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Project IGCP 437

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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

3th day

The Historical Taranto Tyrrhenian deposits (Last Interglacial Period, OIS 5)

by

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The Taranto area

In the Taranto area (Fig. 3.1) the Mesozoic carbonate basement is dislocated by NW-SE faults into a step-like arranged blocks gently dipping from the Murge plateau towards both Jonian Sea and Bradanic foredeep (Pagliarulo and Bruno, 1990). The Mesozoic limestones are covered by a transgressive sequence composed at the base by the *Calcareniti di Gravina* Formation (Upper Pliocene) (Robba, 1969), which rapidly passes upward into the *Argille subappennine* Formation, deposited around 1,150 ka B.P., as demonstrated by the K/Ar analysis carried out on interbedded tuphitic levels (Capaldi *et al.*, 1979), and referable to Sicilian on the basis of its calcareous nanno fossils content (Mazzei, 1985).

A transgressive clayey-sandy unit, about 4 metres thick, overlies the *Argille subappennine* Formation (Fig. 3.2). It is characterized by *Gephyrocapsa* SP3 calcareous nannoplancton which suggests a Middle Pleistocene age (*Pseudoemiliana lacunosa* biozone) for this last unit (Mastronuzzi and Sansò, 1998).

From the Middle Pleistocene onward, the superimposition of the regional uplift and glacioeustatic sea level changes produced a number of step-like marine terraces along this coastal area, between 400 m of elevation and the present sea level.

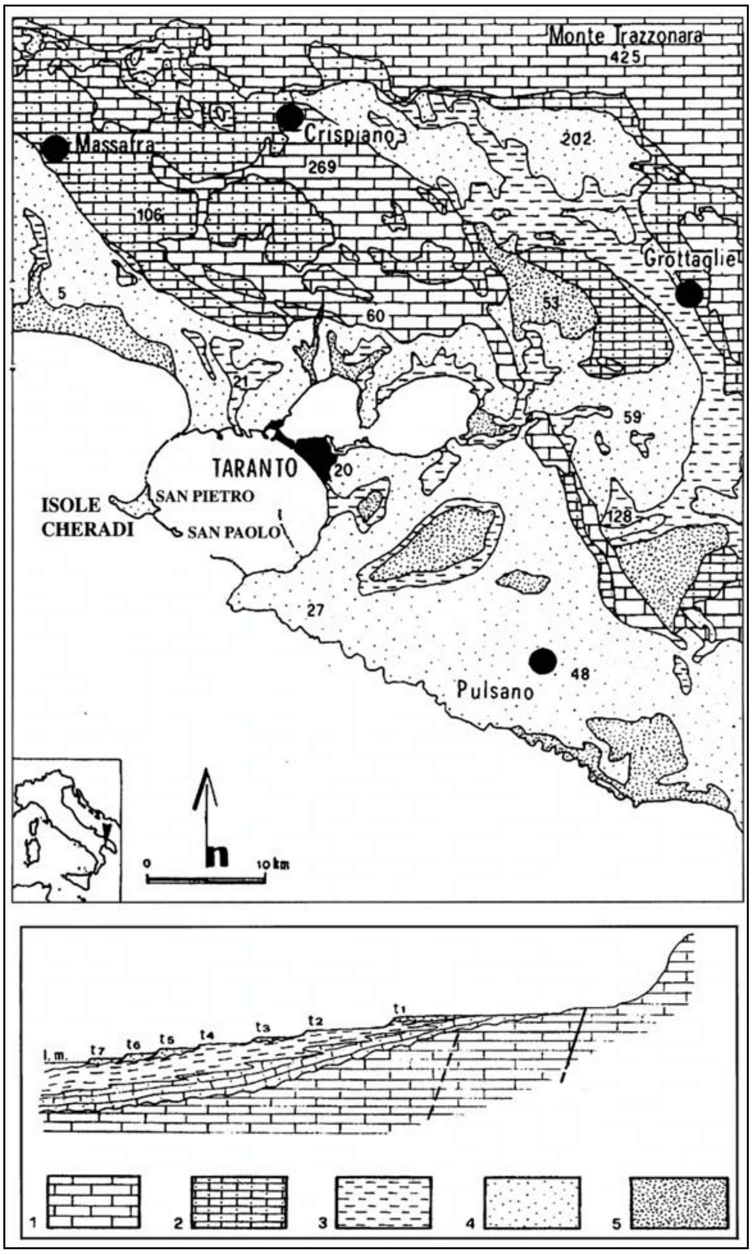


Figure 3.1 - *Geological map of Taranto area. 1 – Limestone (Calcare di Altamura unit; Upper Cretaceous); 2 – calcarenites (Calcareniti di Gravina unit; Middle Pliocene – Lower Pleistocene); 3 – clays (Argille Subappennine unit; Middle Pliocene – Lower Pleistocene); 4 – marine terraces deposits type "panchine" (Middle Pleistocene – Upper Pleistocene); 5 – alluvial, beaches and coastal dune deposits (Late Pleistocene - Holocene).*

In the Mediterranean basin, the Taranto area is surely one of the most famous as regard the Tyrrhenian – OIS 5 deposits. Cita and Castradori (1994) suggested this area as the best for the definition of OIS 5 GSSP - Global boundary stratotype section. In fact, the marine terrace deposits cropping out in the Taranto area are well-known and extensively studied (i.e.:Verri and De Angelis D'Ossat, 1899; Gignoux, 1913; Selli, 1962; Gigout, 1960a,b,c; 1962; Ricchetti, 1967; 1972; Cotecchia and Magri, 1967; Cotecchia *et al*., 1969; Martinis, 1970; Martinis and Robba, 1971; Boenzi *et al*., 1985; Caldara and Laviano, 1980; Caldara, 1987; Dai Pra and Stearns, 1977; Hearty and Dai Pra, 1992). Some of them are characterised by thin bioclastic calcarenites deposits, in Italy also known as *"panchine"* (Mazzanti and Parea, 1971), whereas others are represented only by abrasion surfaces They have been referred to Middle and Late Pleistocene ages (Ricchetti, 1967; 1970; 1971; Ciaranfi *et al*., 1992; 1994).

In the area of Taranto, the *"panchine"* rest on a flight of stairs stretching between 45 m and the present sea level. The marine terrace surfaces still retain their original seaward slope; nevertheless, they show some effects of neotectonic activity, generally represented by slight tilting of the terrace top surfaces or strong fracturing of the calcarenitic terrace bodies. However, the most important modifications are due to subaerial erosion, which has particularly affected the pre-Tyrrhenian marine terraces (Mastronuzzi and Sansò, 1993b).

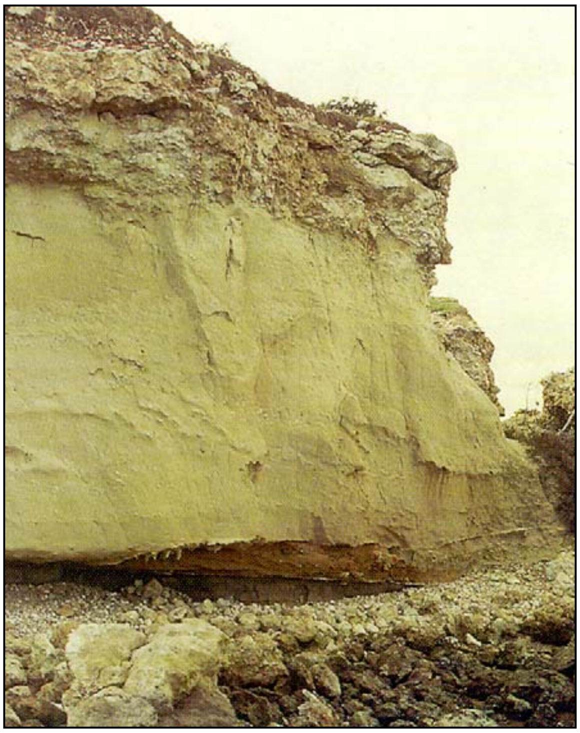


Figure 3.2 - *The cliff at Punta La Forca locality on San Pietro island. a - clays (argille Subappennine unit; Middle Pliocene – Lower Pleistocene); b – sands with cold fauna (Hyalinaea balthica (Schroeder) and Arctica Islandica (L.); Middle Pleistocene); c – grey-greensilty-sands with Gephirocapsa SP3 (Middle Pleistocene); d – OIS 5a marine terraced deposits.*

The two youngest and lowest terraces with elevations between 20-30 m and the present sea level, are correlated to the Tyrrhenian sea-level high stands (Gigout, 1962; Ricchetti, 1967, 1972; Dai Pra and Stearns, 1977; Hearty and Dai Pra, 1985; 1992; Belluomini *et al*., 2002).They are well exposed in numerous places and often retain a rich senegalese fauna (Nickles, 1950), with a lot of specimens of *Strombus bubonius* Lamarck and/or *Cladocora caespitosa* (Linneo) colonies (Cotecchia *et al*., 1971; Dai Pra and Stearns, 1977; Hearty and Dai Pra, 1985;1992; Hearty *et al*.,1986; Belluomini *et al*., 2002). This last one is generally associated with warm-temperate fauna and can be confidently considered a good marker of warm or warm-temperate waters (Peirano *et al*., 1996; 1999; 2003; Laborel, pers.comm.).

U-series datings have been carried out on *C. caespitosa* specimens with different results, most likely because of diagenetic transformations of the corals which may affect the geochemical system (Hillaire-Marcel *et al*., 1996).

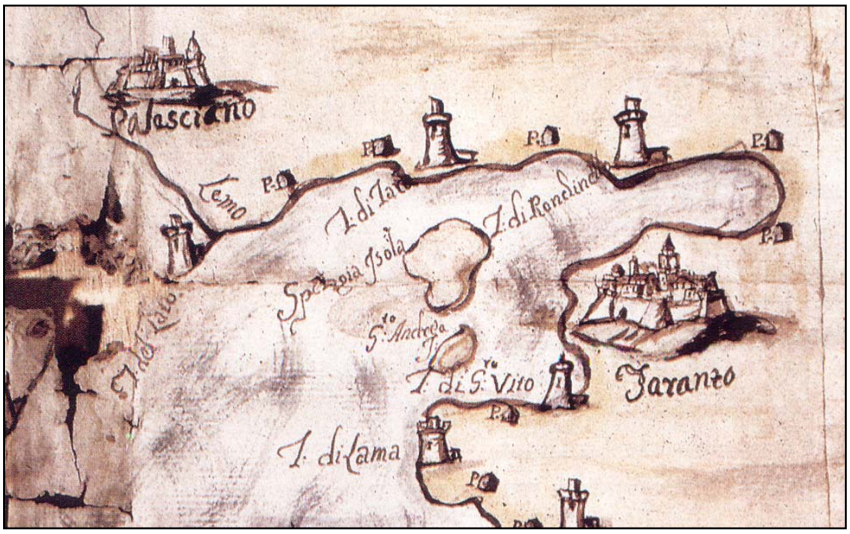


Figure 3.3 - *An ancient map of 1741 showing the peninsula where the downtown of Taranto was build about 700 years b.C. (Archivio di Stato di Taranto).*

