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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

Otranto / Taranto - Puglia (Italy) 22-28 September 2003
Quaternary coastal morphology and sea level changes

Project 437

1st day

Late Quaternary sea-level change evidences in a stable coastal area

by

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Introduction

The coastal landscape from Otranto to Leuca, along the eastern coast of southern Salento, is dominated by a steep slope extending from about 100 m above m.s.l. to about 50 m of water depth (Fig. 1.1). This first magnitude landform has been interpretated by several Authors as a high, degradated fault scarp (i.e. Palmentola and Vignola, 1980). However, recent geological studies pointed out that this regional slope roughly coincides with the Late Cretaceous margin of the Apulia platform (Bosellini and Parente, 1994) (Fig. 1.2). Along this margin several carbonate systems are laterally disposed and grafted one upon the other. Three of these systems are clinostratified and include well developed reef tracts of Priabonian, early Chattian and early Messinian age (Fig. 1.3) (Bosellini *et al.*, 1999).

The cause of this unusual stratigraphic architecture is the relative tectonic stability of the Salento peninsula which acted since the late Cretaceous as an elevated area in the center of the wider Mesozoic Apulia carbonate platform. This elevated area recorded the most important geodynamic events occurred in the area such as the mid-Cretaceous emersion and retreat of the Apulia platform margin, the yo-yoing movement associated with the development of a foreland bulge and subsequent foreland basin related to both the Hellenides-Dinarides and Apennine thrust system, and the final Pleistocene uplift.

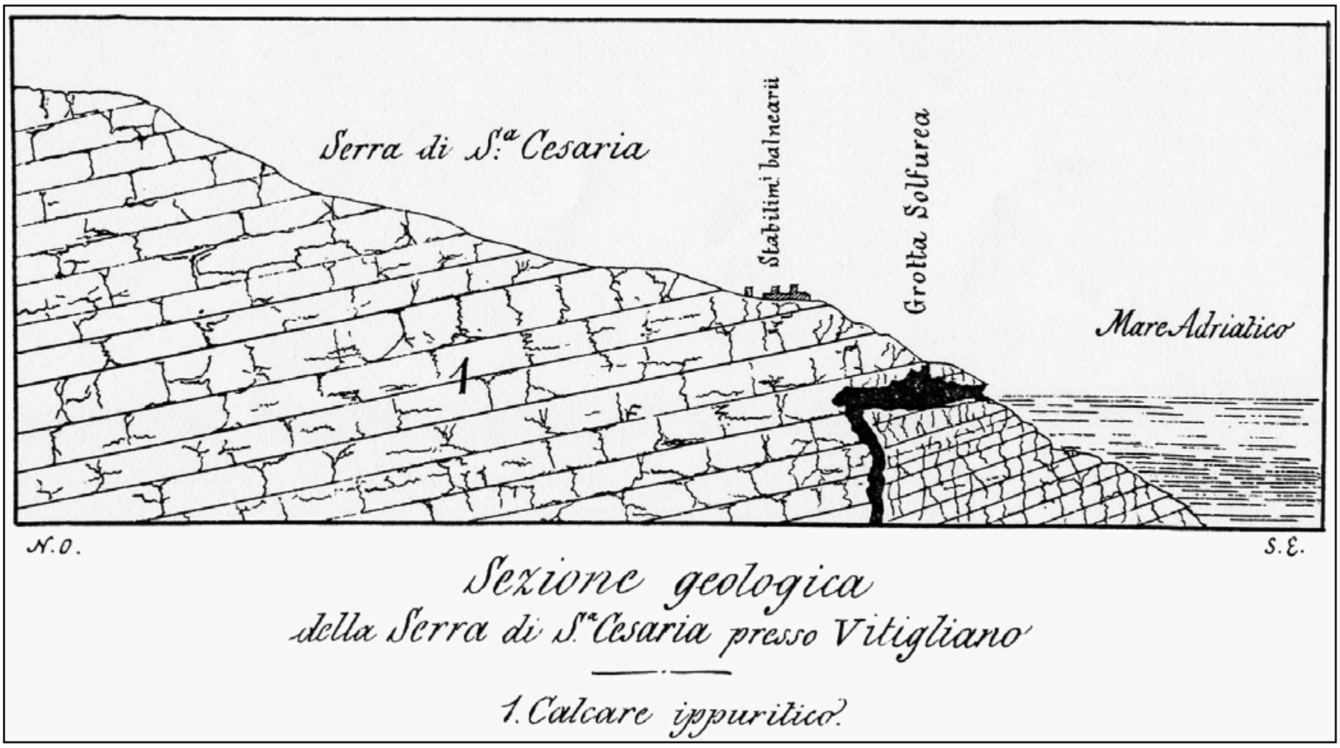


Figure 1.1 - *The geological cross section of Santa Cesarea coastal slope after De Giorgi (1922). The rising of thermal sulphuric sea waters along a main fault plane is shown.*

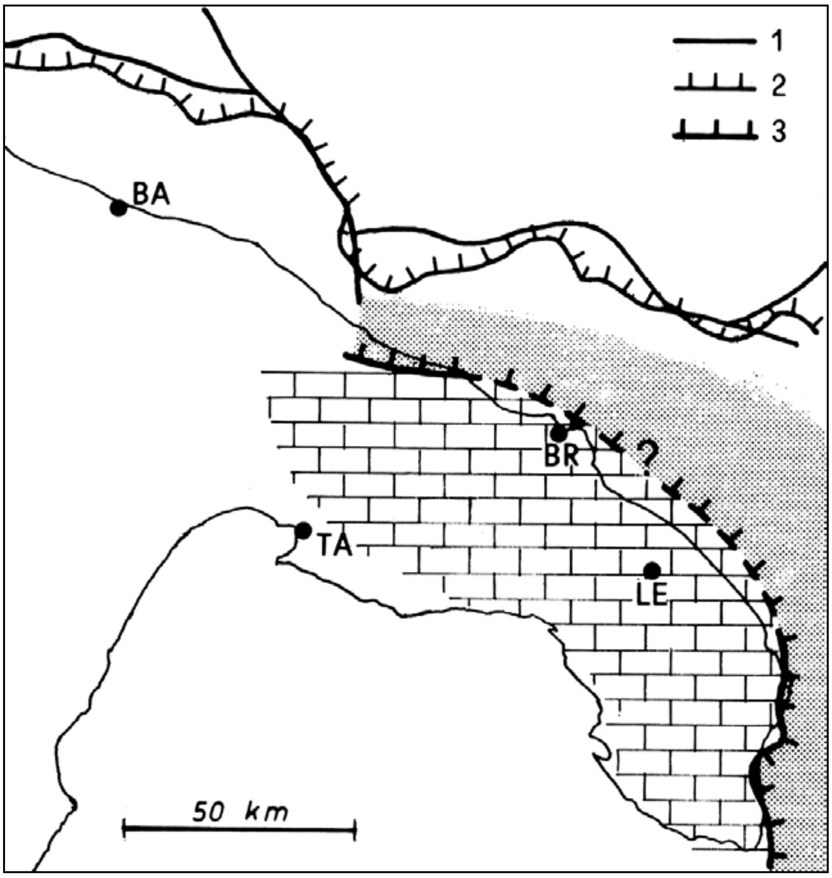


Figure 1.2 - *The eastern margin of Apulia carbonatic platform according to: 1. De Dominicis and Mazzoldi (1987), 2. Ricchetti et al. (1988), 3. Bosellini and Parente (1994).*

