Pliocene); 5, Tolfa Flysch (aquitard with least permeability; Late Cretaceous - Eocene); 6, Poggio S. Benedetto Sandstone (aquitard with least permeability; Oligocene); Tuscan Nappe carbonate aquifer consisting of: 7, Scaglia - Diaspri - Calcari selciferi - Rosso ammonitico (Liassic - Paleogene), 8, Calcare massiccio (Liassic), 9, Calcare cavernoso - Anidriti di Burano Formation Late Triassic); 10, normal fault; 11, thrust;12, well; 13, permeable cataclastic belts; 14, emergence of thermal waters; 15, flow direction in the volcanic aquifer; 16, flow direction of thermal waters; 17, upward flow of thermal waters through the permeable cataclastic belts. V1 = well Vico 1 and V2 = well Vico 2 of Enel. ST1, ST2, ST4, ST5 wells of Terny Company.

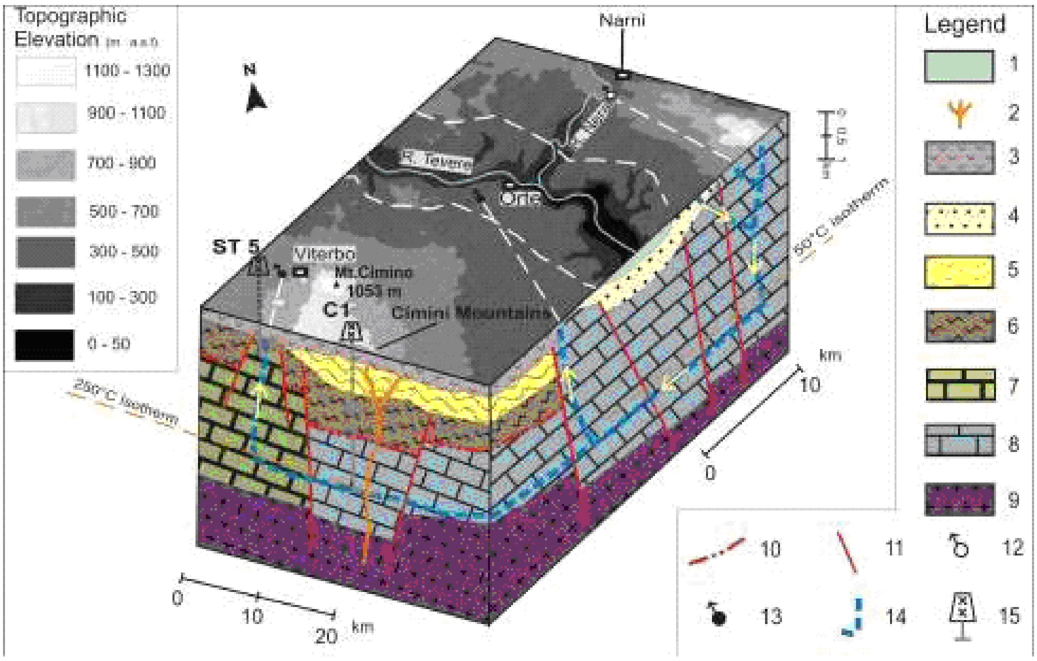

Figure 2 – Hydrogeological scheme showing the groundwater flow of the carbonate aquifer of central Apennine which feeds the Viterbo hydrothermal system. Modified from Chiocchini et alii (2010). Legend: 1, alluvial sediments (Pleistocene – Holocene); 2, magma intrusions of the Cimino and Vicano volcanic districts (Pleistocene); 3, volcanic units of the Cimino and Vicano districts (volcanic aquifer; Pleistocene); 4, clayey and sandy - gravelly sediments (shallow aquifer; Pliocene – early Pleistocene); 5, mainly clayey sediments (aquitard with least permeability; early Pliocene); 6, Tolfa Flysch (aquitard with least permeability; Late Cretaceous - Eocene); 7, units of the Tuscan Nappe (carbonate aquifer; Late Triassic - Paleogene); 8, units of the Umbria – Marche Succession (carbonate aquifer; Late Triassic - Paleogene); 9, phyllite – quartzite substrate (aquitard with least permeability; Permian); 10, thrust; 11, normal fault; 12, springs of the River Nera; 13, thermal springs of Orte and Viterbo; 14, route of groundwater that feed the springs along the River Nera and the thermal springs of Orte and Viterbo; 15, well. ST5 = Terni Company well. C1 = Enel well.

INTRINSIC VULNERABILITY MAP OF GROUNDWATER BODIES IN THE EMILIA-ROMAGNA APENNINES

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KEY WORDS: Intrinsic vulnerability, groundwater, the Water Framework Directive (WFD), the Emilia-Romagna Apennines

FOREWORD

Following the instructions contained in the implementing provisions of Directives 2000/60/EC (the Water Framework Directive) and 2006/118/EC, the Emilia-Romagna groundwater bodies (GWB) Map was drafted in 2009. For the first time a knowledge framework on regional mountain aquifers was thus outlined and applied to the Management Plans developed by Basin Authorities. It was subsequently requested to undertake a classification of groundwater bodies based on their intrinsic vulnerability.

INTRINSIC VULNERABILITY IN MOUNTAIN AREAS, ASSESMENT AND PROBLEMS.

Over the past decade, the hydrogeology of the regional mountain sector was for the first time systematically studied at the wide area level, thanks to the efforts of the Regional Geological Survey. It is well known that the mountain sector of the Region is to date documented by a much smaller hydrological data quantity than the one referred to the plain, Due to the delay with which regional studies have begun and given the misleading idea of having to do with a "second class" or "unknowable" drinking water supply.

Moreover, the mountain sector, due to geological reasons, suffers from more local variability scenarios fostering the storage of underground water. All these factors require experts to proceed by successive approximations, when regional scale maps have to be developed. The definition of intrinsic vulnerability (IV) is the one provided in literature by Civita (1987). This hydrogeological issue is significant when applied for processing information at a scale with a large denominator (ie 1:250.000), thus giving rise to a preliminary regional framework to be compared with the one referring to hydrogeological situation identified at national level.

To reach this result a nonparametric method can only be used for assessing IV as the GNDCI-CNR Method, dating from the late '80s and referred to by the more recent " Linee–guida per la redazione e l'uso delle carte della vulnerabilità degli acquiferi all'inquinamento" (De Maio et al, 2001). In the case study, in fact, a GWB cartography is available which, through the comparison with the 1:10.000 geological database, allows us to trace back (via the prevalence criterion of) to lithology and structural-stratigraphic context of the geological units that compose them, given that they are the most permeable hydrogeological units of the Emilia-Romagna Apennines.

The GNDCI-CNR Method is based on direct comparison between several hydrogeological pre-defined situations, according to the Italian geological setting; six IV classes are obtained, ranging from very low to extremely high degree. The GNDCI-CNR Method application to the Emilia-Romagna Apennines area needs to be duly adjusted, to avoid flattening out the IV classes down to the "medium" or "medium to low" degree, as demonstrated by a previous study experience (Viel, De Nardo and Montaguti, 2003). This adjustment to the local geology has been obtained by applying the "relative IV" concept, by comparing GWB hydrogeological items, starting from a few benchmarks deriving from the Method caption attributions, thus obtaining a preliminary result, as schematized in Figure.

TESTING THE GNDCI-CNR METHOD IMPLEMENTATION

Seizing the opportunity provided by this applied research, a test is underway to implement the IV classification obtained using the GNDCI-CNR Method, with reference to the data available in the Geological Survey data bases. The following factors are considered, through geostatistic methods:

• density of springs, tectonic lineations, drainage, hypogean cavities.

• acclivity classes and the presence of paleosurfaces, with sub-lowland areas where pedogenesis achieves the utmost development,presence of "stable" wooded areas.

The purpose of these analyses is to identify areas within GWB in which the initial IV value, according to the GNDCI-CNR classification, could reasonably be raised in grade, without neglecting the need to "generalize" the possible zoning, by realistically taking into consideration its applicability for planning purposes. The result that will be obtained is in any case compatible with a 1:100.000 - 1:250.000 scale. As already shown in previous experiments (Viel et al, 2003) it is possible to outline preliminary integrated aquifer vulnerability maps, matching intrinsic vulnerability maps with land use ones, available in previous regional information systems, serving as point of reference with respect to more detailed analyses, which could be obtained only through (not always available) local census results of centers of danger.

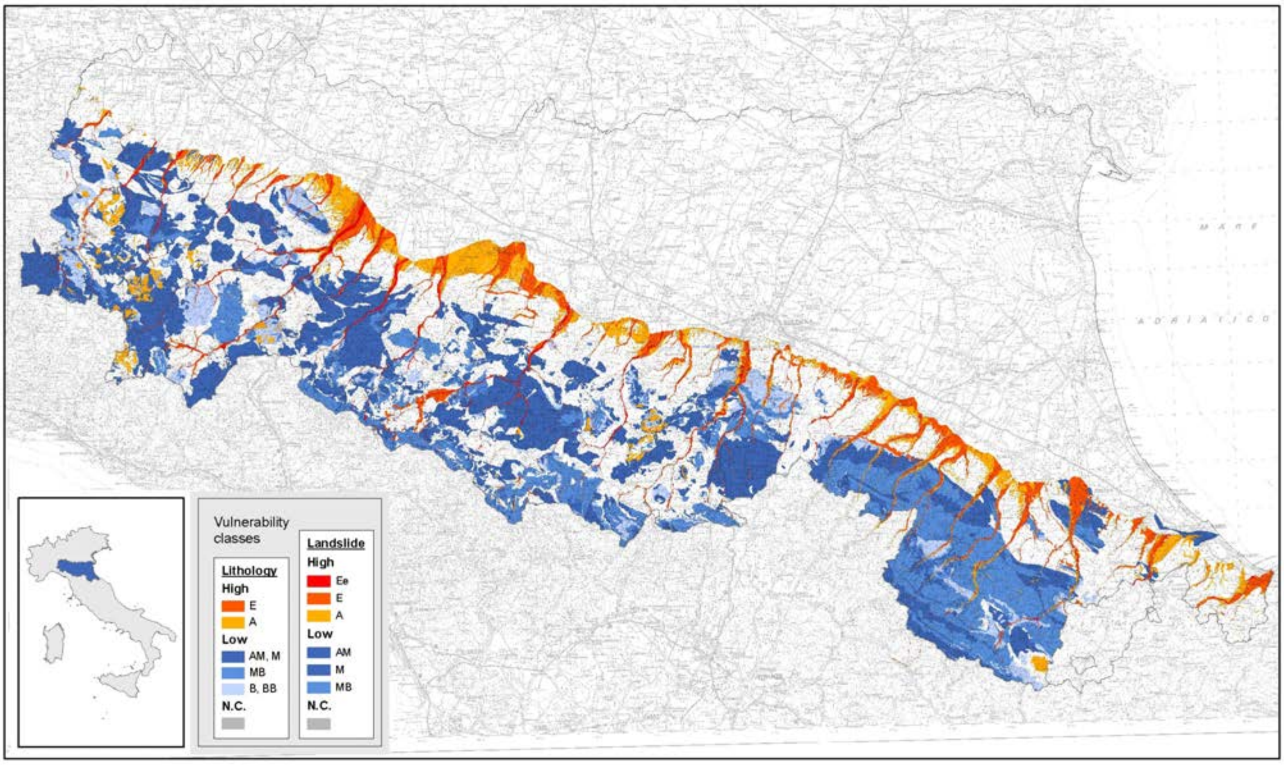

Figure 1 – intrinsic vulnerability map of groundwater bodies in the Emilia-Romagna Apennines, according to the locally adapted GNDCI-CNR Method

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CATONE: AUTONOMOUS UNMANNED SURFACE VESSEL FOR HYDROGRAPHICAL MEASUREMENT AND ENVIRONMENTAL MONITORING

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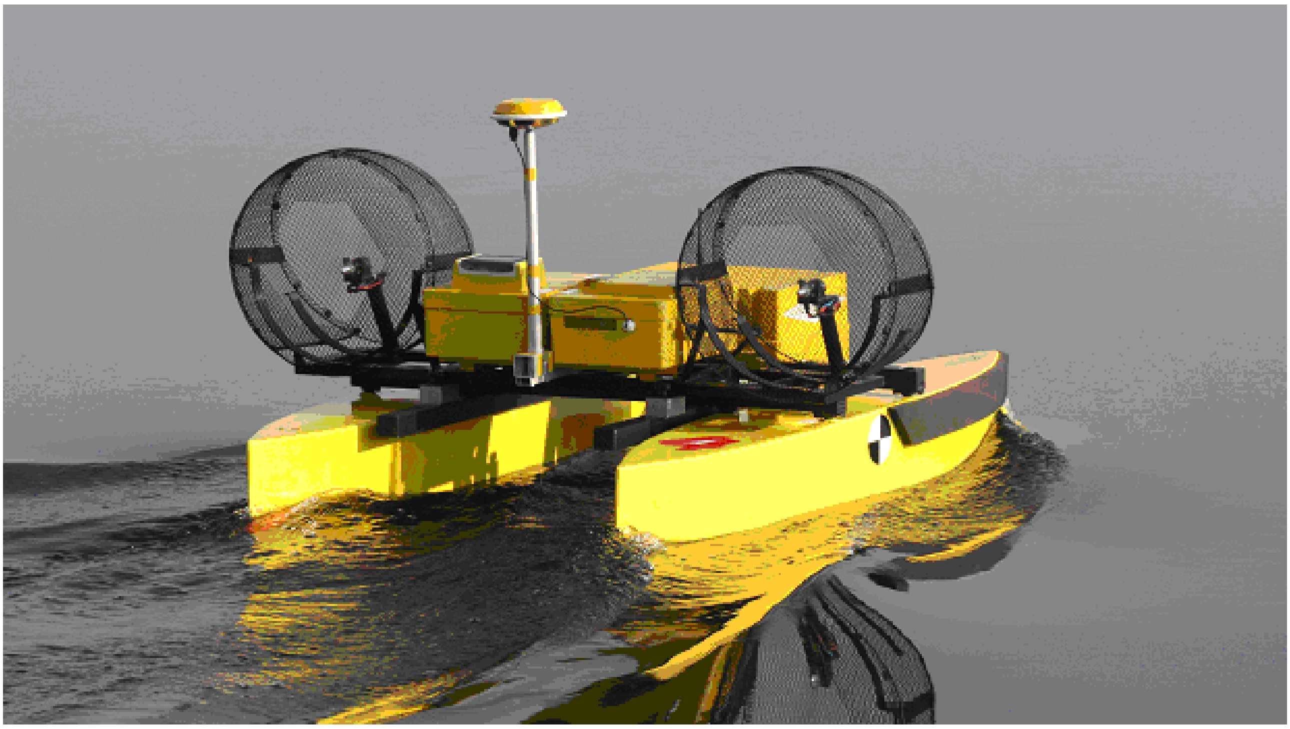
KEY WORDS: Unmanned Surface Vessel, USV, bathymetry, robot boat, environmental survey.



