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Reservoir- and aquifer-characterisation using outcrop analogs

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Characterisation and prediction of the subsurface architecture in hydrocarbon reservoirs and groundwater aquifers requires a genetic understanding of sedimentary heterogeneities. This can be achieved in studying comparable surface outcrop analogs. We propose a simple, process-based methodology to analyse heterogeneities in a rigorously hierarchical way, moving from the smallest to the largest sedimentary units (particles to basins):

1) Microscale heterogeneities: caused by particle and pore properties (size, composition, texture etc.), which are determined by depositional and diagenetic fluid dynamics.
2) Mesoscale heterogeneities: caused by various stratification styles, which are controlled by the major hydrodynamic processes.
3) Macroscale heterogeneities: caused by facies and architectural elements, recording dynamics and preservation of facies tracts.
4) Megascale heterogeneities: caused by the fundamental sedimentary cycles and sequences, which reflect the stratigraphic dynamics of small baselevel fluctuations.
5) Gigascale heterogeneities: caused by the stacking of fundamental cycles within a cycle hierarchy, which is controlled by long-term baselevel dynamics.

Understanding the formative processes of each scale allows to deduce „rules“ and predictions on the distribution of heterogeneities in the subsurface. This approach of „dynamic stratigraphy“ is illustrated by two case studies using outcrop analogues for subsurface reservoirs and aquifers. A combination with petrophysical (porosity, permeability, gamma-ray logs) and geophysical tools (3-D georadar) should lead to an integrated data set for reservoir/aquifer modelling from microscopic to seismic scale.

Engineering Properties of Qauternary Deposits in Basrah City, South of Iraq

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As due to the strategic importance of Basrah city, south Iraq, the architectural expansion of the city requires a great deal of studies of the geotechnical properties, engineering behaviors and classification of the soil bearing strata reprisented by the Quaternary deposits. For such purposes a number of (121) sites distributed randomly all around the city through (478) boreholes of depths (10-48) m below mean sea level are studied.
The data are obtained from the tests of Atterberg's limits, grain size distribution, and the (n-values) for SPT.
Tbe Quaternary deposits are classified into two main groups; firstly the cohesive represented by the recent clay and silty clay and Alhammar Formation deposits. And secondly is the noncohesive deposits represented by sands of Dibdiba Formation.
According to the consistency of cohesive deposits and the compactness of noncohesive deposits, ten strata can be identified starting from the ground surface, as follows:
Stiff brown silty clay (CL & CH), very stiff brownish-grey silty clay.or clayey silt (Cl, CH & OH), stiff grey clayey silt (CL), medium to stiff gray clayey silt laminated with silt (CL), soft grey clayey silt laminated with silt (CL, CH & OH), medium to stiff grey clayey silt (CL, CH & OH), medium to siff grey clayey silt (CL, CH & OH), stiff grey clayey silt (CL), very stiff grey sandy silt clay and clayey silt (CL, CH & OH), hard brown clayey silt (CL & CH), and very dense silty sand with sand (SM).

(Geo)Statistics on thin turbidite sandstones in the Upper Austrian Molasse Basin

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The Tertiary Molasse basin in Upper Austria is part of the Alpine foredeep. The Oligocene/Miocene Upper and Lower Puchkirchen Formations and the basal Hall Formation were deposited in this foredeep in a deep marine environment and consist of an alternation of siliclastic deposits with various grainsizes. The thin bedded turbiditic sandstones form gas reservoirs in RAG's concession area. Detailed geological characterization of the reservoirs is difficult. The individual sandstones and sandy conglomerates are generally too thin to be resolved on a seismic section. Reservoirs are made up of several sandstone sheets with interbedded shales and conglomerates. The succession is characterized by numerous submarine erosions. Prominent impedance boundaries are formed by a range of lithological contacts and are not always related to a reservoir rock. In the past, only mapable packages that contained reservoir sandstones were interpreted on the seismic.
In the statistical approach, well reservoir parameters and seismic attributes are compared to find relations between them. One or more surfaces are mapped that are associated with a sequence of interest. Various seismic attribute maps of this surface are generated. If a correlation is found it can be used to create a reservoir property map by co-kriging the seismic grid and the petrophysical data. Statistical techniques are used to identify separate populations or groups. The standard tests of statistical significance are not applicable where the data points are not independent. It has proved difficult to model the subtle stratigraphic variations. Map validation is being used to date: Evaluation of patterns and distributions in light of other geological or production information.

The results have been promising in the stratigraphically complex Munderfing gas field and in the Oligocene Friedburg gas field. Less successful have been attempts to use this method where well control is sparse. The Miocene Upper Puchkirchen A1 and A2 series were analyzed in the Puchkirchen area. The complex lithology that overlies the unconformity at the top obscures the reservoir distribution maps. The results from the geostatistics in the Puchkirchen area are not yet tested.
In general, the resulting maps show patterns that have to be compared with the general sedimentoligical model. They can lead to modification and refinement of the existing models, and tell us something about the specific processes and basin geometry at the time of deposition. The maps and it's subtle patterns also form a validation criterion for the still experimental method of (geo)statistics within RAG.