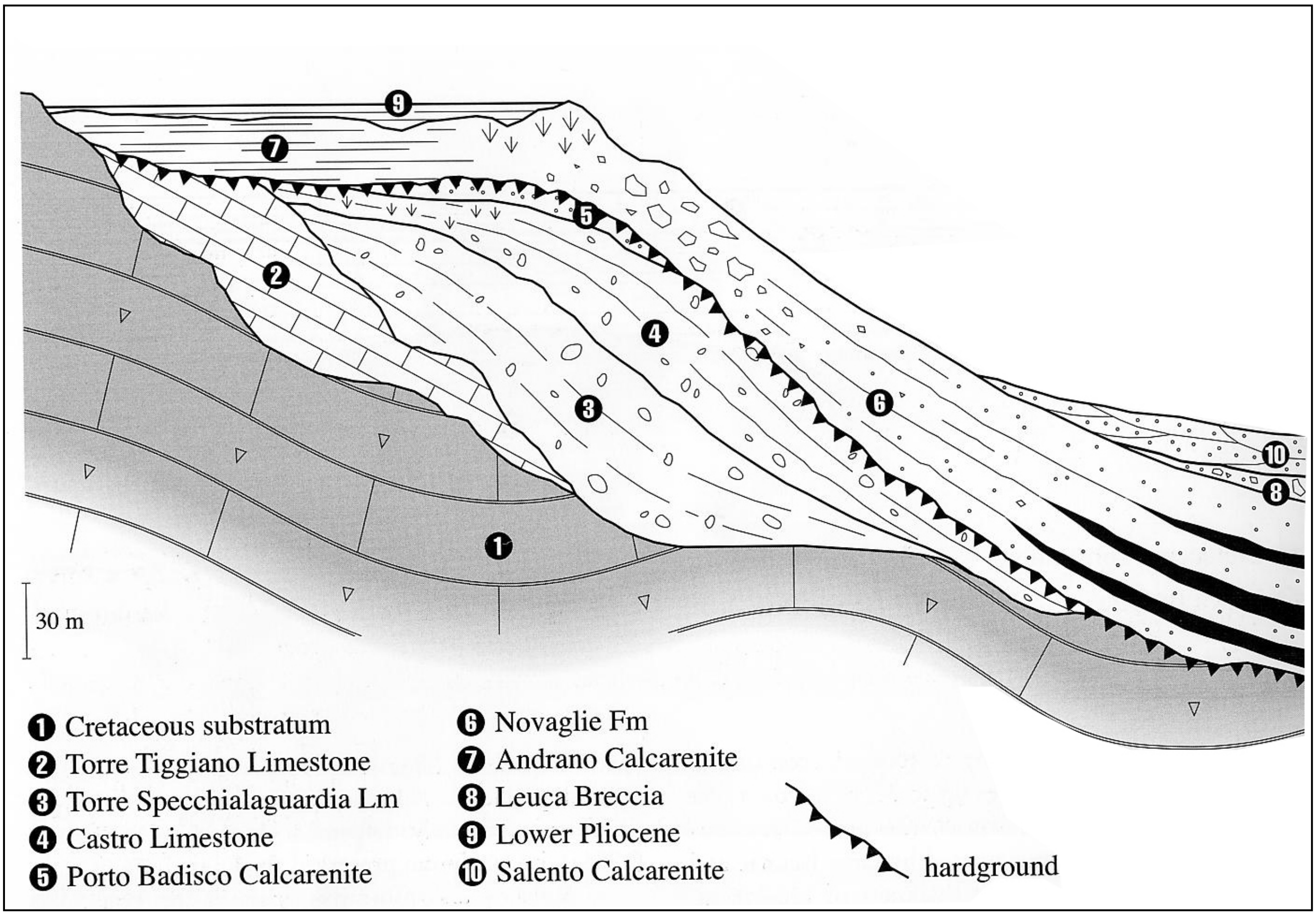
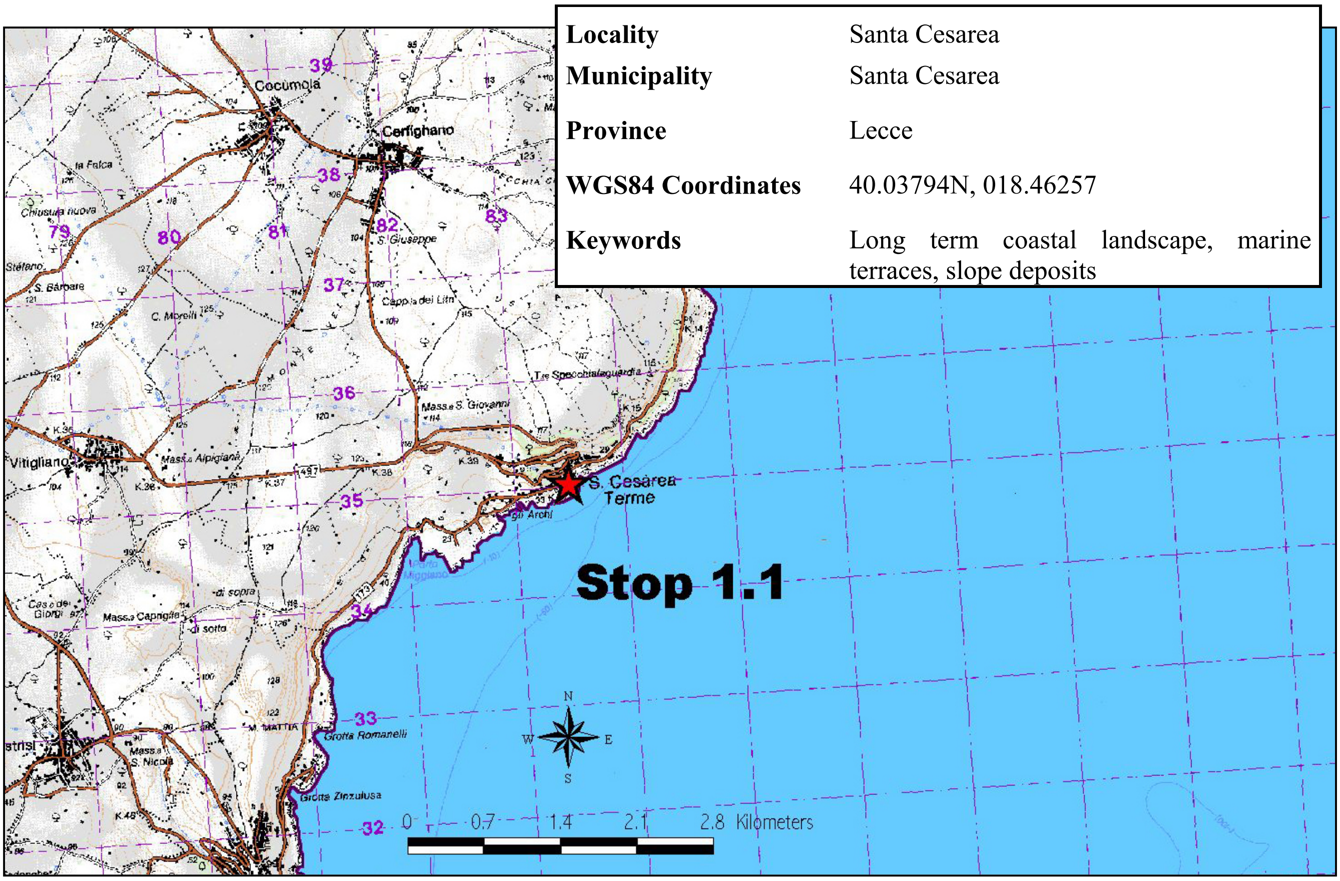