GENERAL

Logistic constraints, difficulties, risks and economical impact of the bathymetric measurement are known matters . This activity, in fact, implies the presence of human conductors and operators on board of motorized boats that often have to be transported in places difficult to be reached or, even worse, dangerous and hazardous for humans such as, for instance, quarry lakes, landslides, risky or contaminated areas. In certain cases environmental constraints or shallow water prevent boats powered by outboard engines to operate. The company aerRobotix, with the contribution of Geo Survey, have developed a new approach based on the use of small " unmanned" boats capable of carrying out bathymetric measurements and other environmentally-oriented activities in total or partial autonomy. Such innovative solution avoids risks for the persons, eliminates any kind of pollution, reduces the number of operators involved, makes the activity more flexible. Efficient mission management, small size, handling easiness and very limited power consumption allow for low operational costs. The proposed poster describes this new approach and the relevant lesson learned. It provides details about the characteristics and advantages that the unmanned surface vehicles offer for bathymetric surveys and also for other possible application in the environmental field like, among others:

- Water quality measurement/monitoring
- Discharge measurements via ADCP doppler systems
- Video surveillance of the basin bottom, of the water surface and/or of the coast
- Precisely localized distribution of colouring water markers
- Precisely positioned collection of water samples
- Distribution of chemical products
- Temporary replacement of fixed data acquisition stations.
- Bird scaring over drinkable water basins and fish-breeding ponds.

Finally the poster presents recent successful applications of the unmanned boat "CatOne", including first evidences of the effectiveness of Continuous Vertical Electrical Soundings for agricultural canals seepage detection.

MAIN CHARACTERISTICS

CatOne is a family of multi-purpose catamaran-robot that proves especially effective in situations requiring recurring, very repetitive, long endurance activities or in those to be carried out in dangerous and hazardous environment and in sensitive ecosystem. The navigation takes place completely automatic, slaved to a precise GPS positioning reference system. In addition to the typical sonar sensor for bathymetry the robot can host and carry on board a large variety of sensors and equipment. Other specific characteristics makes CatOne capable of operating in very shallow water, in presence of algae and in sensitive ecosystems, namely :

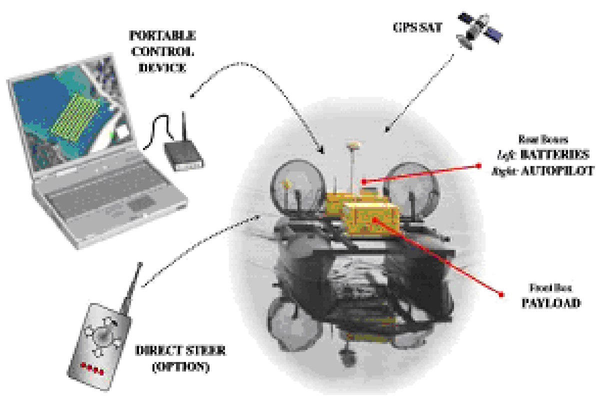
- very low draft
- absence of propeller and rudders in the water
- zero pollution emission (electric propulsion)
- low noise
- virtually no disturbance to the depth contour of shallow water and to the flora and fauna.

Low weight and small dimensions make CatOne's ground handling easy. The number of required operators can be reduced to just a person. Partially disassembled, the catamaran can be easily transported over the roof of a medium-size car or inside a Station Wagon . Time for assembly and preparation for the mission takes just a few minutes.

The control system represents a valuable component, assuring autonomy and operational flexibility.

It consists of :

Ground control station. The operator defines, through a user friendly interactive display, the vessel



routes and plans the mission. Once activated, CatOne executes autonomously its mission . A data link communication system feeds the control station with all data necessary to the operator who, if necessary, can take correcting or emergency actions.

A computerized on board system that autonomously drives the mission taking as a positioning reference GPS data, integrated by other inertial and magnetic sensors input .

MAIN DATA (DEPENDING ON MODEL)

Length	1.6 - 1.9 m
Width	1.0 - 1.2 m
Weight (empty)	12 - 20 kg
Pay load	up to 45 kg
Propulsion	Electrical
Energy	High energy density LiPo rechargeable batteries
Operational speed	5 km/h
CO2 emission	zero
Navigation modes	Fully automatic , remotely controlled or mixed
Endurance	8 hours (prolongable by additional battery packages)
Operators	One person can supervise up to three units
Transportation	Station wagon, monovolume car or car roof carrier

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MODELLING GROUNDWATER FLOW BASED ON A 3D HYDROSTRATIGRAPHIC RECONSTRUCTION OF THE CARBONATIC AQUIFER SYSTEM OF SALENTO (PUGLIA, SOUTHERN ITALY)

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KEY WORDS: water resources, groundwater, salt water intrusion, fractured aquifers, Salento.

INTRODUCTION

The Salento peninsula (Southern Italy) is a typical Mediterranean basin, where the main aquifer is hosted in Cretaceous carbonatic rocks (Calcare di Altamura) mostly overlaid by sediments with low permeability; it is therefore a fractured and karst aquifer, with a poor recharge and complex relationships with the sea. In order to develop a tool to assess the water balance at regional scale, a groundwater flow model has been developed. The conceptual model is developed on a GIS-based reconstruction of the 3D geological and hydrostratigraphic model. Further details can be found in Giudici et al. (2012).

HYDROSTRATIGRAPHY

The Salento carbonatic continental shelf is part of the Apulian foreland which was created during the Apenninic orogenesis and corresponded to a wide antiformal structure, WNW-ESE trending, block-faulted, and was variably uplifted during late neogenic times.

The hydrostratigraphic model of this area is obtained from processing and correlation of surface and subsurface data, namely lithologic data, descriptions of geologic formations and of their physical properties that reveal the nature of subsurface rocks, sediment types and contained fluids. In particular borehole logs from 515 wells were interpreted and reclassified, in order to fit the conceptual hydrostratigraphic framework for the study area. Some gaps in data coverage have been partly compensated by elevation data of exposed portions of the Cretaceous units.

Thanks to the digital database, the subsurface data have been merged not only with digital geological maps, but also with control points from shallow wells that do not reach the bedrock and with observations of sedimentary structures outcropping in quarries and other areas excavated for infrastructures and buildings.

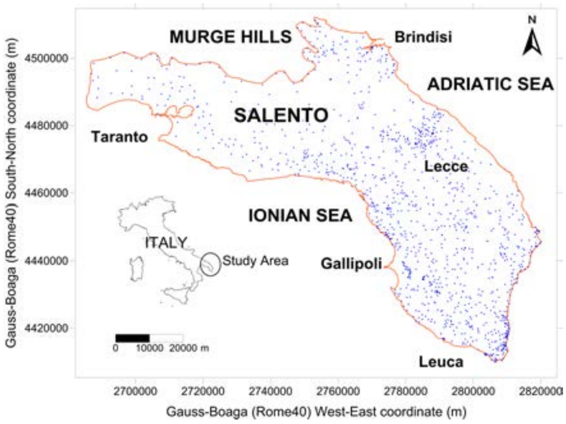

Figure 1 – Map of the study area and position of the points used for the reconstruction of the hydrostratigraphyic model.

Seven hydrostratigraphic units (HUs), have been recognized and the surfaces that delimit each HU were obtained through interpolation of the point data by kriging, cross-checking the results and validating them also with the aid of several 2D geological sections.

The oldest HU, corresponding to the main, deep aquifer of the Salento peninsula, is made up of alternating layers of variable thickness of Cretaceous to Oligocene limestones and dolomitic limestones, which are very permeable, due to fracturing and karst features. This HU is mostly represented by the Calcare di Altamura formation, that constitutes the basement of the entire region, extends for thousands of meters in depth (5,600 m in Agip 1977) and outcrops in the corresponding highest reliefs of the area ("Serre"). Along the oriental rocky coast of the peninsula, the HU includes also several carbonate systems not only of Cretaceous but also of Eocene (Torre Specchia La Guardia and Torre Tiggiano Limestone) and Oligocene (Castro Limestone) age, that are laterally adjacent to each other, grafted upon each other, but separated by erosion surfaces. The top surface of this HU reaches a maximum elevation of 250 m above the mean sea level in correspondence of the western side of the area whereas it lies 250 m below the sea level both along the eastern and western coast. The interface between fresh and salt water lies within this HU and extends inland over the whole peninsula. The aquifer is under pressure where the limestones are overlain by confining, more recent and usually less permeable rocks.

Morphostructural depressions of Mesozoic carbonatic basement, often bordered by normal faults principally oriented from NNW to SSE and secondarily from ENE to WSW, have produced sedimentation basins that were filled up in different phases and are now occupied by the remaining HUs.

The Oligocene and Lower to Middle Pleistocene (subappennine clays) HUs are mainly impermeable, whereas Miocene, Pliocene, Lower Pleistocene and Upper Pleistocene HUs might host porous aquifers of secondary relevance as water resources at the regional scale, due to their limited spatial extension and thickness. Therefore, this work is focused on the Cretaceous HU.

MATHEMATICAL MODELING

Groundwater flow is modelled with a finite difference conservative scheme, which considers the 2D fresh water flow under pseudo-steady conditions, i.e., simulating an equilibrium condition averaged over a period including one or more hydrological years. The model is based on the classical Ghyben-Herzberg's approximation (Bear, 1979), but introduces non standard boundary conditions along the coast. In fact, where the top of the Cretaceous HU is outcropping along the coast, then the aquifer can be assumed phreatic and a drainage type boundary conditions is assigned, in order to model outflow of fresh water from the aquifer; on the other hand, where the Cretaceous HU is covered by less permeable HUs and therefore the contact between the aquifer and the sea occurs off shore, a prescribed water head, obtained from field data interpolation is assigned.

Aquifer recharge is estimated by taking into account both the spatial variability of the annual rainfall and the hydrostratigraphic structure. Water abstraction is estimated from published data.

RESULTS

The absence of a stable widespread monitoring network and the presence of low hydraulic gradients prevent from a robust estimation of hydraulic conductivity with automatic calibration methods. Nevertheless, a preliminary analysis gives a first guess of areas with high and low conductivity and shows that the complexity of the deep aquifer reflects itself in the variability of the conductivity field.

The development and application of such a model of groundwater flow at large scale in the main deep limestone aquifer of the Salento peninsula was possible thanks to the availability of a 3D hydrostratigraphic model, which is the basis to understand the permeability structures of the aquifer and aquitard system.

At some places, along the north-western and the eastern coast, the modelled piezometric head becomes negative (Figure 2), which is a physically inconsistent condition. This conclusion implies that, at the scale of the model, in those areas, most of the aquifer is saturated with salt water. The location and extension of these areas are in agreement with the observations of Regione Puglia (2009).

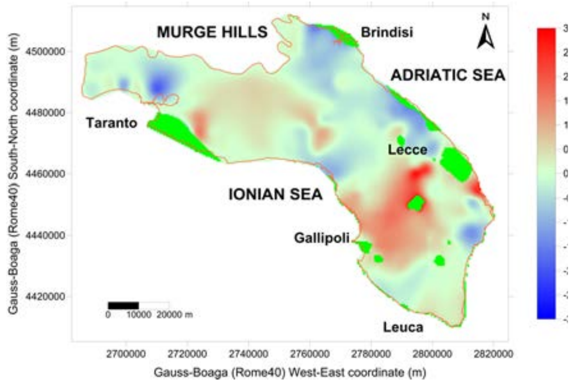

Figure 2 – Map of the differences (in meters) between modelled and observed water heads: green areas show the regions where the modeled water head is negative.

