Field Trip Guide Book - P10

Volume n° 3 - from D01 to P13

32nd INTERNATIONAL GEOLOGICAL CONGRESS

CONTRASTING PATTERNS OF LATE QUATERNARY TECTONIC UPLIFT AROUND THE COASTLINE OF SICILY

Leaders: F. Antonioli, S. Kershaw, P. Renda, D. Rust

Post-Congress **P10**

Florence - Italy
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Front Cover:
Steve Kershaw explains the tidal notch formation at Taormina during a fieldtrip (foto F.Antonioli)

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1. Introduction

Sicily sits astride the African-European plate boundary and much of the eastern coastline is defined by a major fault system juxtaposing continental and oceanic-affinity crust. This complex tectonic setting, the subject of recent plate-tectonic modelling studies, also involves Mount Etna, Europe's most active volcano. Several coastal sites, particularly on the Eastern (high uplift) and Northern coastline (quasi still-stand), display well-preserved sequences of marine terraces, most notably including those assigned to the MIS 5.5 higstand (named also Tyrrhenian in Mediterranean sea) primarily on the basis of the distinctive Strombus bubonious warm-water fossil mollusc and now at elevations up to about 150 m. Newly published work by the leaders of the trip has extended the tectonic record into the Holocene by using uplifted and laterally extensive marine notch features formed at sea level; the carbonate bedrock and microtidal environment of the Mediterranean allowing unusually high precision.
Goal of this field trip in Sicily is to visit two coastal area in tectonically very different zone, the NW coast with few vertical movement (but showing horizontal movement due to strike slip faults) and the NE coastal area that show very active uplift up to Pleistocene with Holocene acceleration.

Fruitful interdisciplinary discussions are expected between field trip participants on formation mechanisms, dating and tectonics. Fieldtrip is shown on the number 248, 249, 250, 251, 252, 253, 254, 255, 256, 262, 270 of the Italian geological maps.

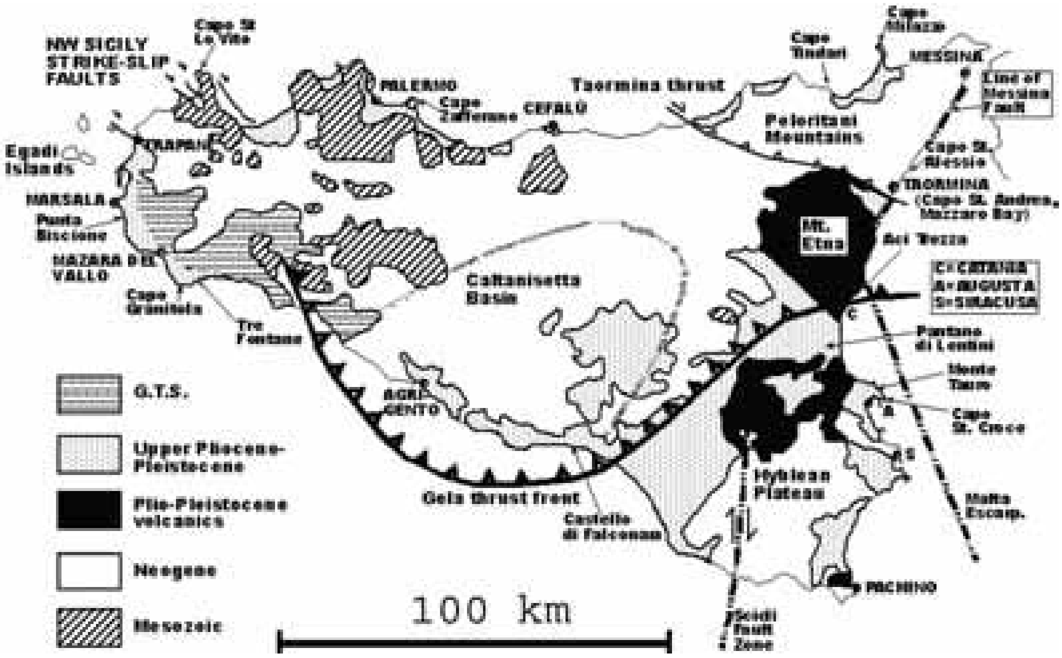

Figure 1 - Regional geology and tectonic of Sicily.

2. Regional geologic setting

2.1. NW Area

The NW sector of Sicily (with the Egadi Archipelago) represent the emerged western edge of the Sicilian–Maghrebid Chain, which originated from the deformation of the Meso-Cenozoic Northern African continental margin. The geological setting of the area (Fig. 1) is characterized by the overthrusting of tectonic units referable to the Panormid carbonatic platform and its margins on units belonging to other palae-ogeographic domains (such as the Trapanese basin; Giunta and Liguori, 1972; Abate et al., 1991, 1993; Catalano and D'Argenio, 1982); the piling up of SE-verging thrust sheets in the Middle –Upper Miocene and in the Middle Pliocene tectonic phases determined the overlying of brittle rocks over more

Figure 2 - The organizers of this field-trip (Kershaw, Rust, Renda and Antonioli). On the background Taormina terraces is looked.

ductile rocks.

Further (Pleistocenic) disjunctive and strike-slip tectonics, occurred mainly along NW–SE, NE–SO, N–S and E–W oriented normal fault systems, caused the splintering up into blocks with differential raising and the formation of structural highs alternated to basins (D'Angelo et al., 1997). In the Capo San Vito Promontory, this is reflected by the occurrence of lowered sectors, presently occupied by coastal plains (Castelluzzo and Cornino Plains; Abate et al., 1991). Moreover, the recent tectonics created favorable conditions for the onset of both deep-seated and surficial gravitational slope deformations, which are particularly widespread along the eastern flank of the peninsula (Agnesi et al., 1995). The Capo San Vito Promontory and the Island of Marettimo are characterized by Mesozoic–Tertiary units composed of carbonatic, evaporitic and silicoclastic deposits, overlain in discordance by late orogenic clastic deposits (Abate et al., 1991, 1996). Several orders of subhorizontal abrasion surfaces, interpreted as raised marine terraces, are present at different heights (up to 160 m) along wide coastal tracts of the W Sicily. Their formation has been considered to be of Middle-Upper Pleistocenic age, since they cut not only carbonatic rocks and marl-stones of Mesozoic age but also terrigenous, evaporitic and calcarenitic formations of Late Miocene to Lower Pleistocenic age (D'Angelo and Vernuccio, 1996).