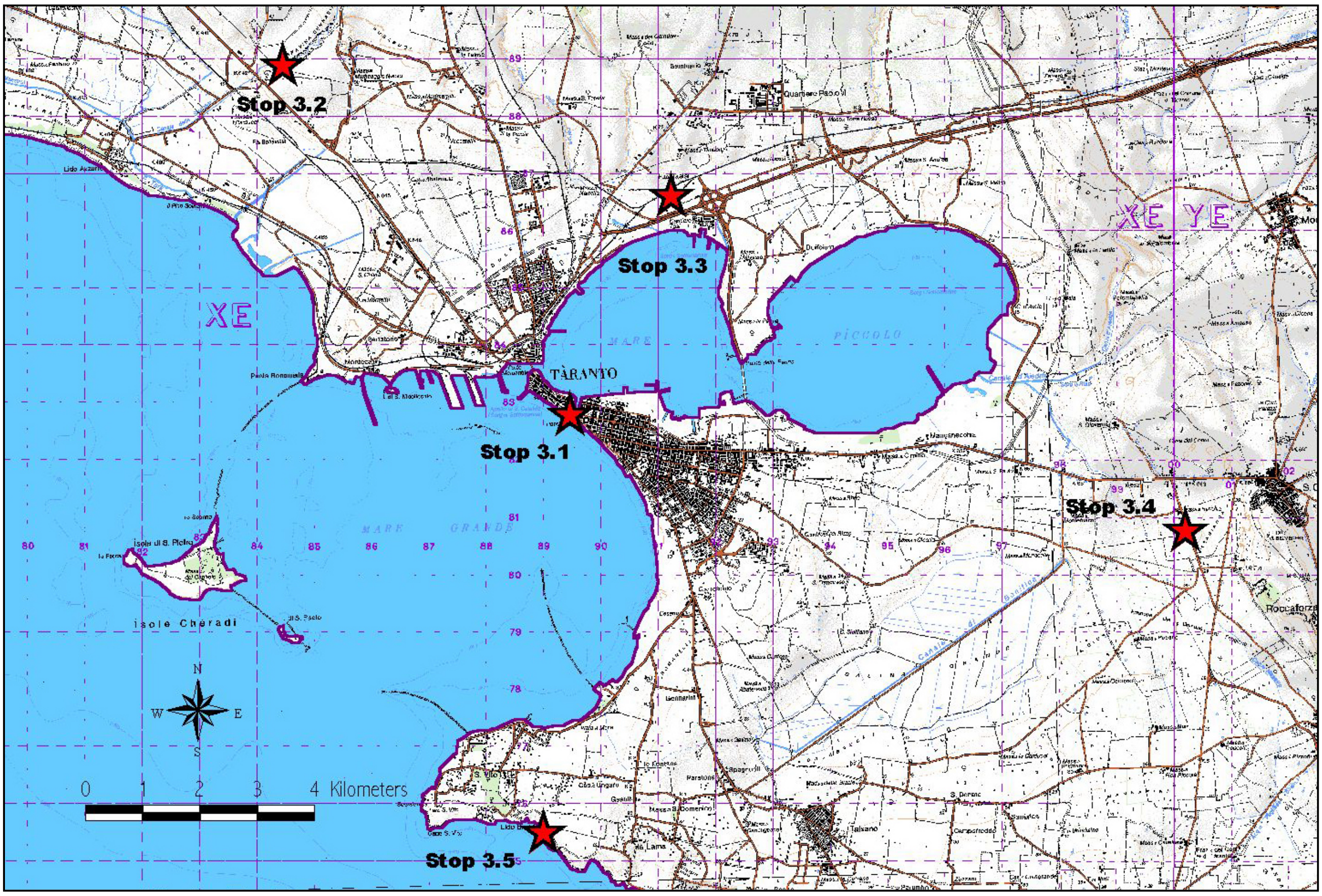
Also the amino acid geochronology performed in the Taranto area in the past have not yet clarified a satisfactory scheme for these deposits. Notwithstanding, some problems were solved with an astute finding by Belluomini *et al*., (2002). In this paper was performed a direct calibration using the ratio between the non-protein D-alloisoleucine amino acid and its protein L-isoleucine isomer (aile/ile or D/L) and U-series age from individuals of the same taxa. Following a different approach of calibration (see APK method in Mitterer and Kriausakul, 1989) were obtained the same results. Besides the so-called absolute age calibration, that have permitted to characterised some high sea-stands in corrispondence with OIS 3, 5a, 5c and 5e, results are in close agreement with recent study performed by Hillaire-Marcel *et al*. (1996) and Mauz *et al*. (2000) for regions which is thermally similar to the Taranto area.

Clearly the paper of Belluomini *et al*. (2002) is not the final sentence about the marine deposits and terraces of Taranto area and additional data from other sites of the area are needed.

For this reason, the numerous biostratigraphic and chronostratigraphic studies carried out in Taranto area have not yet clarified the relationships between stratigraphic and morphological units, i.e. sedimentary cycles and terraced surfaces.

Site 3.1

Locality	The channel
Community	Taranto
Province	Taranto
WGS84 Coordinates	40.75788N, 17.69728E
Keywords	OIS 5 upper shoreface-foreshore sequence



Stop 3.1.1 The Navigable Channel and the Aragonese Castle (G. Mastronuzzi, P. Sansò, P. Tuccimei, P. Vesica)

The city of Taranto is located at the top surface of a narrow peninsula elongated in W-E direction, between the Mar Piccolo to the north and the Mar Grande to the south (Fig. 3.3).

These two sub-elliptical bays are shaped into the sediments of the two youngest marine terraces; the bays are bordered by cliffs and by narrow beaches placed at the mouths of relict valleys. According to Mastronuzzi and Sansò (1998), the particular shape of shoreline seems to be the effect of the geological structure of this area, its erosive history and wave diffraction.

During the first colonisation of the Taranto area as colony of Sparta, about 700 b.C., the harbour was placed in the Mar Piccolo which was in communication with Mar Grande only from the natural channel of Porta Napoli, at the northwestern side of the town centre. The present depth of this isthmus, less than 3 m, is not the original one; all the N and NW coastal area of the town centre has been reclaimed by the sea. In fact, the destruction of Taranto as consequence of war against Rome in the 271 d.C. first and by arab pirates in the 961 d.C. then produced a large amount of material which was used to

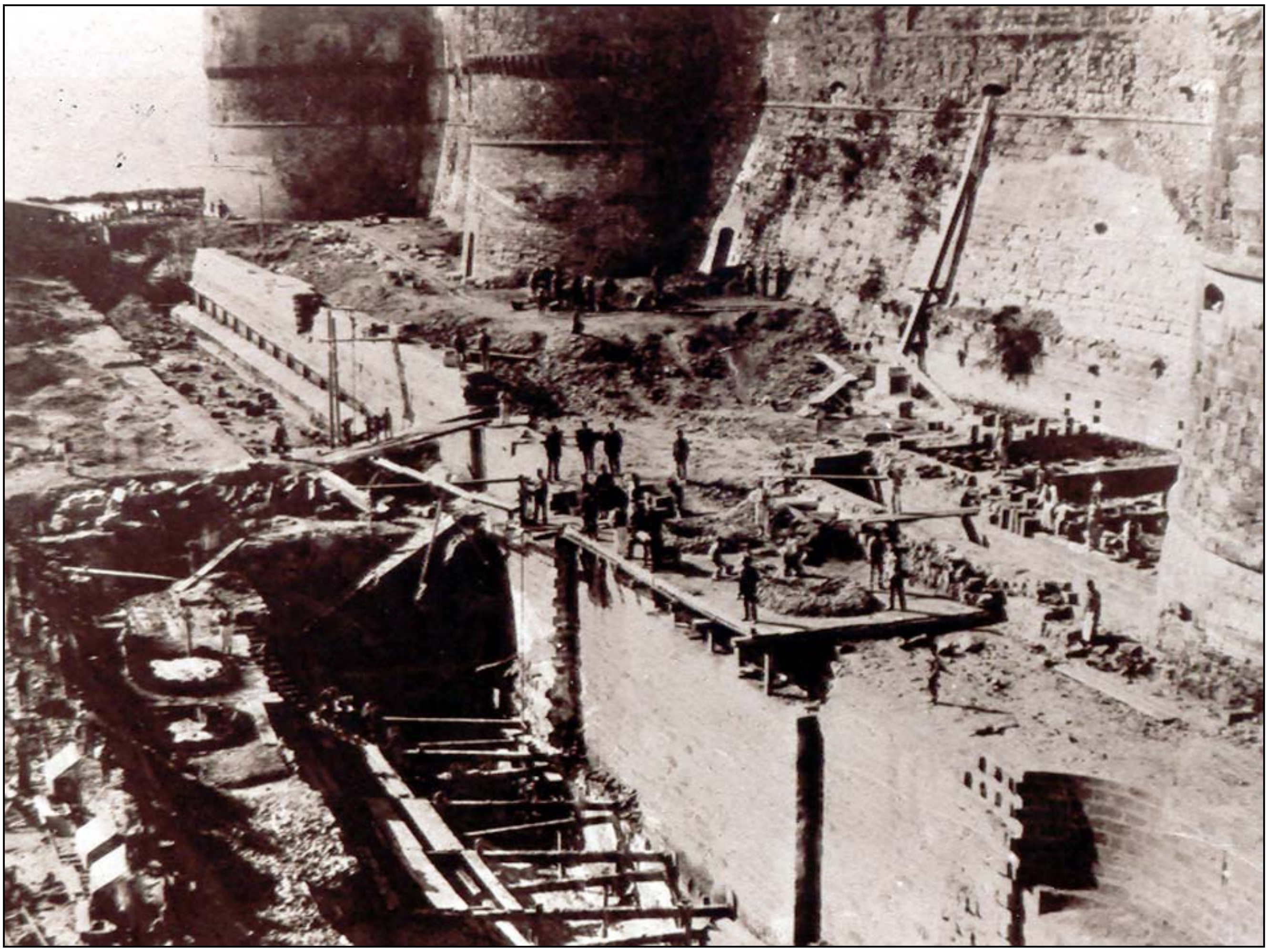


Figure 3.4 – *The construction works of the navigable channel in a photo of 1885 (Mastronuzzi' s Collection)*

Figure 3.5 - *A specimen of S. bubonius coming from the southern coast of Mar Piccolo.*

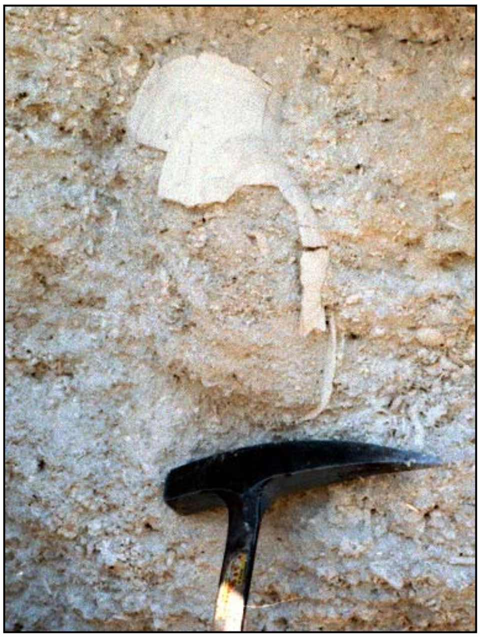


Figura 3.6 - *A specimen of P. glycymeris coming from the same locality of the Strombus of Fig. 3.5.*

enlarge the town. In the Channel of Porta Napoli dump deposit are up to 9 m thick. The present old town of Taranto was built from 971 by the Prince Niceforo Foca II. The Navigable Channel of Porta Lecce was realized only at the end of the XIX century (Fig. 3.4) when the Mar Piccolo of Taranto was selected by the government of the Kingdom of Italy as main base of the Italian Royal Navy.