Figure 1.3 - *Schematic diagram showing the Apulia platform margin and the slope stratigraphy of the eastern Salento peninsula (from Bosellini et al., 1999).*

Site 1

Locality	Santa Cesarea
Municipality	Santa Cesarea
Province	Lecce
WGS84 Coordinates	40.03794N, 018.46257
Keywords	Long term coastal landscape, marine terraces, slope deposits



Stop 1.1 – The longterm coastal landscape from Otranto to Santa Maria di Leuca (E. Centenaro, F. Gianfreda, G. Mastronuzzi, P. Sansò)

The submerged and emerged part of the coastal slope is marked by platforms, discontinuous notches and relict sea caves (Mastronuzzi and Sansò, 1991; Parroni and Silenzi, 1997;Centenaro *et al.*, 1998; 2002).

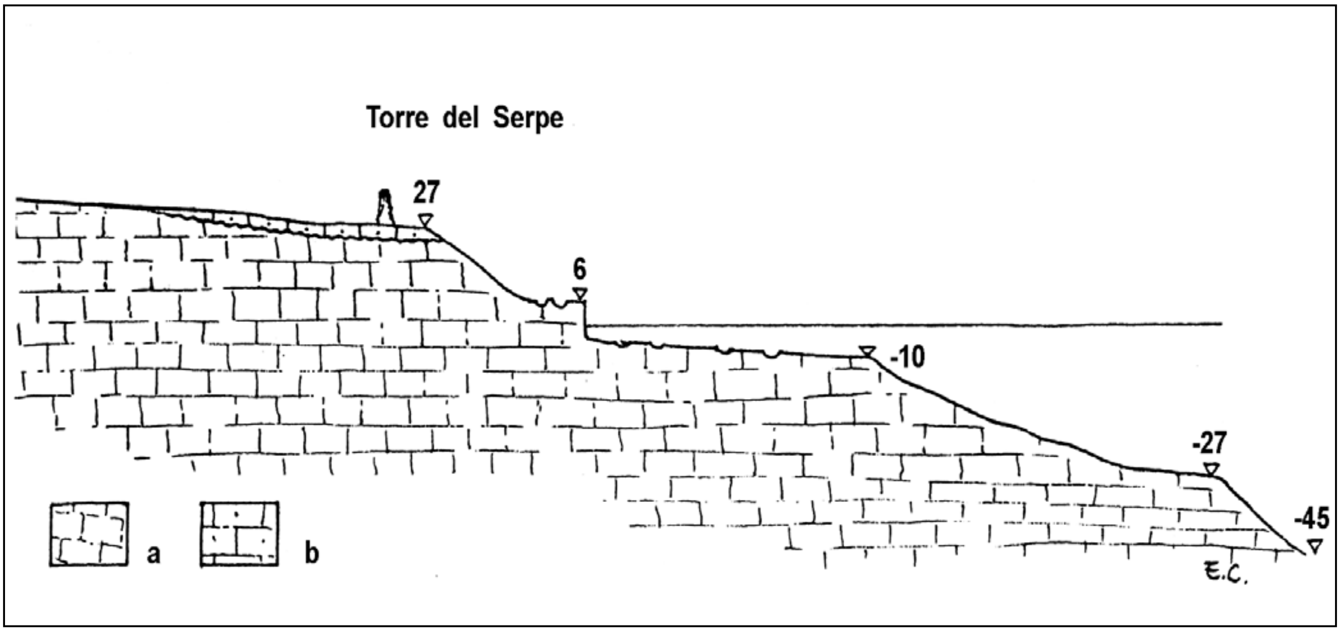


Figure 1.4 - *Morphological cross section of the eastern Salento coastal slope at Torre del Serpe locality. Legend: a) Mesozoic limestones; b) Calcareniti di Andrano formation.*

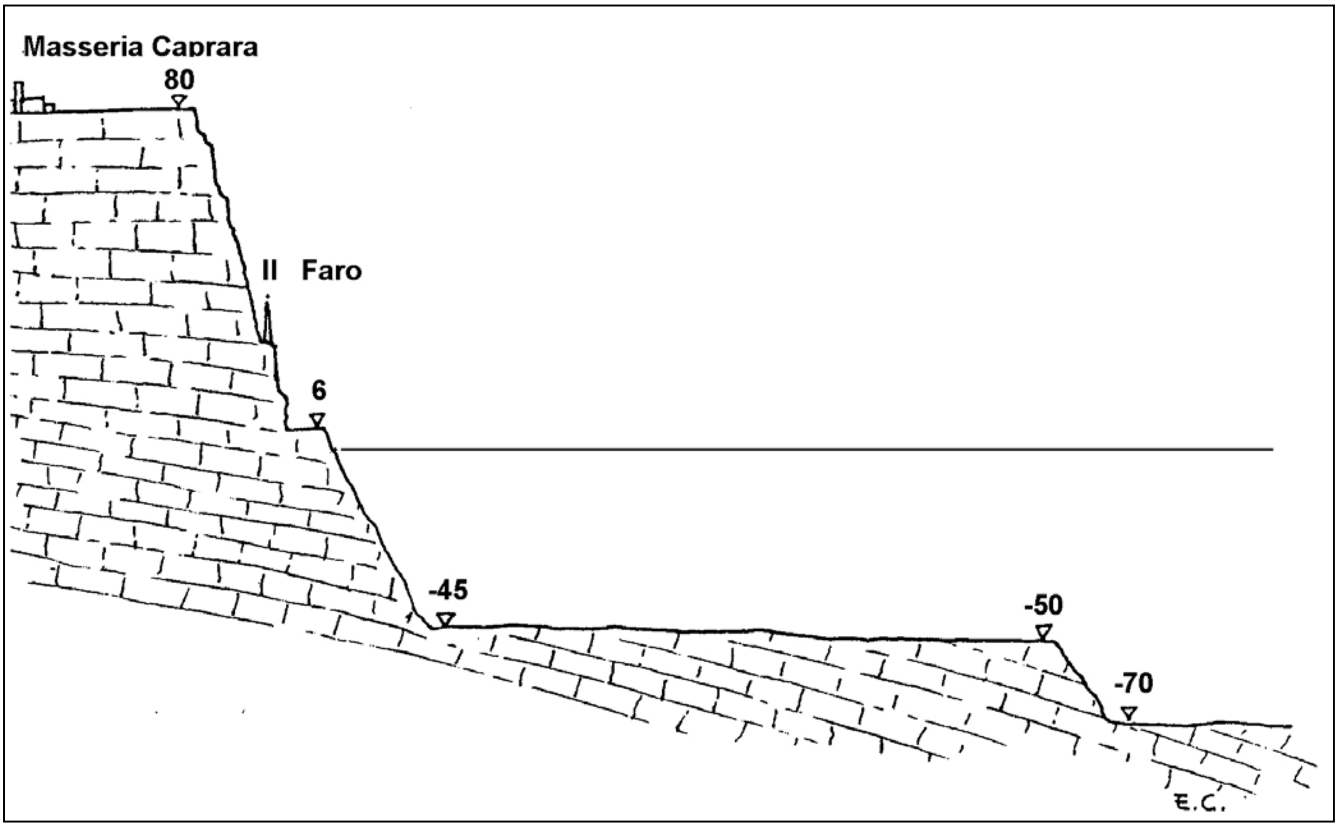


Figure 1.5 - *Morphological cross section of the eastern Salento coastal slope to the south of Capo d'Otranto locality.*