2.2. NE Area

Northeastern Sicily is situated at the southern margin of the Tyrrhenian microplate, which includes Calabria (Gvirtzman and Nur 1999). The area of NE Sicily is composed of sedimentary and metamorphic rocks within a southward-verging system of thrusted nappes, the Appennine-Maghrebian Chain, developed above the northward-dipping African plate. The resulting tectonic depression above the margin of the African plate has created a foredeep along the northern margin of the African continental crust which is occupied by early Quaternary clays. These clays form the substrate for much of the eastern and southern flanks of the Mount Etna volcanic edifice and are known as the sub-Etnean clays (Lentini, 1982). Farther to the south, this African crust is represented at the surface by the platform carbonates and clastics of the Hyblean plateau which make up southeastern Sicily. To the north of Sicily, in the Tyrrhenian Sea, subduction is marked by the Aeolian Islands volcanic arc. Overall, this tectonic regime imposes north-south compression to the northeastern Sicily region (Lanzafame et al., 1997).

Field relationships between rocks of the Appenine-

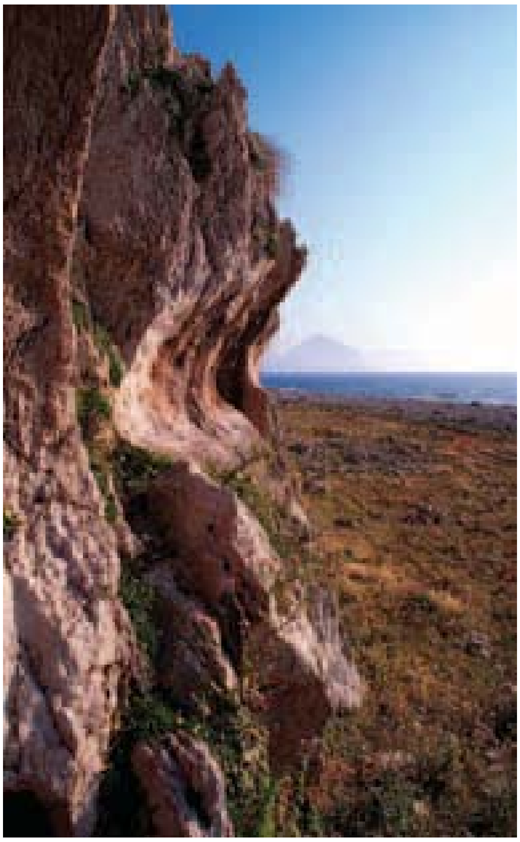

Figure 3 - Marine tidal notch at Cala Mancina (St. Vito) 8 m b.s.l.

Figure 4 - A submerged cave at -30 m on the St. Vito Promontory showing a stalagmite with serpulids overgrowth.

Maghrebian Chain and the early Quaternary marine clays indicate that thrusting in this compressional regime continued until at least mid-Pleistocene times (Lanzafame et al., 1997), while active regional uplift is indicated by several lines of evidence. In particular, the early Quaternary marine clays are now found several hundred metres above sea level (Romano, 1979), and well developed uplifted Tyrrhenian marine erosional platforms occur at about 130 m at Taormina as well as in Calabria on the other side of the Messina Straits.

This compressional framework is transected by a number of seismogenic structures of regional tectonic importance. Of these, the largest is the Malta Escarpment, a structure that intersects the African margin on the southern side of the Mediterranean at a high angle. It strikes NNW-SSE and defines the eastern and southeastern edge of the Sicilian continental shelf, marking the boundary with the oceanic-affinity crust of the Ionian Sea to the east. Dip-slip displacement on the Malta Escarpment amounts to some 3 km, and where it intersects the coast of Sicily on the eastern side of Mount Etna a series of active faults (the Timpe fault system) produce scarps up to 200 m and fault planes displaying both dip-slip and right oblique slip kinematic indicators (Lanzafame et al., 1996; Monaco et al., 1997). This major structure, although its continuity is disrupted by interactions with other faults, has been interpreted as passing through northeastern Sicily as a series of structures which ultimately displace the Aeolian arc by approximately 6 km in a right-lateral sense (Lanzafame and Bousquet, 1997).

The most important structure which intersects the faulting associated with the Malta Escarpment is the NNE-SSW striking Messina fault system. The 1908 Messina earthquake was attributed to a blind fault in the Messina area (Valensise and Pantosti, 1992), and although there is uncertain linkage of the faults along the part of NE Sicily coast north of Etna, the uniform trend of these faults provides good reason to consider them as a group of faults. This system defines the northeastern coastline of Sicily bordering the Straits of Messina, and produces fault scarps in the mid-Holocene age surface of the Chiancone deposits on the eastern side of Mount Etna (Lanzafame et al., 1996), and coastal-bounding faults in the Taormina area. These faults meet the onshore expression of the Malta Escarpment (Timpe faults) on the east coast, but we stress that the Malta Escarpment-Timpe faults and Messina fault system are different fault groups.

Figure 5 - Aeolian calcarenites of Lower Pleistocene age containg Elephas and Hippopotamus.

Eastern Sicily coastline can be divided into the following parts, from N to S: 1) NE Sicily of the Appenine-Maghrebian Chain; 2) Monte Etna volcanic region; 3) Catania Plain of the collision zone between Europe and Africa; 4) Hyblean Plateau of the African Plate foreland. Evidence and interpretations of coastal movement in these 4 parts will be summarized, with indication of controls.

3. Field itinerary

DAY 1

Arrive in the morning at Palermo airport. Stop 1: S.Vito lo Capo, Pleistocene terraces, in particular MIS 5.5 marine notches, inner margins and Strombus b., Elephans and Iippopotamus in Early Pleistocene calacarenite. Stop 2, Vermetids reef. Stop 3, Cornino, faulted marine notch. Stop 4, Cefalù MIS 5 fossils and terraces (if we are in time). Night at Milazzo.

