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Project IGCP 437

Coastal Environmental Change
During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

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Quaternary coastal morphology and sea level changes

Project 437

2nd day

The coast of southern Salento

by

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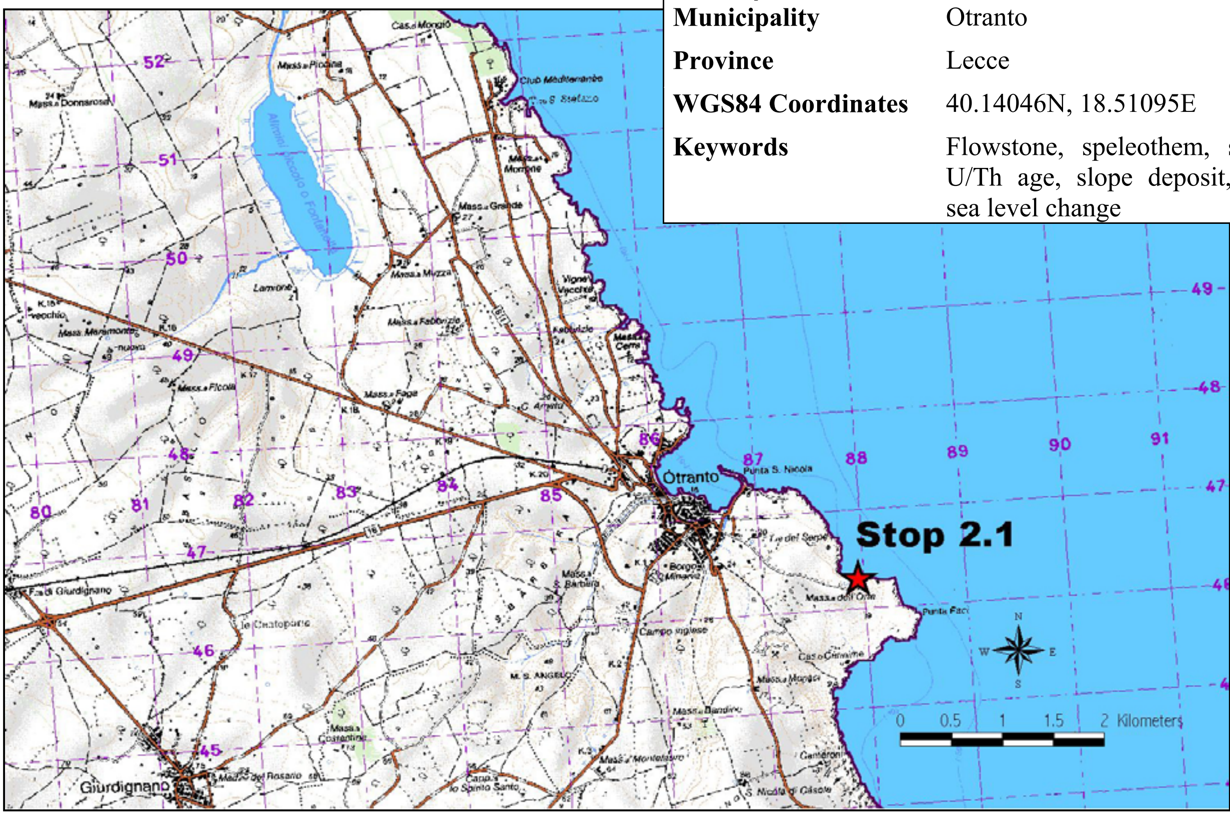
Introduction

The landscape of Salento peninsula is composed of a rolling surface gently sloping northwestward, from about 40 m at its northern border to the 150 at its southernmost part. In details, it is made of low sediplains interposed to narrow ridges which trend in NNW-SSE direction and are up to 200 m a.s.l. high. According to Palmentola (1987), six order of marine terraces can be recognised along the Salento coast. The highest surface is tilted northward between 175 and 80 m of altitude; it is dislocated by faults and could be dated back to the Lower Pleistocene. The second terrace is recognisable at about 80 m of altitude whereas the third one stretches between 60 and 50 m of altitude. The fourth terrace is marked by sediments with *Strombus bubonius* Lamarck and referable at the OIS 5e; it can be found between 25 and 30 m above p.s.l.. Two lower, narrow platforms placed at 15 m and 3-4 m of altitude could be referred to the oxygen isotope stage 5c and 5a, respectively.

The landscape of Salento peninsula is widely affected by karstic landforms, mainly dolinas and sinkholes, linked to a number of karstic morphogenetic phases developed under different climates during the continental periods occurred since the end of Cretaceous to the present. The ancient karst surfaces were fossilized during marine transgressions and partially re-exposed during the regressive phases. The drainage network is poor developed. It is composed of short endorheic streams which flow into karstic sinkholes or in depressions and of relict valleys linked to ancient shorelines. Some of these last valleys show the lower part below present sea level.

Site 2.1

Locality	Masseria dell'Orte
Municipality	Otranto
Province	Lecce
WGS84 Coordinates	40.14046N, 18.51095E
Keywords	Flowstone, speleothem, sea cave, U/Th age, slope deposit, notches, sea level change



Stop 2.1 - The Masseria dell'Orte cave section
(E. Centenaro, G. Mastronuzzi, P. Sansò, G. Selleri).

The Masseria dell'Orte cave opens in the Palombara Bay (Fig.2.1); here a narrow abrasion platform, about 5 m wide, can be found at 6.2 m a.m.p.s.l.. It is covered by a coarse breccia very well cemented. The inner margin of the platform is marked out by the presence of small cave, about 2 m high and 4 m wide. Along the cave walls, boreholes and boring bivalves in living position can be still observed.

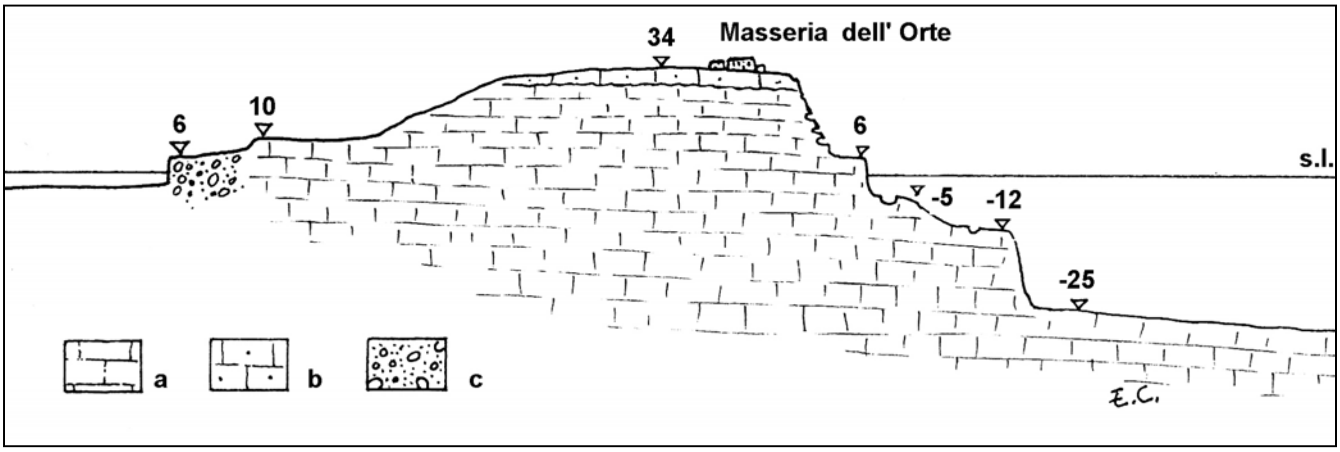
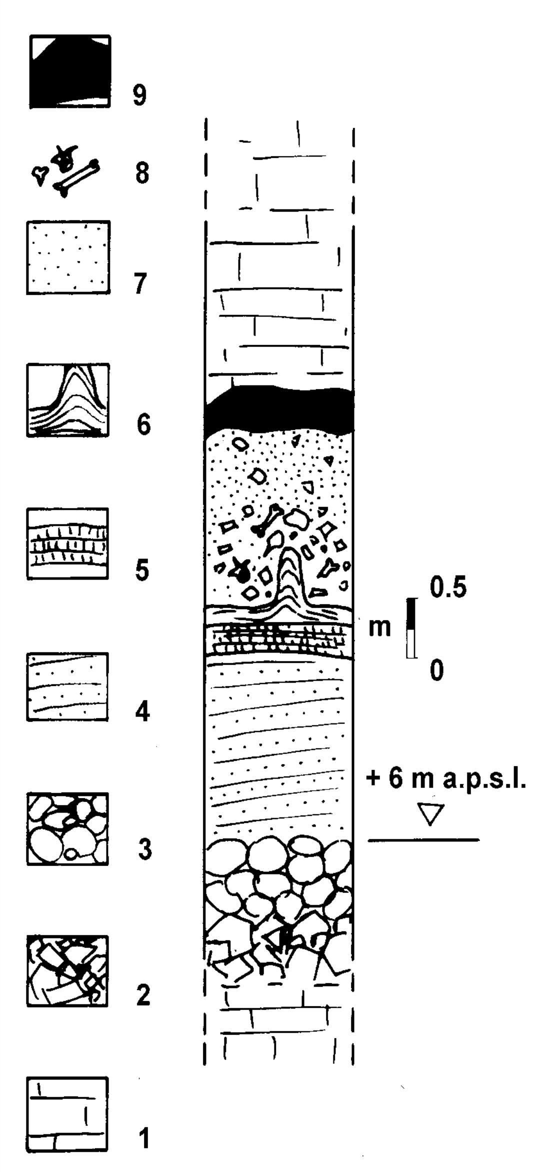


Figure 2.1 - *Schematic morphological profile at Masseria dell'Orte locality. Legend: A) Mesozoic limestones; B) Calcareniti di Andrano formation (Upper Miocene); C) Formazione di Leuca formation (Lower Pliocene).*

Figure 2.2 - *A view of the Masseria dell'Orte cave sequence.*



The cave is partly filled by a well cemented, clinostratified calcarenite made of about 60% bioclasts, 30% quartz grains and 10% by heavy minerals with piroxene and garnets (Fig. 2.2).The high dip of laminae, the granulometric and petrographic characters would suggest an aeolian origin of this deposit.

The calcarenite is closed upward by a 5-20 cm thick flowstone. U/Th analysis performed on this last one yielded an age older than the limit age of the method, about 350-400 ka. A columnar stalagmite, about 50 cm high, follows upward; it yielded an U/Th age of about 185 ka.

A brownish slope deposit made of abundant dark red matrix and isolated limestone clasts, closes the sequence. The deposit is marked out by the presence of vertebrate bones (Fig. 2.3).

The limestone cliff of Palombara bay is marked out by a sequence of three notches, about 0.5 m deep and 0.4÷0.7m high (Fig. 2.4). They can be followed for about 15 m and are slightly tilted towards the North. Notches surface is covered by a thin calcareous concretion and shows the same weathering of surrounding rock. Nothces are placed between 8 and 13 m a.m.p.s.l. and displaced about 0.5 m by a vertical fault.

The morphology of notches and the lithological uniformity of limestone, proved by petrographic analysis and Schimdt hammer tests, would suggest a marine origin for these notches.

The data suppied by the analysis of Masseria dell'Orte cave confirm the long-term stability of the Otranto-Leuca coastal area and the occurrence of a long period of emersion between the Middle Pleistocene and the Last Intergacial period.