The stratigraphic sequence of Taranto is generally characterised at the base by Sicilian grey-blue clays (Mazzei, 1985), about 1,150 ka old (Capaldi *et al*., 1979), cropping out along the coast of Mar Piccolo. Transgressive deposits referred to the Tyrrhenian follow upward. They are characterised by an evident facies variability. In fact, the surface occupied by the modern town, placed between 22 to 4 m above p.s.l., is shaped on laminated calcareous sandstones, algal calcarenites, fine calcareous sands, bioturbate arenites with pebble levels. In general they are characterised by a warm phauna with *S. bubonius, Cardita calyculata senegalensis* (Reeve), *Hyotissa hyotis* (L.), *Conus testudinarius* Martini; are frequent well developed bioconstruction of *Cladocora caespitosa* and large specimens of *Panopea glycymeris* L. and *Pinna nobilis* L. (Fig. 3.5, Fig. 3.6).

In the area of the historical centre, from the westward side of Porta Napoli channel to the Government Building, eastward of Navigable Channel, the local stratigraphic sequence is characterised of well cemented sandstones, up to 33 m thick (Fig. 3.7). The base of this deposits is up to 14 m below present sea level. The area of the ancient harbour, where the first settlement of human presence – ancient Neolithic and Phoenician - is recorded, was placed on the top of this deposit, in the Scoglio del Tonno area and in the area at present occupied by the romanic church of San Domenico. The Scoglio del Tonno area was destroyed to build harbour structures at the end of XIX century (Gorgoglione, 1994; 1999).

The Navigable Channel is 12 m deep in the center (Messina, 1888) and is entirely cut in the sandstone deposit which are at present well exposed along its banks. Sandstone blocks obtained by the Channel cut wERE used to realize the retaining walls. On the other hand the same situation occurred for the the ditch of the Aragonese Castle - which was completed in the 1492 - which supplied building material for the Castle and for the main patrician building on seaside.

Drill perforations indicate that the sandstone deposit overlies directly the Sicilian grey-blue clays. In details, it is characterised by low angle cross laminated sandstones made of bioclastic and terrigenous, bad sorted sands. Fossil remains are represented by reworked shells of gastropods and bivalves (i.e.: *Glycymeris* sp; *Cerastoderma* sp; *Bittium* sp; *Cerithyum* sp); usually they are recognisable in mechanical concentrations.

The presence of ripples and megaripples, of levels of concentrate bioturbations due to the activity of *Echinocardium cordatum* Pennant alternated to levels without bioturbations would indicate a depositional environment corresponding to the passage between the lower and the upper shoreface. The thickness of the sedimentary body marks the rise of sea level and the progressive closing of an embayment, may be a river valley shaped in the Sicilian clay during a former continental phase. The gradual sea level rise was accompanied by the development of a large sandy bar that at beginning closed the submerged river valley and then, when sea level rose up to the slopes of the valley, partly limited as submerged barrier an open lagoon which extended landward in the area of present Mar Piccolo.

Unfortunately, this sedimentary body does not retain elements useful for the determination of its age. As *extrema ratio* Aile/lle age determinations were performed on the rare reworked bivalves (*Glycymeris* sp and *Cerastoderma* sp.) sampled in the mechanical concentration. They yielded an unlikely age of about 30 ky.

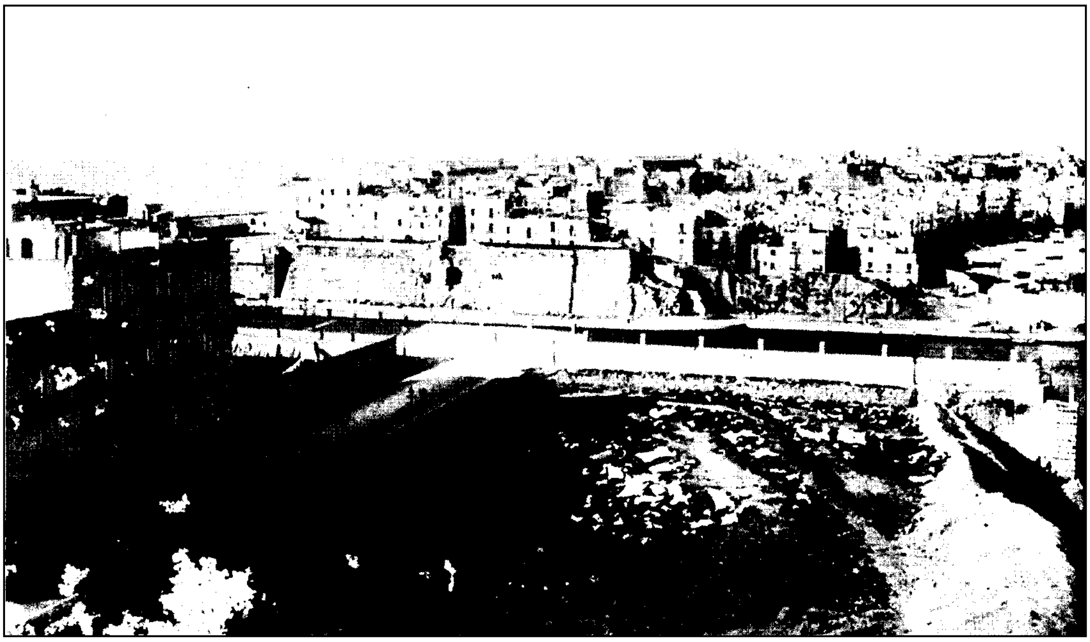


Figure 3.7 - *A view of the Channel and of the exposition of the sandy bar sequence before the build of the protection wall (about 1895 (Mastronuzzi' s Collection)).*

More valid indications about this submerged barrier come from the heteropic sediments. In fact the described sandstone laterally shades westward, in Masseria Ruggiero locality (near the railway station) into fine calcareous sands marked by *S. bubonius*, whereas eastward, in the Solito area, algal calcarenite with *S. bubonius, C. caliculata senegalensis, H. hyotis* and large bank of *C. caespitosa* can be found. These relationships would suggest a Tyrrhenian age for the sandstone deposit.

In background: Punta Rondinella, Chéradi Islands, Capo San Vito and Mar Grande (G. Mastronuzzi, P. Sansò, P. Tuccimei, P. Vesica).

Punta Rondinella

In this locality and at San Pietro Island, basal grey-blue clays are overlain by about 1 m of well cemented and bioturbated calcarenite with rare mollusk shells and by 1.5 m of well-cemented conglomerate (Fig. 3.8, Fig. 3.9).

The transgressive contact between this two units is placed at about 0.2 m a.s.l.. The conglomerate is composed of pebbles derived from the Apenninic Chain or the Murge plateau; it retains rare *Cerastoderma* sp., *Glycymeris sp* and pectinides. Upward this regressive sequence is covered by a discontinuous thin layer of pinkish fine sands rich in bivalves (*L. Lacteus* (L.) and gastropods (*Conus* spp., *Jujubinius* spp., *Clanculus* spp., *Gibbula* spp., *Cerithium* spp., *Bittium* spp., *Turritella* sp.). At the top of the present cliff, remains of a V millennium b.C. settlement have been find (Gorgoglione, 1994; 1995).

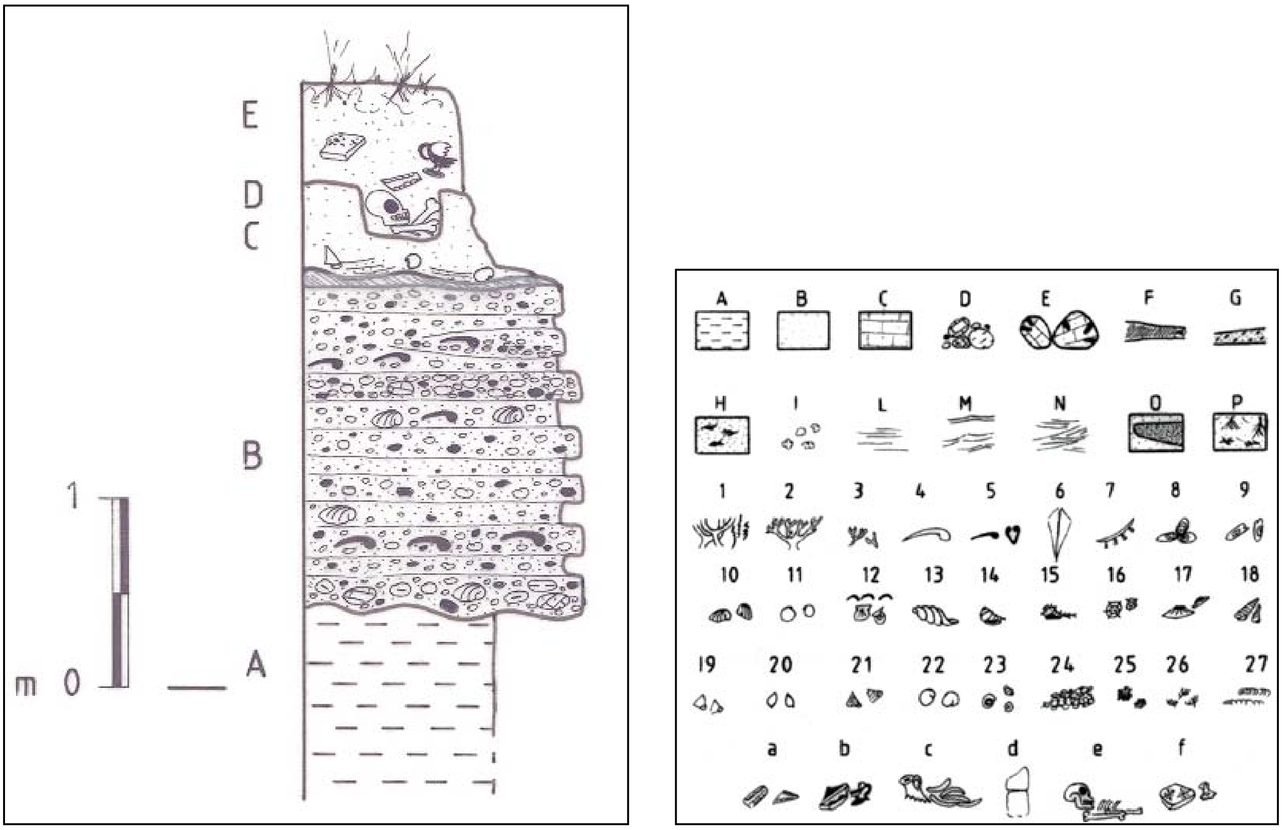


Figure 3.8 - *Stratigraphic section of Punta Rondinella. A - clay; B - sand; C - calcarenite; D - conglomerate; E - blocks with Lihtophaga holes; F - carbonatic crust; G - ash layer; H - paleosoil; I - caliche; L - parallel lamination; M - wavy lamination; N - cross lamination; O - hut's floor; P - soil; 1 - bioturbations; 2 - Cladocora caespitosa in life position; 3 - fragment of C. caespitosa; 4 - Arctica islandica; 5 - Glycymeris spp.; 6 - Pinna nobilis; 7 - Spondylus gaederopus; 8 - Ostrea lamellosa; 9 - Arca spp.; 10 - Cerastoderma spp.; 11 - Loripes lacteus; 12 - bivalve shells; 13 - Caronia sp.; 14 - Murex brandaris; 15 - Truncularioipsis trunculus; 16 - Astrea rugosa; 17 - Patella ferruginea; 18 - Bittium and Ceritium spp.; 19 - Clanculus spp; 20 - Conus spp.; 21 - Gibbula spp.; 22 - Helix pomatia; 23 - pulmonate gastropods; 24 - algal encrustation; 25 - rhodolites; 26 - bryozoans; 27 - echinoid traces; a - Neolithic artifacts; b - Greek pottery; c - Roman pottery and tiles; d - Late Roman wall; e - Late Roman burial; f - maiolica.*

Figure 3.9 - *The Punta Rondinella section.*

This sequence leans to a relict cliff. It is with the top at about 17-18 m a.s.l. shaped in clays and, in its uppermost part, calcarenites rich in *Acanthocardia tuberculata* (L.) and *Bittium* sp.. This last deposit is in continuity with the deposit with *S.bubonius* of Masseria Ruggiero.