The St. Vito lo Capo coastal area has been selected for the field trip for: (i) its uncommon conservative morphological setting, with well-preserved geomorphological and depositional features connected with Quaternary sea-level fluctuations, such as a succession of marine notches and terraces (Fig. 3) located both above and below the present m.s.l.; (ii) the presence of accurate and datable indicators of palaeo-sea levels (Vermetid bioconstructions and submerged speleothems (Fig. 4), the use of which was subordinate to the knowledge of the vertical crustal movements affecting the coastal sector.
Extensive outcrops of Quaternary phorms and deposits occur in the coastal plains of San Vito, Castelluzzo and Cornino (Tp); they are represented by bioclastic calcarenites, conglomerates with sandy matrix, lacustrine sands and gravels and aeolian calcarenites (Fig. 5). Particularly, littoral calcarenites and conglomerates, associated with the lowermost marine terrace, outcrop in lenses along the western coastal

Figure 6 - The inner margin of a submerged terrace well carved between -15\18 m around all St. Vito Promontory.

tract of the Capo San Vito Promontory and on the coasts of Egadi islands. They have been ascribed to MIS 5.5 higstand for the presence of a typical warm molluscan fauna (with Strombus bubonius and other Senegalese taxon; Abate et al., 1993,1996; Mauz et al., 1997). On the base of their present-day height (W side of the Capo SanVito Promontory), previous authors pointed out respectively, for the area, a relative stability and a limited, differential uplift during the last 125 ka (Abate et al., 1996; Mauz et al., 1997).
We will see a coastal sector including three coastal plains (San Vito, Castelluzzo and Cornino Plains) nearby to San Vito Promontory and the submerged area in front of these, with the aim to study the Upper Quaternary

Figure 7 - Broad Dendropoma platforms at Cape S. Vito.

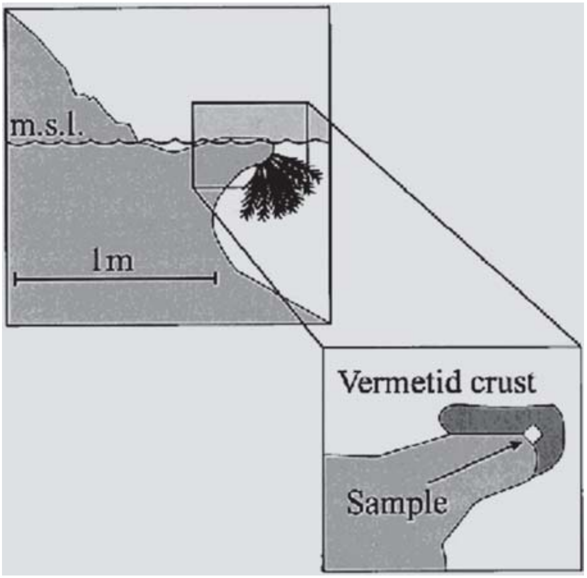

Figure 8 - Sampling site in the innermost part of the Dendropoma platform (from Antonioli et al., 1999).

tectonic trends. The morpho logical evidences of the seven marine terrace (from + 90 to about -18 m) surveyed consist in a subhorizontal erosional platforms, with a remarkable lateral continuity (see coloured geomorphological map from Antonioli et al., 2002a, attached with this volume) and locally well-preserved marine deposits lenses. Marine notches (at 8, 15, 45, 60 and 70 m above the present sea level) were also found. The geomorpho-logical mapping of marine erosion surfaces was improved by a spatial elaboration of altimetric data using the Arc/info GIS.

The marine forms were, thus, ascribed to the Middle and Upper Pleistocene, by morphological and stratigraphic criteria. Dating trough U/Th method on speleothems, which locally coat marine notches, provide only the upper chronological limit for the Terrace II (linked to the notch at + 62 m) modelled in a period before 78,000 years ago and for the lower terrace of the emerged sequence (Terrace VI, lying at 8 m a.s.l.) modelled before 19,695 year BP, which means before the LGM and, as suggested by other observations, in correspondence of the Last Interglacial.

Only the shallowest of presently submerged terraces (Terrace VII) shows a good lateral continuity and ranges from -15 to -18 m b.s.l. (Fig. 6). On the basis of tha altitude this terrace could have developed during MIS 7 (Bard et al., 2002).

The palaeontological analysis of the marine sediments showed the presence of a ‘‘Senegalese’’ fauna, with mollusks as S. bubonius in several bioclastic lenses overlying the VI-order Terrace of the geomorphological map.

Most carbonate rocky shores of NW Sicily are marked by a coalescence of living shells of the gastropod Dendropoma in a construction that is variably developed as a response to wave impact. The fossil reefs are reliable sea-level indicators. The thickness of the reef samples never exceeds 30–40 cm below sea-level, whereas all 14C dates fall within a range of few centuries. Some small fragments ejected by violent sea storms date back to 2500 years cal BP. No samples older than 6200 years cal BP have been detected so far. The present distribution of Me-

Figure 9 - Mushroom-like Dendropoma formation (from Antonioli et al., 1999).