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STUDY OF HYDORODYNAMIC AND HYDROCHEMICAL CHARACTERISTICS OF GOROUNDWATER IN FISSURED-KARSTIC AQUIFER FOR DEILINEATION OF GROUNDWATER SOURCE PROTECTION ZONES

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KEY WORDS: carbonate aquifer, hydrodynamics, hydrochemistry, stable isotopes, tritium, carbon-14

INTRODUCTION

The investigated area comprises the north western part of Mt. “Ivančica”, which is located at north western Croatia. Mt. “Ivančica” is composed of rocks ranging in age from Paleozoic to Quaternary. However, from hydrogeological point of view, Triassic carbonate deposits are particularly important because of great amounts of accumulated groundwater which is used for public water supply of surrounding areas. Detailed hydrogeological research of the catchment area of four spirngs - “Žgano vino”, “Bistrica”, “Šumi” and “Beli zdenci”, was carried out in 2007 and 2008 for the purpose of defining groundwater source protection zones. Besides hydrogeological mapping, which was performed to spatially separate carbonate aquifer from aquitards and aquicludes, the spring discharge capacities were also measured on several occasions and spring groundwater samples were taken in different hydrological conditions of aquifer for chemical analyses. The discharge capacities of 4 springs were measured periodically from July 2007 to February 2009. Totally 10 measurements were carried out. Groundwater was sampled from the springs in July and September 2008 and in February 2009. Prior to taking water samples from individual springs, the following parameters were measured ‘’in situ’’ by probes of WTW company: EC, TDS, T, pH, turbidity and oxygen content in waters. At the Hydrochemical Laboratory of the Department of Hydrogeology and Engineering Geology – Croatian Geological Survey, the concentrations of the basic anions and cations were measured. The content of chlorides, sulphates and nitrates were measured by ion chromatograph of the LabAlliance company, whereas the concentrations of orthophosphates and ammonium were measured by the spectrophotometer DL/2010 of the HACH company. The concentrations of calcium, manganese, sodium and potassium were measured by the atomic adsorber of the Perkin Elmer company. The content of HCO_3^- was determined by titration. The results for ions were processed using the Netpath software. Data quality was further assessed using the charge balance between the sum of cations and anions (expressed in meq/l), which was always <±5%. The ratios of stable isotopes of δD and $\delta^{18}O$ in sampled water were measured at the Joanneum Research Forschungsgesellschaft mbH Institute of Water Resources Management (WRM) Hydrogeology and Geophysics in Graz, Austria and tritium was measured at Hydrosys, Budapest, Hungary. The carbon-14 activity of sampled waters was measured at Ruđer Bošković Institute, in Laboratory for measurements of low level activities, Zagreb. The results of performed investigations facilitated detailed insight in:

- hydrodynamic conditions of the aquifer and
- differences in mean residence time of groundwater discharging at monitored springs.

HYDROGEOLOGICAL FEATRUES OF GROUNDWATER SOURCE CATCHMENT AREA

The observed springs are located along the fault which brought into contact Triassic carbonate aquifer and impermeable clastic deposits of Paleozoic, lower and middle Triassic or lower Miocene age. The fault contact is the part of pronounced transcurrent fault zone with right lateral motion which can be tracked from Prigorec to Gotalovec, and along which horizontal movement of blocks took place in middle part of Mt. “Ivančica”.

According to the conditions of their appearance, the springs belong to gravity overflow spring category. The fissured-karstic aquifer is composed of middle and upper Triassic carbonate rocks: dolomites, limestones, dolomitic and limestone-dolomitic breccias as well as tectonic breccias.

RESULTS

The monitoring results of spring discharge capacitiy are shown in Fig. 1.

Figure 1 – Spring discharge capacity measurements

Date	Žgano Vino	Bistrica	Šumi
	Q [l/s]		
Jul-07	20-23	52-54	21
Sep-07	20	55	22
Nov-07	18	40-50	20
Dec-07	19-20	55	22
Jul-08	21.7	64.5	21.3
Aug-08	21.4	66.9	17.9
Sep-08	20.8	62.1	13.5
Oct-08	21.1	65.7	19.7
Nov-08	19.8	65.7	15.7
Feb-09	22.5	70.1	25.2

The stability of spring discharge capacities is noticeable. However, the "Šumi" spring is separated with slightly higher oscillations as compared to the "Bistrica" and "Žgano vino" springs. Because of technical difficulties, the discharge capacity of the spring "Beli zdenci" could not be measured at the location of the spring, so that it was estimated from quantities used for public water supply. On average it equals 10 l/s without significant oscillations.

According to major cations and anions of the spring waters, they belong to the CaMg-HCO_3 hydrochemical type. This is the primary water type which is principally derived from dissolution of carbonate minerals (calcite and dolomite) that compose the aquifer.

The spring water EC values vary from 408 to 439 μS/cm. The water temperatures at the springs were in accordance with the annual air temperature of the springs recharge area and vary from 9.1°C do 10.5°C. In the investigated area the water temperatures are uniform as EC values throughout the monitored period. Uniform distributions of EC and T indicate a low degree of underground krastification.

Spring waters are characterized by very low concentrations of nitrate, sulfate and chloride. Concentrations of nitrates vary from 3.5 to 5 mg/l. Sulfate concentrations are between 4 to 7.5 mg/l and chloride concentrations vary from 1.7 to 2.6 mg/l. Sampled spring waters have not been affected by anthropogenic influence in catchment areas. Concentrations of ammonium and phosphate were below detection limit of the instruments. The spring waters are not microbiological polluted and they have been good saturated by oxygen.

The measured hydrogen and oxygen ratios of sampled spring waters lie on or near the LMWL and clearly are derived from local precipitation that substantially homogenized in the underground (Fig. 2).

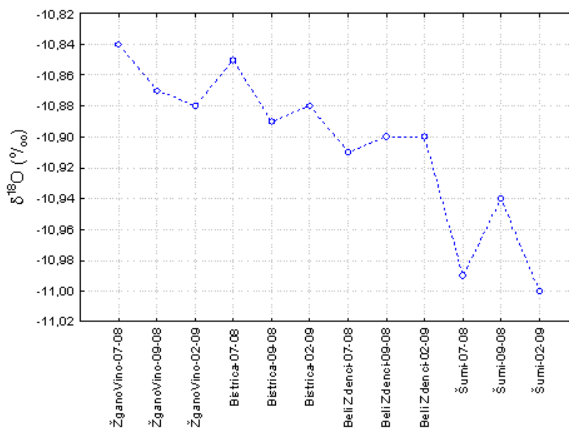

Figure 2 - Stable isotope composition of water samples collected from springs relative to the meteoric water line for Klagenfurt

The most depleted ratios of $\delta^{18}O$ were measured in the waters from spring Šumi (Fig. 3). In general, the spring which recharge is at the higher altitudes where temperatures are lower precipitation will be isotopically depleted (Gat & Gonfiantini, 1981; Clark & Fritz, 1997; Einsiedl et.al., 2009; Land & Huff, 2010) (Fig. 3). The variation of the tritium content and depleted ratio of $\delta^{18}O$ of the spring Šumi indicate groundwater renewability by precipitation from higher altitudes and short mean residence time. Large variations in ratios of $\delta^{18}O$ were not observed in sampled spring waters of "Beli zdenci", "Bistrica" and "Žgano vino". Also, very low tritium activity were measured in waters of "Beli zdenci", "Bistrica" and "Žgano vino". The measured data indicate the long circulation time of groundwater in the catchment area of the springs.

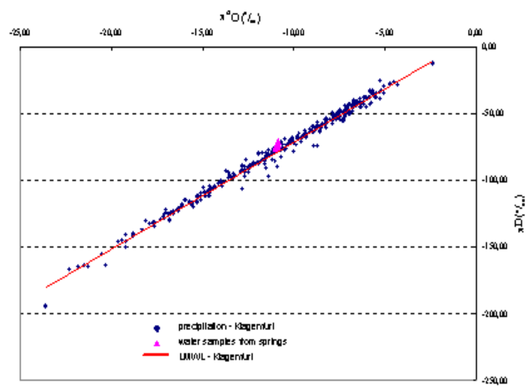

Figure 3 - Distribution of $\delta^{18}O$ in sampled spring waters

CONCLUSIONS

According to Regulation on determination of sanitary protection zones of the drinking water source (OG 55/02), groundwater must have a minimal travel time of 50 days from the external boundary of II. protection zone before it enters groundwater capture. If the travel time, e.g. through unsaturated zone, is longer than 50 days, the II. protection zone can be omitted. Since the results of analyses of hydrodynamic and hydrochemical features point to relatively short mean residence time of groundwater discharging at the “Šumi” spring, the II. protection zone was defined for this spring. On the contrary, II. protection zones were omitted for the springs “Bistrica”, “Žgano vino” and “Beli zdenci” as the consequence of relatively long mean residence time of groundwater. The study is a good example of successful application of described methods for groundwater source protection zones delineation in fissured-karstic aquifers, in situations where tracer tests can not be applied in order to estimate mean groundwater velocities which are subsuqently used for dimensioning of protection zones

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MAPPING THE SPATIAL DISTRIBUTION OF ARSENIC, BORON AND AMMONIUM IN THE DEEP GROUNDWATER BODIES OF EMILIA-ROMAGNA (ITALY) AND NATURAL BACKGROUND LEVELS ASSESSMENT

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KEY WORDS: cartography, arsenic, boron, ammonium, statistical assessment, natural background levels, threshold values.

INTRODUCTION

Estimation of natural background levels (NBLs) of heavy metals and inorganic compounds detected within regional scale aquifer bodies is required by the EU WFD (Water Framework Directive) 2000/60/CE and the GWDD (GroundWater Daughter Directive) 2006/118/CE. Mapping areal distributions of NBLs and threshold values (TVs) could improve our understanding of the space evolution of the chemical species that might compromise the good chemical status at large scales. Chemical species concentrations are typically monitored within a regional scale monitoring network and can display significant local variations within the same groundwater system. Cartographic rendering of spatial distributions of target species provides a synthetic and efficient way to quantitatively assess relevant trends.

METODOLOGY

Selecting the appropriate methodology to estimate the natural background level of given compounds depends on the type of available data and the objectives to be achieved. Amongst different existing methodological approaches, we select a framework based on the statistical analysis of the distribution of concentrations monitored over time by the Emilia-Romagna Region. We analyze and compare the preliminary results associated with two different methodologies, i.e., Component Separation and Pre-Selection (BRIDGE, 2007). Both frameworks make use of monitored information within a given water body to provide (a) estimates of the level of natural background concentration, and (b) the threshold values of target chemical species. Component Separation estimates NBLs upon discriminating a mixture of natural and anthropogenic components, jointly contributing to the monitored concentration values. Pre-selection estimates the NBLs by excluding a priori, from the available data-set, samples that could be considered as anthropogenically influenced.

AREA OF STUDY

We applied these methods to three large scale groundwater bodies delineated within the Emilia-Romagna Region (2010), in compliance with the EU WFD and D. Lgs 30/2009. We employed time series recorded at several monitoring locations included in the extensive network of observation wells managed by the ARPA – Regional Agency for Environmental Protection. The aquifers selected are representative of planar investigation scales of the order of hundreds of Km. Free surface and confined groundwater flow conditions have been distinguished. The following species were analyzed: Arsenic, Boron, and Ammonium. These were associated with significant concentrations in the samples examined.

RESULTS

Estimated values of NBLs and TVs indicate that in the cases examined the two methodologies provide comparable results, rendering background concentrations and, consequently, threshold values of the same order of magnitude. Both methodologies lead to estimates of NBL values for arsenic which appear to be inconsistent with the observation that the largest arsenic concentrations are found in the deep groundwater bodies and only to a minor extent in the upper aquifers. We note that both methodologies render a unique value of NBL (and, therefore of TV) for each groundwater body examined. These are therefore representative of a median behavior of the system that is not completely consistent with the areal distribution of the median concentrations of the species analyzed.

CONCLUSIONS

We conclude that (a) the results of these statistical methodologies should be jointly considered with an improved understanding and quantitative modeling of the physical processes that dominate the (hydro-geo-chemical) space-time evolution of the species analyzed, in particularly for the Arsenic, in the groundwater system; and (b) evaluations of areal NBLs and TVs are required to obtain a cartographic representation of background levels consistent with the real change in local concentration due to natural phenomena affecting the system at large scales.

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POSSIBILITIES FOR MULTIPURPOSE USE OF KARST GROUNDWATER IN CENTRAL PARTS OF BELGRADE (SERBIA)

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KEY WORDS: karst, groundwater, geothermal energy, multipurpose use

SUBSURFACE GEOLOGY (GEOTHERMAL ENERGY)

The management of energy sector development strategy in Serbia is based on energy efficiency and the utilisation of renewable energy sources. In order to realize available amounts of energy that can be obtained from renewable sources the explorations of hydrogeothemal potentiality were carried out on the territory of Belgrade in the period from 2005 to 2011. According to the first data, the value of heat energy accumulated in groundwater to 30 °C is estimated to about 150 MW. The mentioned explorations reached as deep as 200m. Hydrogeologically, there are singled out two aquifer types, significant from the point of view of hydrogeothermal resource exploitation. The first one is a compact aquifer formed in alluvial deposits of the Sava and the Danube Rivers, whose groundwater reserves with the temperature ranging from 14°C to 17 °C, are estimated to 2000 l/s.