In details two platforms, at about 5 m and between 20 and 50 m of depth, are well recognisable in the area of Torre del Serpe (Fig. 1.4). To the south of Capo d'Otranto, a steep slope joins the outer edge of IV order terrace to a 2 km wide platform placed at about 50 m of depth (Fig. 1.5).

The outer edge of this platform is represented by step about 10-16 m high sloping about 12°. The surface of platform is widely covered by coralligenous with intervening patches of sands, bedrock or silt.

The emerged part of the steep coastal slope is marked by four raised abrasion platforms (figg. 1.6, 1.7). The highest is placed at 65 m and cut through the *Sabbie di Uggiano Formation*. Its inner margin is marked by some caves, most likely of marine origin, and a notch largely modified by the long subaerial exposure so that it does not retain biogenic features anymore. The second platform can be recognized at an altitude of 40 m, shaped on the *Calcarenite di Porto Badisco Formation*. A tectonic phase occurred before the formation of the third surface, as testifies by a 10 m displacement of the second surface. Two lower platforms mark the emerged part of the coast at 15÷20 m and at 8-10m above p.s.l..

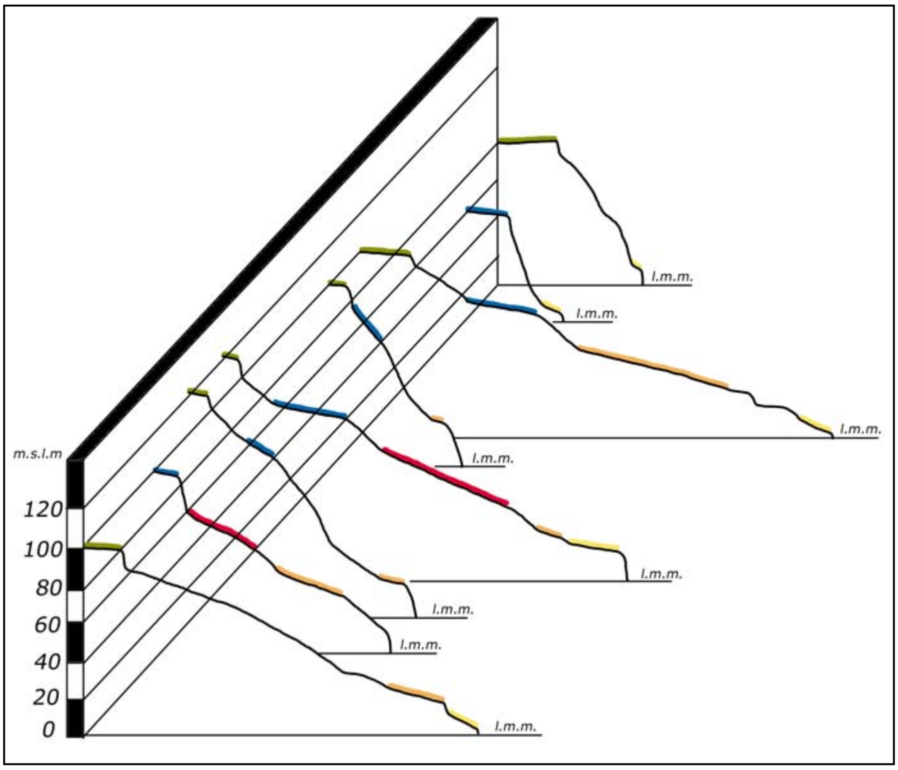


Figure 1.6 - *Synoptic view of cross profiles carried out at several localities along the Otranto - Castro coastal slope.*