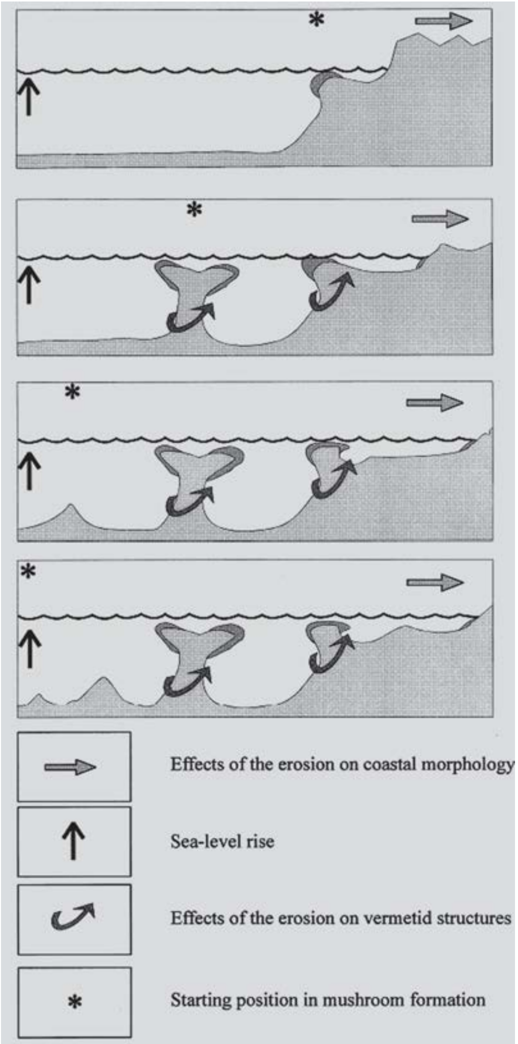

*Figure 10 - Outline of the mechanisms of the mushroom-like Dendropoma concretioning. Light grey rightward arrows indicate the effects of erosion on coastal morphology. Black arrow upward points out the sea-level rise. Symbol * marks the starting position in mushroom formation (from Antonioli et al., 1999).*

diterranean vermetid platforms should result from a northward migration related to the long term effect of the Holocene sea surface temperature SST warming. Some consideration on the morphology of the reefs and the comparison with the available data point out that Dendropoma reefs are excellent biological indicators of sea-level fluctuations especially when detected and sampled in tectonically stable areas as those in NW Sicily. On the contrary, if the palaeosea level curve is known Vermetids can be used as tectonic uplift marker.

Figure 11 - A Strombus bubonius outcropping at 4 m on the St Vito coast.

Due to the lack of palaeoclimatic indicators comparable to coral reefs, geologists investigating recent climatic changes in temperate areas like the Mediterranean sea must rely on substitute reef-like indicators. Dendropoma platforms (Fig. 7) exhibit many characteristics pertaining to good indicators: first of all, their localization in warm-temperate areas such as Atlantic Ocean and the Mediterranean Sea, their easy access for sampling and dating purposes using 14C techniques, then their limited range vertical growth, restricted to the intertidal level and, occasionally, to the uppermost part of the infralittoral

zone. surfaces. The samples dated were collected on flat areas where the Dendropoma reefs are mostly developed in broadness and thickness. On limestone promontories as S. Vito, Dendropoma ledges are smaller, up to 1 m long and 10 cm thick. In flat coastal areas, Dendropoma platforms, from 5 to 10 m broad, coalesce to form a single, uninterrupted rim stretching

Figure 12 - Cornino, a faulted marine notch carved during Middle Pleistocene.

for several kilometres. Each platform is 20 to 40 cm thick, and the upper 8 to 10 cm consist of living organisms (Fig. 8, 9, 10) . The upper, living part lies at MSL and, consequently, is exposed during low tide and submerged during high tide. Radiocarbon dating was carried out on the most ancient, fossil part of the reefs, which is located at 30–40 cm below the present sea-level. Because the whole studied area is tectonically stable, the 30–40 cm which separate the living individuals from the fossil Dendropoma are here deemed as indicative of the actual sea-level rise for the last 400–460 cal yrs (Antonioli et al., 1999).

Stop 1:

We will reach the inner margin of the MIS 5.5 terrace in the Castelluzzo plain (8-13 m); will be also possible to see the fossil senegalese fauna containing Strombus bubonius (Fig. 11). The continental early Pleistocene calacarenite, contain (near the Strombus b. site) also few but evident Elephas and Ippopotamus bones and teeth.

Stop 2:

Many kinds of different vermetids reef will be visited; could be also possible (near the Tonnara del Cofano) to snorkel in the sea to observe thickness and structure of the reef. Some vermetids reef seems to be presently faulted from strike-slipe faults.

Stop 3:

Cornino, a faulted marine notch will be visited, the notch is related with IInd order terraces (Middle Pleistocene, Fig. 12).

Stop 4:

Near the Cefalù harbour was discovered, in little caves between 9 and 12 m, many marine fossils shells, well preserved, associated with many Lithophaga holes (the bedrock is limestone). The aminoacid analyses provided an age of MIS 5.

DAY 2 & DAY 3

Stop 1, Milazzo MIS 5.5 terrace and Holocene uplifted marine notches; stop 2, Holocene uplifted deposits. Stop 3, Ganzirri (near Messina), marine Holocene uplifted conglomerate. Night at Taormina. Stop 4, Taormina, Holocene uplifted marine notches (by boat). Stop 5 uplifted tearraces at Taormina. Stop 6 S.Tecla, stop 7 Acitrezza. Catania Airport in late afternoon.

Figure 13 - Milazzo peninsula, the MIS 5.5 marine terraces, presently at the altitude between 70 and 85 m.

Figure 14 a,b,c - The Taormina MIS 5 terrace at 95-115 m. 14c, the white arrow enhance the MIS 5.5 transgression on Giurassic limestones occurred 125 ka BP.

MIS 5.5 deposits altitude
In eastern Sicily, correlations of MIS 5.5 highstands are based on Strombus bubonius discovered at 86 m (Bonfiglio and Violanti 1983) at Capo Peloro, correlated with the inner margin terrace at 110m. On the Milazzo promontory the MIS 5.5 terrace is well exposed up to the altitude between 70 and 85 m (Fig. 13), but Catalano and Cinque (1995) published that the inner margin of this terraces was found south of the Milazzo promontory on the mountain of Sicily at an altitude of 130 m. Between Capo Peloro and Taormina is possible to see a well carved terrace at altitude compraised between 110 and 140 m. In the Taormina area we (Antonioli et al., 2002b) discoverd a fossiliferous marine conglomerate deposit on a terrace (Fig.14,15) with an inner margin at 120 m, in an area where undated terrace morphology and altitude data have been published (Monaco et al., 2002). Based on ESR methodology applied to fossils sampled at an altitude of 105 m in Taormina, we attribute this terrace to MIS 5, probably 5.5. This age allows us to constrain the date of one point in a very long coastline that is otherwise undated. On the Catania\Etna volcan area Monaco et al., (2002) have mapped and aged the MIS 5.5 inner margin of terrace at the altitude comprised between 175 m (Aci Trezza) and 165 m at Catania (Fig. 16).