The other aquifer type is a karst aquifer formed in limestone of Miocene age constituting central parts of Belgrade. The study area covers the surface of 50 km2 being bordered by the Sava and Danube rivers from west and north and by hills of Topčidersko Brdo, Dedinje and Banjički Vis (Figure1).

Carbonate formations belong to the Tortonian and the Sarmatian while, Urgonian limestone (Lower Cretaceous) overlain by Sarmatian limestone is also stated at several locations by test drilling forming a unique karst aquifer. Depths of test-production wells in central parts of the city reach 200 m. Single well yield ranges from 5 l/s, to 20 l/s. On the basis of values of the karst environment hydrodynamic parameters (from 5 *10-4 to 6 *10-1), it can be stated that the limestone is highly porous and karstified. Temperatures of the karst aquifer groundwater range from 16°C to 25°C, and the mean annual air temperature for the Belgrade area amounts 12.5°C. According to the chemical composition, generally, the groundwater is of a HCO3- Ca-Mg type of the overall mineralization of 0.3 g/l to 0.8 g/l, of pH value from 6 to 8, while the hardness varies from 18°dH to 20°dH.

Currently available amounts of the karst groundwater from production wells are about 200l/s. Hydrogeothermal resources are used for the needs of cooling/heating of low energy residential facilities with the use of heat pumps. A few public buildings, such as health centres also use the karst water.

Favorable chemical composition of groundwater creates opportunities for multipurpose use, such as watersupply, technical water (fire protection purposes, grass watering), even for balneological purposes. After passing heat exchanger, groundwater do not change the quality, so can be used in mentioned purposes. With regard to the development of the karst aquifer estimated reserves of the Tortonian and the Sarmatian limestone are about 800l/s. Bearing in mind both the amounts and the temperature, it is possible to provide 40MW of heat energy from the hydrogeothertmal resource with the utilisation of heat pumps.

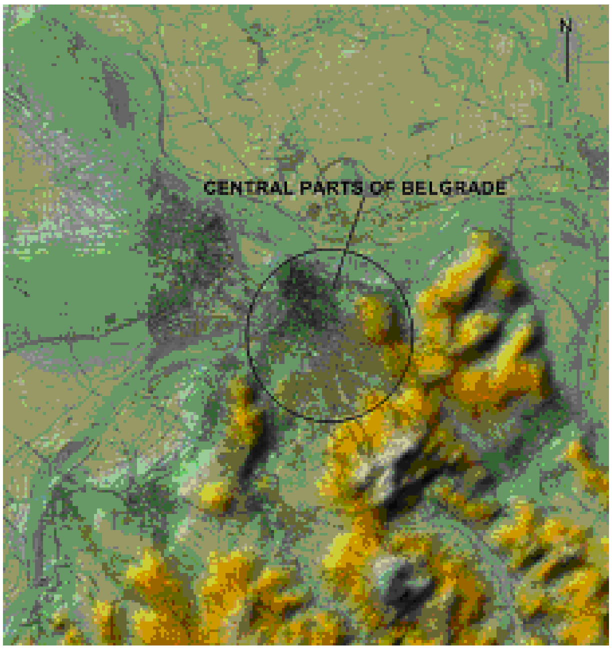

Figure 1 – Study area-Central parts of Belgrade

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SYNERGY OF OPTICAL AND X-BAND RADAR IMAGES FOR MAPPING SNOW PARAMETERS IN MOUNTAIN AREAS

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KEY WORDS: snow parameters, optical images, COSMO-SkyMed, snow water equivalent.

INTRODUCTION

The knowledge of snow parameters such as grain size, wetness and especially snow water equivalent (SWE) is of utmost importance to understand the hydrological cycle and to evaluate the contribution of snow melting to water resources during summer. Furthermore, the snowpack characterization is also a key issue for risk prevention such as avalanches and floods. In this context, microwave space-borne remote sensing systems and in particular the new generation X-band Synthetic Aperture Radars (SARs) satellite constellations, such as COSMO- Skymed (CSK) represent a valuable support to improve the knowledge on the spatial distribution and temporal evolution of snowpack parameters because of their acquisitions in all weather conditions and to the capability of the microwave signal to penetrate into (and thus interact with) the snowpack. Moreover, this last generation satellite has a low revisit time over the same area [Schellenberger et al., 2011].

The SAR backscattering coefficient is sensitive to diverse snow parameters (e.g., the grain radius, the density, the free liquid water content) in a different way depending also on the incidence angle and the polarization of the signal [Ulaby et la., 1986]. Moreover, the capability of the signal to penetrate the snow layer depends on the status of the snowpack itself (e.g., on the amount of free liquid water content). All these factors make difficult the estimation of snow parameters from SAR images. In order to deal with these issues, the multi-polarization acquisition mode of the new generation SAR systems is commonly exploited [Pettinato et al., 2011], despite a certain level of ambiguity still characterizes the SAR signal especially for particular snow conditions. In this paper the synergy of dual polarization X-band SAR backscattering signals with ancillary data derived from optical/thermal satellite imagery (MODIS images) is investigated and exploited for the retrieval of snowpack parameters on a mountain area in the Alps. This approach represents an effective strategy to improve the study and monitoring of snow by using currently available satellite remote sensing systems.

METHODOLOGY

In the first part of the work a sensitivity analysis of radar backscattering coefficients in VV- and VH- polarization extracted from COSMO-SkyMED images and MODIS Land Surface Temperature (LST) to snow parameters were carried out. The radar backscattering coefficients data sets was also partially simulated by a dual layer electromagnetic backscattering model coupled with the Integral Equation Model for the surface scattering [Fung, 1994]. A dataset of snowpack biophysical parameters (depth, density, snow grain radius, temperature and wetness) collected from the meteorological stations maintained by the hydrological department of the Province of Bolzano during the winter 2010/2011 in the Alto Adige (central Alps) were considered.

The analysis results can be so summarized:

1. Both SAR backscattering and MODIS LST showed a sensitivity to snow density and wetness;
2. SAR backscattering is also sensitive to snow grain radius, but only when the snowpack is sufficiently dry (wetness close to 0%);
3. No appreciable sensitivity is observed to the depth of the snowpack.

The outcome of the sensitivity analysis was a key step for the definition of a system for the estimation of snowpack parameters from satellite data. Based on the results of the above-mentioned analysis, the attention was focused on the density, the wetness and the grain radius (only for dry snow). In greater detail, snow density and snow wetness level were estimated exploiting both the SAR and the optical thermal signals. The retrieval process was addressed by using a Support Vector Regression algorithm for providing a continuous estimate of snow density while a more conservative SVM classifier has been exploited for retrieving discrete wetness levels. The considered levels are 4: dry, dump, wet and very wet. Concerning the grain radius estimation, the SAR backscattering signals without additional information on snow surface temperature were exploited. The final architecture of the retrieval system is shown in Figure 1.

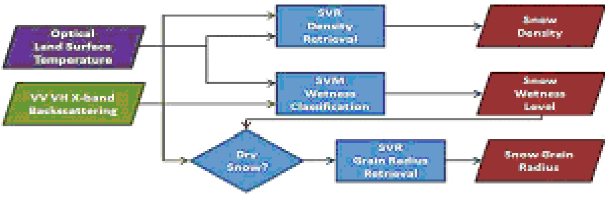

Figure 1 – Block diagram of the proposed system.

RESULTS AND CONCLUSIONS

The proposed system has been first trained using a cross validation scheme on a subset of the available reference samples (training set), and then applied to the remaining set of samples (test set). The retrieval accuracy has then been assessed by comparing estimated and measured snow biophysical values. For comparison purposes, a similar experiment was carried out without considering the information from the optical/thermal imagery. Table 1 summarizes the results achieved for the grain radius, the density and the wetness in both experiments. Results achieved point out the improved accuracy in the characterization of snowpack characteristics when both SAR and optical thermal data are exploited according to the proposed system. This is true for both the density and the wetness parameters. This result suggests the effectiveness of the integration of SAR and optical/thermal data for the retrieval of snow parameters, while points out the capability of the proposed retrieval architecture to properly exploit the combined information of multiple remote sensing sensors for improving the retrieval of the desired target parameters. The experimental analysis was then extended to the generation of distributed maps of snowpack variables, by applying the proposed system to the available set of Cosmo-Skymed SAR images coupled with the corresponding MODIS acquisitions. As explanatory example, Figure 2 shows the estimated snow density map corresponding to the early spring satellite acquisitions (4th of April, 2011). As expected, the retrieved values are in average quite high, ranging from 300 to 400[Kg/m3], due to the melting of the snow. Spatial patterns of snow density can be easily appreciated, thanks to the high spatial resolution of the SAR imagery. This and other results (not reported here for space constraints) confirm these patterns and provide promising indications on the capability of the proposed system or mapping snow parameters on a distributed alpine area.

Target Variable	SAR Backscattering	SAR Backscattering & Modis LST
Dry Snow Grain Radius - RMSE	0.1 [mm]	--
Density - RMSE	51.8 [Kg/m^3]	42.6 [Kg/m^3]
Wetness level – Overall Accuracy	77%	85%

Table 1. Summary of the performance achieved.

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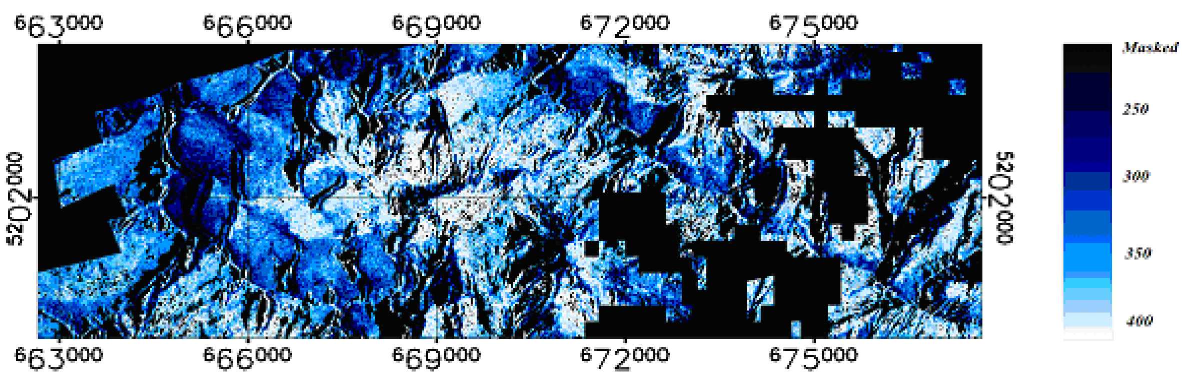

Figure 2 – Estimated snow density from X-band Cosmo Skymed SAR and MODIS LST imagery acquired on April, 4th, 2011. Black areas are associated with cloudy MODIS pixels.

URBAN RUNOFF WATER QUALITY IN CENTRAL INDIA

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KEY WORDS: Runoff water quality, cluster analysis, factor analysis, central India

INTRODUCTION

The urban runoff water pollution is one of the major diffuse pollution sources for depleting water qualities [Cornelissen et al., 2008]. It greatly affects the water quality [Chang et al., 2004; Zafar & Alappat, 2005]. Several studies have shown that a wide variety of pollutants are present in rainwater runoff [Allen et al., 2001; Nabizadeh et al., 2005; Nouri & Naghipour 2002, Polkowska et al. 2002,]. At least 70% of surface water of India is polluted in some ways, and many of the groundwater reserves have also been contaminated as a result of runoff pollutants.

This study describe quality and sources of contaminants in urban runoff water of the most polluted city, Korba (22° 21′ 0″ N & 82° 40′ 48″ E), India.

EXPERIMENTAL

Korba city is famous for power supply (□ 40000 MW Yr^{-1}), to the whole Chhattisgarh state. The population of the city is □ 1 million. At least 90% rain (75 cm) was precipitated in summer, July – September, 2008. Seven rain runoff water samples were collected from Thermal Plant area during months, July – August, 2008 in a 5-lit cleaned polyethylene container [APHA, 1998]. After collection, the runoff water was filtered, and physical parameters i.e. pH EC and TDS values were measured. The sample was divided into two portions. The first portion was used for analysis of ions. The second portion was acidified with few drops of ultrapure nitric acid (E. Merck) for analysis of the metals.

The Dionex DX120 Ion Chromatograph, USA equipped with anion and cation separation columns and conductivity detector was used for analysis of the ions. The GBC AAS type-932/HG-3000 was employed for the analysis of the metals i.e. Mn, Fe, Cu, Zn, Pb and Hg. Factor analysis (FA) was used to apportion sources of the pollutants in the runoff water [Parinet et al., 2004].