Aile/lle age determinations have been performed on bivalves coming from Punta Rondinella and Punta Lo Scanno on San Pietro Islands. The age of most samples appears to cluster around the OIS 5a.

Numerous U/Th age determinations have been performed on *Cladocora caespitosa* samples (5684 –A; 5794 A; 5795 B; 5899 – A and ISP 2) coming from Punta Lo Scanno on San Pietro Island (Table 3.1); they permit to identify a supposed late last interglacial age corrisponding to isotope substage 5a.

Sample	Aragonite (%)	[U] ppm	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	$[^{234}U/^{238}U]_{t=0}$	Age (ka)	Lab.
5684 – A C. caespitosa	97	3,198±0,158	1,148±0,025	0,505±0,028	6,0±0,2	1.183	75,0[6,2/-5,9]	A
5794 – A C. caespitosa	96	2,596±0,020	1,101±0,006	0,530±0,013	9,2±0,4	1.127	80,6[3,0/-2,9]	A
5795 – B C. caespitosa	96	2,752±0,052	1,106±0,014	0,698±0,021	5,7±0,2	1.150	126,1[7,8/-7,2]	A
5899 – A C. caespitosa	94	2,589±0,028	1,100±0,006	0,333±0,006	7,9±0,2	1.113	43,6[1,0/-1,0]	A
ISP2 C. caespitosa	>98,5	3,230±0,076	1,121±0,024	0,555±0,018	95	1.155±0.031	86,4±4,2	B
ISP2 Glycymeris sp.	-	0,580±0,009	1,129±0,017	0,336±0,015	infinite	1.146±0.019	44,2±2,4	B
ISP4 Glycymeris sp.	-	0,844±0,017	1,121±0,022	0,669±0,017	1293	1.168±0.030	116,8±5,2	B
T2M – ISP5 Pinna nobilis	-	0,616±0,029	1,124±0,019	0,262±0,012	377	1.142±0.022	48,4±2,0	B

Table 3.1 *– U/Th age determinations performed on C. caespitosa and molluscs coming from Isola di San Pietro A - CERAK Faculté Polytechnique di Mons – Belgio; B - Dipartimento di Scienze Geologiche dell'Università "Roma tre"*

Chéradi islands

On the Chéradi Islands the complete sequence of Quaternary deposits crops out. The best sections occur along the coastal perimeter of San Pietro Island since the smaller San Paolo Island is almost entirely covered by military structures of XVIII and XIX century.

The Punta Lo Scanno section (Fig. 3.10) is placed in front of Punta Rondinella, about 5 km to the SE. The stratigraphy is similar to that of Punta Rondinella: at the base spheric colonies of *C. caespitosa* included in sandy matrix lie directly on clays. The overlying conglomerate consists of mechanically concentrated bivalve shells. Among them, *Glycymeris insubrica* (Brocchi) is the most diffuse species whereas *Arca* sp. specimens can be found in the uppermost part of this level along with a restricted *Glycymeris* populations. The sequence is capped by a thin, discontinuous layer of pinkish fine sands, with gastropods (*Conus* spp., *Jujubinius* spp., *Clanculus* spp., *Gibbula* spp., *Cerithium* spp., *Bittium* spp.) and bivalves (*Loripes lacteus* (L.)), with about 1 m of archeological filling on top.

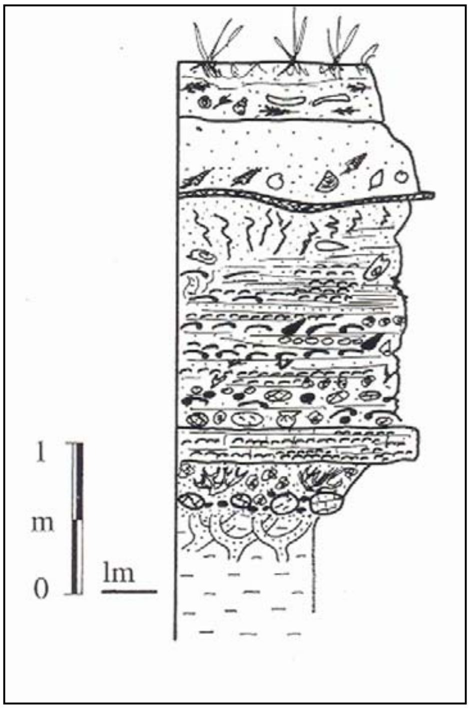


Figure 3.10 - *Stratigraphic section Punta lo Scanno on San Pietro island (legend in Fig. 3.8).*

Another good section can be seen along the cliff N-facing of San Pietro island (Apodonia beach). The sequence consists of: 1) basal conglomerate, made up of blocks, up to 1.5 m in diameter, affected by the biological activity of lithophaga and including some valves of *Glycymeris* and *Ostrea* sp.; 2) calcarenites, silt and sands, up to 2 m thick, with abundant specimens of *Pinna nobilis* (L.) and *Glycymeris glycymeris* (L.) or *insubrica* (Brocchi) in life position. These sediments were probably deposited in a low energy environment; 3) continental sands with variable thickness (< 1 m), marked by the presence of an ash layer; 4) marine sands with echinoid traces and, in the lowest levels, mollusk debris; 5) continental sands with abundant remains of *Helix* sp.; 6) soil with numerous shells of *Helix* sp., *Pomatia* sp. and *Rumina* sp. which yielded radiocarbon ages of 15,262 ± 350 and 8394 ± 150 years B.P. (Dini *et al*., 2000; 2001). The sequence is capped with a soil containing numerous remains of Neolithic artifacts and pottery ranging from Classical to the Middle Age.

In the Punta la Forca section, the lowermost part (Fig. 3.2) is made of laminated grey-blue sandy clays which are unconformably overlain by bioclastic grey-green silty sands.

The contact is marked with fine sands including some pebbles of clays and specimes of *Arctica islandica* (L.), *Macoma calcarea* (Gmelin) and *Hyalinaea balthica* (Schroeder). The grey-green silty sands lack macrofossil remains; however, the presence of *Gephyrocapsa* SP3 in the nannoplankton assemblage allows us to correlate this unit to the Middle Pleistocene - *Pseudoemiliana lacunosa* biozone (Mastronuzzi and Sansò, 1998).

Sample	Fossil remains	Uncalibrated Age	D13C ‰	D18O ‰	Calibrated Age (1σ cal a b.C.) (+)	Lab.
ISP 21a	*Loripes lacteus*	36430+/-1450	<-7	--	--	A
ISP 19	*Helix pomatia*	34185+/-945	<-7	--	--	A
ISP 21b	*Vermetids*	23130 +1670/-1380	-2,4	--	--	B
ISP 4a	*Helix*	15262+/-350	-4,64	-1,07	16293	A
ISP 4b	*Helix*	8394 +/- 150	<-7	--	7445	A

Table 3.2 – *^{14}C age determinations performed on molluscs coming from Isola di San Pietro. A - Laboratorio di Geochimica Isotopica dell'Università degli Studi di Trieste; B - Geochron Laboratoires, Krueger Enterprises Inc., Cambridge, Massachusets, U.S.A.. (+)age calibration was performed by mean of CALIB 4.3 software (Stuiver and Reimer, 1998).*

An erosion surface marks the contact between the bioclastic grey-green silty sands with the overlying conglomerate body. Its lower part is marked with bioclastic calcarenitic blocks with traces of boring organisms, pebbles of clays and Apennine rocks. Upward, the conglomerate grades into an algal deposit which suggests a high energy bank environment. The macrofauna is characterized by C. caespitosa, *Patella ferruginea* Gmelin, *Spondylus gaederopus* L., *Pteria hirundo* (L.), *Striarca lactea* (L.), *Natica* sp., *Astraea rugosa* (L.), *Truncularïopsis trunculus* (L.), *Bursa scrobiculator* (L.), and serpulids as well as remains of crustaceans and marine vertebrates.

The sequence is capped by a discontinuous soil horizon which contains continental gastropods (*Helix, Pomatias* and *Rumina* spp.).

The southwestern coast of San Pietro Island, between Punta La Forca and Punta La Dogana, is represented by bioclastic calcareous sandstones (*"panchine"*) which rest on grey-green silty sands. The transgressive surface dips gently seaward and is marked by clayey and calcarenitic blocks. The "*panchine"* deposits are very rich in calcareous algae and in *C.* caespitosa colonies. The molluscan fauna contains *Glycymeris* sp., *S. gaederopus, Ostrea edulis* L., *Mytilus edulis* L., *Venus verrucosa* L., *P. ferruginea, A. rugosa*, *T. trunculus*.

An abrasion platform, up to 40 m wide, cuts the *"panchine"*; it is bordered landward by a small step marked by numerous lithophaga boreholes. The abrasion platform is covered by a veneer of pinkish/red sands characterized by abundant *L. lacteus*, numerous remains of gastropods (*Haliotis tuberculata lamellosa* Lamarck, *Homalopoma sanguineum* (L.), *Murex brandaris* L., *Conus* spp.*, Jujubinius* spp.*, Gibbula* spp.*, Cerithium* spp.*, Bittium* spp., and *Turritella* sp.), and by traces of echinoids. Radiocarbon age determinations carried out on a *L. lacteu*s specimen yielded a radiocarbon age of 36,430 ±1450 years B.P. (Mastronuzzi *et al*., 1999), a probable minimum age.

The sequence of Punta La Dogana is exposed on a cliff whose foot is cut on clays. A conglomerate layer made up of calcarenite and clayey pebbles marks the contact with the overlying *"panchina"*. The latter is made up of sediments rich in calcareous algae, very similar to those recognized at Punta La Forca and along the southwestwern coast of San Pietro Island. The *"panchina"* is covered by reddish, loose, laminated sands containing *Helix pomatia* (L.) specimens which yielded a radiocarbon age of 34,185 ± 945 yearsr B.P. (Mastronuzzi *et al*., 1999).

Upwards, fine bioclastic sandstones interbedded with pinkish sands characterized by bivalvia *L.lacteus* and numerous gastropods (*H. tuberculata lamellosa, M. brandaris, H. sanguineum, A. rugosa, Jujubinius* sp.*, Clanculus* sp.*, Gibbula* sp.*, Cerithium* sp.*, Bittium* sp.) are found. The sequence is capped with a soil which contains archeological remains ranging from Roman to Middle Age.