Holocene fossils beach altitude

NE Sicily shows well-developed Holocene erosional coastal forms, with tidal notches cut into well-cemented limestones,

Figure 15 - Marine conglomerate, particular of the fossil that provided and ESR age for MIS 5.

years (5067 cal BP) at Capo St. Alessio (Stewart et al., 1997), and approximates to the mid-Holocene deceleration of sea-level rise. Overall, Holocene coastal uplift rates (c. 1.4 mm/y) exceeded sea-level rise. The floor of +5m notch is well-enough preserved to show it formed during a stillstand and and lower notches are poorly displayed (Rust and Kershaw, 2000); only at about +2 m is an obvious notch present. A comprehensive survey of underwater geomorphology in Mazzaro Bay, Taormina (Antonioli et al., 2003a) shows no submerged tidal notches; instead abrasion notches and subaerial karst are displayed; thus the history of relative sea-level change shows a sustained rise during deglaciation, with a deceleration in mid-Holocene, followed by coastal uplift that is more rapid than sea-level rise. However coastal uplift was slow enough for erosion

and some locations show uplifted organic remains that are sea-level sensitive (e.g. Dendropoma and coralline algae such as Lithophyllum byssoides, Molinier & Picard,1953; Antonioli et al., 1999; Kershaw 2000). At Taormina and St. Alessio the limestone coast lacks

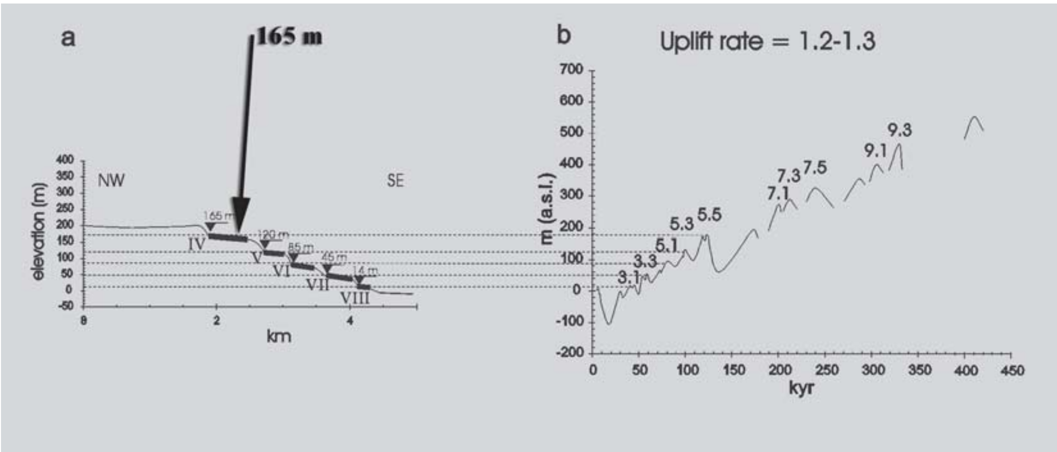

Figure 16 - Mount Etna, Catania, some terraces carved on lava, the Mis 5.5 terrace show an altitude of 165 m.

the present-day tidal notch; this important morphological information allows us to be sure that uplifting is presently active. A prominent notch with well-defined roof lies at c.+5 m above bmsl in the Taormina area, above which no evidence of Holocene marine influence is seen, and therefore marks the maximum height of relative sea level during Holocene sea-level rise. This deeply cut notch is dated at 4880±60 14C to remove notch floors in exposed locations. Among local variations, the most prominent is at Capo St. Alessio, where deeply cut notches in a large limestone block include an undated uplifted notch at +2 m; this has been interpreted as equivalent to the +5 m notch elsewhere, displaced down to +2 m on the downthrown side of a local coast-intersecting fault (Rust and Kershaw, 2000) (Fig. 17, 18, 19, 20). The limesto-

Figure 17 - Satellite image of northeast Sicily showing the location of the study area and major structural lineaments relevant to this study.Image courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center. (From Antonioli et al., 2003a)

ne headland at Capo Milazzo preserves three undated notches with a roof at +2 m, above which the bedrock is dominated by subaerial erosion. Slower uplift of this area than of Taormina, during the late Pleistocene, is indicated by the notch pattern and also the lower altitude of MIS 5.5 terrace than at Taormina (+115 m). In the Ganzirri area (between Messina and Capo Peloro), ceramics fragments of Piano Conte style Lipari island, characteristic of the Neolithical period - 4,600 ± 400 yr BP - were found into the littoral dune at 3,0 m above present sea-level. Archaeological and stratigraphic data have led to point out the period of the emergence of the littoral dune and the setting up of Ganzirri lagoon and have permitted to calculate a tectonic uplift rate of the Capo Peloro Peninsula ranging between 0.8 mm a-1 and 0.4 mm a -1 during the last 5 kyr (Antonioli et al., submitted).

2) Monte Etna coastline volcanics do not preserve tidal notches, but Lithophaga shells collected from a reef at Aci Trezza show Holocene uplift at rates possibly as high as 3.0 mm/y (Firth et al. 1996). Lack of sea-level sensitive species in the Aci Trezza reef suggests that it grew in deeper water. The reef is strongly and irregularly eroded, and suggestions that it contains uplifted notches (Kershaw, 2000) are unlikely to be correct.

3) The Catania Plain has revealed evidence of Holocene uplift (Monaco et al., 2003), and may be slowly uplifing. Problematically, the coastline does not have rocky outcrops, so that notch formation cannot be observed; therefore the behaviour of this area remains open to interpretation.

Relationships between the 4 areas and models of crustal behaviour indicate that east Sicily is tectonically complex. The quasi-stability of the Hyblean foreland and the Catania Plain foredeep are probably due to the locked subduction zone beneath Sicily, but uplift in Etna and NE regions are less easy to explain. It is unlikely that crust-mantle elastic-viscoelastic models can provide a reason for the differences in movement rates, and those differences are more reasonably explained by the complex tectonics relating to the Calabrian arc, although the exact mechanisms remain unclear.

The southern Calabria coastline is characterized by high water energy of waves hitting steep cliffs that descend direcly into the sea. The morphological record is not preserved because the lithologies are not limestones, for these reasons uplifted Holocene deposits have not been discovered only recently.