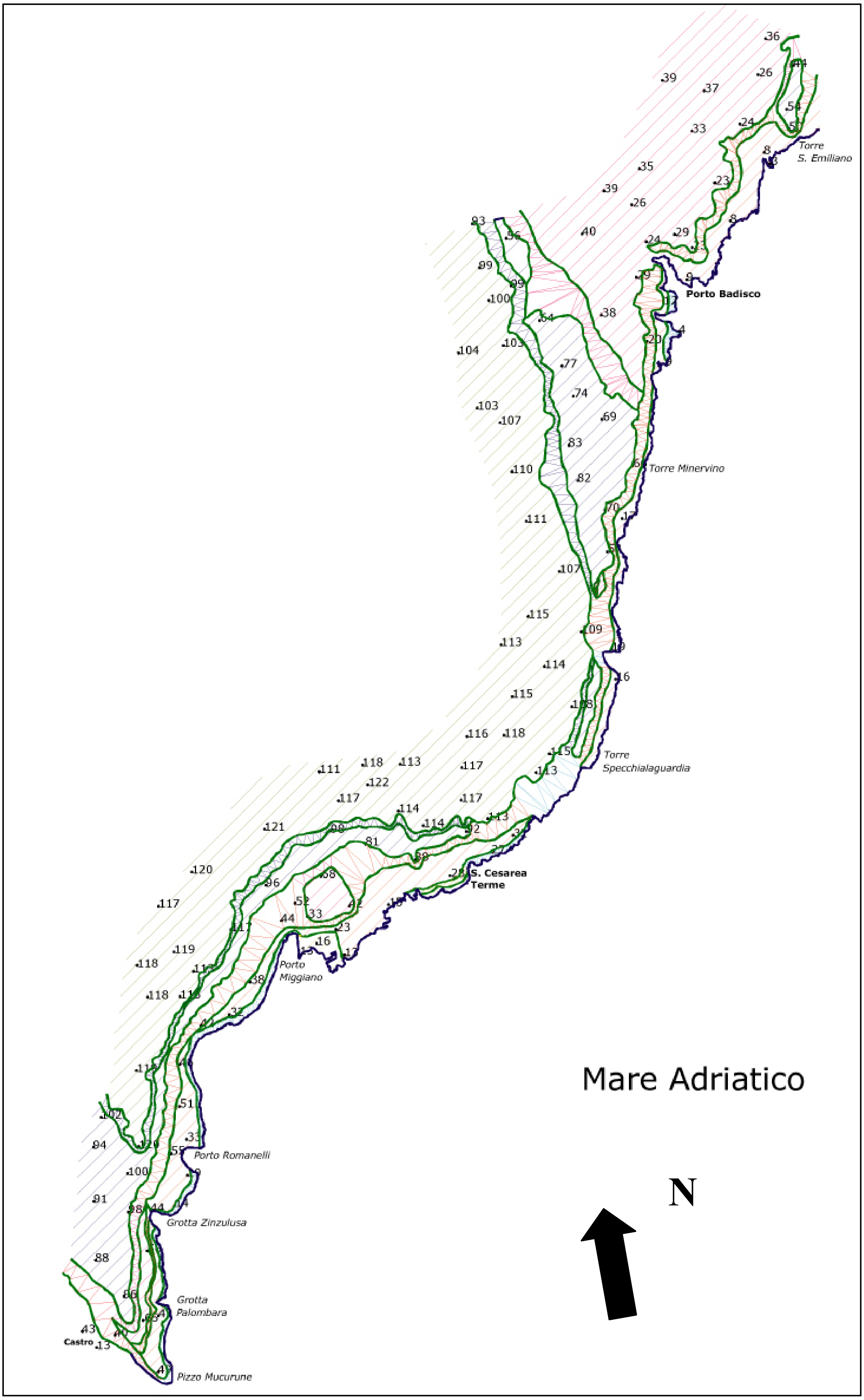


Figure 1.7 - *Geomorphological map of Otranto-Castro coastal slope. Arrows indicate relict cliff; lined areas mark terraces surface.*

Figure 1.8 - *A view of Grotta Romanelli bay. A subaerial erosional notch divides the Mesozoic limestones (lower part) from the clinostratified Castro limestone (upper part).*

Figure 1.9 - *A view of the marine notch placed at about 10 m above p.s.l. at Grotta Romanelli*

The lowest surface is represented by a narrow wave-cut platform, recognizable at Grotta Romanelli (Fig. 1.8, 1.9) and Le Striare (Fig. 1.10) localities. In the first place the platform is at about 7.4 m above the present biological mean sea level and is related to a notch and a belt of boreholes by Lithophags ending at about 9.8 m above biological m.s.l.. In the second locality the platform is placed at about 2 m above the biological mean sea level and seems related to a notch whose base is placed at about 6.7 m above the biological mean sea level. Both the platforms constituted the pavement of coastal caves and are marked by potholes covered by a thin beach deposits made of pebbles with rare fossil remains without any significance (*Patella lusitanica* Gmel., *Conus mediterraneus* Brug., *Trochus umbilicoris* L., *Littorina neritoides*, L.) (Blanc, 1921) (Fig. 1.11). Notwithstanding no absolute age determinations have been obtained for these deposits, they have been referred to the last interglacial on the base of their altitude and are often used to calculate the late Quaternary uplift of this region (i.e. Cosentino and Gliozzi, 1988; Bordoni and Valensise, 1998). The subsequentely development of a thick slope deposits, generally represented by red breccia, covered the small abrasion platform and the cave placed at its inner margin (Fig. 1.12). Breccia deposits is marked by numerous bones of vertebrates indicating temperate-warm climatic conditions (*Elephas* sp, *Hippopotamus* sp, *Cervus* sp, and soon on) (Di Stefano *et al.*, 1992). This deposit has been generally referred to the last interglacial period (OIS 5c or 5a) on the base of its altitude

However, the occurrence of some archaic carnivores (*Canis* cf. *mosbachensis*) pointed out by Sala (1980) and by Masini *et al.* (1991) would indicate the terminal part of Middle Pleistocene.

Thick slope deposits developed during last glacial age promoted by cold-dry climatic conditions. These deposits are made by a coarse breccia, retaining large amount of vertebrate fossils, shading upward to thin laminated sandy layers (Fig. 1.13). Pulmonate gastropods collected in the sandy levels in the upper part of sequence yielded an AMS radiocarbon age of 27615±345 years BP.

Figure 1.10 - *The wave-cut platform placed at about 2 m above p.s.l. backed by Le Striare caves.*

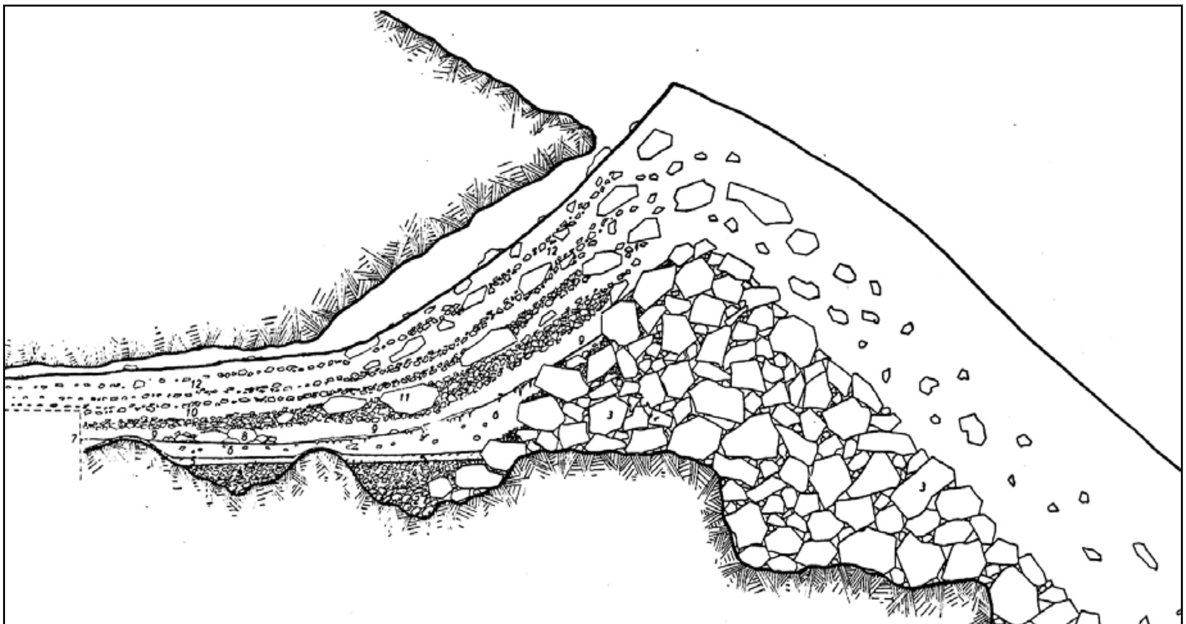


Figure 1.11 - *Schematic cross section of Grotta Romanelli filling (from Blanc G.A., 1953, modified).*