Figure 2.3 - *Stratigraphic section of Grotta Masseria dell' Orte cave. 1- limestone; 2 – blocks; 3 - breccia; 4 – marine arenites; 5 – flowstone; 6 – speleotheme; 7 – continental sands; 8 - mammalian remains; 9 - cave.*

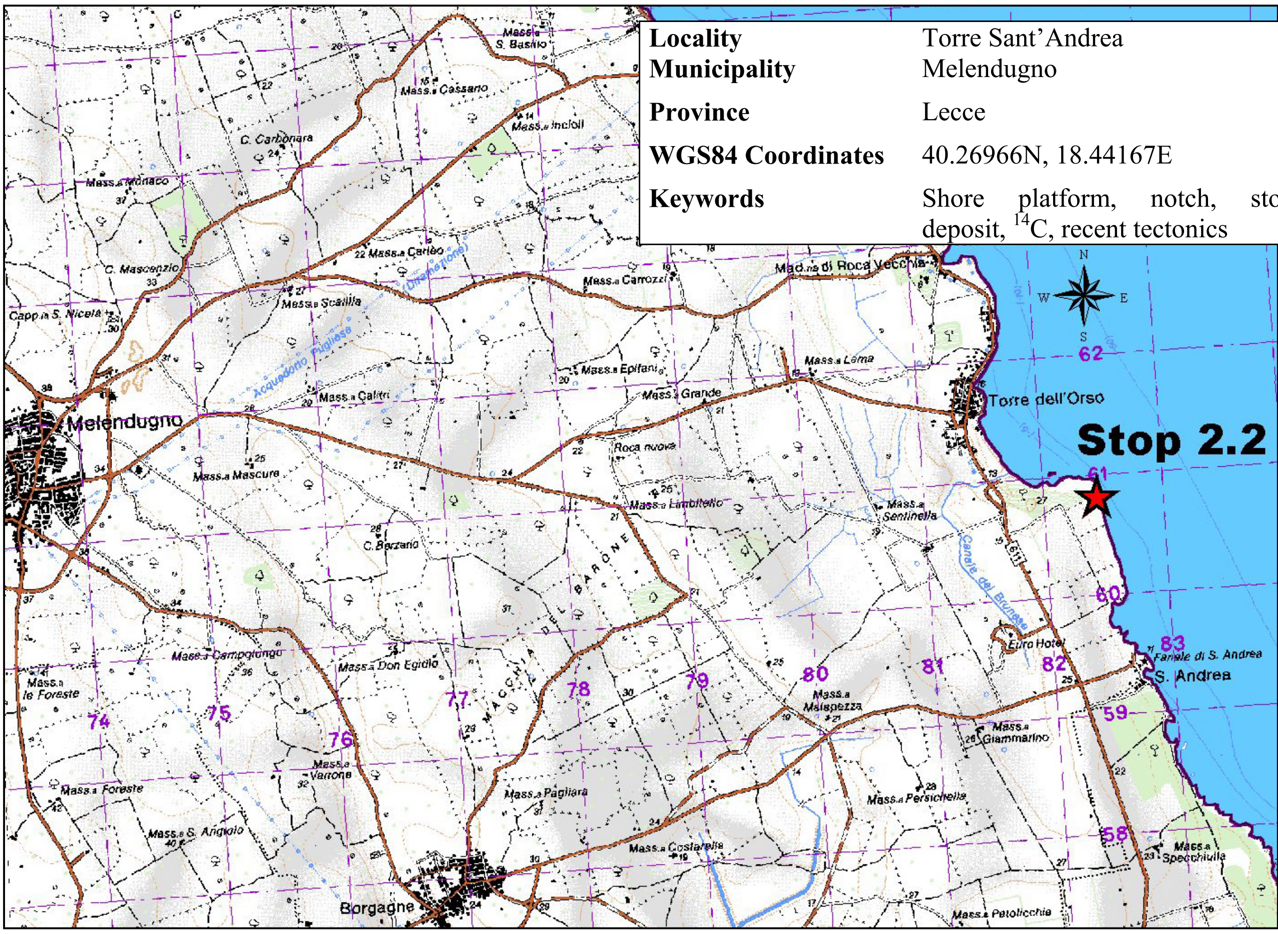
Figure 2.4 - *A view of the displaced marine notches which mark the southern cliff of Palombara bay.*

No Sample	Locality	Type	$(^{234}U/^{238}U)_{t=0}$	Uppm	Age (ka)
PL3	Grotta Le Orte	Speleotheme	1.075	0.563+/-0.003	184, 8 (+12.8/-11.4)
PL2 (2)	Grotta Le Orte	Flowstone	1.019	0.985+/-0.005	>350

Table 2.1 – *U/Th age determinations performed on carbonate concretions collected at Grotta Le Orte on CERAK, Faculté Polytechnique de Mons (Belgio).*

Site 2.2

Locality	Torre Sant'Andrea
Municipality	Melendugno
Province	Lecce
WGS84 Coordinates	40.26966N, 18.44167E
Keywords	Shore platform, notch, storm deposit, ^{14}C, recent tectonics



Stop 2.2 - The raised shore platforms of Otranto - Torre dell'Orso (G. Selleri, G. Mastronuzzi, P. Sansò).

Geological and morphological setting of the area.

Calcareous - clayey sands, calcareous sandstones and marly calcarenites referred to Middle Pliocene - Lower Pleistocene crop out along the coastal area stretching to the north of Otranto. They are transgressive on calcareous breccias and calcareous marls of Lower Pliocene age which can be recognized in the area of Otranto village where Miocene limestones and calcarenites can be also detected. The Mesozoic basement crops out extensively to the south of Otranto whereas northward it deepens in NE direction because of faulting. In the Alimini lakes area it is placed about 210 m below sea sea level; the Plio-Pleistocene units show in this area a large thickness, of about 100 m.

The coastal landscape of Otranto - Torre dell'Orso area is marked out by six main orders of marine terraces placed between 103 m and a few meters above mean sea level (Fig. 2.5). Marine terraces are 2-3 kilometers wide and separated by degradated, low cliffs. The shaping of cliffs has been accomplished by the development of numerous, short river cuts which rarely affect more than one order of marine terraces.

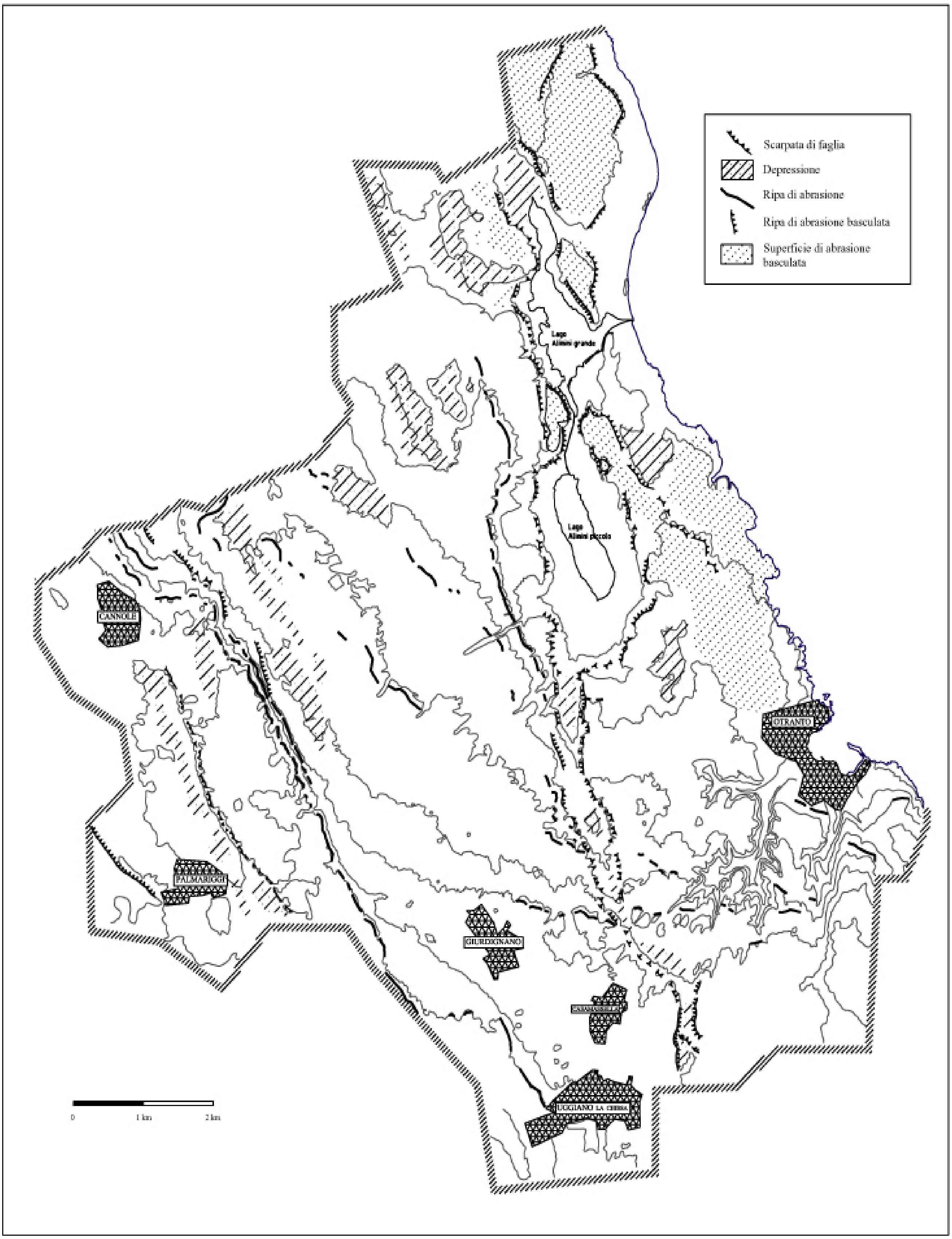


Figure 2.5 - *Morphological sketch of the eastern Salento coastal area.* ***Legend*** *- scarpata di faglia: fault scarp; depressione: depression; ripa di abrasione: marine cliff; ripa di abrasione basculata: tilted marine cliff; superficie di abrasione basculata: tilted abrasion platform.*