New findings in 3 sites near Scilla (Fig. 21) show an uplifted fossil beach between 2 and 4 m above present sea-level. Radiocarbon dating of marine shells collected at 3-3.4 m has given ages ranging between 2,7 and 3,9 yr cal B.P. The new 14C dates and amended sea-level curves are used to show that in the coast between Villa S.Giovanni and Scilla the tectonic

Figure 19 - The Holocene uplifted marine notch at St Alessio

uplift over the past 2,7-3,9 kyr has been proceeding at an average rate of 1.6-1.8 mm a-1 (Antonioli et al., submitted). Also at Ioppolo (Antonioli et al., 2003) was found a fossil beach between 1.5 and 2.5 m showing 14C ages compraised between 5.4 and 5.7 kyrs cal BP. In eastern Calabria, Pirazzoli et al., 1997, found at Capo Rizzuto an Holocene deposit at 0.9 m, 2.9 kyrs cal BP.

Sea level change along the Italian coast is the sum of eustatic, glacio-hydro-isostatic, and tectonic factors. The first is time-dependent while the latter two also vary with location. Of the latter, the glacio-hydro-isostatic part exhibits a well-defined pattern and is readily predictable whereas the tectonic component exhibits a less regular pattern that is of generally shorter wavelength and less predictable. Together these components result in a complex spatial and temporal pattern of relative sea level change around the central Mediterranean coast-line, observations of which provide information on earth-rheology, on rates of vertical tectonic movements, and on the global ice-ocean balance during glacial cycles. A recent work (Lambeck et al., submitted) has predicted the sea level curve for different sites in Italy, with new models for the eustatic and glacio-hydro-isostatic contributions to Holocene sea level change where the latter have been calibrated against data from 23 tectonically stable sites in Italy. In particular we have now for all the sites in eastern Sicily and Calabria the possibility to compare the predicted curves for each site with the uplifted data and calculate more precise uplift data (Fig. 22).

Stop 1:

Capo Milazzo (Fig. 23) MIS 5.5 terrace and Holocene notches. We park vehicles on the MIS 5.5 terrace, clearly shown as flat surface. Then walk 1 km down to the end of the peninsula to examine tidal notches at, and up to 2 m above, sea level. Although undated, the notch profiles are consistent with the profiles at Taormina (Day 3), with an uplifted notch roof, above which no marine erosion is seen, plus an intermediate

Figure 18 - Aerial photograph of the Sicily coast adjacent to Taormina,showing details of the locations of the sampling sites ;number 4 indicates the Antonioli et al., sampling site; numbers 1-3 are the sites studied by Stewart et al. (1997). The window shows the locationof Taormina town. (From Antonioli et al., 2003a)

Figure 20 - The Holocene uplifted marine notch at Mazzaro bay, Taormina.

notch. A modern active notch at sea level can be measured from the living Dendrapoma rim, and varies from tidal to surf notch, depending on the degree of exposure, visible on the two ends of a small offshore island. This is a good location to discuss notch formation; Rust & Kershaw 2000, interpreted both tidal and surf processes operating together here.

Stop 2:

We will visit the eastern sector of the Milazzo Promontory were outcrop between +1 and 1.50 m on the bedrock (metamorphic) a fossil beach containing infralittoral species as:Barbatia barbata,Clanculus sp.,Columbellar ustica,Mitridae sp,Vermetus sp, Gibbula sp,Bittium reticulatum,Truncularioopsis trunculus, Patella coerulea,Nucella lapillus ecc ecc. Gringeri et al., 2003, descoverd this and others outcrops along eastern and northern coast of Milazzo giving a prliminary age using 14C. The analysis of a Patella sampled at 2.0 m on the sea level provided an age of 5.9 ka cal BP (Fig. 24). Using the Lambeck's model the correspondent is about 1.6 mm\a

Figure 21 - A fossil sampled at 3 m of altitude on the Scilla coast.

Stop 3:

At Ganzirri on the coast in front of Calabria will be possible to see an interesting well cemented conglomerate containing few marine fossils, first 14C analysis provided the Holocene uplift rate. Cross of Messina town and night at Taormina.

Stop 4:

Early in the morning we will take (at Mazzaro bay) some boats to visit the rocky Giurassic limestone coast of Taormina. Here will be possible to see an

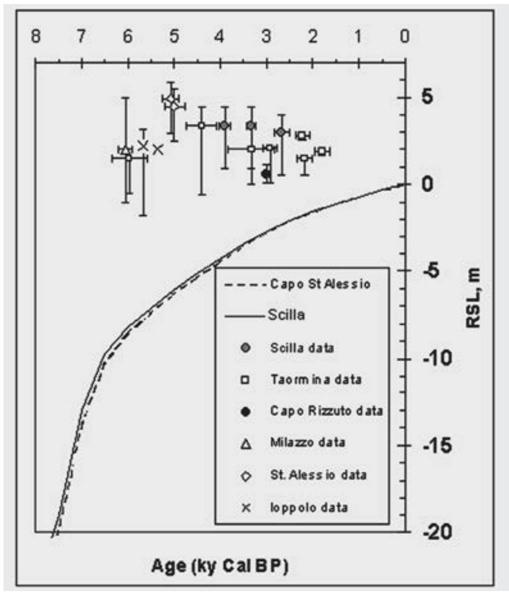

Figure 22 - The predicted sea level curve from Lambeck et al., submitted, compared with southern italian coastal uplifted sites.

Figure 23 - Particular of the geological map of Milazzo, last upgrade is 1881!

that was interprted as co-sismic from De Guidi et al., 2003 (Fig. 25). Should be intersting discuss this interpretations. Seem to absent the marine notch at present sea level, where is possible to observe a well developed algal reef. All theese morphology seem to be compatible with the Malta escarpement sited in the near offshore.

Stop 5:

Near the beautiful town of Taormina is possible to observe moore that one marine terraces, in particular at the altitude of 97-120 m there is a terrace that cut the limestone with a 10 m thik marine conglomerate containg fossil shells, Antonioli et al 2002 aged the terrace at MIS 5, using ESR methodology (Fig. 14-15).