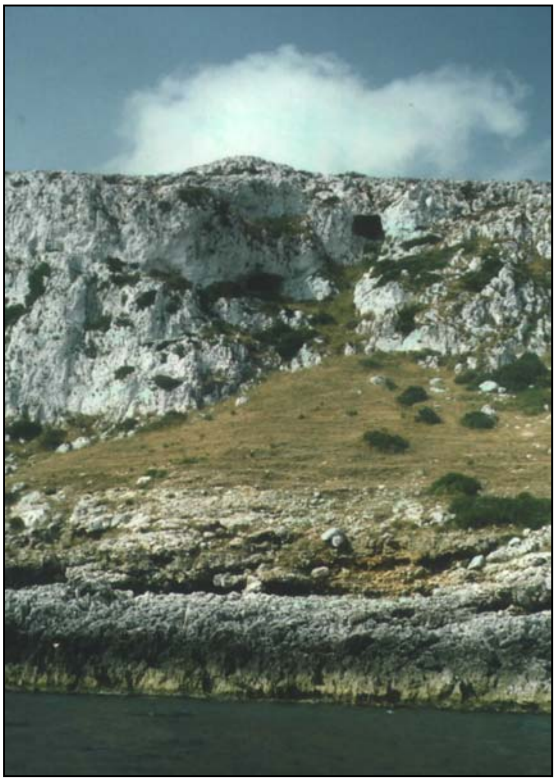
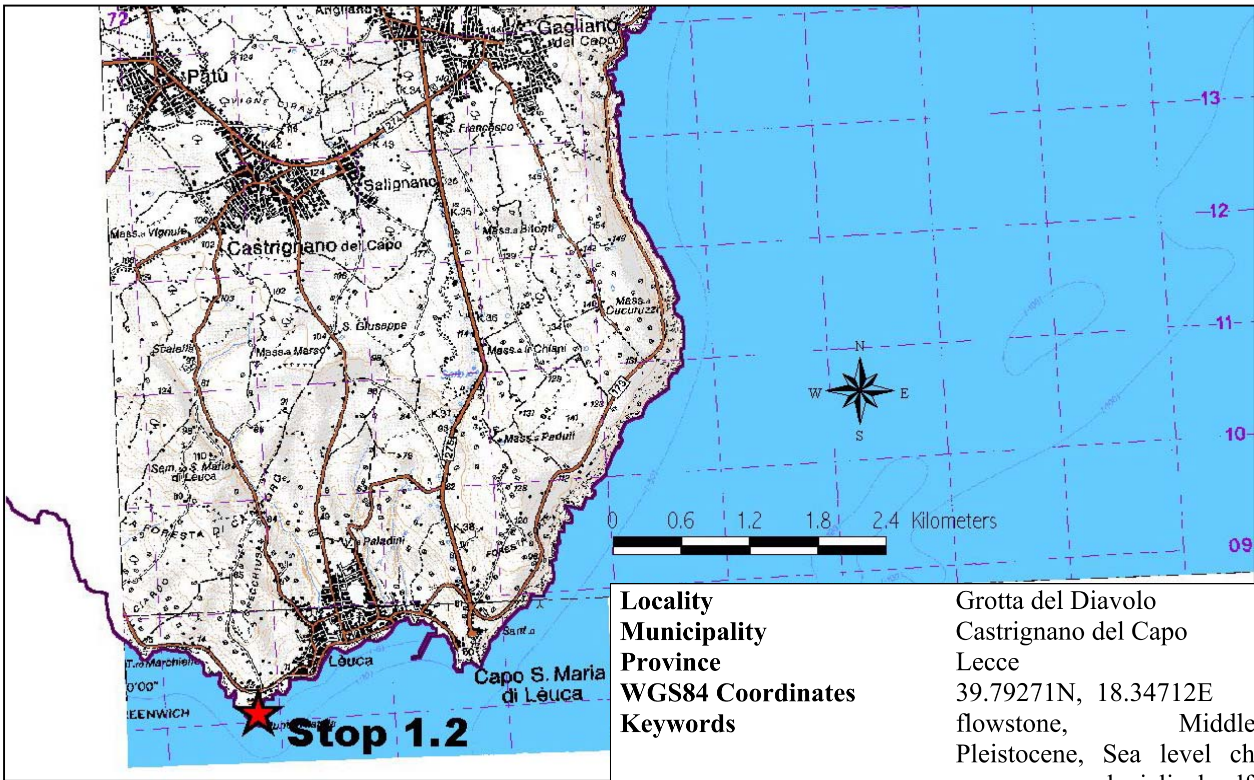


Figure 1.13 - *Thin laminated sandstones with continental gastropods close upward the Otranto-Leuca slope deposits.*

Figure 1.12 - *A view of the thick slope deposit which mantles the Otranto-Leuca coastal slope.*

Site 1.2



Locality	Grotta del Diavolo
Municipality	Castrignano del Capo
Province	Lecce
WGS84 Coordinates	39.79271N, 18.34712E
Keywords	flowstone, Middle-Late Pleistocene, Sea level change, sea caves, polyciclic landforms, U/Th age, Uplift rates

Stop 1.2 - The Grotta del Diavolo sequence: a key to understand the Middle-Late evolution of a stable coastal area (G. Mastronuzzi, Y. Quinif, P. Sansò, G. Selleri)

Numerous sea caves studded the coast of Salento peninsula (Fig. 1.14) (Orofino, 1986; Dantoni and Onorato, 1995; Onorato *et al.*, 1999; Centenaro *et al.*, 1998; 2002).

They are shaped in Upper Mesozoic or Oligocene limestones and contain more or less complex stratigraphic sequences made by marine and continental deposits. These sequences have been studied throughout the first half of the last century for the rich palaeontological and palethnological contents of continental levels (i.e.: Botti, 1871; Blanc *et al.*, 1958; Palma di Cesnola and Borzatti, 1964; Graziosi, 1971; Piperno, 1991; Di Stefano *et al.*, 1992). Notwithstanding, no detailed geomorphological and stratigraphical analyses have been carried out so far. Some suggestions about relative sea level changes recorded in the cave fillings have been formulated but they have been never supported by direct geomorphological evidences or absolute age determinations (Blanc, 1953; Anelli, 1967; Cassoli *et al.*, 1978; Cosentino and Gliozzi, 1988).