RESULTS AND DISCUSSION

The water was slightly acidic (pH = 6.6) with moderate conductance value of 1461 µS cm^{-1}. The volume weighted mean(VWM) value of ions i.e. Cl^-, NO_3^-, SO_4^{2-}, NH_4^+, Na^+, K^+, Mg^{2+} and Ca^{2+} was 2372, 1491, 2857, 979, 218, 501, 405 and 1127 mg l^{-1}, respectively. The sum of total mean ratio of the [Σanion] / [Σcation] was found to be 0.9, indicating the acidic nature of the water.

The VWM value for Mn, Fe, Cu, Zn, Pb and Hg was 0.91, 3.32, 0.31, 3.04, 0.48, and 0.04 mg l^{-1}, respectively. The permissible limits for Cl^-, NO_3^-, SO_4^{2-}, Mg^{2+}, Ca^{2+}, Mn, Fe, Cu, Zn, Pb and Hg in drinking water are 250, 45, 200, 30, 75, 0.1, 0.3, 0.05, 2.0, 0.05 and 0.001 mg l^{-1}, respectively [WHO, 2004]. The content of ions and metals (except Zn) in the runoff water of Korba was found to be higher than permissible limits.

Table 1 summarizes the sorted FA results, including the variable loadings, eigen values and variance explained by each factor. Five factors accounted for 97.30 % of the total variance were extracted.

Factor 1 accounted for 37.98 % of the total variance. The iron has a strong and positive loading factor while Pb, Hg, NO_3^- and Ca^{2+} are negatively loaded on factor 1. This suggested different sources of metals. The ions i.e. NO_3^- and Ca^{2+} are associated with metals i.e. Pb and Hg. It suggested the impact of nonpoint source pollution.

Factor 2 accounted for 22.11 % of the total variance and included variables i.e. EC, TDS and Zn. The mineralization of runoff water and Zn transport were indicated by factor 2.

Factor 3 accounted for 18.08 % of the total variance and included ions i.e. Na^+, NH_4^+ and K^+. It could suggest different impacts, which contributed to runoff water quality such as burning of the coal and illicit discharge of industrial wastewater.

Factor 4 explained 10.22% of the total variance and has a negative loading value of the parameter level (thickness of the precipitate), which would seem to be a controlling factor on the content of heavy metals such as Cu, Pb, Hg and ions Ca^{2+}, NO_3^-. Factor 5: the fifth factor accounted for 8.91 % of the total variance, and included Mn with a moderate positive loading factor, Cu and SO_4^{2-} with negative loading factors. These loading factors suggested different sources for Mn, Cu and SO_4^{2}.

TABLE 1. FACTOR ANALYSIS LOADING DATA					
Parameter	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Level, cm	0.24	0.19	-0.06	-0.91	0,15
pH	0.26	-0.65	0.31	0.63	-0.14
EC, µS cm^{-1}	0.13	0.85	0.45	-0.13	-0.16
TDS, mg l^{-1}	0.15	0.84	0.46	-0.12	-0.15
Cl^-, mg l^{-1}	0.09	0.56	0.68	0.47	0.06
NO_3^-, mg l^{-1}	-0.90	-0.29	-0.30	0.11	0.05
SO_4^{2-}, mg l^{-1}	-0.54	-0.10	-0.34	-0.19	-0.72
Na^+, mg l^{-1}	0.11	0.09	0.98	0.03	0.05
NH_4^+, mg l^{-1}	0.15	0.02	0.99	-0.03	0.04
K^+, mg l^{-1}	0.19	0.00	0.96	0.06	0.03
Mg^{2+}, mg l^{-1}	-0.21	-0.05	-0.52	0.50	0.52
Ca^{2+}, mg l^{-1}	-0.71	-0.03	-0.27	0.54	0.34
Mn, mg l^{-1}	0.34	-0.56	0.21	0.08	0.71
Fe, mg l^{-1}	0.80	0.09	0.45	0.28	0.25
Cu, mg l^{-1}	0.00	0.19	0.07	0.29	-0.90
Zn, mg l^{-1}	0.25	0.91	-0.27	-0.07	-0.13
Pb, mg l^{-1}	-0.95	0.04	-0.05	0.03	-0.28
Hg, mg l^{-1}	-0.97	-0.09	0.04	0.22	-0.01
Eigen value	6.84	3.98	3.25	1.84	1.60
% Total variance	37.98	22.11	18.08	10.22	8.91
% Cumulative variance	37.98	60.10	78.17	88.39	97.30

CONCLUSION

The runoff water is a potential non – point sources for polluting water bodies in the country. The anthropogenic activities (i.e. industrial and coal burning emissions) are major sources of ions and metals in the runoff water. Nitrate level in runoff water was found to be a several folds higher than permissible limit of 45 mg l^{-1}. It is expected to be a major culprit for the surface water eutropication in this region. Similarly, the contamination levels of toxic metals i.e. Mn, Fe, Cu, Pb and Hg were found to be much higher than permissible limits.

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POTENTIAL GROUNDWATER POLLUTION IN CENTRAL INDIA

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KEY WORDS: Groundwater quality, Sources, Central India.

INTRODUCTION

Now-a-days, deterioration of ground water quality is a serious growing concern in Indian continent [Satoshi, 2008]. The need for water has produced an increasing withdrawal of groundwater in India, consequently resulting in a deterioration of the quality [Borah et al., 2009; Buragohain et al., 2010; Khodapanah et al. 2009; Laluraj et al. 2005; Raju 2007; Sharma & Jain, 2006; Tatawat & Chandel, 2008].

The high incidence rate of stone diseases (i.e. nephrolithiasis, cholelithiasis, urolithiasis) in humans, damaging of the wet and bush land ecosystems and corrosion of materials i.e. houses, pipelines, buildings, roads, water supply systems, etc. of this region have marked in Bemetara area (81°27'-81°41'N & 21°40'-21°48'E) of central India. Therefore, in the present work, the groundwater quality and sources of the contaminants in the groundwater of the Bemetara are discussed.

MATERIALS AND METHODS

The groundwater of the Bemetara area has been selected for the proposed investigation due to presence of high salt contents. The saline water is used by ≈ 0.1 million peoples. The saline water causes deterioration of water quality, plant biodiversity and food grains yields. The area is occupied by Mesoproterozoic marine sedimentary hard rocks. The gypsiferous Maniari formation produces gypsum karst and their dissolution causes inland salinity to the area.

Groundwater samples were collected in duplicate during the post-monsoon (January, 2010) and monsoon period (September, 2010) from 16 stretches over area of ≈ 400 km^2 by using the established method (APHA, 2012). Some surface The physical parameters i.e. pH, EC and TDS values were determined at spot, immediately after collection. Ions (i.e. Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Mg^{2+} and Ca^{2+}) were analyzed by ion chromatography (Dionex DX120), equipped with anion separation column, cation separation column and conductivity detector. The hardness and alkalinity were determined by the titration methods. The metals were monitored with the Varian Liberty AX Sequential ICP-AES and AA280FS atomic absorption spectrophotometer, equipped with VGA-77. Multivariate statistical analysis was used for the source apportionment [Laaksoharju et al., 1999; Malinowski, 1991]. The statistical software STATISTICA 7.1 was used for the multivariate statistical calculations

RESULTS AND DISCUSSION

The conductivity and total (Mg+Ca) hardness values ranged from 892 - 3930 µS cm^{-1} and 587 – 2600 mg l^{-1} with mean value of 1997±405 µS cm^{-1} and 1404±306 mg l^{-1}, respectively. The concentration of Cl^-, NO_3^-, SO_4^{2-}, HCO_3^-, NH_4^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, Al and Fe during the post monsoon period (January, 2010) was ranged from 7- 76, 1.2 – 18.4, 244 – 2330, 255 – 850, 1.1 – 4.0, 30 – 437, 2.1 – 10.4, 43 – 341, 169 – 660, 1.1 – 1.7 and 0.32 – 0.90 mg l^{-1} with mean value of 37±10, 7±3, 1058±292, 508±97, 2.0±0.5, 107±46, 5.0±1.0, 117±34, 387±84, 1.4±0.1 and 0.52±0.09 mg l^{-1}, respectively. The ratio of the [Σanion]/ [Σcation] was 1.02±0.04 in the post monsson period but the value was decreased in the monsoon period. The SO_4^{2-} ion is dominating species and well correlated with species i.e. Na, Mg, Ca, Al and Fe (r = 0.68 – 0.91). Generally, two types groundwaters: Ca-Mg-SO_4-HCO_3 and Ca-Mg-Na-SO_4-HCO_3 occurs due to dissolution of the gypsum and dolomite minerals.

Factor analysis was applied to data set obtained from 16 groundwater samples in the post mosoon period. Four factors explained 83.04% of total variance and following sources were apportioned: Factor 1 is correlated with high loading value of EC, TDS, SO_4^{2-}, Na^+, Mg^{2+}, Ca^{2+}, Al and Fe and explained 47.22% of total variance, and represents the mineralization of the groundwater.

Factor 2 was strongly correlated with the physical parameter i.e. depth, which was negatively correlated with the variable age, accounted for 15.22% of total variance and could be assigned as the influence of deep groundwater on the chemical composition.

Factor 3 was marked by NO_3^- and NH_4^{+}, and accounted for 11.20% of total variance and could represent the agricultural land use characteristics.

Table 1. Factor loading matrix and total variance explained during post monsoon period: January, 2010

Parameter	F-1	F-2	F-3	F-4
Depth	0.14	0.94	0.02	0.09
Age	-0.17	-0.90	-0.17	-0.08
pH	0.09	0.20	0.42	0.62
EC	0.96	0.21	0.02	0.16
TDS	0.96	0.22	0.02	0.17
Cl^-	-0.16	0.12	0.13	-0.94
NO_3^-	-0.21	0.07	0.76	-0.03
SO_4^{2-}	0.96	0.14	-0.11	0.01
HCO_3^-	0.54	0.38	-0.20	0.51
NH_4^+	0.14	0.02	0.84	-0.03
Na^+	0.80	-0.08	0.28	0.25
K^+	0.04	0.54	-0.09	0 .67
Mg^{2+}	0.91	0 ;08	0.24	0.15
Ca^{2+}	0.81	0.32	-0.30	-0.06
Al	0.84	0.33	-0.18	0.17
Fe	0.82	-0.23	-0.09	-0.03
EV	6.71	2.57	1.84	2.16
% TV	47.22	15.22	11.20	9.40
% CV	47.22	62.44	73.64	83.04

F = Factor, EV = Eigen value, TV = Total variance, CV = Cumulative variance

Factor 4 accounted for 9.4% of total variance and is marked by Cl^- and could represent the impact of irrigation flow return on the groundwater quality.

CONCLUSION

The groundwater of the Bametara area is brackish in nature due to high contents of Mg^{2+}, Ca^{2+}, SO_4^{2-} and HCO_3^- ions. The groundwater is seemed to be unsuitable for the drinking and agriculture purposes due to high salinity. The salinity is related to precipitation and dissolution processes of gypsum and dolomite rock salt due to overexploitation rate in the study area. The groundwater salts are also increasing surface water salinity. Avoiding over-irrigation and plantation of high salinity tolerance plants are solution for the sustainable agricultural development in this region.

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HYDRODINAMIC ANG GEOCHEMICAL EVOLUTION OF THE UNCONFINED COASTAL AQUIFER SYSTEM OF THE MESOLA WOOD (NORTHERN ITALY)

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KEY WORDS: Mesola wood, aquifer, isotopic composition, hydrochemistry.

TITLE OF SECTION

Many coastal sectors in the Mediterranean region are subject to seawater intrusion in aquifers resulting in severe deterioration of the quality of the groundwater resources. In its fourth assessment report the Intergovernmental Panel on Climate Change underlines, amongst other issues, the followings as possible effects of climate change and extreme climate events: i) decreased freshwater availability due to saltwater intrusion phenomena, ii) salinization of irrigation water and cultivable land, iii) crop damage and lower yields. All these potential parameters make the coastal areas particularly vulnerable.

The principal factors controlling the salinization can be grouped into two categories: local causes and global ones. The geomorfological evolution of the coast is one of the most important local causes. This is related to the natural evolution of the shore environment, which is in a state of continuous change, and to the human intervention on the territory and on land use. Other important local factors are associated with subsidence phenomena, groundwater over-exploitation, lithological composition of the aquifer system, presence of connate waters and the variation of the river flow (decrease of the alimentation of the aquifer system along the hydrographic network).

On the other hand, global factors possibly influencing salinization processes are represented by climate changes (e.g. decrease of the precipitation; increase of the evapotranspiration) and fluctuations of the relative sea level.

Italy is one of the countries where the problem is felt most severely. According to an Official Report of the Italian Ministry of the Environment (1997), numerous saltwater intrusion phenomena have occurred along the entire 8,500 km of Italian coastline.

The artificial recharge of the aquifers or desalination of saltwater are very costly solutions. As a consequence, the determination of the spatial distribution of dominant salinisation processes is crucial for designing adequate groundwater management strategies, since different degradation processes require different remedial and conservation measures.

Also, from the point of view of groundwater resources, the deltaic area are important coastal reservoirs, in which eustatic changes of sea level have had a dominant role in the hydrological conditions of the deltas and their hydrogeologic behaviour in relation to seawater intrusion.