Stop 6:

Timpe faults at Santa Tecla. The area is dominated by prominent faults striking generally NNW-SSE, called the Timpe fault system which are generally regarded as an onshore continuation of faulting associated with the Malta Escarpment. The most likely individual candidate for this continuation comes onshore at Santa Maria La Scala and defines the linear cliffed coast extending southwards. The scarp was well established before 15 ka lavas were emplaced and yet post-emplacement offset is relatively small. Farther north, as shown by the mapping (Fig. 26-27), these faults are covered by unbroken lavas from the 1329 eruption.

Figure 24 a,b - The uplifted Holocene fossils beach of eastern sector of Milazzo Promontory.

evident marine notch named by Rust and Kershaw 2000 roof notch, presently uplifted at 4.9 m, the notch e some fossils were aged by Firth et al., 1996, Stewart et al 1997 and Antonioli et al., 2003. Between the sea level and the roof notch are present also (but with minor morphological evidence) other notches

Similarly, at Santa Maria La Scala the main scarp is covered by unbroken lavas of the 394 BC flow; only farther downslope are these lavas cut by a low scarp developed along an apparently minor fault in the Timpe system. Very good overviews of the Timpe faults can be seen from the main road near Acireale, and from

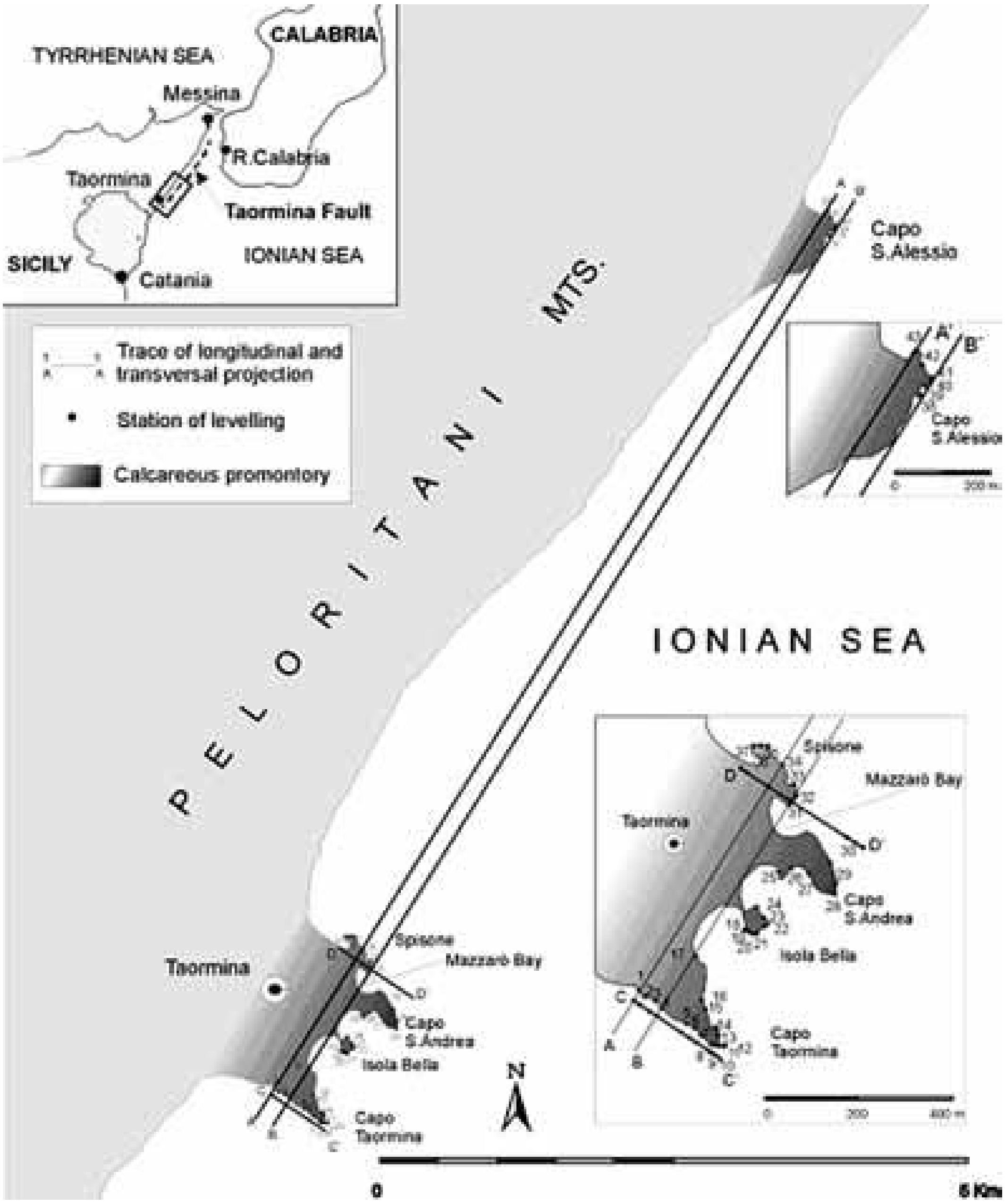

Figure 25 - An interpretation of the marine notch formation at Taormina, Vertical projected profiles, on SSW –NNE and WNW –ESE directions, of the elevation uplifted marine notches occurring on the footwall of the Taormina Fault (from De Guidi et al., 2003).