Capo San Vito

The coastal area located to the southeastern of Taranto, around Capo San Vito, is characterized by a very large marine terrace composed of Last Interglacial *"panchine"* which directly overlay the Lower Pleistocene - Sicilian clays by means of a pebbles level (up to 1 m of diameter). Terrace deposit is locally represented by an algal calcarenite with globular colonies of *C.caespitosa* and large specimens of *Spondylus gaederopus* (L.)*, A. rugosa, P. ferruginea* but without evident warm fauna (Fig. 3.11).

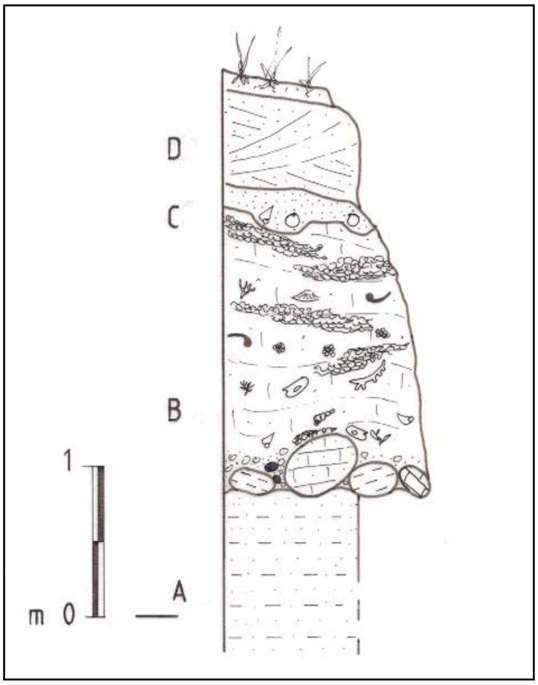


Figure 3.11 - *Stratigraphic section near the Capo San Vito Lighthouse (legend in Fig. 3.8).*

Site 3.2

Locality	Roman bridge – Gravina di Leucaspide
Community	Taranto – Statte
Province	Taranto
WGS84 Coordinates	40.75788N, 017.69728E
Keywords	OIS 5 deposits, inner margin, Cladocora caespitosa, U/Th age determinations, sapping valleys

Stop 3.2.1 – The inner margin of OIS 5 deposits
(G. Mastronuzzi, B. Mauz, P. Sansò, P. Tuccimei, P. Vesica)

Northwest of Taranto, near the Roman bridge which crosses the Gravina di Leucaspide, a marine terrace surface is easy recognisable between 37 and 19 m of altitude.

The local stratigraphic sequence (Fig. 3.12) shows at the base the Mesozoic limestones, locally marked by large specimens of Rudists. On the limestones a transgressive deposit can be recognized. Its base in made of limestone pebbles (up to 0.80 m of diameter) whose surface is affected by boreholes of Litophaga sp and bioerosion made by sponges. Medium calcareous sands of variable thickness with globular colonies of *C. caespitosa,* up to 0.50 m of diameter, follow upward.

U/Th age determinations performed on a sample of *C.caespitosa* marked by an Aragonite/calcite ratio of about 96%, indicate an age of 107.7±1.5ka corresponding to the OIS 5c. On the other hand, the surface is in continuity with the deposit characterised by presence of S. bubonius at 18 m a.p.s.l. at Masseria Ruggiero (specimens of S.bubonius collected in this locality are at the Palaeontological Museum of Univerity of Bologna).

The inner margin of the marine deposits is recognisable with good approximation inland at about 37 m a.p.s.l.; it is pointed out by a sharp slope change and by a level of well rounded pebbles. These last ones show evident bioerosion due to sponges activity. It can be assumed that the elevation of the inner margin is at about 37 m.

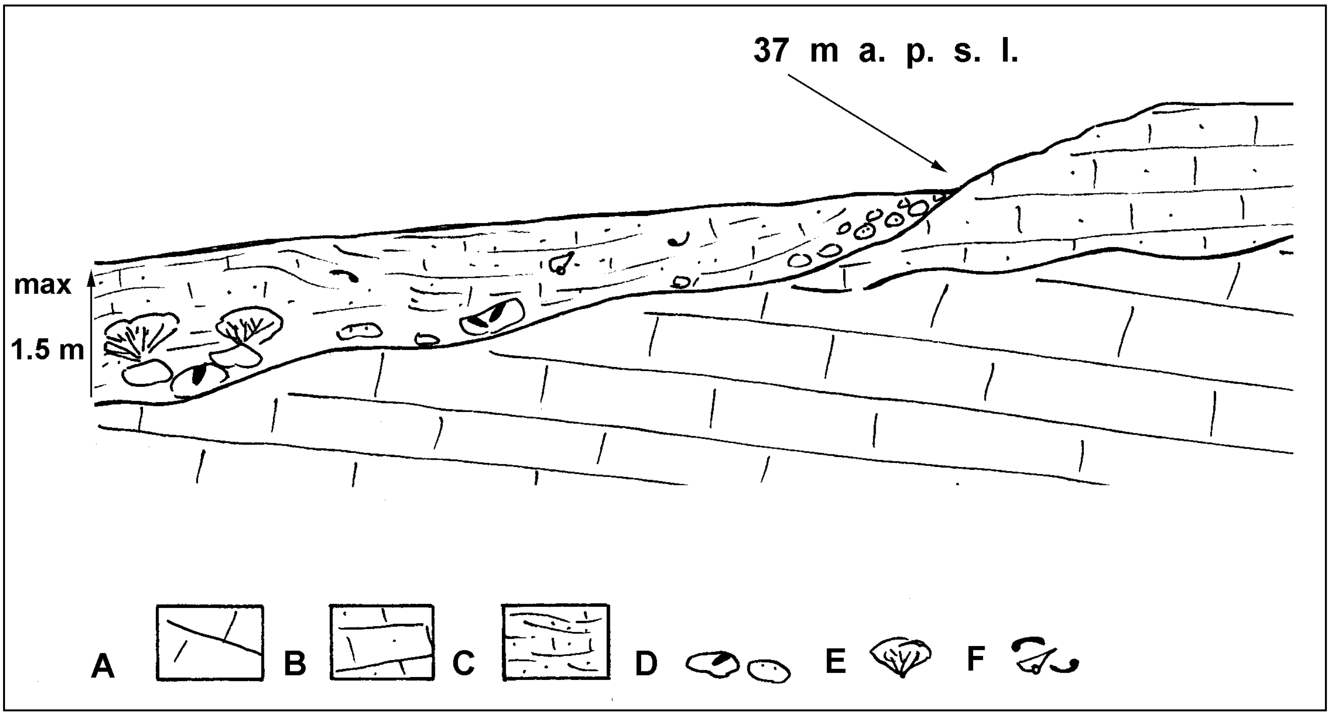


Figure 3.12 - *Stratigraphic section recognisable at Ponte Romano locality. A – Limestone (Calcare di Altamura unit; Upper Cretaceou); B – calcarenites (Calcareniti di Gravina unit; Middle Pliocene – Lower Pleistocene); C – Marine deposits of OIS 5; D – Pebble and blocks with Litophaga boreholes; E – Globular colonies of C. caespitosa; F – Bivalves shells.*

In the same area an OSL age determination has been performed on a sample of well cemented fine sandstone coming from the area of the relict cliff of Punta Rondinella. The age of 93±8 ka may indicate a correspondence with some U/Th age determinations performed on *C.caespitosa* (cfr. Stop 4.3).

Taranto Ponte Romano / Masseria Ruggiero	**Elevation (m a.p.s.l.)**	**Age (ka)**	**References**
Strombus bubonius	≈ 18	125 (+)	Palaeontological Museum of University of Bologna
inner margin	37 ± 2	-	Mastronuzzi, 2001
Cladocora caespitosa	20	107.7±1.5(*)	Mastronuzzi and Sansò (2002a)
sandstone shoreface	25	93±8 (°)	Present paper

Table 3.3 – *Synoptic table of OIS 5 deposits and landforms in the area to the northwest of Taranto. (+) Age deduced by bibliography; (*) Absolue age performed by mean of U/Th analises on C. caespitosa (CERAK, Mons, Belgium); (°) Absolue age performed by mean of OSL analises (Università di Bonn, Germany).*

In Back ground: Ponte del Re – Castellaneta (bibliographic note)

From Ponte Romano Locality we can extend our view on the westernmost coast of Puglia until the limit with Basilicata before, and then with Calabria. This area was well studied by several Authors in different time (Montcharmont – Zei,1957; Neboit and Réynard, 1973; Cotecchia and Magri, 1967; Vezzani, 1967; Bruckner, 1980; Boenzi *et al.*, 1985; Hearty, 1986; Caldara, 1987; Dai Pra and Hearty, 1988; Hearty and Dai Pra, 1992; Westaway, 1993).

The coastal landscape is characterised by presence of a staircase of marine terraced stretching from about 200 m of elevation to the present sea level (Amato, 2000; Bianca and Caputo, 2003). Deposits are represented by sands and pebbles belonging to backshore – foreshore – shoreface environment without a significant fossil assemblage.

Recent study pointed out the difficult to date it by OSL age determination (Zander *et al*., 2003). Hearty (1986) performed determinations of ratio Aile/Ile (0.29±0.02) on *Glycymeris* sp shells sampled at 43 m a.p.s.l., belonging to the Piano San Nicola deposits, ranging between 85 and 40 m a.p.s.l. at the limit between Puglia and Basilicata. The Aile/Ile ratio suggests a late Last interglacial age allowing the correlation of these deposits with the Shoreline Complex II of Hearty and Dai Pra (1992) corresponding to Aminozone C and isotope Substage 5a, of about 50-75 ka.

A faunal assemblage typical of the last interglacial deposits with *S. bubonius, C. calyculata senegalensis, H hyotis, C. testudinarius, Cymatium trigonum* (Gmelin) (Caldara, 1987) has been found only in the sections of Ponte del Re, near Castellaneta (Taranto) (Boenzi *et al*., 1985; Caldara, 1987). Here, the marine deposits could represent the complete transgressive-regressive cycle related to the maximum high stand of the last interglacial period. Determinations of Aile/Ile ratios on *Glicymeris*, *Anadara* and *Arca* sampled in Ponte del Re section suggested an age corresponding to Aminozone E and isotope Substage 5e (Hearty and Dai Pra, 1992).

Unfortunately, deposits are never coupled with a precise morphological sea level marker; the shoreline at about 45 m a.p.s.l. is defined only in base of the outcroppings of deposits with Senegalese fauna (Boenzi *et al*., 1985).

In summary, the elevation of last intergalcial deposits occurring in the area ranging from Calabria to Taranto suggest a decrease of tectonic uplift from 0.70 mm/y near to the Appennine zone to 0.40 mm/y at Ponte del Re (Dai Pra and Hearty, 1988; Hearty and Dai Pra, 1992; see also: Bordoni and Valensise, 1998; Amato 2000).