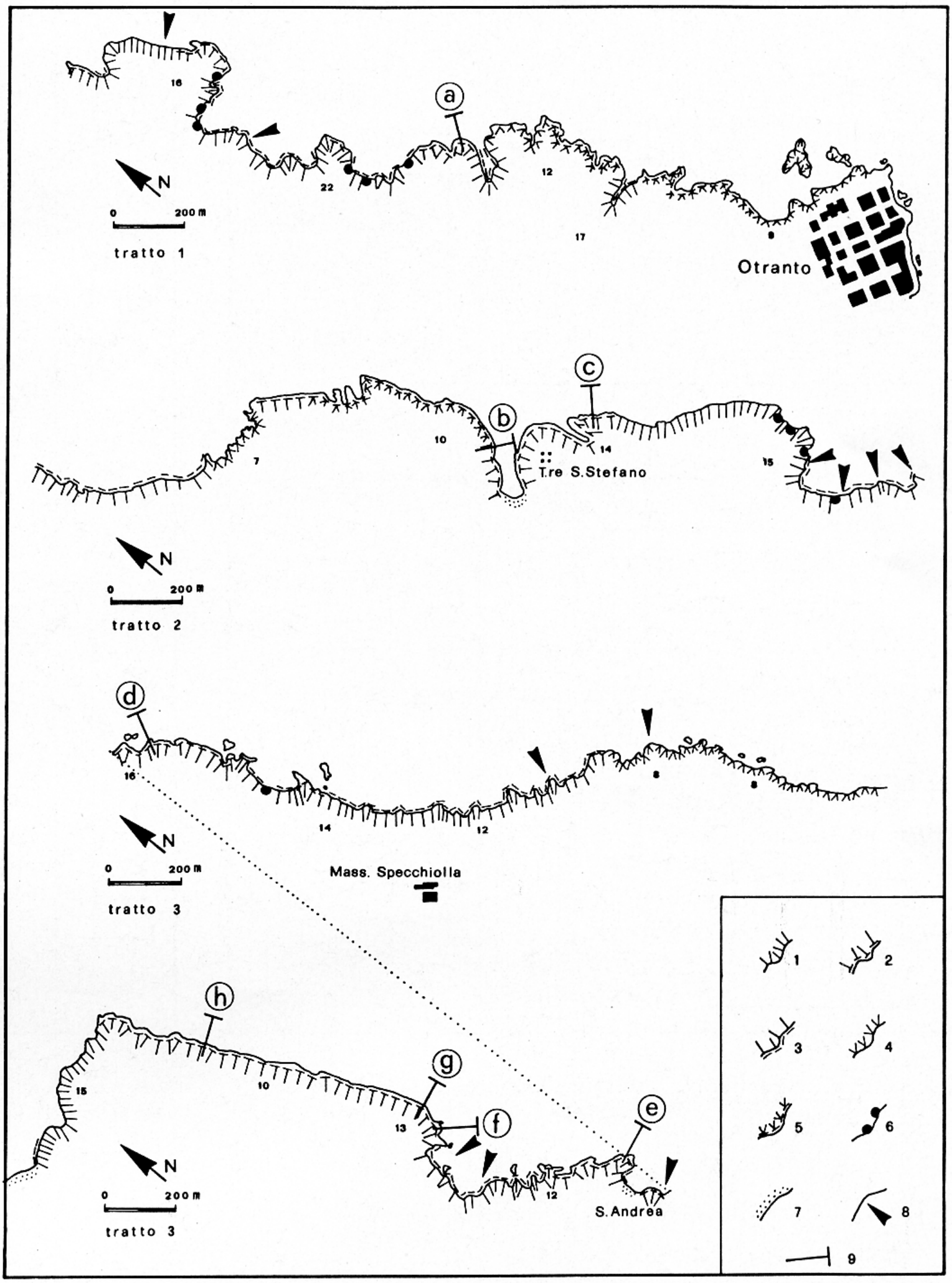


Figure 2.6 - *Morphology of the coast between Torre dell'Orso and Otranto. Legend: 1) active cliff; 2) cliffs with emerged wave-cut platform at the foot; 3) cliffs with submerged wave-cut platform; 4) sloping coast; 5) sloping coast with emerged platform; 6) sea caves; 7) pocket beach; 8) coastal tract in fast retreat; 9) position of profiles reported in Fig. 2.7.*

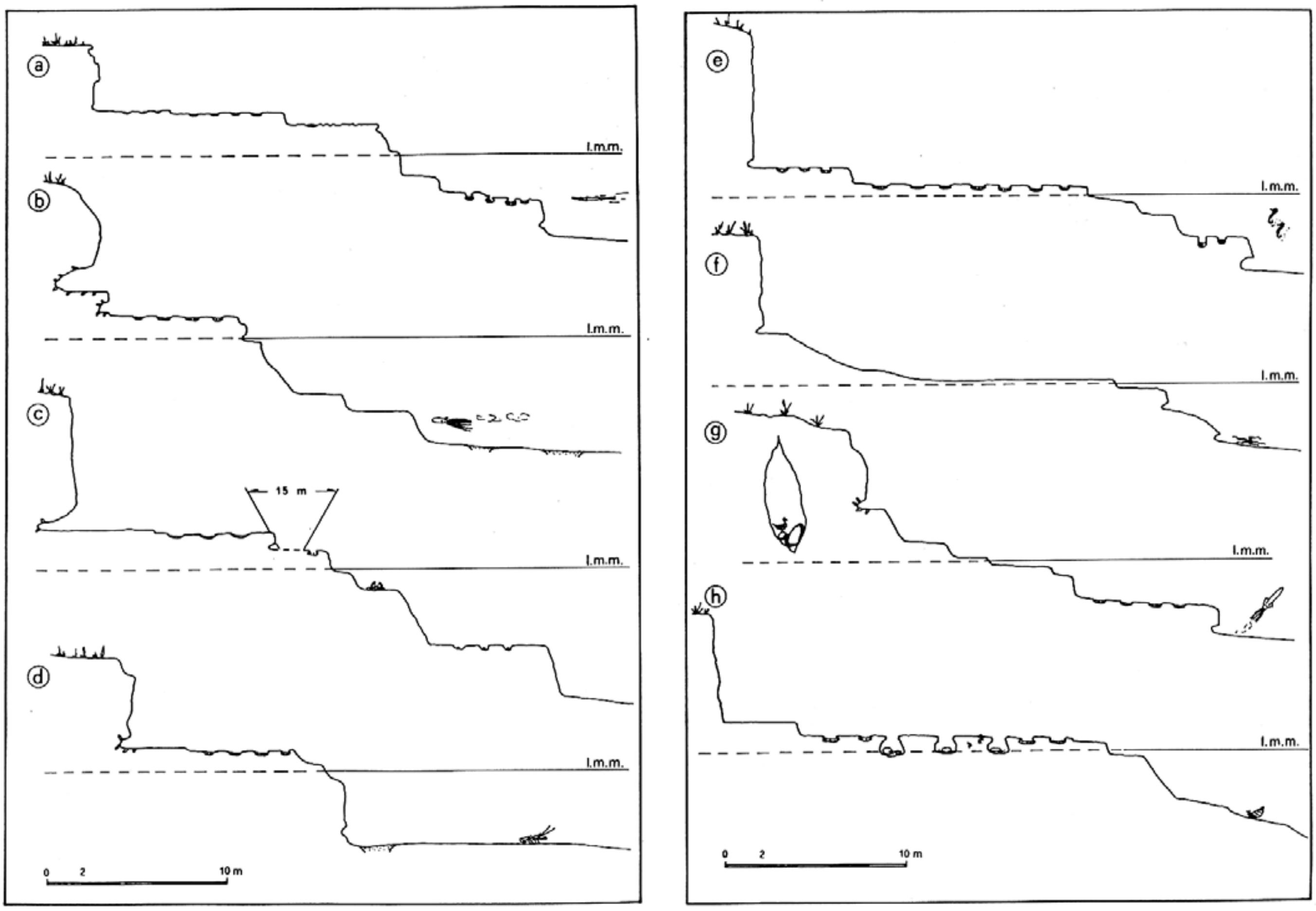


Figure 2.7 - *Morphological profiles of raised shore platforms between Torre dell'Orso and Otranto. Vertical and horizontal scales are the same.*

Figure 2.8 - *A view of the wave-cut platform placed at +3 m above p.s.l. placed to the south of Torre dell'Orso.*

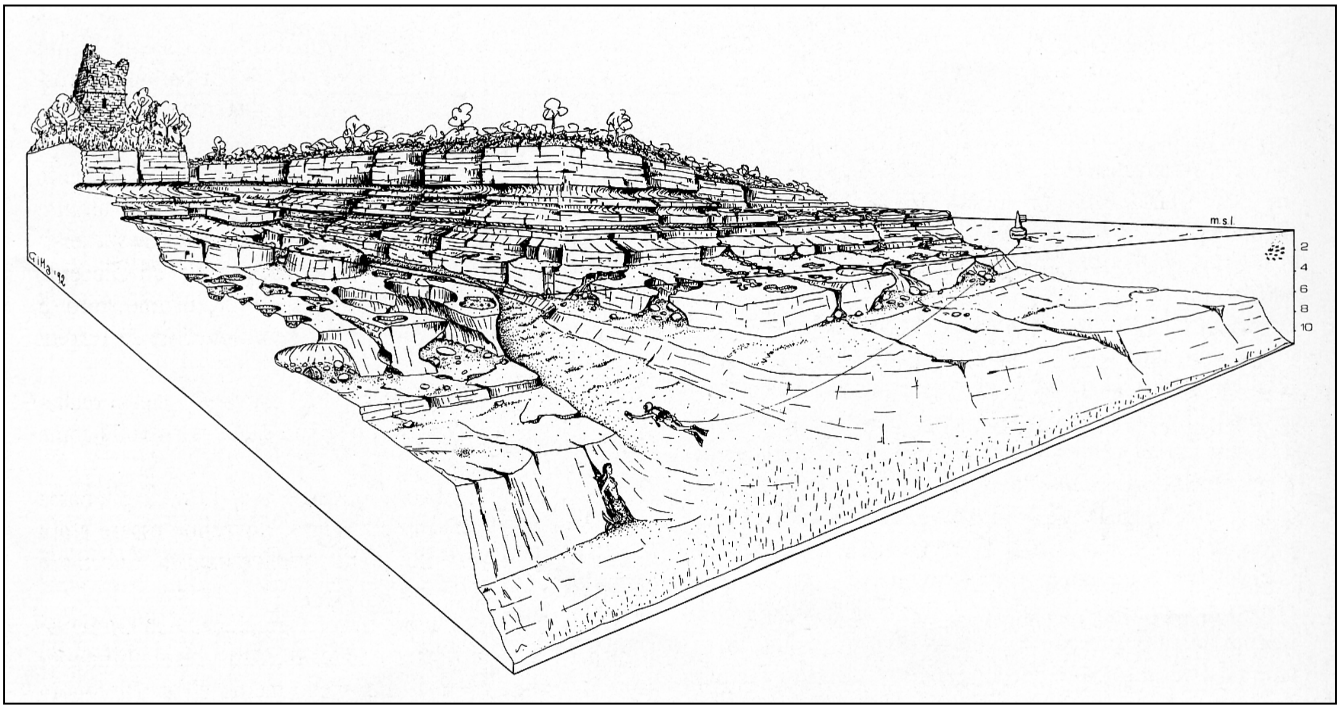


Figure 2.9 - *Schematic block diagram of the Torre Santo Stefano coast.*

Figure 2.10 - *A view of the storm deposits preserved at the inner margin of the highest raised platform at Torre Santo Stefano localities.*

Figure 2.11 - *A thick deposit of travertino cementes storm deposits at Torre Santo Stefano localities. On the foreground the present storm wave deposit can be recognized.*

The drainage network is poor developed with the exception of a drainage basin recognizable at the southernmost part of the area which is well organized and linked to a submerged shoreline.

A system of NNW-SSE elongated depressions running near the coastline breaks the stair-case of marine terraces. The depressions occurring to the northern sector of the area show a peculiar rhomboid shape and are bordered by straight, high scarps; two of these depressions are occupied by the Alimini lakes. In the southern part of the area, depressions are elliptic in shape and bordered by scarps which are cut by short river valleys.

The raised shore platforms of Torre dell'Orso.