The Nature Reserve of Mesola wood is located in the delta Po river area (Northern Italy) and covers an area of about 1058 hectares. The wood is a fragile ecosystem characterised by a high biodiversity extremely sensible to even small environmental changes.

The fauna of this area includes: two species of ungulates a) fallow deer (in the 1995 about 1000 subjects) and b) red deer; hares, wild carnivores as badgers, polecats and weasels, insectivores as hedgehogs, wild rodents as harvest mice. Also numerous are the birds, both permanent and migratory. The flora includes: holm of the transintion environment, Hornbeam, poplar and Fraxinus.

In line with these premises and in order to define the hydrodynamic and geochemical evolution and the major hydrochemical risk areas of the Mesola wood coastal aquifer and especially the behaviour of the local unconfined aquifer, geomorphological, lithological, hydrogeological, geochemical and isotopical data have been collected and analysed.

The analyses of the historical series of the monthly precipitations document a important variations of the annual precipitations as well as of their distribution during the hydrological cycle.

Moreover, integrated analysis of the hydrochemical (K, Na, Mg, Ca, Cl, SO_4 HCO_3, Cr, Mn, Fe, Ni, As, Se, B, Sr, Rb, Li, Ba, Pb) and isotopic (Sr87/Sr86, O18, H2) composition measured in samples collected from the hydrographic network and from the unconfined aquifer, at different depths; and the comparison of the actual data with measurement realised on the 1978 (Arpa database) allowed to obtain the following outcomes:

a) define the relationships between of Bertuzzi Valley water and the unconfined aquifer;

b) recognise the complex role played by the numerous channels of the artificial hydrographic network to the underground water resources;

c) identify the deep and geometry of the fresh-salt

interface;
d) evaluate the hydrochemical evolution of the aquifer system; and
e) identify the areas characterised by high geochemical risk potentially associated to intrusion phenomena of salty water.

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GROUNDWATER FLOW AND NITRATE CONTENT IN THE SHALLOW AND UNCONFINED AQUIFER OF THE UPPER PLAIN OF THE PROVINCE OF MODENA.

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KEYWORDS: Nitrate, groundwater level, T. Tiepido, A0 aquifer, agricultural pollution

INTRODUCTION

Due to the widespread of intense agricultural activities, nitrate pollution is one of the main causes of groundwater quality deterioration.

In Emilia Romagna Region, high amount of nitrates are commonly detected along the upper part of the Po plain, where infiltration processes from the ground-surface could become more active through the coarse deposits of the alluvial fans. In the case of the Taro, Enza, Tiepido, Sillaro shallow aquifers, this phenomenon is so severe that NO_3 content can exceed the maximum limit for safe drinking water law (50 mg/l) up to reach 140 mg/l (Marcaccio 2008).

The aim of this work is to improve the knowledge on the groundwater flow and quality characterising the shallower and phreatic aquifers. Field activities has been done between autumn 2010 and summer 2011 (2 campaigns) and they focused on 53 wells spread over the Tiepido alluvial fan (Province of Modena).

They consisted of groundwater levels monitoring and physical analyses (temperature, pH, electrical conductivity), while waters were sampled for chemical in-lab characterization (major ions and NO_3).

Results allowed to provide several thematic maps which could be useful for further groundwater vulnerability studies: groundwater level; overview of the chemical quality state; distribution of pH, electrical conductivity, NO_3, SO_4, Cl.

HYDROGEOLOGICAL SETTING

The study area is located in the upper portion of the plain of the Province of Modena. The area coincides with the alluvial fans of the Secchia and Tiepido rivers, close to the foothills, and it has an extension of about 85 km^2.

The stratigraphy is composed by 150 meters of alluvial continental sediments (Plio-Pleistocenic age). It is made up of gravelly and sandy horizons (aquifer; permeability up to 10^{-4} m/s) separated by silty clayey levels (aquiclude-aquitard) (Gasperi et al. 2005).

In the research only the first 20 meters in depth of the unconfined aquifer were characterized. This portion was identified as A0 by Emilia Romagna Geological, Seismic and Soil Survey. Laterally A0 is not always continuous and in some cases it is closed by aquicludes, giving rise to springs. Moreover it is characterized by perched aquifers. A0 is recharged directly by the rainfall and by the surface water bodies. Geological Survey has identified below the A0 aquifer the unconfined A1 aquifer. In some cases the two aquifers are directly connected; in other cases they are separated by aquitards, which allow low vertical exchanges of groundwater between A0 and A1.

In the current research, only wells with maximum depth in the order of 10-20 meters have been taken into account. As proposed by the Geological, Seismic and Soil Survey of Emilia Romagna region, they match to A0 aquifer (the shallowest one).

METHODS

During the first campaign, (October 2010), 46 wells showed the presence of groundwater. Among them, 28 wells were selected as representative of the entire aquifer and revisited during the June 2011, together with other points of the river network (Grizzaga, Gherbella, Tiepido) for physical monitoring (groundwater level, electrical conductivity, total dissolved solids, pH, temperature) and water sampling.

The following ions contents were evaluated in laboratory: Ca (10 samples), Na (26 samples), Mg (10 samples), K (26 samples). Cl (26 samples), SO_4 (26 samples), NO_3 (10 samples), HCO_3 (10 samples.

RESULTS

Wells placed in municipality of Maranello and Formigine were completely dried. In the other ones, the groundwater table depth ranged between 0.50

and 15 meters.

No substantial difference, was detected between the two campaigns if we exclude few wells where the water table decreased of some meters. This phenomenon seems related to the intense crop irrigation.

The interpolation of water table levels (Fig. 1) shows as the shallow aquifer is connected and recharged by the Tiepido river. Moreover, local intense pumping were highlighted in Formigine and Maranello municipality.

For the chemical point of view, groundwater is Ca-HCO_3 while pH is between 6.60 and 8.20. The electrical conductivity varies from 590 (foothills area) up to 2190 µS/cm (distant part of the alluvial fan). Cases of agricultural or human pollution have been detected; some samples were characterized by high NO_3 contents (4 wells exceeded 50 mg/l, max. value 146 mg/l; Fig.1) and in some samples, NO_3 was associated to remarkable level of Na (max. 151 mg/l), K (max. 10 mg/l), Mg (max. 60 mg/l), Cl (max. 368 mg/l), SO_4 (max. 191 mg/l) (Fig. 2).

In the local rivers, the electrical conductivity of the water is in the range 378 and 2020 µS/cm, instead the pH is in the range of 7.75 - 8.94. In the Tiepido the amount of NO_3 is in the range 1 – 20 mg/l. The direct recharge from the river to groundwater, together with the low concentration in NO_3, favours a dilution in the amount of NO_3 in the A0 aquifer.

CONCLUSION

The work has permitted to elaborate a first groundwater level map of the shallowest aquifer hosted inside the alluvial fan of the Tiepido river. The interpolation showed an important recharging process from the Tiepido river while, north-westward the interpolation shows an important recharging process of the groundwater by Tiepido river. At north-westward of the map, instead, it shows as the groundwater level was lowered by the agricultural and industrial water supplies and/or by the drainage action caused by the near Secchia river's alluvial fan (which is characterized by high hydraulic conductivity and by high thickness of gravelly sediments). The physical and chemical measures highlighted cases of pollution by human activities, probably agricultural. In some wells, the nitrates content exceeded 100 mg/l and high concentration of K, Mg, Cl was found.

Figure 1 – Groundwater level map of the alluvial fan of the T. Tiepido (max. 145 m, min. 32 m). Black arrow groundwater flow direction; red point – well without water; cyan point – well with water; colored rectangle - well with water and respective amount of NO_3.

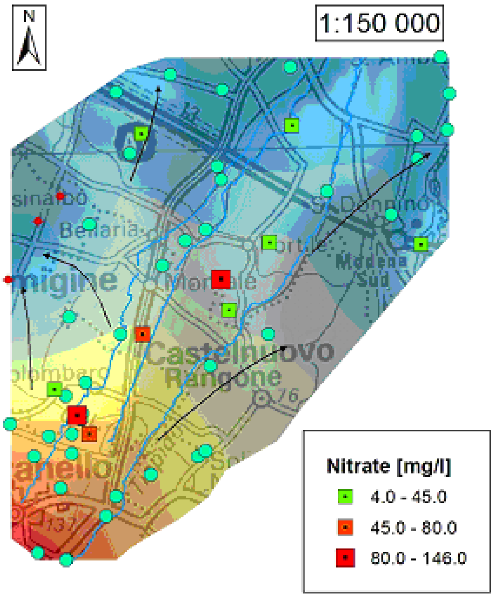

Figure 2 – Schoeller diagram of the ten groundwater samples (NO_3 points) that are shown in Figure 1.

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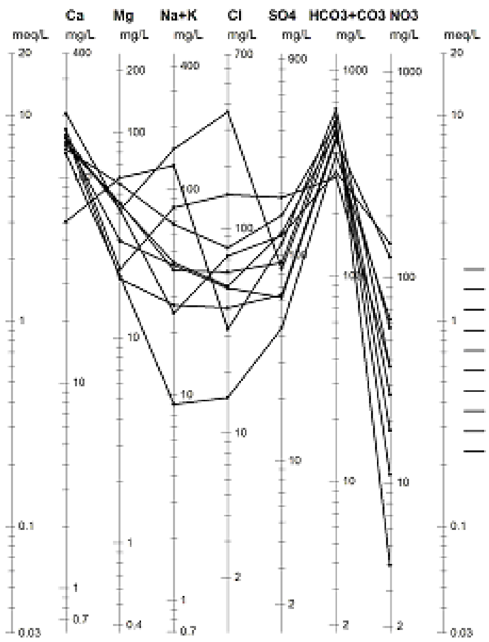

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EVOLUTION OF THE RAJAPUR THERMAL SPRING (MAHARASHTRA) THROUGH THE GUGI GRANITES (KARNATAKA), WITH AN EXPERIMENTAL APPROACH

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KEY WORDS: Water-rock interaction, mixing.

ABSTRACT

The evolution of Rajapur thermal spring, together with the experimental result on the granite-water interaction at 100 °C, indicate that Precambrian granites are main heat source for the Rajapur thermal water. Rajapur thermal spring is located on the west coast fault (India). Thermal water is evolved through the Gugi Archean granite and with the Precambrian basement rock.

INTRODUCTION

Eighteen thermal springs are located along the west coast of India. These springs discharge through the Deccan Volcanic Province (DVP) but few of them show close relationship with the basement Precambrian gneisses and granites of the Dharwar craton (Ramanathan and Chandrasekharam, 1997). In the present study focuses on the Rajapur thermal spring located along the west coast of India and issuing through the Deccan volcanic flows and demonstrates that the spring is circulating within the high heat generating Precambrian Granites located below the Deccan volcanic flows. These granites occur as inliers within the basalt flows near Rajapur. The nearest location where large outcrop of this granite occurs is near Gugi in the state of Karnataka, India (Fig 1). Here, Precambrian granite is exposed with Proterozoic sediments, mainly carbonates of Bhima basin. These are marked by the Gugi fault of a width of 500 m and these rocks have been reported with high U, Th content (Kumar and Srinivasan, 2002).

The thickness of Deccan Flood Basalt (DFB) varies from 2500 to 3000m along the west coast and these are traversed by the large numbers of N-S trending faults and dykes (Hooper, 1990). West coast thermal springs are controlled by the major tectonic features, i.e. west coast fault (Chandrasekharam, 1985; Minissale et al., 2000). Variation of the geothermal gradient from the boreholes is observed about 57°C/km (Chandrasekharam, 2000). Late Archean granitoids constituting the basement for the Neoproterozoic Bhima Group are exposed along the southern margin of the Bhima basin in southern India. This study aims at geochemical evolution of the Rajapur thermal spring using experimental leaching test of water rock interaction and geochemical signature of the surface water, groundwater and springs water.

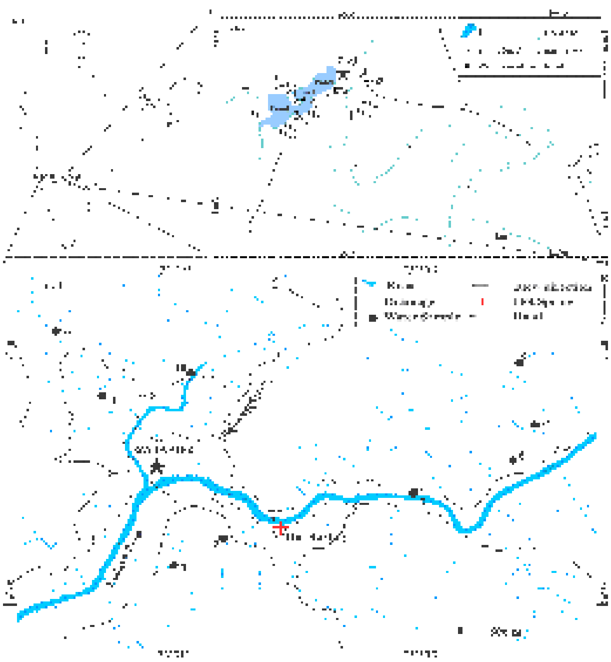

Figure 1- (a) Location of the study area, (b) water and granite rock sampling sites in parts of Gugi area, (c) water sampling sites in parts of Rajapur area.