Ionian Coast Piano San Nicola * (Cosenza, Calabria) Ponte del Re § (Castellaneta, Taranto)	**Elevation (m a.p.s.l.)**	**Aile/Ile**	**Age (ka)**	**References**
(*) Inner margin	≈ 85	-	-	Hearty , 1986
Glycymeris sp	≈ 45	0.29 ± 0.02	Late Last Interglacial 50-75	“ Hearty and Dai Pra, 1992
(§) Inner margin (°)	45	-	-	Boenzi *et al*., 1985
Strombus bubonius	≈ 35	-	122±4(+)	Boenzi *et al*., 1985; Caldara, 1987
Glycymeris sp	-	0.43±0.03	-	Hearty and Dai Pra, 1992
Anadara sp	-	0.41±0.02	-	“
Arca sp	-	0.33±0.02	-	“

Table 3.4 - *Synoptical table of OIS 5 deposits and landforms in the coastal area between Puglia and Lucania. (+) Age deduced by correlation with deposit of Mar Piccolo area (Hearty and Dai Pra, 1985); (°) maximum elevation of the sediment; there are not geomorphological evidences.*

Stop 3.2.2 – The sapping valley of Gravina di Leucaspide
(G. Mastronuzzi, P. Sansò)

The landscape of the coastal area stretching from Taranto to Mottola is marked by three morphological units. The first unit is represented by the rolling, top surface of the Murge plateau, placed between 340 and 425 m of altitude. It is bordered seaward by the second morphological unit, a steep flight of steps of marine terraces which was produced during the Middle – Upper Pleistocene by the combination of regional uplift and glacioeustatic sea level changes.

In the Taranto - Mottola area, seven orders of marine terraces can be recognized. They are generally narrow wave-cut platforms shaped directly on Mesozoic limestones or Plio-Pleistocene calcarenites and separated by small, subparallel relic sea cliffs. The entire flight of steps is gently tilted toward the southeast.

At Gravina Gennarini locality (Fig. 3.13), the terraces bordered landward by the 55 and 35 m paleo-shoreline, are associated with marine deposits. The higher one is characterised by coarse, bioclastic sediment with *C. caespitosa* which dated at about 290 ka (Th^{230}/U^{234} method by Dai Pra and Stearns, 1977) and referred to the isotopic stage 7 of Schackleton and Opdyke (1973) isotopic curve by Westway (1993). The lowest terrace is marked by the presence *of S. bubonius* Lmk., which suggests a Tyrrhenian age (substage 5e) (Dai Pra and Stearns, 1977; Hearty and Dai Pra, 1992). A *C. caespitosa* specimen collected to the north of Mass. Gennarini in its top layers yielded a Th^{230}/U^{234} age of 107.7± 1.5 ka (table 2).

Those marine terraces are dissected by narrow, straight valleys which represent the third, fundamental element of the landscape. Each relict coastline is, in fact, marked out by the mouth of short valleys. They are encased several metres below the surface of the marine terrace surfaces and in several cases show very sharp deviations (Gravina di S. Marco valley, Gravinola vecchia valley, Gravina di Riggio valley).

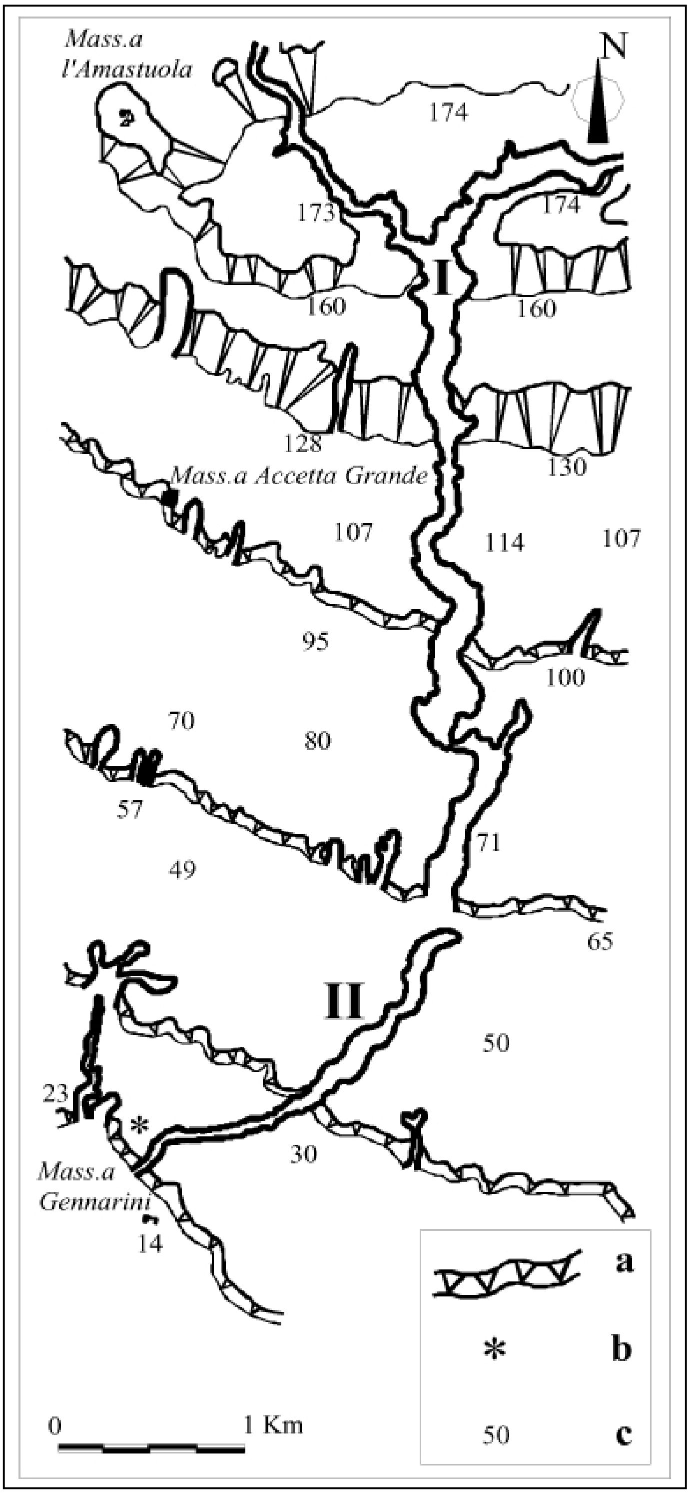


Figure 3.13 - *Geomorphological sketch of the complex Gravina Gennarini (I) – Gravina di Leucaspide (II); a – relict shoreline; b – location of C. caespitosa sample dated at about 107 ka by means of U/Th age determination; e – elevation (m).*

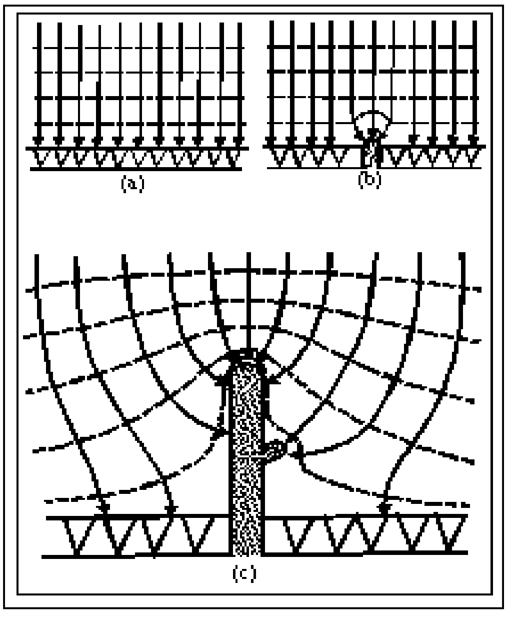


Figure 3.14 - *Development of sapping valley network according to the model proposed by Dunne (1980).*

The longest and deepest valleys have their mouth at the foot of the relict cliff which borders landward the wide marine terrace placed at about 55-60 m of altitude. The latter was shaped during the stage 7 sea level highstand. These last valleys are constituted by a single trench, up to 5 km long, no more than 120 m wide and up to 50 m deep, characterised by constant width. The top surface of the marine terrace is sharply cut by the subvertical valley side slopes. These last ones are shaped through in the Plio- Pleistocene calcarenites in their upper part, at present affected mainly by rock fall and slide, and on Mesozic limestones towards the bottom. Sharp deviations in the main course are frequent, generally at tributaries confluence. Both tributaries and head valleys end abruptly by means of a steep face. Only the longest valleys (Gravina di Colombato valley, Gravina di Leucaspide valley) divide headward into two short branches.

A normal drainage network appears in the area to the west of Mottola where Plio-Pleistocene calcarenite are covered by an unpervious, sandy-clayey marine sequence which allowed a significative overland flow. Because of the recent uplift of the area, streams deeply incise the Plio-Pleistocene calcarenites and the Mesozoic limestone producing locally spectacular canyon-like valleys which are also locally named '*gravine'* (Gravina di Castellaneta valley, Gravina di Laterza valley, etc.) (Parenzan, 1963; 1989a; 1989b; 1992).

However, if sapping processes could be partly responsible for the development of these last landforms, they show features clearly related to the overland flow as the main cause for they development (meanders, numerous tributaries, width growing from head to mouth, well-defined watershed, and so on).

Valley network genesis

The process responsible for the valley development can not be linked to overland flow because of the high permeabilities shown by the outcropping rocks and the flatness of the landscape. On the other hand, the morphological features of the valleys along with the hydrogeological conditions of the area suggest that groundwater sapping has been the main process involved in the development of the observed drainage network.

A model for the development of a valley network by sapping process has been proposed by Dunne (1980) (Fig. 3.14). According to this model the elevation of a smooth land surface shaped on permeable and relatively homogenous rocks above sea level causes the slope of the regional water table and the drainage of groundwater toward sea level.

The underground flow will be affected by the presence of fractures that produce a local increase in the hydraulic conductivity of the rock body and an enhancement of chemical weathering along this zones. In turn, chemical weathering renders them more permeable inducing a feed-back mechanism.The valley development starts with the formation of a small embayment due to a main outcropping fracture zone or an erosional notch. This ground depression induces a deformation in the shape of water table with flow lines concentrating at the edge of the initial indentation and promoting very effective sapping processes. Subsequentely, the valley extends headwards, producing a progressive increase in the flow convergence, in the intensity of the sapping processes and in the related rate of headward erosion. Headward sapping proceeds faster than valley widening because the valley head is the site of the greatest convergence.

The process of repeated failure and retreat at the end, as well as branching, produces a network of river valleys. Tributaries, in fact, grow as groundwater, emerging along the valley side-walls exploits zones of greater hydraulic conductivity, i.e. main joint planes. Valley heads compete for groundwater, as increasing the number of spring heads, each of them drains from a smaller area so that if some heads grow faster and leave the neighbouring branches dry because of subsurface piracy.

The valleys occurring in the central area of Puglia region show very peculiar morphological features which generally mark out valleys developed by sapping process (Higgins, 1984; Laity and Malin, 1985). These features can be summarised as follows:

a) valley widths are essentially constant;
b) valley heads and valley walls are steep with occasional slumps or slide blocks;
c) valley floors tend to be aggraded and nearly flat, forming abrupt angles with the valley sides;
d) valleys growth is affected by the joint pattern;
e) valleys do not have a surficial watershed;
f) surfaces of the marine terraces, into which the valleys are extended, show no evidence of surface run off;
g) where pre-existing relict overflow channels are present they are abruptly cut off by the later, steep-walled valleys.

Sapping valleys and Pleistocene sea level changes

The peculiar morphology of the valleys network developed along the coastal area of Puglia region (Fig. 3.15), along with the lithological and hydrogeological characteristics of the area clearly point out the leading role of groundwater sapping as the main morphogenetic process. Furthermore, morphological analysis shows that valley development was enhanced during Pleistocene high sea level stands. In fact, as strictly linked to sea level, the aquifer and the interface sea water/ fresh water followed the numerous relative sea level changes and the relative shifts of the coastline occurred during the Middle-Upper Pleistocene. Each sea level highstand induced the development of a marine terrace, a coastline and a number of short valleys. The latter flow orthogonally to the related coastline because of sapping processes. Subsurface piracy was then responsible for the development of regularly spaced long valleys which dried out the smaller ones.