The coast stretching from Torre dell'Orso to Otranto, on the eastern side of southern Apulia, is represented almost entirely by cliffed coasts (Dini *et al.*, 2000) (Fig. 2.6). These rocky coasts are cut in Middle Pliocene - Lower Pleistocene sediments (Bossio *et al.* 1989), composed of gently seaward sloping strata of fine fossiliferous calcarenites interbedded with clayey calcareous sands and somewhere with blue sandy clays.

Numerous tracts of cliff coasts show a peculiar profile characterised by both submerged and subaerial platforms (Fig. 2.7). The lowest platform is 15 m below m.s.l. and is covered by terrigenous/bioclastic sands with *Cymodocea nodosa* (Ucaria) Areshoug and *Posidonia oceanica* Delile. It is in morphological continuity with the bottom of Torre Santo Stefano ria. A second platform is located between 11 and 6.5 m below m.s.l. and has a width ranging up to 80 m. The cliff which borders it landward shows blocks at its foot and the presence of marine grottos. A third platform is recognizable between 4 and 3 m below m.s.l.. It is bordered landward by a 3 m high cliff which in some places shows a notch about 0.3 m deep at its foot.

Furthermore, two wide platforms characterize the subaerial part of these cliffs (Fig. 2.8). In fact, the lowest one is between 1.0 and 2.2 m above m.s.l.; the other one between 2.8 and 3 m above m.s.l.. Both of these last two platforms, up to 40 m wide, are bordered in some places - i.e. Torre Santo Stefano - by a more or less deep notch (Fig. 2.9). The cliff/platform junction is hidden by blocks from the bordering cliff and cemented by deposits of travertine which formed at their base.

Figure 2.12 - *A view of a boulder covered by Vermetids which has been carved and transported at the inner margin or raised shore platform by storm waves.*

A sample of these deposits (Orso1 sample) yielded a radiocarbon age of 1358±80 years BP. At Torre Stefano locality, storm deposits preserved at the inner margin of the highest raised platform yielded the radiocarbon age of 2060±50 years (TSS7 sample) and 1920±50 years (TS2 sample) (Fig. 2.10, 2.11, 2.12).

According to Mastronuzzi *et al.* (1994), the raised shore platforms of Torre dell'Orso could be of Holocene age because the low degradation of the cliff notwithstanding the erodibility of the outcropping rocks. Furthermore, the lack of slope deposits which would have been developed during last glacial period and the absence of sediments older than 2000 years BP would confirm this chronological attribution.

The morphological evidences of recent tectonic activity

The geomorphological analysis of the entire coast stretching between Otranto and Torre dell'Orso has been carried out to understand the significance of Torre dell'Orso raised shore platforms which would indicate an important, recent tectonic activity in the area.

The geomorphological analysis of the coastal landscape of eastern Salento revealed many other evidences of recent tectonic activity, mainly represented by the break of marine cliffs continuity and by the tilting of marine terraces top surfaces. These evidences are linked to a complex tectonic alignment NNW-SSE trending which has been active until very recent time. It affected the development of lowest marine terraces, related shorelines and drainage network, and was responsible for the development of scarps and depressions, two of them occupied by Alimini lakes.

A system of depressions and scarps breaks the continuity of a relict marine cliff with foot at 30 m of altitude placed to the south of Alimini piccolo Lake. Another marine cliff and some river cuts linked to it are broken off by depressions near the SS16 road; in particular, river cuts show an evident bend at their final tract. A scarp breaks a marine cliff whose foot is at 70 m of altitude in the area between Otranto and Casamassella. The scarp is marked by a NNW-SSE orientation in its northern part and by a N-S direction in its southern one and it is in continuity with the system of depressions. Finally, relict marine cliffs placed to the west of the system of depressions show different altitude of those ones occurring to the east.

Tilted abrasion surfaces and marine cliffs occurred in the area stretching between the Alimini lakes depressions and the present coastline. The widest marine terraces have been recognized at Frassanito locality, tilted toward SE between 27 and 8 m of altitude; in the area between Alimini grande Lake and the S.Cataldo-Otranto road, tilted northeastward between 17 and 7 m of altitude; in the strip between Alimini piccolo Lake and the coastline, where two tilted abrasion surfaces separated by a low cliff have been recognized. In particular, the lowest of these two surfaces is tilted towards NE and strecthes between 25 and 10 m of altitude.

Recent tectonity activity of faults occurring along the coast of Salento has been reported by some Authors (Martinis, 1962; Palmentola and Vignola, 1980). More recently, Merlini *et al.* (2000) point out offshore Capo S.Maria di Leuca a remarkable sea floor deformation due to normal active faulting.

N°	Sample	Locality	Material	Altitude (m)	$\delta^{13}C_{PDB}$ (‰)	$\delta^{18}O$ (‰)	Uncalibrated Age (years BP)	Calibrated Age (cal years BP)	Lab.	Reference
1	Orso 1	Torre Santo Stefano	Travertino	3.0	-	-	1358 ± 80	1280 ± 55	A	Dini *et al.*, 2000
2	TS 2	Otranto Torre Sant'Andrea	Marine shells	2.8	-0.4	-	1920 ± 50 AMS	1343 ± 75	B	Selleri *et al.*, 2003
3	TSS 7	Torre Santo Stefano	Vermetids boulder	2.5	-	-	2060 ± 50	1484 ± 90	A	Dini *et al.*, 2000

Table 2.2 - *Radiocarbon age determinations performed on continental and marine deposits occurring on the Torre dell'Orso wave-cut platforms. A - Laboratorio di Geochimica Isotopica, Università degli Studi, Trieste (Italia); B - Geochron Laboratoires Krueger Enterprises Inc. (Cambridge, Massachusets, U.S.A.).*

Site 2.3

Locality	Fontanelle
Municipality	Gallipoli
Province	Lecce
WGS84 Coordinates	40.06543N, 17.99599E
Keywords	Strombus Bubonious, OIS5, raised beach, Tyrrenian

Stop 2.3 The deposits of *Strombus bubonious* Lamarck at Gallipoli (bibliographic note)

The marine deposits cropping out at Fontanelle locality near Gallipoli have attracted Quaternary geologists and palaentologists throughout the last century Firstly, Gignoux (1913) described the sequence recognisable along the cliff, showing at the base bluish clays with *Cyprina islandica* and Isocardia cor shading upward into grés with *Chlamys septemradiatus*. The sequence is closed by coarse calcarenite marked by *Strombus bubonius* (Fig. 2.13, 2.14, 2.15).

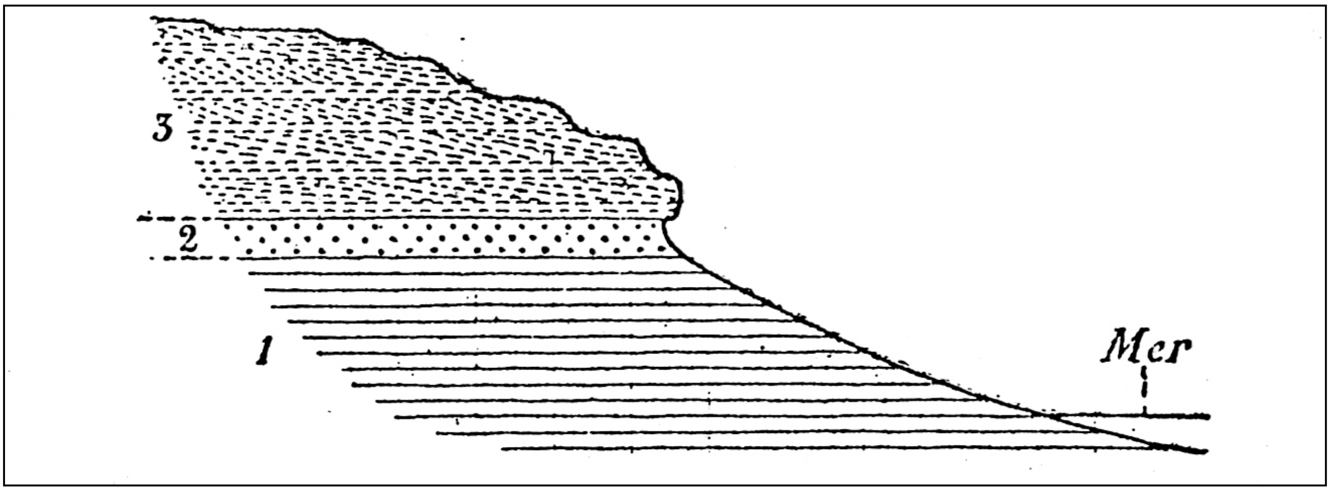


Figure 2.13 - *The stratigraphic section of le Fontanelle, at Gallipoli, after Gignoux (1913).*

Further description of this site have been produced by De Giorgi (1922)(Fig. 2.16), Blanc (A.C., 1953), Mirigliano (1953, 1956), Gigout (1960c), Cotecchia *et al.* (1969), Hearty and Dai Pra (1985; 1992) (Fig. 2.17). According to these last Authors, during last interglacial period, a small cove contained a pocket beach between two heads shaped on Sicilian sandstone. Present coastal erosion has completely destroyed the pocket beach deposit exposing only the highest supratidal zone of the *Strombus bubonius* beach along the cliff. However, a thin soil layer can be recognized inside the beach deposit which separates the lower planar bed of the shoreface from an upper zone with highly concentrated shells.

In the Mediterranean region, *Strombus bubonius* Lamarck and/or Senegalese fauna mark the marine terrace sediments referred to the "Tyrrhenian".

Figure 2.14 - *A view of the Le Fontanelle section (Gallipoli).*

Figure 2.15 - *A mechanical concentration of Strombus bubonius Lamarck marks the foreshore sediment closing the sequence of Le Fontanelle (Gallipoli).*

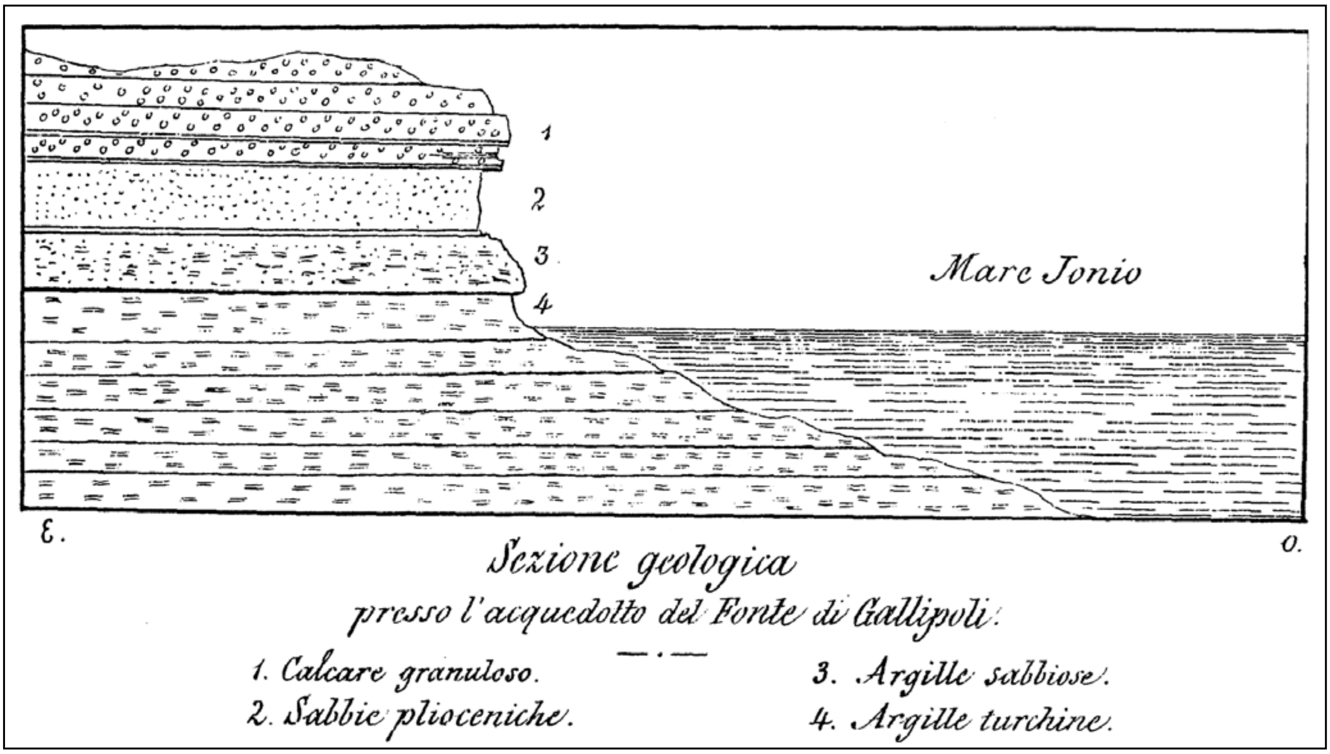


Figure 2.16 - *The stratigraphic section of le Fontanelle, at Gallipoli, fromDe Giorgi (1922).*