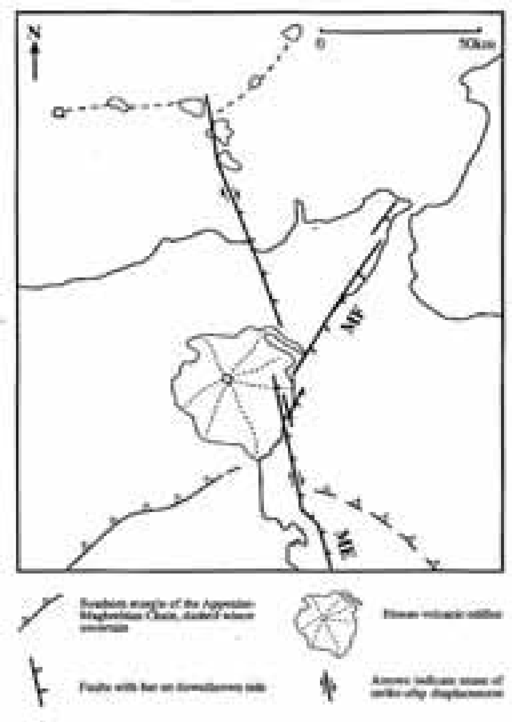

Figure 26 - Map of the regional tectonic setting of north-eastern Sicily. ME = Malta Escalpment. The faulting associated with this major crustal-scale feature is continued onshore on the eastern flank of Mount Etna as the Timpe fault system. MF = Messina fault system. The Appenine -Maghrebian Chain is a southward verging complex of thrusted nappes associated with northward subduction of the African plate beneath Etna and northern Sicily (from Lanzafame et al., 1996).

the minor road between Santa Maria La Scala and Santa Tecla. If time allows we will visit the fault scarp to view slickenlines which show sense of movement.

Stop 7:

Aci Trezza: coralline-serpulid Holocene reef on the uplifting footwall of Malta escarpment. Here early Etna basalts are encrusted by a reef coating, now strongly eroded. The reef structure is beautifully exposed, and shows a main phase of growth, followed by erosion and infilling, visible in the field . The coralline algal suite does not contain any sea-level critical species, and the reef has been interpreted as a deeper water structure (Kershaw 2000). Lithophaga borings on the outer surface of the eroded reef are Holocene, and suggest uplift over the last 6000 y (Firth et al., 1996). The reef itself may be older, and the oldest date (unpublished is c. 9000 y BP). Interpretation of the history of this reef remains problematic, and further work is in progress.

Acknowledgments

We thanks Carmelo Monaco that provided some figures.

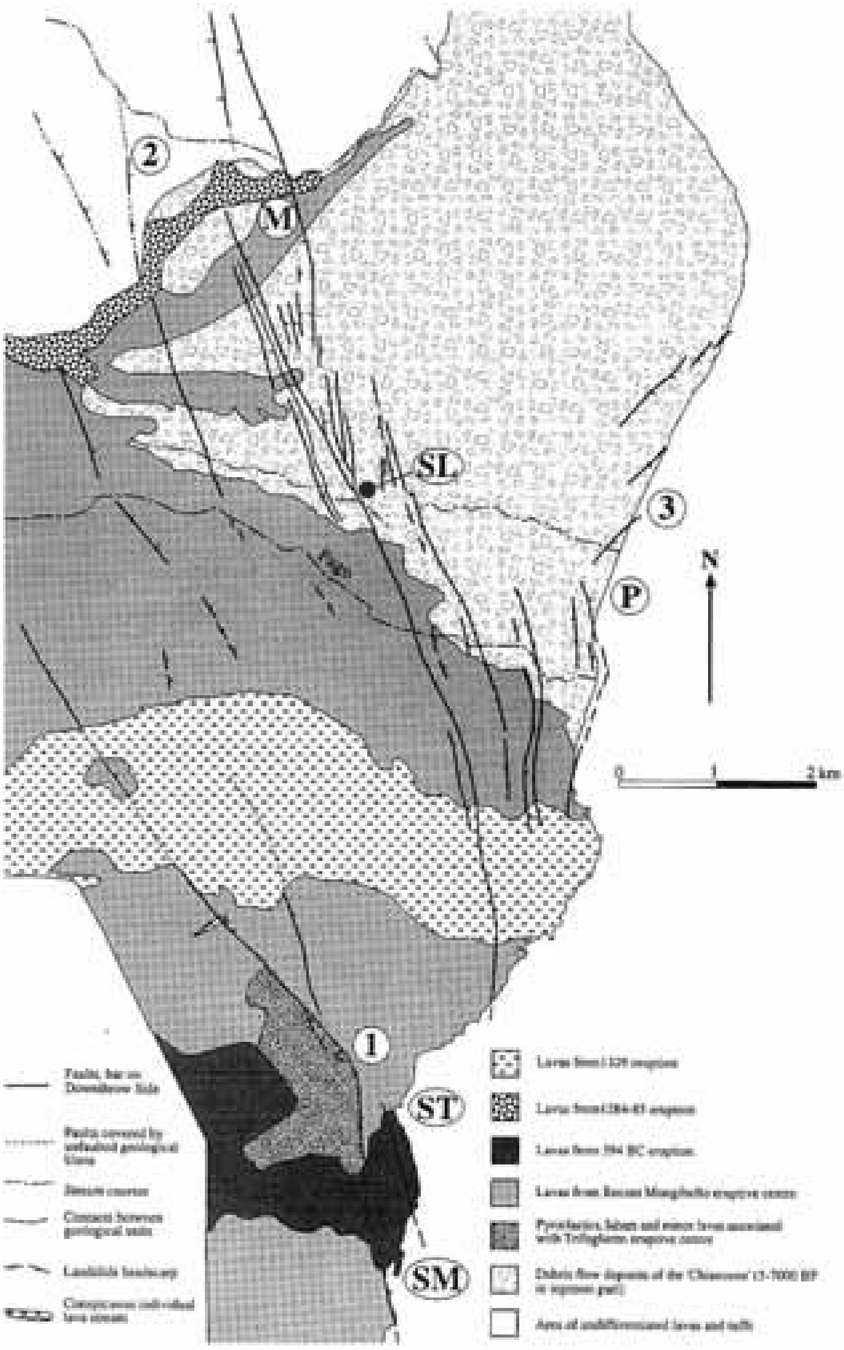

Figure 27 - Structural and geological map of the eastern flank of Mount Etna showing the NNW-SSE Timpe fault system and the subsidiary NE-SW faulting along the coast with probable affinity to the Messina fault system (Figure 1). Localities 1, 2 and 3 refer to structural data collected from fault exposures discussed in the text. The following small towns are also shown: M=Macchia, P=Praiola, SL=San Leonardello, SM=Santa Maria La Scala, ST=Santa Tecla (from Lanzafame et al., 1996).

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Back Cover:
field trip itinerary

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FIELD TRIP MAP

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