Figure 3.15 - *A view of rock falls affecting the slopes of Gravina di Riggio sapping valley, near Grottaglie (Taranto).*

Figure 3.16 - *The cross section of Gravina di Leucaspide sapping valley is marked by a box profile*

Episodic uplift could induce similar process, triggering an abrupt abortion of valley development with hanged short valleys formation. On the contrary, longest valleys could develop during period of relative tectonic quiescence. However, Apulian foreland is supposed to be a relatively stable region, characterized since Middle Pleistocene by costant, low rate of uplift; rapid, coseismic movements have been recorded only at its northermost and seismic area, the Gargano Promontory (Mastronuzzi and Sansò, 2002c). Then, Apulian stair-case arranged marine terraces development is primarily linked to glacioeustatic sea level changes superimposed on a constant rate of uplift.

Sapping processes and valley formation did not occur during the Middle-Upper Pleistocene with the same rate and did not produce the same morphological effects. Around the Murge plateau, in fact, the longest and the deepest valleys are generally related to relict shorelines which are placed at about +13 and +4 m on the Adriatic coastal area and at about +60 m on the Ionian one. In this last case the relative marine terrace was referred to a pre-Tyrrhenian sea level highstand related to the isotopic stage 7 (Dai Pra and Stearns, 1977; Westaway, 1993). Furthermore, the thalweg of longest valleys is characteristically very flat and without any significant break in slope, forming a sharp contact with valley sides, suggesting that they formed during a single morphogenetic events. In fact, if they had been the result of the superimposition of valleys belonging to different generations, a number of knick points would have marked the valleys longitudinal profile.

As geological features remained the same during the Middle and the Upper Pleistocene, the difference in the magnitude of the sapping processes is most likely due to the different hydraulic head which characterised the aquifer during Pleistocene times. It is probable that a steep water table occurred during periods of wet climate and fast sea level rise. A fast sea-level rise, accompanied by increased rainfall, induces the thickening of the aquifer, the steepening of the water table, the increase of the hydraulic head at springs and enhanced sapping processes. Both those conditions were most likely fulfilled during a pre-Tyrrhenian high stand (OIS 7).

Site 3.3

Locality	Santa Teresiola
Community	Taranto
Province	Taranto
WGS84 Coordinates	40.75788N, 017.69728E
Keywords	OIS 5 deposit, Cladocora caespitosa, *S.* bubonius, U/Th age determination, Aile/lle

Stop 3.3.1 – The *Cladocora caespitosa* bank of Santa Teresiola locality
(G. Mastronuzzi, P.Sansò, P. Tuccimei, P. Vesica)

At Santa Teresiola site the most elevated deposits attributed to the Last Interglacial period in the area of Mar Piccolo crop out. This section (Fig. 3.17) is well known from previous studies since it yielded several U-series age determinations perfomed on *C. caespitosa* specimens (Cotecchia *et al.*, 1971; Dai Pra and Stearns, 1977; Dai Pra and Hearty, 1992; Belluomini *et al.*, 2002) (cfr Table 3.5). The lower part of the section is characterized by clays, probably belonging to the *Argille subappennine* Formation, overlaid by transgressive terraced deposits. These latter sediments are represented by silty sands marked near the base by little colonies of *Ostrea* sp. in living position which are overlaid by well-devoloped colonies of *C. caespitosa*. These colonies, up to 1 m high, are characterised by prevalent vertical development and are locally scattered on a surface of about 0.6 km^2 placed at about 12 m a.p.s.l.. The sequence grades upwards into sands with fragments or little colonies of *C. caespitosa* and *C. glaucum, Glycymeris* sp, *Arca* sp, *Ostrea* sp. and *Pecten* sp.. The largest colony of C. caespitosa has been found near Santa Teresiola farm. Smaller colonies with vertical development have been recognized also along the western side of Punta Penne. Globular colonies of *C. coestiposa* up to 40 m^2 of extension are recognisable along the southern coast of Mar Piccolo, between il Fronte and Solito area. Here the senegalese fauna assemblage is also characterised by presence of typical *H. hyotis, C.calyculata senegalensis*; very large specimens of *P. nobilis, P.glycymeris* and *S. gaederopus* are also present. The section of Santa Teresiola lacks of any *S. bubonius* specimens even though they are particularly frequent in what we suppose to be the same sedimentary body cropping out near Punta Penna and along the southern coast of Mar Piccolo. In some localities, as for example along the Galeso river, the *C.caespitosa* bank is covered by lens – laterally extended up to 20 meters - of brown silt with rare marine fossil. On the top of these lens reworked shells and fragments of C. caespitosa are placed (Fig. 3.20, Fig. 3.21). The presence of a mix assemblage of marine and continental fossil remains at the top of sequence near Punta Penne suggest a regressive phase characterised by floods of continental brown water in the semi-enclosed lagoon where C.caespitosa lived (Caldara and Laviano, 1980).

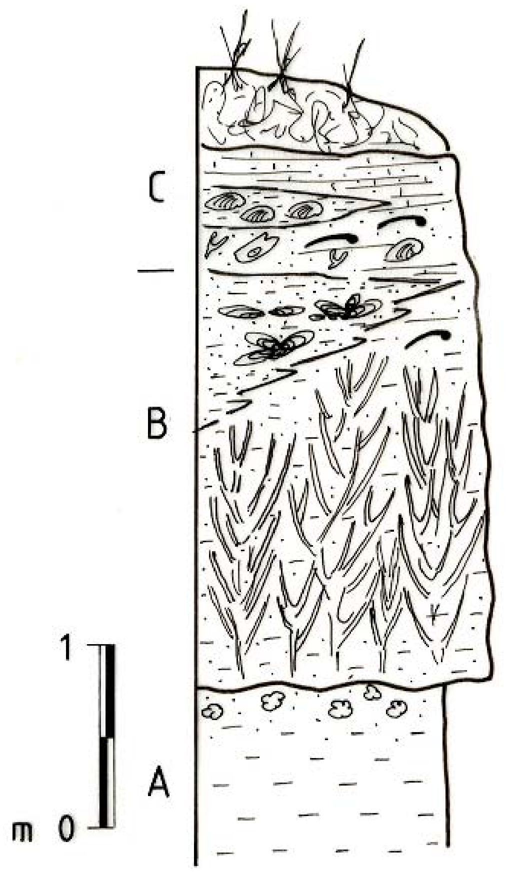


Figure 3.17 - *Stratigraphic section recognised near the Santa Teresiola farm (legend in Fig. 3.8).*

The distribution of specimens of *S. bubonius* and of *Cladocora caespitosa* colonies, as well as the sediment features recognized in the surroundings of Mar Piccolo (Fig. 3.18) suggest that during the Last Interglacial period a sandy bar sheltered landward a semi-enclosed lagoon.

Here, in the most exposed area large banks of *C. caespitosa* developed; this belt shaded landward in a area with bottom depth of about 10-15 meters, marked by low wave energy and significant river waters input which allowed the deposition of carbonatic silts and sands. In this environment an extended cover of Fanerogame which promoted the diffusion of *S. bubonius* should be present (Di Geronimo, pers. comm.).

Finally, near the shoreline a beach made of sands with reworked mix assemblage with S. deposited; it promoted the development of a dune belt which foot is at present at about 27 m (Fig. 3.19).

The deposits with *C.caespitosa* and *S. bubonius* are considered to be formed during the highest stand of the Last Interglacial period. corresponding to the Shoreline complex III of Hearty and Dai Pra (1992), defined by Aminozone E of about 159-86 ka; its age is considered of 125 ka using APK (calib) and 117 using U-series age.

New U/Th age and ratio Aile/lle ratio determinations (Belluomini *et al.*, 2002) suggest an age of deposits with *C.caespitosa* and *S.bubonius* ranging from 140 and 90 ka and point our the absence of evidence of land emersion between the substages 5e and 5c in the area of Mar Piccolo. However, the sequence is characterised by presence of Senegalese fauna only in the lower part.

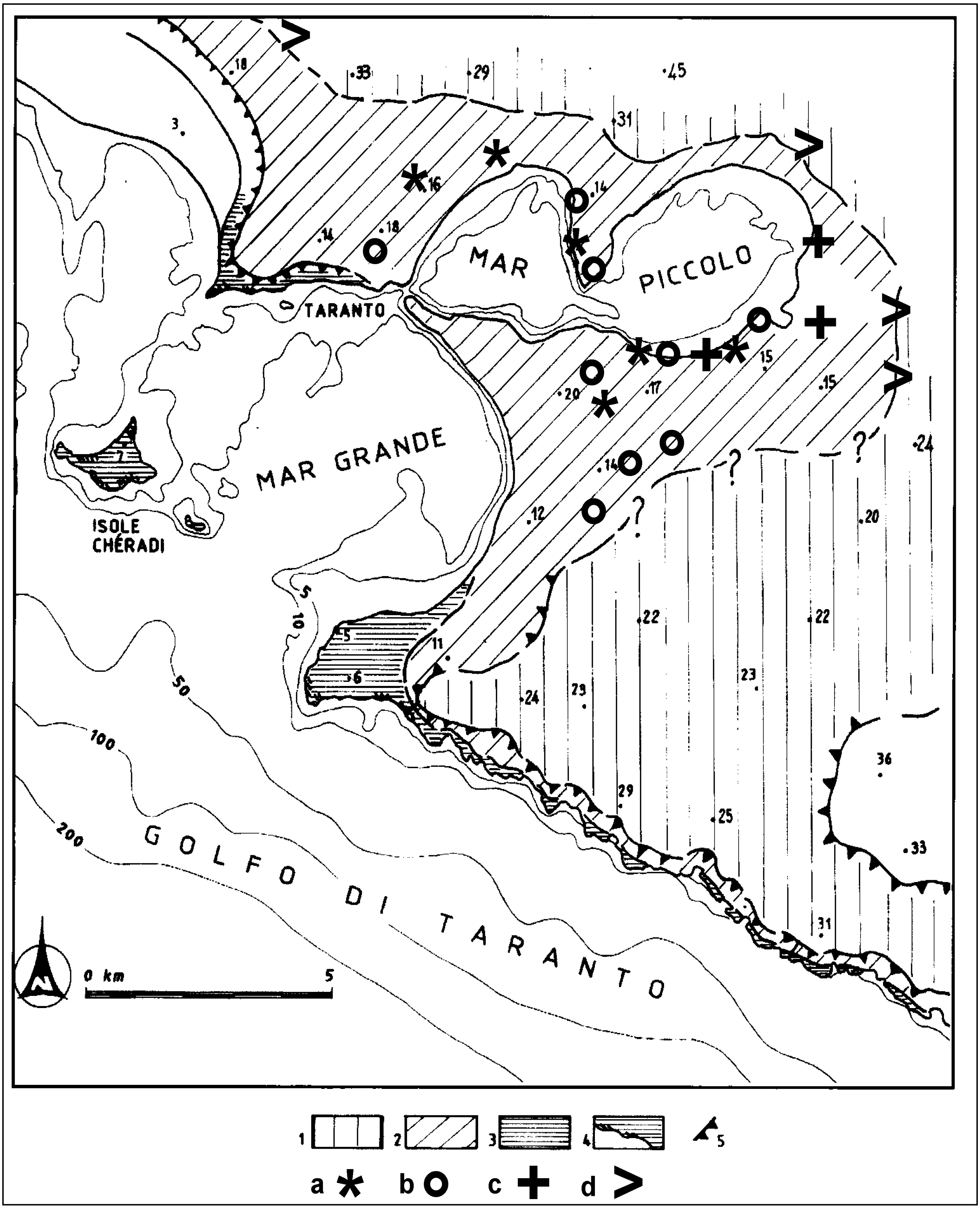


Figure 3.18 - *Distribution of significant fauna in the surroundings of Mar Piccolo area. 1 – OIS 7; 2 – substages 5e-c; 3 – substage 5a; 4 – OIS 3; 5 - relict cliffs; a – C. caespitosa banks; b – in situ Senegalese fauna with S. bubonius; c – reworked senegalese fauna with S.bubonius; d – inner margin/dune belt*