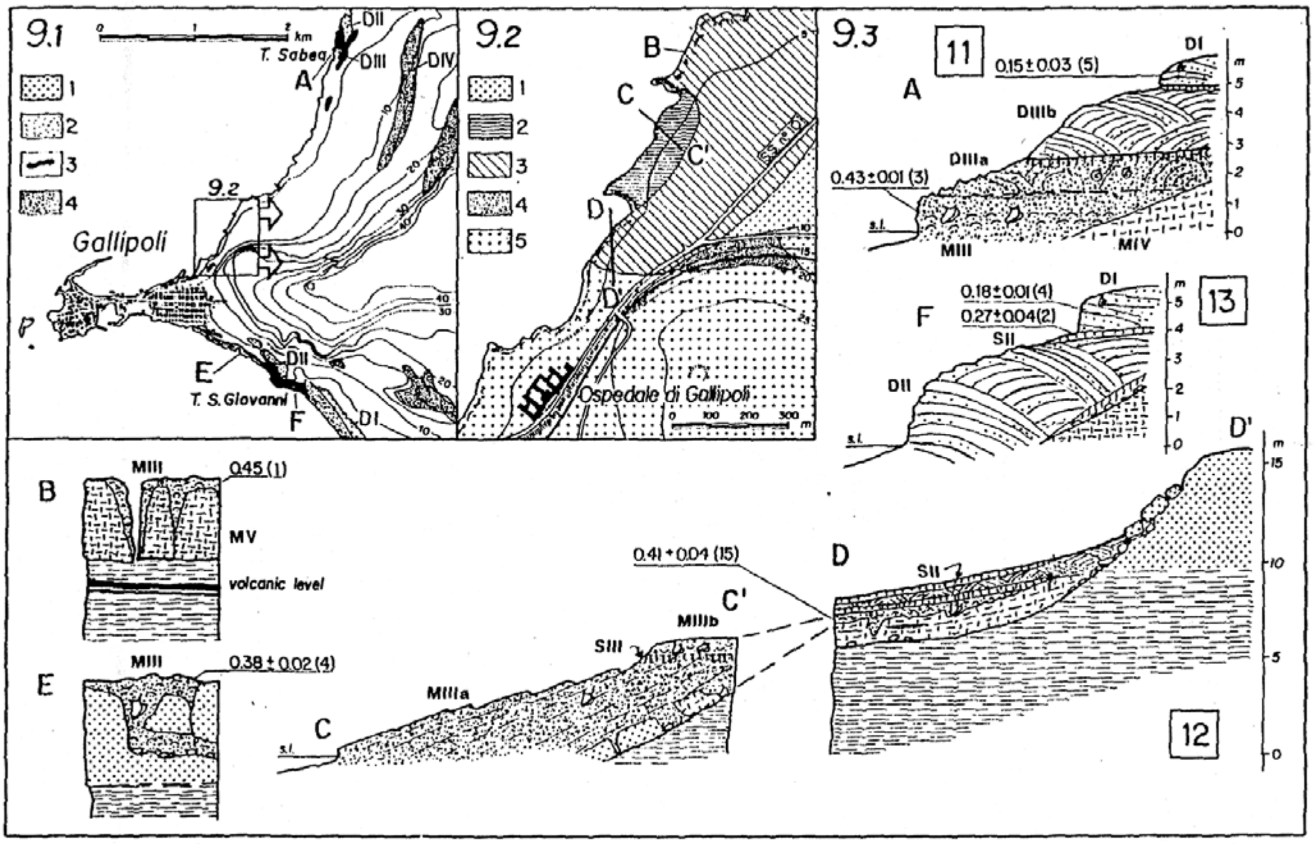


Figure 2.17 - *Stratigraphy of the Gallipoli area according to Hearty and Dai Pra (1992). Site 11 = Torre Sabea; Site 12B, 12C-C', and 12D-D' = Gallipoli (Ospedale); Site 13E and 13F = Torre S.Giovanni. Legend for Figure 9.1 (Gallipoli peninsula): (1) Historical dunes; (2) Holocene dunes; (3) post-Strombus dunes; (4) older dunes.Legend for Figure 9.2 (Ospedale di Gallipoli): (1) Holocene deposits; (2) beach deposits with Strombus bubonius; (3) bioclastic calcarenite; (4) eolianite; (5) "Sicilian" littoral sandstones with Globorotalia truncatulinoides excelsa (Coppa and Crovato, 1985; Rio et al., 1991).*

The term "Tyrrhenian" was proposed for the first time by Issel (1914) and then by Depéret (1918) to indicate marine sediments characterized by a phaunistic assemblage consisting of warm species (with or without *Strombus)* coming from the equatorial coast of Atlantic Ocean (Gignoux, 1911a, b) where "*the most famous and common is Strombus bubonius* Lamarck" (Gignoux, 1913) which moved to the Mediterranean Basin during the Tyrrhenian (Issel, 1914; Deperet, 1918). In particular we would like to focus the attention on Issel (1914). First of all, Issel suggested the use of the term *Tirreno* for the *"…complesso di strati a Strombus* (= "*Couches à Strombes*" of Gignoux, 1911a, b) *e allo spazio di tempo relativo …*". Gignoux (1913) reported in a map attached to his work the places where only one species – not necessarily the Strombus - typical of "*couche à Stombes*" - have been found. In addition Gignoux use the term "*piano Tirreno*" to indicate deposits characterised by the occurrence of some species at present living along the coast of Senegal *("… in cui sono caratteristiche alcune specie viventi oggi nelle acque del Senegal ed estinte nel Mediterraneo*." -). In his paper on the marine terraced deposits of Sardinia, Issel correlated the marine deposits of Camposanto containing *Conus testudinarius* Martini but without Strombus to the marine deposit of Capo S. Elia – Cala Mosca, where *Conus testudinarius* and *Strombus bubonius* Lamarck occur.

Moreover, Bonifay and Mars (1963) affirmed that the *Strombus* is not the characteristic element of the Tyrrhénien: *"Le Strombe n'est pas d'ailleurs pas le seul élément caractéristique de ce niveau qui contient aussi en abondance Conus testudinarius, Turbo rugosus, Patella ferruginea, etc… …*". In this paper they spoke repeatedly about a *"… fauna tyrrhénienne "appauvrie" sans Strombe…"* (= poor Tyrrhenian phauna without *Strombus*). These Authors concluded that Thyrrenian is characterised by "*Eutyrrhénian avec gisement à fauna sénégalienne avec Strombe*" and by "*Néotyrrhénienne avec gisement à fauna sénégalienne appauvrie"* (= without *Strombus*).

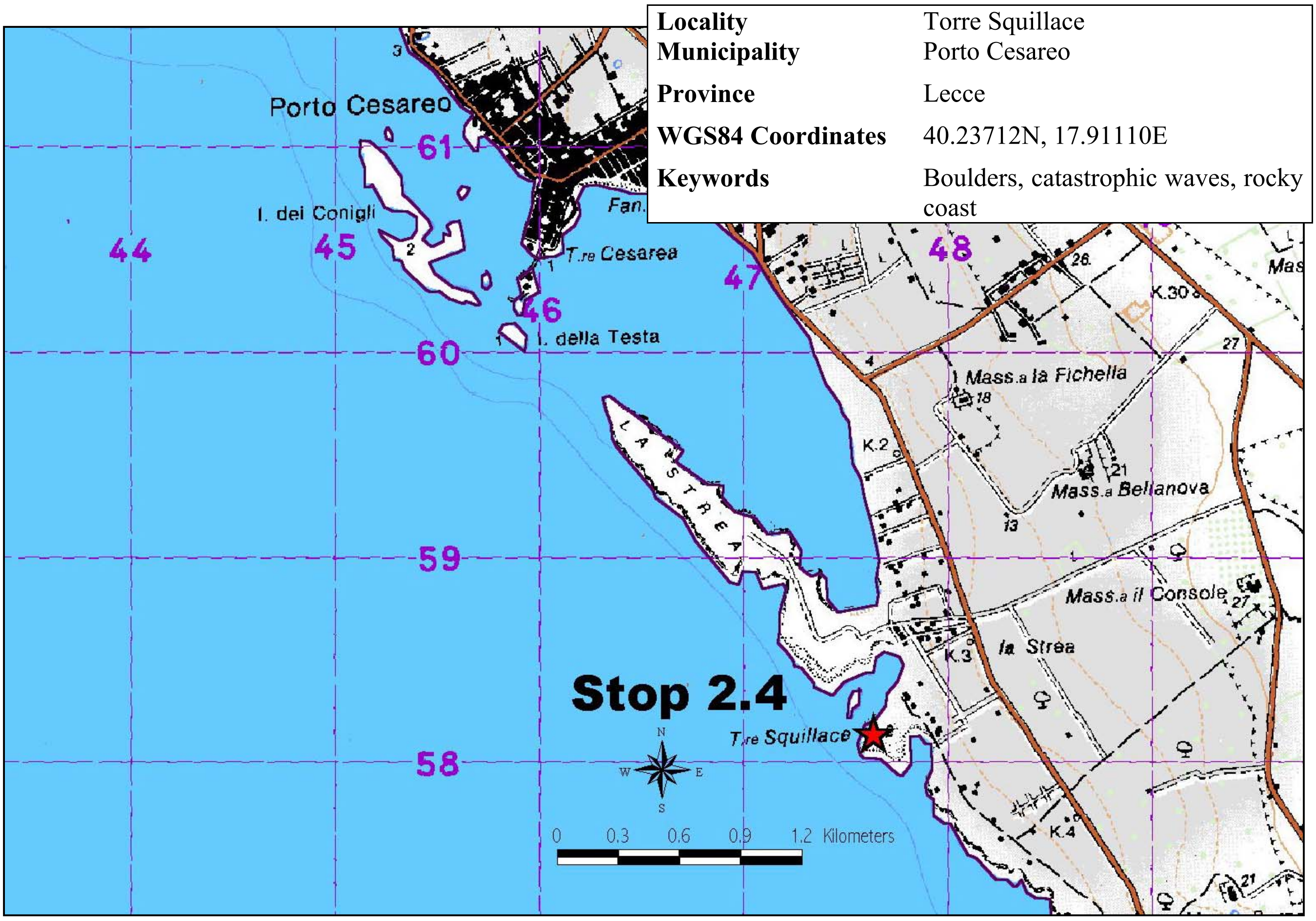
In summary , since *Strombus bubonius* is considered a fossil of facies it is not possible that of all Tyrrhenian deposits (sensu Issel, 1914) with phauna atlantica (sensu Gignoux 1911a,b; 1913) or Senegalese (sensu Bonifay and Mars, 1963) are characterised by presence of this tropical species.