Middle Permian fan-delta complex of the Gorski Kotar (Croatia)

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Intensive uplift occurred at the end of Lower or at the beginning of Middle Permian resulted in molasse type sedimentation and the of vast quantities of siliciclastic sediments were accumulated in the Gorski Kotar area (central part of Republic Croatia). The presence of autochthonous marine fossils (ammonoids, brachiopods, crinoids), found in black shales that intercalate with conglomerates and sandstones, allow the assumption of fan delta type sedimentation.
The successions described in the northern part (successions in the vicinity of Tršce) and in central part of Gorski Kotar (vicinity of Mrzla Vodica) envisioned the two different fan delta type sedimentation which reflect the different depth of the sedimentary basin. Deeper and shallower part of the delta assume the different basin floor morphology and possibly resulted as a consequence of a different subsiding processes due to subbasinal faulting in a tectonically active area.
The sedimentation processes in central part of Gorski Kotar were determined by steep delta slope. Sliding as well as formation of chutes have been noticed. The following fan delta facies were recognized: 1) delta-slope facies and 2) prodelta-shelf facies. The delta slope facies is characterized by several types of conglomerates and usually coarse grained sandstones that are: matrix supported massive conglomerates (Gms), clast supported massive conglomerates (Gmc), normally graded conglomerates (Gg), inversely to normally graded conglomerates ((in)g_2g_1G), gravelly mudstones (GyM), calcrudites (D) and massive sandstones (Sm). The prodelta-shelf facies is determined by: sandstone-shale intercalations (SM), shales (M) and planar bedded calclithites (C). In shale intercalations the autochtonuous ammonoid fauna has been found. Sedimentation processes record the slope-type delta of ETHRIDGE & WESCOTT (1984).
In northern part of Gorski Kotar the sedimentation was determined by low inclined relief with coarse clastic sedimentary rocks described as 1) mouth bar facies and 2) subareal or coastal facies. The mouth bar facies association consists of: normally graded conglomerates (Gg), inversely graded conglomerates ((in)gG), inversely to normally graded conglomerates ((in)g_2g_1G), massive matrix supported conglomerates (Gms), massive clast supported conglomerates (Gmc) planar cross bedded conglomerates (Gp), trough bedded conglomerates (Gt), gravelly sandstones, where gravels faintly mark shallow troughs, (GyS) and parallel laminated sandstones (lS). Subareal or coastal fan delta facies is characterized by irregularly bedded sandstones and gravelly sandstones (A) and micaceous sandstones (B) containing coarse plant detritus. Shales (M) and sandstone-shale intercalations (SM) are interpreted as prodelta-shelf facies. The delta type sedimentation corresponds to shelf-delta of ETHRIDGE & WESCOTT (1984).
Sandstone-shale intercalations, interpreted as prodelta-shelf facies, have similar characteristic in central and northern part of Gorski Kotar and were interpreted as unique "back-ground" sediment deposits connecting the two fan delta types. According to fossiliferous sediments associated with sandstone-shale intercalations (found only in the central part), the same age is proposed for the clastic fan delta sequence of the Gorski Kotar. Analyses of the fossil assemblage in calclithites (C), although considered as resedimented detritus, permit the conclusion of Middle Permian age (SREMAC & ALJINOVIC 1997).
Carbonate sedimentation, equivalent of Bellerophon formation, is missing in Gorski Kotar, thus assuming the hiatus between Permian and Lower Triassic sedimentary rocks. During Upper Permian the intensive inundation lowered the uplifted relief and the Lower Triassic sedimentation was characterised by shallow marine deposition on flat relief.

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Die ICE-Neubaustrecke Köln-Rhein/Main in Hessen: Ein geologisches Schaufenster

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Von der Deutschen Bahn AG wird zur Zeit die Neubaustrecke zwischen Köln und dem Rhein/Main-Gebiet (Frankfurt) gebaut. Der Geologische Landesdienst Hessen war bei den Voruntersuchungen beteiligt und dokumentiert z. Z. die Geologie während der Baumaßnahmen, wobei Einschnitte und Tunnelbauten zusammenhängende Aufschlüsse bieten. Der hessische Teil der ICE-Trasse ist ca. 65 km lang und quert das südliche Rheinische Schiefergebirge und den Nordrand des Oberrheingrabens bis zur Mainebene. Dabei durchläuft sie von N nach S folgende geologische Großeinheiten: Moselmulde, Lahnmulde mit Limburger Becken, Hintertaunus mit Idsteiner Senke, Taunuskamm, Vordertaunus, Hofheimer Rotliegend-Scholle, Mainzer Becken und Nördlichen Oberrheingraben. Die ältesten Gesteine findet man im Vordertaunus mit ordovizisch-silurischen Metavulkaniten/ Metasedimenten und nach N jünger werdend im Hintertaunus mit unterdevonischen Schiefern und Sandsteinen und in der Lahnmulde zusätzlich mit Kalksteinen und Metavulkaniklastika ("Schalstein"). Nach S zu folgen Rotliegend-Fanglomerate sowie tertiäre und quartäre Sedimente wie Ton, Mergel, Kalksteine und Schluff, Sand, Kies. Da sich der Verlauf der Trasse an geologisch jungen Senken orientiert, sind häufig quartäre Deckschichten über tiefgründig verwitterten Gesteinen (Saprolith) angeschnitten. Die geologischen Großeinheiten werden von großen Störungssystemen getrennt, wie z. B. die Taunus-Südrand-Störung oder die Westrand-Störung des Oberrheingrabens. Sie begrenzen auch die verschieden gebauten tektonischen Einheiten des Taunus mit kompliziertem Schuppenbau im Vordertaunus und Taunuskamm sowie einfacherem Schuppen- und Faltenbau in Hintertaunus und Lahnmulde.
Eine Fülle neuer Beobachtungen konnte gemacht werden: Es gelang der Nachweis von Mittel- und Oberdevon im Vordertaunus sowie von Pechelbronn-Schichten (O-Eozän/U-Oligozän) im nördlichen Oberrheingraben und der nach Norden übergreifenden Mitteloligozän-Transgression (Rupelton - Cyrenenmergel) auf den