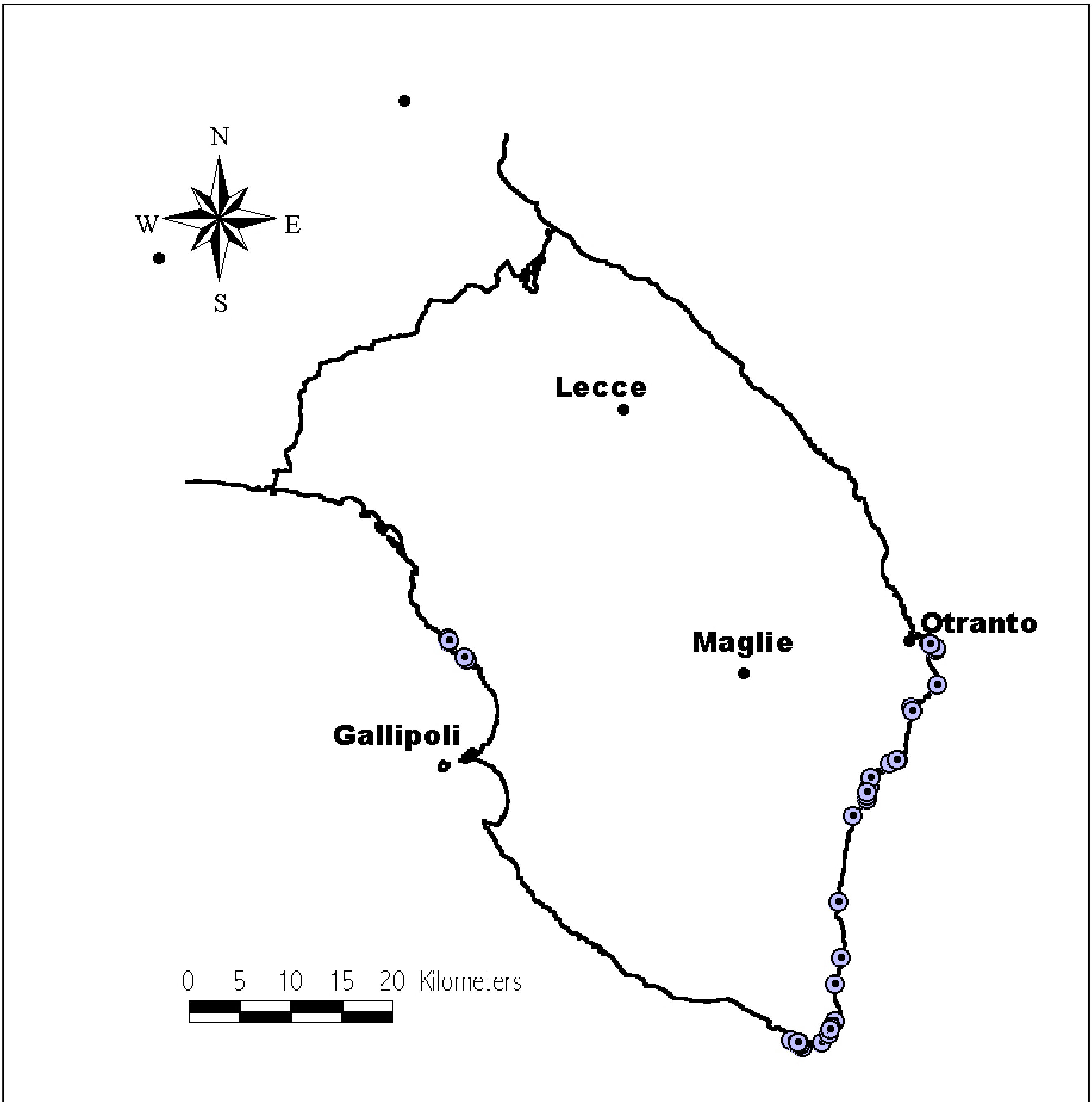


Figure 1.14 - *Geographical position of main sea caves recognized along the coast of southern Salento.*

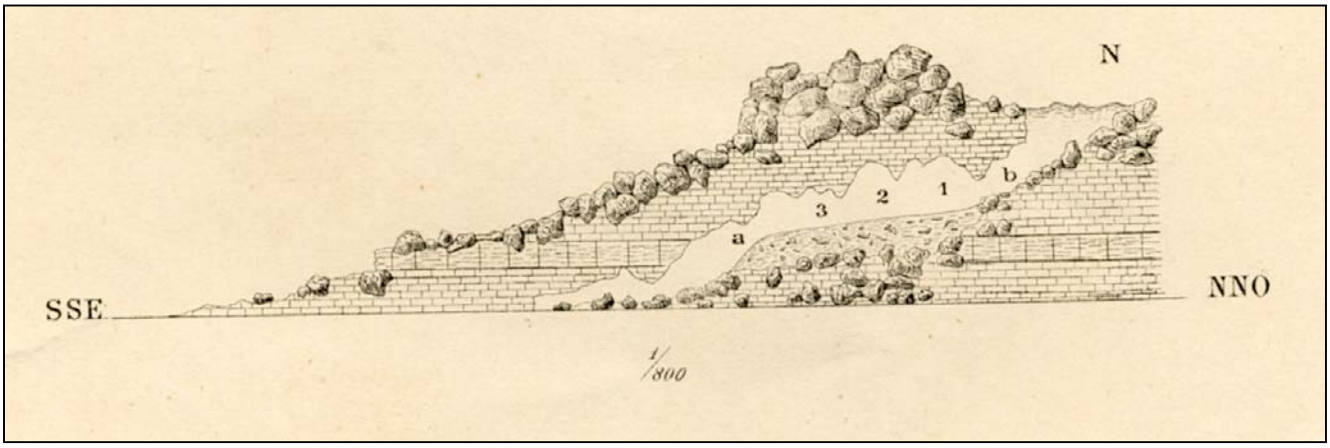


Figure 1.15 - *Geological cross section of Grotta del Diavolo from Botti (1871).*

Figure 1.16 - *The opening of Grotta del Diavolo cave.*

Cave fillings shows generally at the base very coarse beach deposits placed on a wave-cut platform often marked by the activity of boring bivalves. Upward, some generations of slope deposits interbedded with flowstone or speleothemes and, in some cases, beach deposits can be found.

New researches have been carried out on the Grotta del Diavolo (Fig. 1.15; 1.16), to define the stratigraphic sequence of cave filling (Fig. 1.17; 1.18), obtaining a chronological control by means of U/Th (Table 1.1) determinations performed on flowstones occurring at different levels (Mastronuzzi *et al.*, 2002).

At Grotta del Diavolo the stratigraphic sequence, mostly composed of slope deposits, is marked out by three distinct beach levels placed at about +3.0, +3.5 and +5.9 m above m.s.l. and by several flowston The oldest and lowest beach level shows at the base pebbles bored by *Lithophaga* covering the wave-cut platform which constitutes the cave floor (Fig. 1.19). Upward, pebbles give place to medium-coarse sands covered by a flowstone.

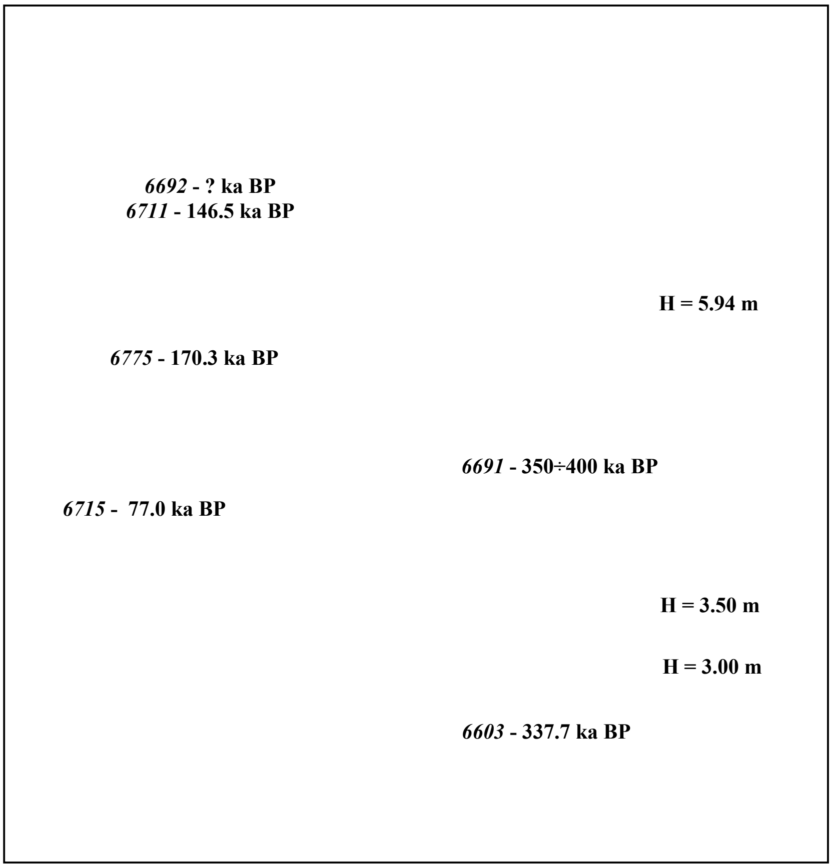


Fig. 1.17 – *Schematic cross section of marine/continental sequence atGrotta del Diavolo cave.*

Figure 1.18 - *A general view of the Grotta del Diavolo filling.*

An U/Th age determination carried out on this last one (6603 sample) would suggest a Middle Pleistocene age (about 340 ka) es and/or speleothemes.