During recent years, Tyrrhenian deposits are generally referred to the last interglacial period, occurred between about 125 and 80 ka B.P. and correlated with the OIS 5 (ore more recente MIS 5) of Schackleton and Opdyke (1973) and Chappel and Shackleton (1986) curves.

In particular, deposits marked by *Strombus bubonius* Lamarck are thought to indicate only the substage 5e, referred to 125 ka BP and frequently used to calculate uplift rates (i.e. Bordoni and Valensise, 1998) even in absence of valuable indicators of sea level.

Site 2.4

Locality	Torre Squillace
Municipality	Porto Cesareo
Province	Lecce
WGS84 Coordinates	40.23712N, 17.91110E
Keywords	Boulders, catastrophic waves, rocky coast



Stop 2.4 – The effect of catastrophic waves on rocky coasts.
(G. Mastronuzzi, P. Sansò)

Along the Ionian coast of Puglia, several tracts of gently sloping rocky coasts are characterized by large boulders, up to 80 tonnes in weight, scattered some meters above m.s.l.. A detailed study of boulder size and position was carried out in this locality, placed near Porto Cesareo (Fig. 2.18).

Boulder lay directly on a bare rocky surface placed at about 2 m above m.s.l. and bordered seaward by a ramp sloping about 15%. Small karstic landforms, shaped on the sub-aerially exposed calcareous sandstones, are mainly represented by potholes, which became increasingly deeper and wider toward the coastline. In the spray zone potholes are coalescent, giving rise to pinnacle-like forms (*Spitzkarren*) separated by wide, flat depressions.

Boulders are generally represented by calcareous sandstone slabs ranging in size from 1x0.85x0.5 to 6.0x2.6x1.6 m^3. Their volume ranges from less than 1 to 25 m^3 and considering a unit weight of 2.35 t/m^3, values less than 1 up to 60 t in weigth can be calculated (fig. 2.19).

Boulders were ripped along strata and joint planes, generally from the lowest part of the ramp, very close to sea level. This evidence is marked out by the presence of wide, relict solution potholes occurring on the upper surface of the largest boulders. Similar features are at present forming only in the lowest part of the spray zone. The flat bottom of potholes is usually tilted landward about 12-40° indicating that at least the largest boulders slid on the rocky platform during transport. Recent, sub-horizontal and smaller solution potholes, about 20 cm deep and 40 cm wide, developed after boulder transportation.

The largest boulder, which broke during transport in four pieces (boulders 10,11,12 and 13), was about 80 t in weight and slid for about 40 m from the mean s.l. to about 1.8 m above sea level (Fig. 2.20).

Since most of boulders are elongated, a detailed survey of their long axis orientation and distribution was carried out (fig. 2.21). Results clearly show that elongated boulders rotated during transport, disposing their long axis tangent to the run-up fans induced by a single wave train approaching the NW-SE oriented coast (in this tract) from the South.

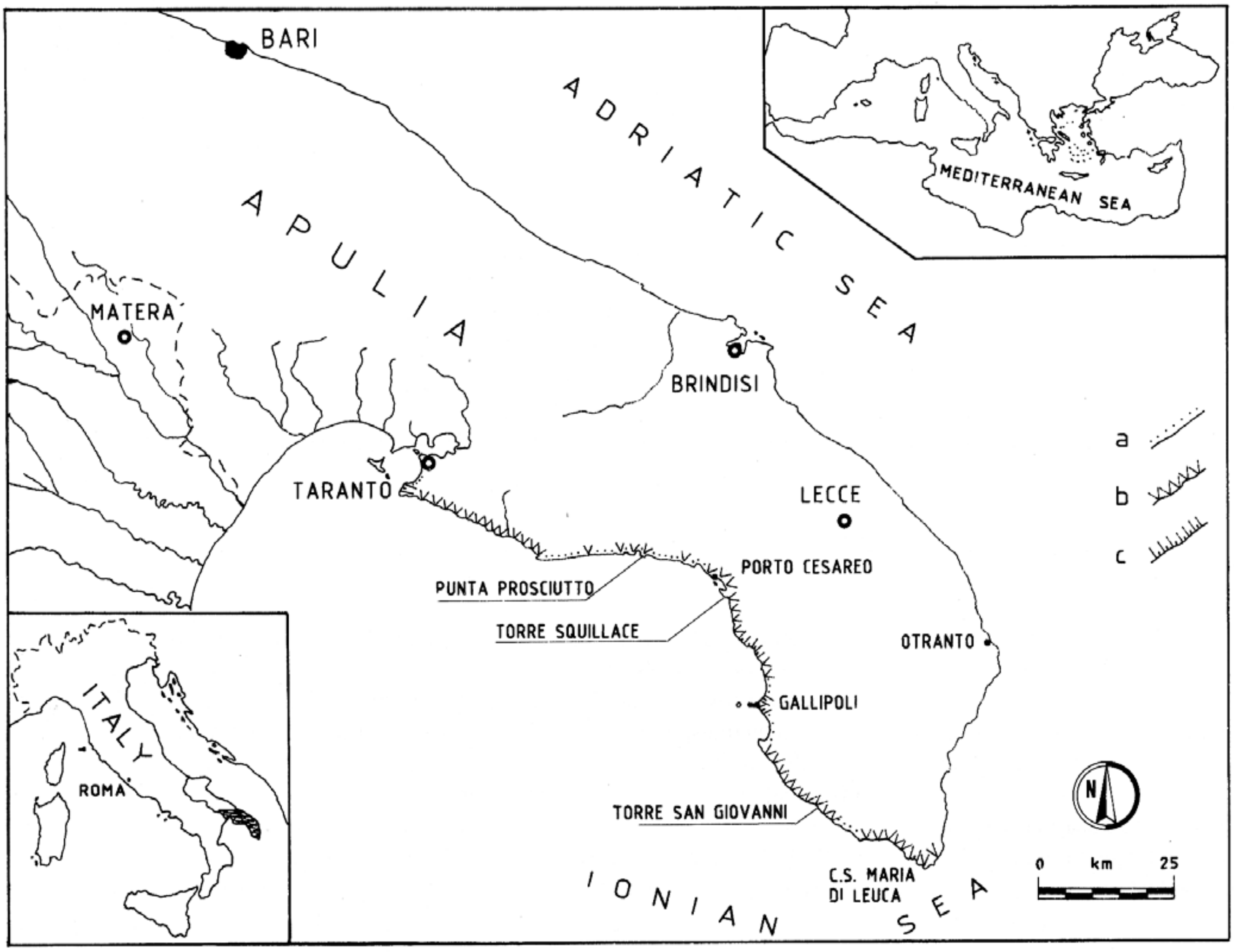


Figure 2.18 - *Morphological type of coast recognised along the Ionian coast of Salento peninsula. Legend: a) beaches; b) gently sloping and convex rocky coasts; c) cliffs.*

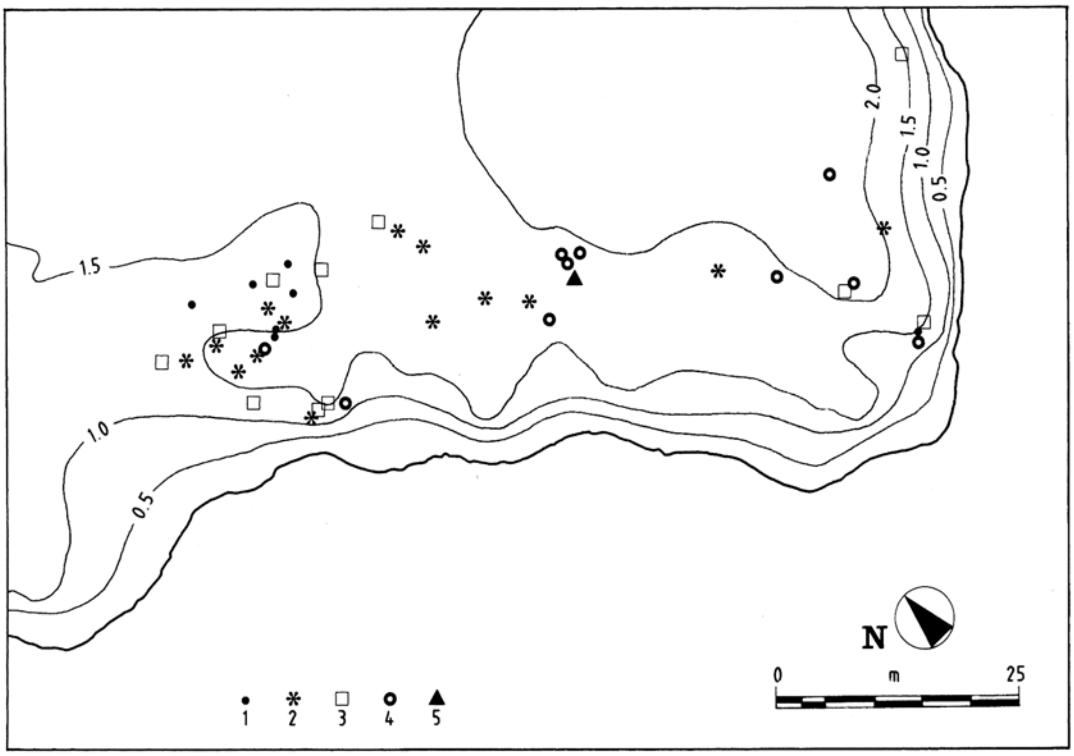


Figure 2.19 - *Distribution of boulders on the rocky platform of Torre Squillace. Boulder weight classes: (1) w< 1 ton; (2) 1< w< 2 tons; (3) 2<w<5 tons; and (5) w>20 tons.*

Boulder accumulations have been recognized in several localities along the Ionian coast, generally where gently sloping rocky coasts are shaped on seaward dipping, stratified, jointed calcareous sandstones, since these conditions promoted the detachment of rock slabs. These last ones, in fact, were ripped generally from the lower part of the spray zone, as suggested by solution features on their surface. More seldom, boulders were transported from below sea level as indicated by Vermetus encrustations, Bryozoa colonies and Lithophaga shells which affect their surface.

Two localities, Chiesa Valeriano (near Torre San Giovanni) and Punta Prosciutto (near Torre Colimena) are, in particular, characterised by a great number of boulders arranged in N-S oriented rows of imbricated elements. The imbrication axis distribution is the same for these two localities and suggest that boulder quarrying and transport were produced by a single, catastrophic wave train approaching the coast from the South.