METHOD OF STUDY

Rajapur area is dominated by the highly fractured Deccan basalt. Some places scoria and layering are marked in basalt formation. The hot spring is issuing water just beside the Kodavli River near the Unhale village, located at 3 km distance from main Rajapur city (Fig. 1C). Water samples from thermal spring, cold water spring, river, hand pump, dug well, and pond were collected for the chemical analysis.

From the Gugi area, 15 granite rock samples were collected, out of which 5 representative grantine samples were selected for the water rock interaction experiment. The granite rocks were crushed to <1mm. The experimental leaching tests of water-rock interaction were carried out in a glass chamber with fluid/solid ration of 10:1 at 100°C. Rain water was used in the experiment as leaching fluid. The experiment was run continuously over a period of 30 days. Average geochemical concentration of major ions present in the interacted water and rain water is given in Table 1.

Table 1- Geochemical data for experimental leaching test

	A*	B**
pH	6.1	8.7
Na^+	0.03	0.96
K^+	0.005	0.08
Ca^{++}	0.15	0.36
Mg^{++}	0.078	0.25
Cl^-	0.09	0.13
SO_4^{--}	0.07	1.22
HCO_3^{--}	0.16	0.75

*A: meteoric water; **B: interacted water; concentrations in epm

RESULT

The major ion concentrations present in the water samples collected from Rajapur thermal spring and from Gugi area were plotted in Piper diagram (Fig 2). Water type of the Rajapur thermal spring is HCO_3 type. The surface water of the Rajapur and Gugi area fall in the Ca-HCO_3 type and there chemistry is compatible with rock through which they flow.

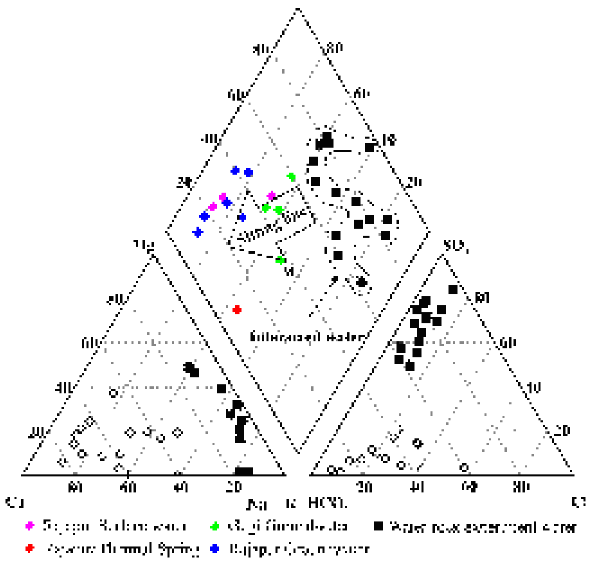

Figure 2- Piper diagram showing the geochemical charactoristics of water samples collected from Rajapur and Gugi area. Interacted water field represents the water samples from water-rock interaction experiment.

In experimental leaching test, the water samples derived from the granites showing wide range of geochemical variation. Most of the interacted water samples fall in the Na-SO_4 field, while the thermal spings of Rajapur and the surface waters fall in the Ca-HCO_3 field (Fig 2) This gives an indication that meteoric water circulating within the granites (host for thermal reservoir) are emerging through the Deccan basalt flows after mixing with the near surface groundwater rich in Ca HCO_3 component. This again strengthens our earlier view (Chandrasekharam and Chandrasekhar, 2010) that the granites are the main source of heat for the thermal springs in several provinces of India.

Thus, the study clearly shows that the rain water circulating within the high heat generating Gugi granite is emerging as CaHCO3 springs within the Deccan basalts near Rajapur.

ACKNOWLEDGEMENTS

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SPRINGS AND GROUNDWATER FLOW SYSTEMS OF MARNOSO ARENACEA FORMATION IN THE ROMAGNA SECTOR OF NORTHERN APENNINES (ITALY)

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KEY WORDS: hydrogeology, spring, groundwater flow systems, monitoring, low flow conditions, stream flow measurements, Northern Apennines, Emilia-Romagna Region

INTRODUCTION AND STUDY SITE

In Northern Apennines (Italy) hard rock aquifers prevail on karst and porous aquifers. A big portion of the chain is formed by siliciclastic and calcareous turbidites, arenites and ophiolites, both effusive like basalts or intrusive like peridotites. These geological units constitute the most valuable groundwater reservoir of the area.

A plenty of springs discharge from these huge outcrops of hard rock aquifers; these springs originate from a variety of groundwater flow systems (GFS), connected to hydrogeological structures of different complexity and depth.

Some previous studies in different test sites of Northern Apennines (DE NARDO et al., 2007; GARGINI et al., 2008; CANUTI et al., 2009; PICCININI et al., in press) allowed to define a first outline of springs and GFS in these geological units: mean spring flow rate is low (VII-VI class of Meinzer), due to the dominant low-medium permeability of the rock mass; the GFS discharge is mainly stream-focused and represents the basis of surface waters environmental flows. Locally, in proper conditions, bigger springs occur, attaining discharges of 10-20 L/s during low flow conditions and so capable to sustain public water supply of local community.

The here presented investigation has been founded by the Public Agency responsible for watersheds hydrologic budgets (Autorità dei Bacini Regionali Romagnoli, Emilia-Romagna Region) and derives from the need to refine the watersheds hydrologic budgets and from an idea of the Geological, seismic and soil survey.

The study area (Fig. 1) has an extension of about 1800 km2 and encloses the mountain sector of the following watersheds: Lamone River, Marzeno River, Montone River, Rabbi River, Bidente River and Savio River.

Marnoso Arenacea Formation mainly outcrops in the study area (Fig. 1), except for the south eastern sector where other calcareous turbidites outcrop.

MATERIALS AND METHODS

An investigation group formed by the authors has planned the hydrogeological characterization and springs/upreach streams monitoring activity on different test sites, in order to evaluate groundwater resources and to rank different GFS in terms of yield, base flow discharge, recession coefficient and hydrochemistry. The aim of the research follows two main goals: the hydrogeological mapping of groundwater resources in Northern Apennines, correlating discharge regime and base flow hydrological behaviour with lithology and geological structure, and the need to get an insight on groundwater balance on the involved watersheds.

Different springs databases have been collected from the Local Water Suppliers and have been analyzed and compared with the geological framework in order to select a sampling data set.

49 springs have been selected for a monitoring activity developed in the summer 2011, in order to measure the low flow conditions (and contemporarily the basic physico-chemical parameters) and to analyze the recession phase of the spring hydrogram. At two springs a continuous monitoring system has been set up, in order to get a more detailed recession curve.

Concerning the monitoring activity on streams, 24 stream sections have been selected for the measurement of flow rate during the recession phase of summer 2011, by means of an electromagnetic current meter. Each section has been measured from 3 to 4 times in the summer, in order to get the recession coefficient.

The watersheds have been divided in sub-watersheds, for which the “specific hydrogeological productivity Pi” (L/s*km2) and the “coefficient of infiltration CI” has been determined, expressed, respectively, by the base-flow specific discharge (referred to the whole sub-basin) and by the ratio between the direct recharge and total rainfall inside the sub-watershed. Direct recharge for each sub-watershed has been estimated by average summer discharge and recession coefficient according to the methodology of Gargini et al. (2008).

Rainfall and air temperature occurrence all over the area were defined, as contour lines, either as historical record (1960-2004) or in reference to the hydrological years of investigation; from the raw data potential and actual evapotranspiration have been determined (according Thornthwaite & Mather 1957).

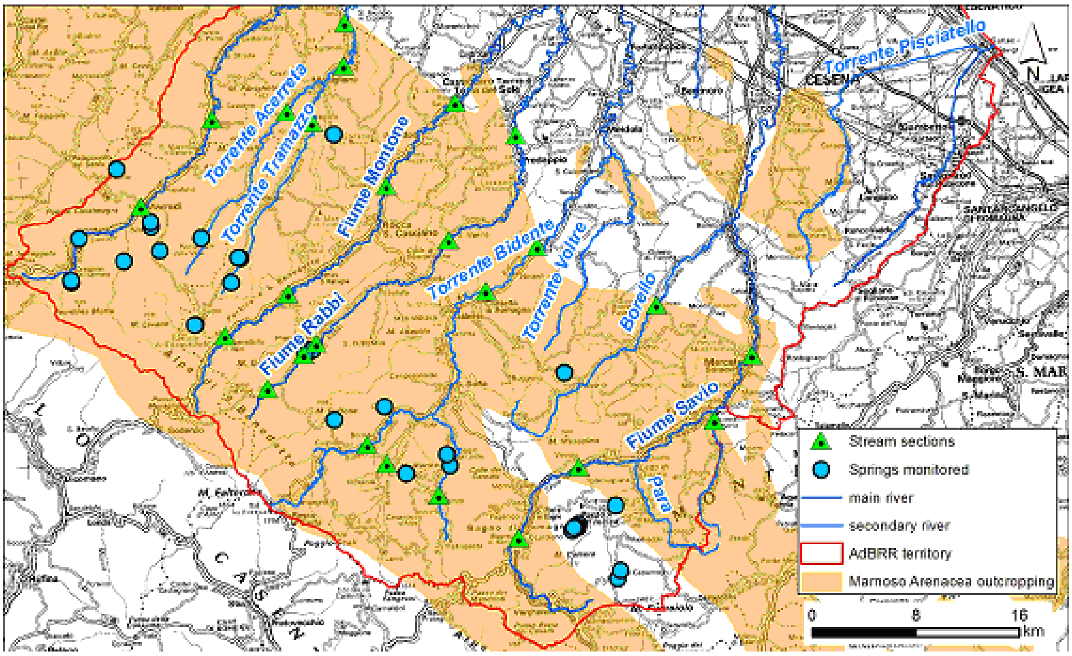

Figure 1 – Schematic map of the study area (scale 1:500,000).

MAIN RESULTS

The main results obtained from the investigation are:

- a first census of springs used for public water supply on the study area;
- the hydrogeological characterization and parameterization of 49 springs, selected on the area for their importance (in terms of location, geological setting, flow rates, ...);
- the characterization of low flow conditions in the main streams of the study area;
- the hydrogeological classification of the different members of Marnoso Arenacea Formation and the definition of main hard rock aquifers in the study area;
- the hydrogeological productivity of the different sub-watersheds;
- the hydrogeological map for the studied area.

ACKNOWLEDGEMENTS

Concerning the data collection and the technical assistance during the field activities, we are very grateful to all the technicians of the following Water Supply Agencies: Consorzio di Bonifica Romagna Occidentale, HERA Imola, Società Acquedotto Valle del Lamone, HERA Forlì-Cesena, Romagna Acque-Società delle Fonti, Soggetel.

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GROUNDWATER FLOW MODEL “SAARLAND” – A REGIONAL GROUNDWATER FLOW MODEL AS TOOL FOR WATER ADMINISTRATION

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KEY WORDS: Germany, Saarland groundwater model, finite elements, model actualisation strategy.

The State of Saarland, with only 2570 km² one of the smallest states of Germany, has a long industrial history, based on coal mining and steal milling. Going back to the 18th century, this industrial history led to a massive immigration, especially from the surrounding regions, and to a fairly high population density of 400 inhabitants per km². Both, industrial tradition and dense population, are the main reasons for a pronounced compartmentation of land use and thus to a series of environmental conflicts.

According to German Water Law, any project that is likely to have an impact on the quantitative or qualitative status of groundwater is defined as use of water subject to authorisation. Thus, a multitude of projects have to be analysed every year if they suppose a threat for groundwater. Though groundwater modelling is a tool used frequently in the region since about 30 years, it is not always easy to verify their results, especially when the documentation does not include all the data used for the modelling process.

MODEL OBJECTIVES

In 2007, the Minister of Environment decided to finance the project unilaterally with approximately 400.000 € with the following targets:

- a complete overview over the groundwater situation in Saarland in a coherent picture, taking into account the interdependence of neighbouring catchments and the existence of lateral recharge, reducing at the same time the influence of border .
- to create a neutral basis of comparison for future groundwater models by third parties, providing the Environmental Protection Agency with a practicable tool simplifying the necessary controlling process when judging models that accompany applications for groundwater allocation, remediation plans for contaminated land etc.
- to establish a minimum quality standard for groundwater modelling in the region
- to facilitate third party models by providing scientifically sound data for both geometry and hydraulic parameterisation
- to provide the necessary base for an integrated assessment of the impending flooding of the coal mine workings

But one of the main purposes of the model was certainly to simplify and accelerate the processing of groundwater issues within Saarland’s Environmental Protection Agency by providing information about depth to water table, flow direction, presence and dimensions of cones of depression and so on. This is especially important considering the consequences that the implementation of the so called debt brake will have on the labour situation of the Land’s employees. The debt brake forces Saarland’s government to cut the running expenses from a level of approximately 1.25 billion € by 10% every year until 2020, mainly by reducing labour costs. For the coming years, the staff at the Groundwater Department will be reduced considerably by a fairly high number of retirements and and only a a third of the employes will be replaced. The model can help to mitigate the consequences of staff reduction by providing the necessary informations at a mouse click.