Reddish stratified slope deposits, about two meters thick, follow upward. Some speleothemes (samples 6691, 6709 and 6710) mark biostatic period and breaks in breccia development occurred about 350-400 ka and 245 ka, respectively.

The second beach level, composed of medium-fine sands about 30 cm thick, has been found at about 5.9 m a.p.s.l. covering a thin flowstone (sample 6775). It is covered at its turn by another speleotheme (samples 6692 and 6711) (Fig. 1.20). The U/Th age determinations indicate for the beach deposit an age between 170.3 and 146.5 ka BP. The obtained chronological data would refer beach deposition at 150 ka BP.

The third beach level is composed by laminated medium-fine sands, few centimeters thick, placed at 3.5 m above p.s.l.. This deposit is closed by a stalagmite (sample 6715) about 78 ka BP old (Fig. 1.21).

The cave sequence is closed by brownish breccia deposits retaining remains of continental vertebrates which can be referred to the last glacial period (Fig. 1.22).

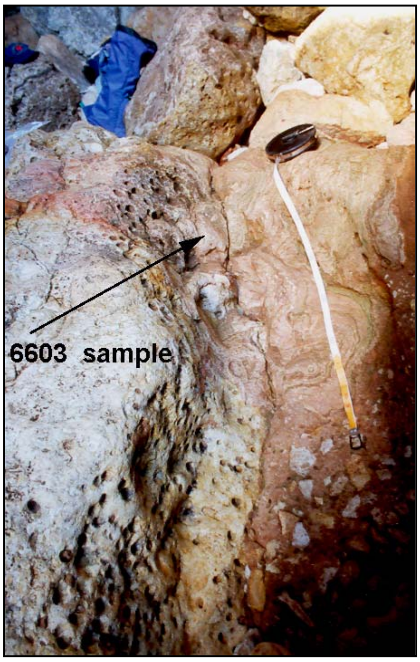


Figure 1.19 - *A view of the boulders bored by Lithophaga and covered by a thick flowstone (6603 sample, 337.7 ka BP). A thick red breccia deposit follows upward.*

Figure 1.20 - *A thin layer of beach sediment, placed at about 5.9 m above p.s.l., is interposed between two thin flowstones.*

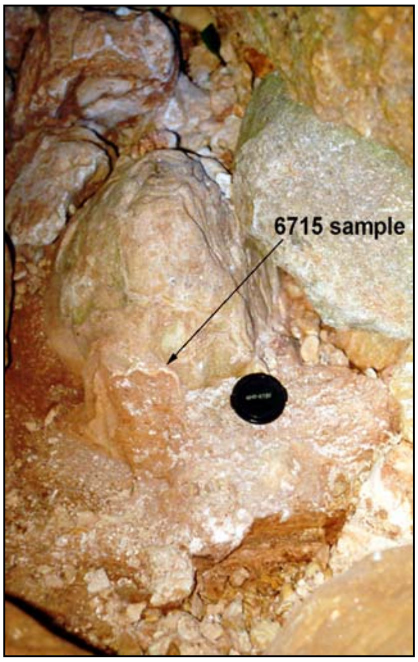


Figure 1.21 - *A view of the speleotheme covering a beach deposit placed at 3.5 m above p.s.l..*

Discussion

The geomorphological data collated at Grotta del Diavolo site suggest that coastal evolution in this area occurred according the following model:

a) during a high sea level stand a sea cave developed. Boulders coming from roof collapse rested on the cave floor and were rounded by wave action and bored by Lithophaga organisms;

b) a long period of emersion followed. The general conditions of aridity promoted the development of breccia deposits. These conditions were broken by short periods of relative rainfall abundance and speleotheme development;

c) during a following highstand, sea level reached again the cave inducing wave-erosion and the partial re-shaping of the cave. A thin beach deposits formed. It was followed shortly after by a period of concretions development;

d) a new sea level high stand promoted the erosion of cave filling and the deposition of a beach level. Afterwards, a new phase of speleotheme occurred;

e) a new period of cold and arid conditions promoted the development of brownish breccia which filled again the cave;

d) at present time the sea level reached the cave, promoting a new phase erosion of older fillings and producing a new beach at sea level.

Figure 1.22 – *The cave sequence is closed by brownish breccia deposits with remains of large vertebrates referable to the last glacial period.*

This polyciclic evolution can be recognized in other sea caves opening along the Leuca coast, as in the Grotta dei Giganti (Fig. 1.23) and could explain the contrasting palaeontological data coming from Grotta Romanelli (cfr. stop 1.1).

Furthermore, some speculations can be made assuming that Grotta del Diavolo cave has been reached by sea level during high stands and taking into account the sea level curve during the last 450 ka proposed by Waelbroeck *et al.* (2002). Absolute age determinations performed with the U/Th method on speleothemes point out that the first phase of cave development (phase -a-) occurred most likely during MIS 9.3 confirming the long-term stability of this coastal area suggested by Bosellini *et al.* (1999) on the base of regional geological data. Grotta del Diavolo cave was reached newly by sea level during the last interglacial high stands MIS 5.5 and 5.1, the only ones that reached roughly the present position of sea level during last 300 ka. The U/Th age determinations which fix the age of +6 m beach level at 150 ka (6711 and 6775) are most likely slightly affected by groundwater contamination.

Figure 1.23 – *A view of the Grotta dei Giganti near Capo Santa Maria di Leuca along the westward coast of Salento. The marine continental sequence here recognised is the same of the Grotta del Diavolo.*

Sample	Lab.Id	[U]ppm	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	$[^{234}U/^{238}U]t=0$	Age ka
Diavolo 0	6603	0.246±0.002	0.997±0.006	0.955±0.014	46±2	0.992	337.7[+49/-33]
Diavolo 2	6691	3.678±0.025	0.995±0.003	1.009±0.014	66±2	-	equilibrium
Diavolo 4	6692	5.821±0.045	0.979±0.002	1.285±0.027	133±6	-	-
Diavolo 6	6709	2271±0.016	1.008±0.005	0.896±0.011	48±2	1.102	243.7[+13.6/-12.0]
Diavolo 7	6710	2.258±0.018	1.082±0.006	1.056±0.018	41±2	-	-
Diavolo 8	6711	5.155±0.044	0.980±0.004	0.738±0.011	57±2	0.970	146.5[+4.8/-4.6]
Diavolo Y	6715	2.732±0.029	1.042±0.006	0.511±0.009	384±80	1.052	77.0[2.2/-2.1
Diavolo Z	6775	1.992±0.015	1.093±0.005	0.806±0.014	171±18	1.149	170.3[+7.7/-7.3]

Table 1.1- *U/Th age determinations performed on carbonate concretions collected at Grotta del Diavolo - eastern side at CERAK, Faculté Polytechnique de Mons (Belgio).*