Figure 2.20 - *A view of the largest boulder recognized at Torre Squillace locality.*

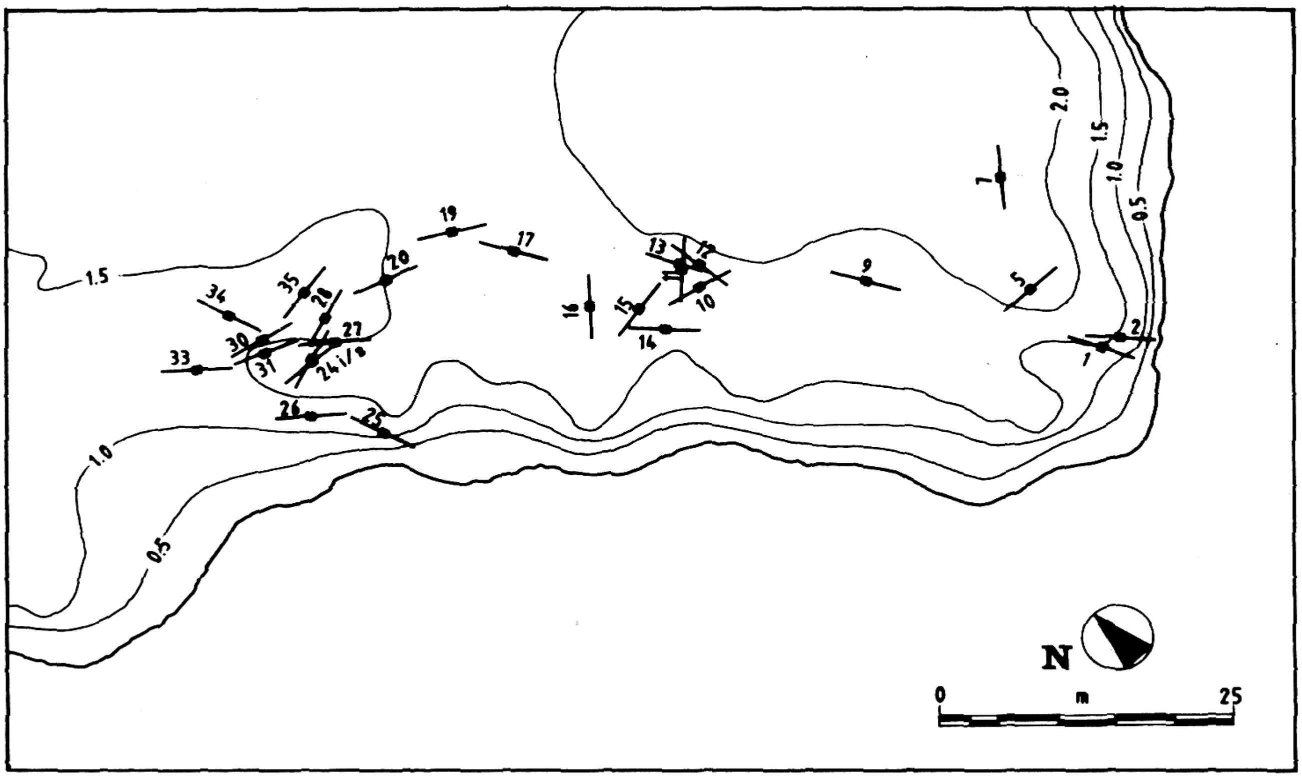


Figure 2.21 - *Long axis orientation of elongated boulders on the rocky platform of Torre Squillace. The resulting pattern shows that elongated boulders rotated during transport disposing their long axis tangent to the run-up fans responsible fro their deposition.*

Discussion

Boulder accumulations occurring along the Ionian coast of Apulia formed clearly during one or more catastrophic events that occurred in recent times. However, the remarkably limited range of long axis and imbrication axis distribution suggests that boulder quarrying and transportation was produced by a single, catastrophic wave train, most likely a tsunami, approaching the coast from the South.

Stratigraphical, morphological and historical data allow us to define the period in which this catastrophic event should have occurred. Some boulders occurring at Torre Squillace locality, in fact, rest on a residual cover of loose beach sediments that can be referred to about 6 ka on the basis of detailed studies carried out on Holocene deposits along these coasts (Dini *et al.*, 2000; Mastronuzzi and Sansò, 2002b). Moreover, the development of horizontal solution features on boulder surfaces implied a not very recent age for this event. On the other hand, the numerous coastal towers built all along this coast during the XV century have never experienced such a destructive event.

More precise age data have been obtained from rare boulders carved from below sea level and transported inland, supposing that they were transported by the same event recorded by the Torre Squillace boulders.

At the Punta Prosciutto locality, one of them shows on the surface encrustations of Vermetids and Bryozoa colonies as well as very diffuse boreholes and shells of Lithophaga.

Radiocarbon age determinations were perfomed both on Bryozoa specimen and Lithophaga shells. An AMS radiocarbon age determination carried out on the former yielded a modern age (less than 100 years BP). Conventional radiocarbon dating performed on Lithophaga shells supplied a non-calibrated age of 700±65 years BP. Age calibration performed according to the Delta R value available for this area would indicate an age between the XV and the XVII century.

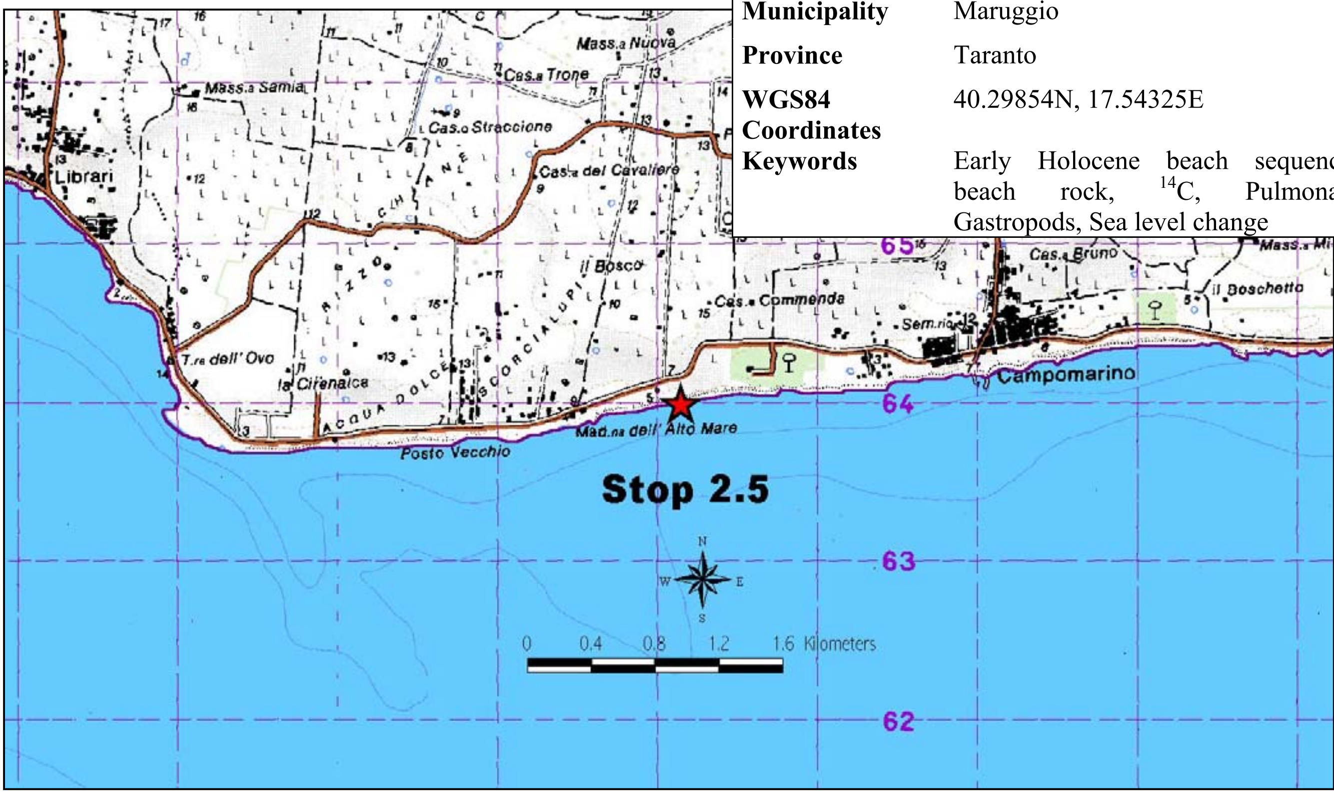
However, historical chronicles do not report tsunamis along the coasts of southern Italy during this period (Tinti and Maramai, 1996), which were deserted because of the occurrence of coastal swamps and the diffusion of malaria. Moreover, the strong attenuation od seismic sea waves in the Mediterranean (Soloviev, 1990) does not allow us to refer the examined catastrophic event recorded along the coasts of southern Apulia to one of the numerous tsunamis which occurred in the same period along the Hellenic, Israeli and Lebanon coasts (Antonopoulos, 1979).

Only Blandamura (1925) reports that the medieval village of Il Casale, placed at Punta Lo Scanno on the Chéradi islands, just few tens of kilometers to the north of the investigated area, was destroyed by an earthquake and flooded by high sea waves. This event most likely occurred during the very strong earthquake which hit southern Italy on December 5th, 1456 (Boschi *et al.*, 1997).

In our interpretation, boulder accumulations recognized along the Ionian coasts of southern Apulia are the effect of a tsunami, most likely related to the December 5th, 1456 earthquake, which approached the coast from the South.

Stop 2.5

Locality	Scorcialupi, Campomarino
Municipality	Maruggio
Province	Taranto
WGS84 Coordinates	40.29854N, 17.54325E
Keywords	Early Holocene beach sequence, beach rock, ^{14}C, Pulmonate Gastropods, Sea level change



Stop 2.5 - The Campomarino Beach sequence: an evidence of Early Holocene relative high sea-level in a supposed stable tectonic area (A. Iannone, G. Mastronuzzi, P. Sansò)

Some morphological elements are very important for the reconstruction of past sea-level stand. In the Mediterranean basin, sea levels indicators are derived from lithological, archaeological and biological sources. In particular, notches and beachrock indicate the intertidal zone (i.e.: Dalongeville and Sanlaville, 1982; Paskoff and Sanlaville, 1983; Dalongeville, 1987; Pirazzoli, 1996). Beachrock can not easily dated due to the lack of material suitable for radiometric analyses; the problem is more important along the beaches nourished by carbonatic bioclastic sands since is very difficult to separate carbonatic cement.

To the North of Campomarino harbour, at Scorcialupi locality, a continuous sequence of beachrock and associated backshore/dune sediments allows to overcome the datation problem (Fig. 2.22). In this locality, infact, beachrock crops out along a strip stretching up to 63 +/- 10 cm above the limit of living brown algae (Fig. 2.23). Along the coast between Taranto (to the NW of Campomarino) and Gallipoli (to the SE of Campomarino) the tide is characterised by maximum range of 40 cm; beachrock can be observed up to 23 +/- 10cm above high tide sea-level.

The beachrock is formed of medium-sized sand particles well cemented and moderately-sorted; they are a packstone composed essentially by fragments of molluscs, red corallinae algae, echinoids, briozoan, benthic foraminifers, intraclasts; detrital grains are also present. Isopachous carbonatic cement forms fringes of uniform crystals grown radially to grain surfaces, whereas interparticle voids are filled of micrite rarely peloidal, in which are dispersed small silty-sized skeletal fragments.