IMPLEMENTATION STRATEGY

Geological and hydro-geological information is not readily available with the same degree of reliability for the entire surface of the state, so it was decided to start with a relatively coarse model, where the geometrical information was mainly derived from the existing geological maps. For the same reason, the model is conceived as stationary model with long-term values for recharge and abstraction. A crucial point was the selection of the software. Only finite element programs ensure the necessary geometric accuracy and the possibility of later grid or mesh refinements. In order to allow for a wide acceptance of the model within the scientific and the planning communities, an option for flexible data exchange as well as a scale independence of the geometric data to the greatest possible extent also were considered as essential. A very important point regarding later actualisations of the model is the complete separation of input data from the actual grid or mesh, depending on the type of model. Additionally, the computing time of finite element models is faster due to their better converging algorithms.

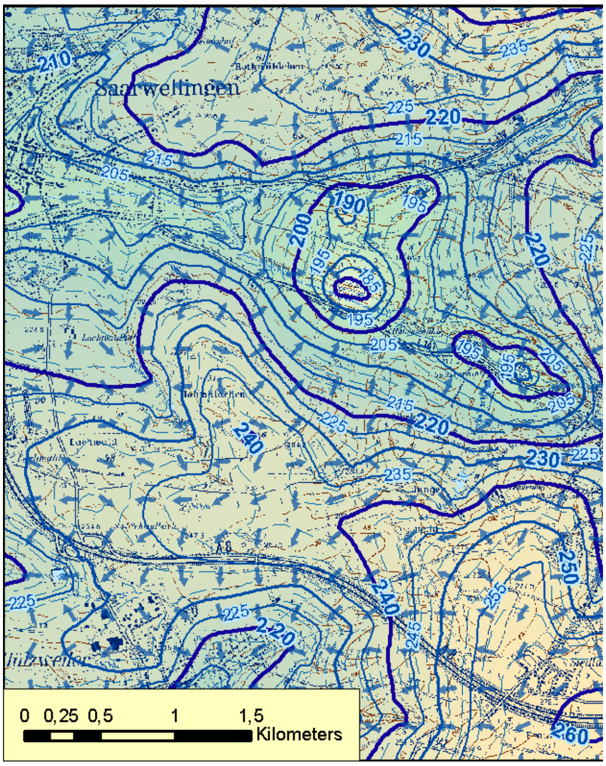

Figure 1 – extract of Groundwater Model Saarland with groundwater surface and flow directions (Saarwellingen abstraction scheme).

INPUT DATA

The groundwater model Saarland is a true 3D model, though with a simplified geology in terms of stratigraphy, aggregated into 11 groups according to their hydraulic properties. Further essential data within the model are the known tectonic discontinuities, net groundwater recharge, drainage network, the digital elevation model, as well as location and mean pumping volumes for every known active water well in the area. The models outer limits are defined as boundary conditions without horizontal exchange of groundwater. A maximum distance of mesh nodes of 200 m and a maximum horizontal deviation from structural elements and contour lines of 5 m was allowed.

RESULTS

The model in its present form has approximately 190,000 nodes and about 280,000 elements in the first layer, summing up to a total of nearly 1,000,000 nodes and 1,200,000 elements. It fulfils completely the expectations, providing information about groundwater surface and flow direction, as well as depth to water table.

The model's results and capabilities are also already very important as a base for the further implementation of the European Water Framework Directive. So was it possible to delineate accurately the catchment areas of the groundwater measuring stations and to determine the impact of land use on groundwater quality.

ACTUALISATION STRATEGY AND OUTLOOK

Modelling groundwater flow for the entire surface of the state only makes sense with an appropriate strategy for continuous model updates. This is especially important for small administrations with limited personnel resources, where the replacement of leaving specialists is not always in accordance with the labour requirement and an adequate passing on of valuable experience is not possible. In these cases, a well maintained groundwater model will help to keep the necessary training periods for new staff short and to reduce potential sources of errors.

For an already understaffed department, most of the required effort will necessarily have to be executed by third parties. The concept for data exchange with third parties therefore exempts planners and scientists from charges if they agree to share their results with the water authority and allow reinserting these into the general model after the necessary quality control and model modification. On the long run, the model will so be continuously improving.

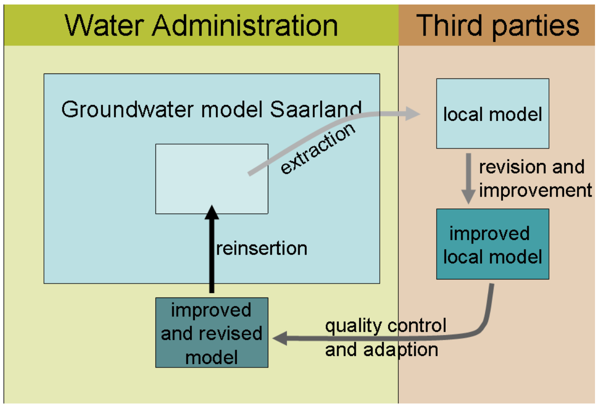

Figure 2 – model actualisation scheme through data exchange with third party models.

Further projects for the coming years are the extension of the model into the French part of the hydraulically interconnected coal basin, as well as an atlas of the surface-near geothermal potential. Regarding the impending flooding of the old coal mines, the Saarland model can serve as a joint prediction and decision tool for the mining company, able to simulate the flooding process and later long-term behaviour of the system.

APPLICATION OF THE OPENLAYERS JAVASCRIPT LIBRARY FOR DISPLAYING AN INTERACTIVE WEB MAP WITH HYDROLOGIC PARAMETERS

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KEY WORDS: OpenLayers, web mapping, GIS, hydrology.

INTRODUCTION

Hydrologic calculations require a large number of spatial input data.. Whether applying empirically derived relationships, performing statistical analyses, or developing new methodologies, all input parameters for hydrologic calculations have a spatial component. The most descriptive way of visualizing hydrologic analyses (input parameters as well as results) is certainly cartographic – using maps. Due to the large number of input data, as well as the diversity of data types, they cannot be all shown on one map simultaneously, therefore a need arises for multiple maps for multiple sets of data.

This paper analyses one way of presenting these spatial hydrologic data on an interactive web map, allowing the user to interactively select which data to overlay. This is done using web technologies and the open-source JavaScript library OpenLayers API (Application Programming Interface), which significantly simplifies the process and reduces the resource requirements of the user (client) computer [1].

METHODS

Although the aforementioned hydrologic data can be presented cartographically in any major GIS software package, this paper deals with the approach that allows the user access to data using a web interface. This implies the following:

- data does not necessarily need to be in the same location as the user, it can be hosted on a remote computer of server,
- the user does not have to be skilled in geographic information systems (GIS); the interaction takes place inside the web browser interface,
- very little resources are needed on the user's computer, since only data being viewed is loaded (as opposed to the traditional approach of loading all data into memory before viewing),
- no extra software licenses are needed on the user's part (which can sometimes be substantial); all incorporated libraries are open-source software,
- it is completely independent of the operating system (Microsoft Windows, Linux, Mac OS, Android, etc.), because of web-based technology.

This approach uses the OpenLayers JavaScript library, which visualizes data of different vector and raster types in the interactive web map. [2]

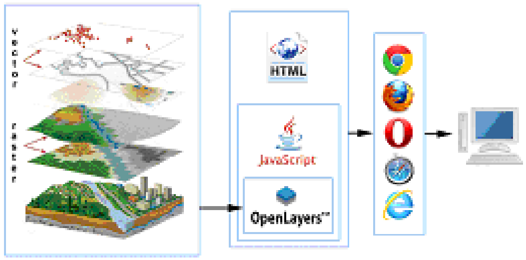


Figure 1 – Data flow scheme from source to client

INPUT DATA

Topographic maps are still the most frequently used resource for terrain data retrieval, mainly due to high availability. These maps show all of the necessary topographical elements for hydrological analysis of catchment areas. The OpenLayers control allows us to visualize topographic maps of different scales, in such a way to automatically show the appropriate scale each time the zoom is changed.

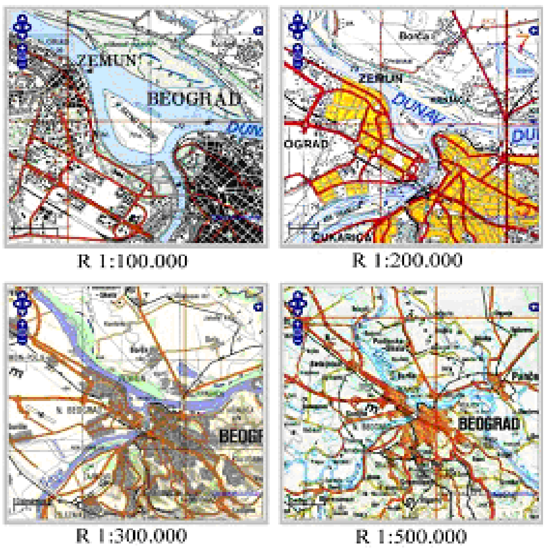


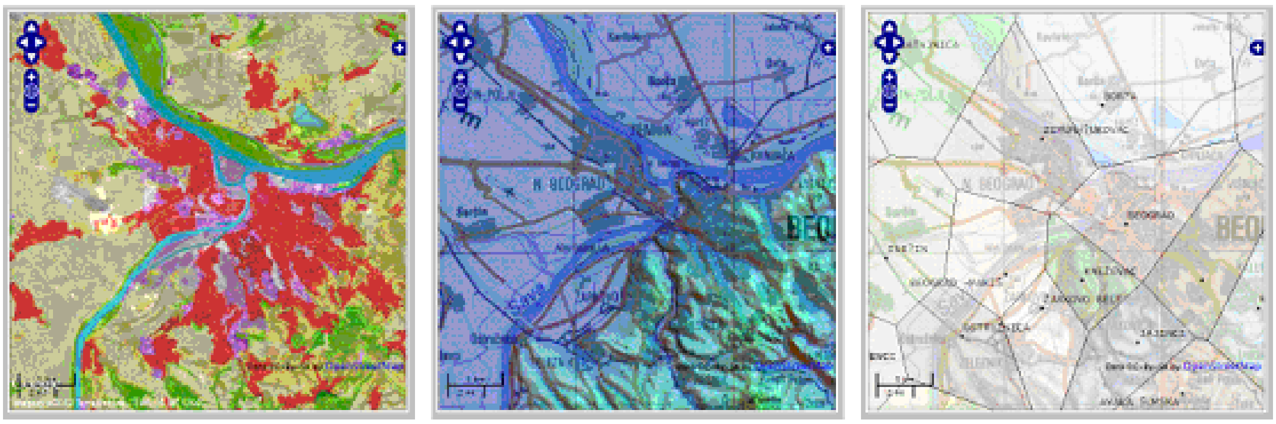
Figure 2 – Topographic maps of different scales

Digital terrain models (DTM and DEM) are digital models or 3D representations of the terrain surface, created from terrain elevation data. A large number of GIS applications exist that can manipulate DTMs, though they require training, and the price (for training and software licenses) can be substantial. The OpenLayers control can display a previously prepared digital terrain model in raster form. One very effective way of visualizing terrain is using a hill shade effect together with a color ramp for emphasizing elevation.

Land cover and land use plays a very important part in hydrological processes such as evapotranspiration, soil humidity, groundwater recharge etc. [3] The CORINE (Coordination of Information on the Environment) program is implemented by the European Commission for the purpose of developing a database with consistent localized geographic information of the land cover of European countries. The Corine Land Cover (CLC) database is available for download from the European Environmental Agency (EEA) website, in vector and raster format. The vector format was displayed in the OpenLayers control with the official color palette.

Rain gauges are a very important source of meteorological data for hydrological analyses, especially for ungauged catchments. One of the most frequently used methods for estimation of total rainfall on a catchment is the Thiessen polygon method, where each rain gauge is assigned a surrounding polygon based on geometrical relationships of surrounding gauges [4]. The construction of these polygons can be performed in GIS software, and then presented in the OpenLayers interactive map.

Google Maps presents a set of cartographic data (spatial with attributes), combined with satellite and aero photo imagery. OpenLayers API supports visualization of data from Google Maps servers, i.e. the four visualization types available from Google: satellite imagery, hybrid display of satellite imagery with labels and roads, street map and topographic map with terrain.



a. Composite: Google satellite + CORINE CLC | b. Composite: Topographic map + DEM | c. Composite: Topographic map + rain gauges

Figure 3 – Example of composite maps from different layer combinations

RESULTS AND DISCUSSION

The data shown in this paper has to be prepared in some GIS environment (such as SAGA GIS, ArcGIS, GlobalMapper etc.), but once prepared, it can be implemented into the OpenLayers application with ease, sharing it with countless potential users.
Figure 3 shows composite maps that the user can create using a simple layer switching control. Very informative layer combinations can be achieved, depending on the desired results.

This effective way of presenting spatial data is very interesting not only for displaying hydrologic data but any spatial data. The effectiveness lies in the simplicity for the end user, as well as the enormous reduction of required resources on the client end.

This concept offers new possibilities for displaying spatial and cartographic data, and will surely significantly change the way geographic information is published in the future.

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