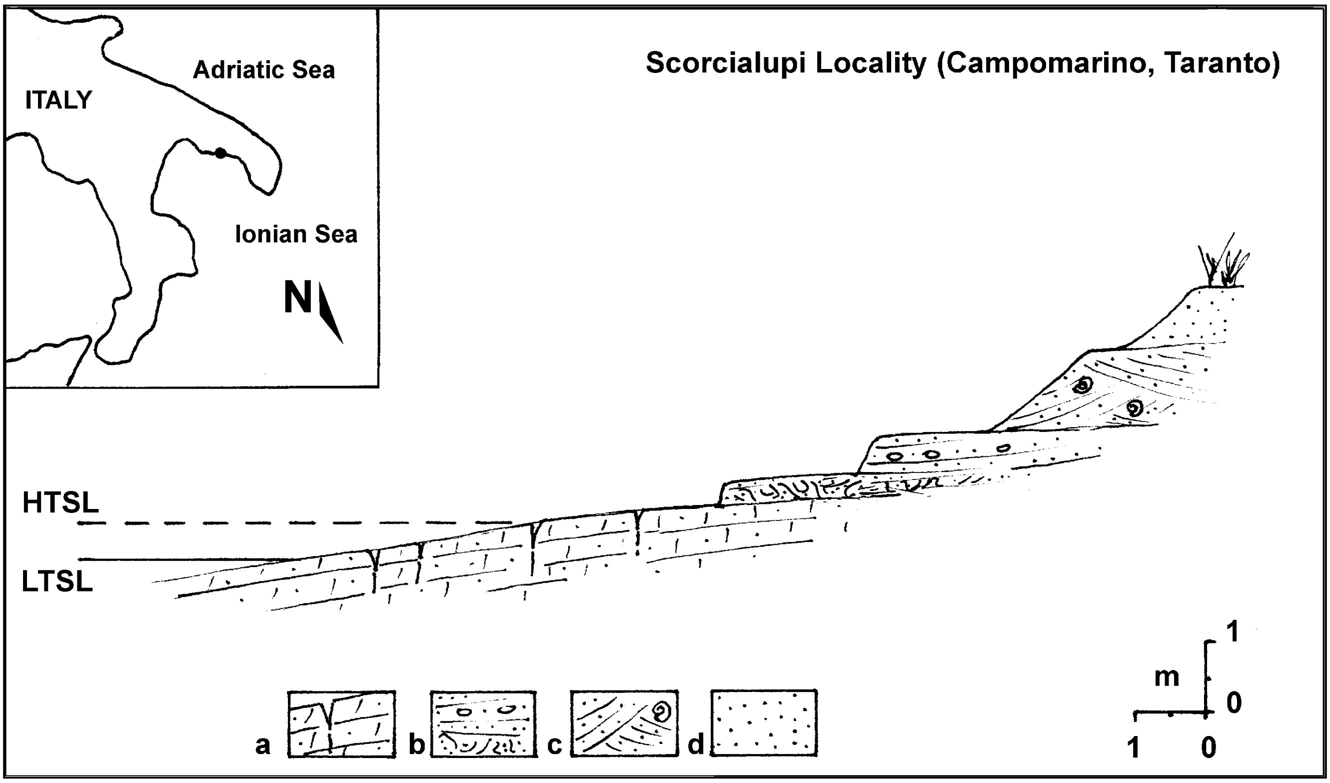


Figure 2.22 - *Schematic stratigraphic sequence recognised at Scorcialupi locality, Campomarino. Legend: a - beachrock; b - shoreface/backshore sediments; c - dune sediments with pulmonate gastropods; d - Greek-Roman dune deposits.*

Figure 2.23 - *A view of the Campomarino beachrock.*

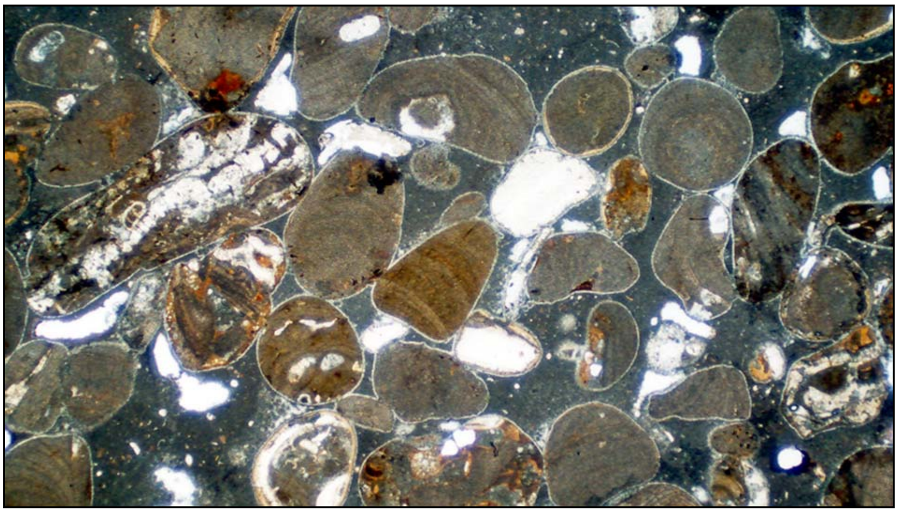
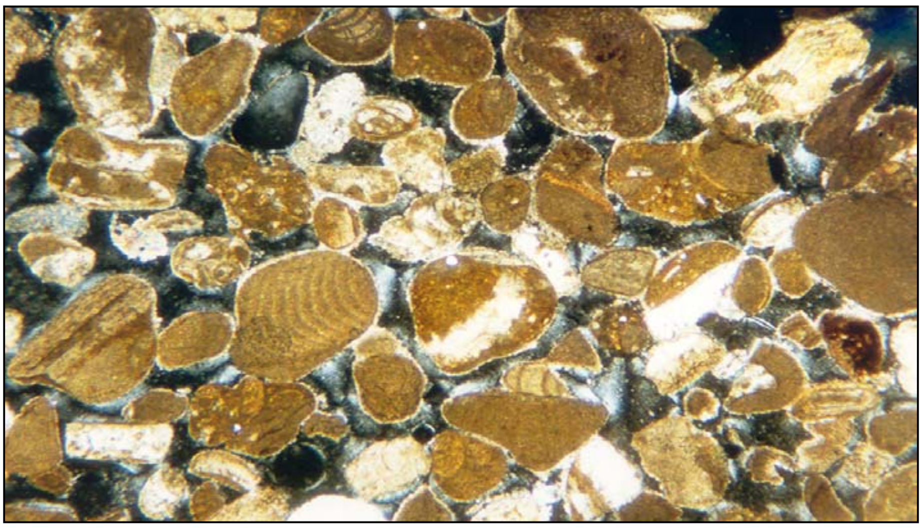


Figure 2.24 - *The beachrock is a packstone composed mainly by fragments of molluscs, red corallinae algae, echinoids, briozoan, benthic foraminifers, intraclasts; detrital grains are also present. Note the isopachous carbonatic cement which forms fringes of uniform crystals grown radially to grain surfaces.*

Figure 2.25 - *Dune deposit is composed of a grainstone with well rounded fragments of molluscs, red corallinae algae, echinoids, briozoan, benthic foraminifers, intraclasts; detrital grains are rare.*



These diagenetic features indicate early cementation of beachrock in intertidal environment under marine-phreatic condition; on the other hand the silty matrix indicates an emergence and a second phase of diagenesis in vadose environment (Fig. 2.24).

The beachrock grades upward into emerged beach sediments that represent the foreshore/backshore area; they are characterised by low angle cross lamination and marked by discontinuous level of small pebbels.

The sequence shades upward into an aeolianite with remains of pulmonate gastropods (*Helix* sp.). The aeolianite is characterised by high angle cross lamination. Its sediments are formed of well sorted fine-sized sand particles medium cemented; it is a grainstone composed by well rounded fragments of molluscs, red corallinae algae, echinoids, briozoan, benthic foraminifers, intraclasts; detrital grains are rare (Fig. 2.25). The aeolianite forma a belt running about parallel to the present coastline. It belongs to the oldest Holocene dune belts that marks the most of southern Puglia coastal area. It has been referred to the post glacial maximum transgression occurred about 6500/7000 years BP (Mastronuzzi and Sansò, 2002b). In particular, on the Ionian side of Puglia region these aeolian deposits have been recognized and dated in several localities. In the surroundings of Torre Sabea, this aeolian unit covers a red soil characterized by the remnants of a Neolithic village which yielded an uncalibrated ^{14}C age of 7900 ± 50 years BP (Mastronuzzi *et al.*, 1989). Helix spp. specimens collected near Torre San Vito in a dune which buried a marine cliff, cut in the last interglacial marine terraced deposit, reveals a conventional ^{14}C age of 6386±70 years BP. According to Cotecchia *et al.* (1969), an aeolianite covering the last interglacial deposit at Posto Li Sorci locality is dated at 6.780 ± 125 years BP .

^{14}C AMS analysis performed on a *Helix* sp. shell (Campo 1 sample) collected in the dune deposit just above Campomarino beach deposits yielded the conventional age of 6600+/- 40 years BP (7546 +/- 21 cal years BP) (Table 3).

According Goodfriend (1983; 1987), Jedoui at al. (1998) and by Fontugne (pers. comm., 2003) radiocarbon age determinations on pulmonate gastropods living on calcareous sandstone could yield some dating problems. Infact, gastropods ingest micro carbonate particles to build their shells. As a consequence of this “biogenic” pollution, shells radiocarbon ages could be older from few centuries to more than two millennia (Goodfriend, 1983; 1986) than real.

However, in our case the age indicated by AMS ^{14}C age determination of Campomarino dune agrees with data coming from dunes placed along the Ionian and Adriatic coast of Puglia region. This aeolian unit formed in a relatively short span of time ranging from 6780 BP to about 5290 conventional years BP, corresponding to 7651 - 6062 cal years BP (Mastronuzzi and Sansò, 2002b).

Discussion

The Campomarino beach sequence suggests with a good definition the position reached by the post glacial maximum transgression along the coast of Puglia. Post glacial trend in "eustatic" sea level can be generally represented by a rapid rising in the early Holocene decelerating sharply around 6500 yr BP, after which only slow sea level rise occurred. Along the Ionian coast, the Campomarino beachrock is at least up to 63 +/- 10 cm above present limit of living algae corresponding to the biological sea level (Laborel and Laborel- Deguen, 1994). Mean tidal range here is about 40 cm; it allows us to calculate a high sea-level stand not less than 25 +/- 10 cm above present sea level whereas the first occurrence of *Helix* sp. in the following beach/dune deposit fixes it at about 7.5 ka cal years BP.

The Campomarino beachrock indicate that after the last glacial low stand, sea-level rose quickly until about 7500 years BP reaching the maximum position at about 0,5 m above the present one; this high stand promoted a first, important phase of beach-dune belt formation. A sea-level drop testified by presence of silt matrix followed.

The field data collated in Campomarino point out a peculiar sea level curve during the Holocene for the southern Apulia coast very different from that one reconstructed from Tyrrhenian coasts of Italy and from curves suggested by available models. Since Campomarino area is considered to be affected by a very small uplift (0.18 m/ka) on the base of altimetrical position of Last Interglacial (OIS 5e) shoreline, the reconstructed Holocene sea level change should be most due to glacioeustasy. The discrepancy from the result of glacioeustatic models could be due to the complex geodynamic structure of Adria plate.