Figure 3.19 - *A view of the dune belt related to the OIS 5 e-c beach in Le Lamie locality in the NE area of Mar Piccolo.*

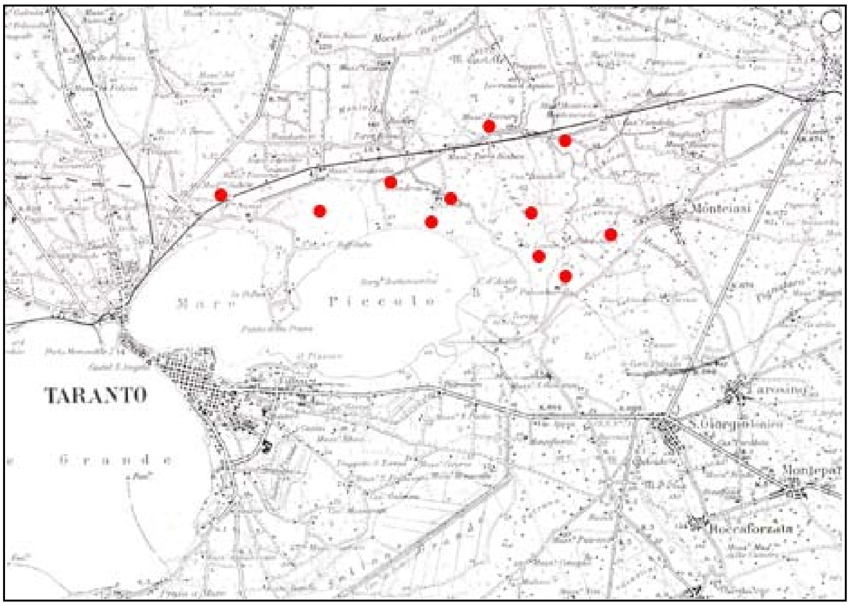
Figure 3.20 - *A view of the Santa Teresiola section. At the base of the slope the Argille subappenine unit is recognisable. The marine terraced deposits are represented at the base by white silty-sands with banks of C.caespitosa; a lens of brownish silty sands with reworked fragments of C.caespitosa and reworked shells follow ; at the top of local sequence about 1 m of calcarenites with reworked coral and bivalves close the OIS 5e-c deposits.*

Figure 3.21 - *A view of the vertical colonies of C.caespitosa, here about 0.7 m high, which characterise the bank of Santa Teresiola.*

Taranto – Mar Piccolo	Elevation (m a.p.s.l.)	Aile/Ile	Age (ka)	References
Strombus bubonius	7 (a)	-	-	Dai Pra and Stearns, 1977
"	15 (b)	-	-	Dai Pra and Stearns, 1977; Mastronuzzi, 2001
"	15 (c)			Dai Pra and Stearns, 1977; Caldara and Laviano, 1980
"	12 (d)			Dai Pra and Stearns, 1977;
"	2/11 (e)	-	-	Dai Pra and Stearns, 1977; Mastronuzzi, 2001
"	19 (f)	-	-	Mastronuzzi, 2001
Cardita calyculata senegalensis, Hyotissa hyotis	16 (g)	-	-	"
Inner margin	35-28 (*)	-	-	Dai Pra and Stearns, 1977
"	28-35 (*)	-	-	Hearty and Dai Pra, 1985
Inner margin – foot of dune belt	27 (*)	-	-	Mastronuzzi, 2001
Cladocora caespitosa(+)	-	-	87±4 (a)	Dai Pra and Stearns, 1977
"	-	-	106±8 (a)	"
"	-	-	130±10 (a)	"
"	-	-	154±13 (a)	"
"	-	-	142±14 (i)	"
"	-	-	142±14 (e)	"
"	-	-	146±12 (e)	"
"	-	-	>260 (e)	"
"	-	-	205±20 (d)	"
"	-	-	117±7 (a)	Hearty and Dai Pra, 1985
"	-	-	128±7 (a)	"
"	-	-	121±7 (a)	"
"			122 ± 4 (!)	"
"	-	-	162+23/-18 (d)(++)	Gewelt M., CEN/SCK, Mol, Belgio in: Dai Pra and Hearty, 1988
"	-	-	134 ±16 (h)	Gewelt M., CEN/SCK, Mol, Belgio in: Dai Pra and Hearty, 1988
Cladocora caespitosa	-	-	125±6 (a) (+)	Szabo, U.S.G.S., Denver Colorado in: Dai Pra and Hearty, 1988
"	9-9.5	-	89.8±4.8 (d)	Belluomini *et al.*, 2002
"	11	-	93 + 8.8/-8.1	Present paper
Glycymeris sp	-	0.37±0.02 (a)	-	Hearty and Dai Pra, 1985
Glycymeris sp	-	0.36±0.01(c)	-	"
Glycymeris sp	-	0.38±0.01(l)	-	"
Arca sp	-	0.29±0.03 (c)	-	"
Arca sp	-	0.27±0.05 – 0.30±0.03 (a)	-	"
Dentalium sp	-	0.31±0.02– 0.61±0.02(a)	-	"
Spisula sp	-	0.26±0.01- 0.36±0.02 (a)	-	"
Cerastoderma sp	9-9.5	0.43±0.01 (d)	-	Belluomini *et al.*, 2002
Cerastoderma sp	11	0.36±0.04 (m)	-	"

Table 3.5 – *Synoptical table of elevation of S. bubonius specimens, aile/ile ratio and U/Th age determinations available for the marine terraced sediments around the Mar Piccolo. (*) These two elevations are referred to Ponte Romano inner margin (35 m a.p.s.l), about 7 km NW of Mar Piccolo, and to the foot of dune belt near Convento vecchio (28 m a.p.s.l.), along the NE coast of Mar Piccolo. The faunal assemblage confirms the identification of the shoreline at about 27 m around the Mar Piccolo. In fact C. caespitosa lives between 0 up to 60 m depth but it is rare below 30 m (Peirano et al. 1994; 1999); Hyotyssa hyotis lves below low tide up to 300 m depth, but prefers the range between 20-30 m depth (De Castro Coppa, 1972); Glycymeris and Strombus could live respectively up to 40 and 60 m depth. The environment could be conditioned by hydrodynamism and by availability of food. The presence of the barrier which partially closed the lagoon, the faunal assemblage, the absence of sedimentary structures, and of the type of sediment suggest a former bottom depth of about 10-15 m. (°) Mean age of S. bubonius sediments.(a) Il Fronte Locality; (b) Casa d'Ayala; (c) Punta Penne; (d) Santa Teresiola; (e) Masseria Pantaleo; (f) Solito Corvisea; (g) Masseria Tuglia; (h) Masseria Baganara; (i) Masseria San Giovanni; (l) Masseria San Pietro; (m) Masseria Natrella*

Stop 3.3.2 - Archaeology and landscape of the North coast of Mar Piccolo near Taranto (S. De Vitis)



Development of human settlement in Tarantine country, in urban area and in extra urban one is deeply influenced by natural and morphological conditions of *site*.

If natural date in the site of modern city - particularly in the Old Town – is very hard to advertise it today, the evidence of land around the North coast of Mare Piccolo is better visible.

Mare Piccolo is an internal sea of great importance being in the past age, before the industrial developing of Taranto a kind of *Umbilucus Urbi.*

Figure 3.22 - *Taranto archaeological sites in North Mare Piccolo Area*

Figure 3.23 - *(a) Archeological site in Mar Piccolo Area (b) Taranto, St. Peter's farm Ruins of Roman Villa*

The presence of Mare Piccolo has got prehistoric an protohistoric settlements so it has got the choise of the site to built Military Arsenal and consequently the one to build the New Town (called Borgo) in the second half of XIX century.

In the same way, the natural amphitheatre converging to Mare Piccolo has brought about particular environmental and productive vocations by which Taranto was famous in Ancient Age, like mussel and fishing farming or the production of clothes made by wool and byssus and then painted by purple.

About the most ancient presence of human life in the country, we haven't trace of Paleolithic sites, which are on the contrary quite large in hills around Martina Franca, in some caves (Laddomada , 1999).

Human settlements become frequent in the area in the area of the second creek of Mare Piccolo in the Ancient Neolithic period near S. Pietro Marrese Farm and in the Recent Neolithic time in S. Andrea, Le Lamie, Palombara Farms.

We can observe the ancient village were quite far to the coast, and it means that sea was, between VI and IV millennium B.C. larger than now, and surely whit a large presence of swamps.

The land around first creek of Mare Piccolo seems to be less rich of finding probably by Galeso valley, with presence of many underground springs of karstic cause.

During the Bronze Age the country shows a fair presence of medium – little sites, from which Aegean and Mycenean pottery comes (Gorgoglione, 1996).

Here we haven't however large dimensioned village like those existing in the same period all along the coast of Jonian sea: Saturo/Porto Perone, Torre Castelluccia, Scalo di Furno, except a settlement found few time ago in site Le Corti/Aiedda and still not studied with archaeological excavations (De Vitis, 2001).

With the foundation of Laconic *apoikìa* of Taranto the North area around Mare Piccolo became *chora*, part of country used by Greek people to farm.

Taranto border runs along the first hills around Mare Piccolo basin.

Really, the limit wasn't well defined during the time; its existence was conditioned by the relations, not ever peaceful, with native people living around.

Taranto's country borders were: to North all the hill over Mare Piccolo basin, from Crispiano, to Martina, Monte Salete e Vicentino Farm near Grottaglie since to Monte Belvedere near S. Giorgio Jonico e Roccaforzata, all the Jonian sea coast from Torricella at the East to Bradano River to the West, Passo di Giacobbe near Ginosa and finally Mottola e Lamastuola Farm.

During the Greek Age (VIII- III c. B.C.) around Mare Piccolo there was a lot of medium and small farms and a certain number of fortified village on the border line, to the military control of the country.

All these settlements had been located by presence of little necropolis and by finding of votive relieves made in terracotta bringing the image of *Artemis Bendis*, the hunter goodness symbol of fertility of land.

All these farms had a maximum increase between the end of V and the IV century B.C. to disappear after the Hannibalic War (209 B.C.). An ancient road linked the most important sites along Mare Piccolo's coast, meeting the *Plateia Megale* (the Greek Main Street) coming out the East gate of city so like Polybio described. In tra area between San Pietro Marrese and Le Lamie Farms had been found some excavations to take out stone blocks, in IV and III century B.C. which reminds, for the kind of material and for size, the Walls of city. In Roman Age the East part of country around Mare Piccolo was divided by method of *Centuriatio* and was given to veteran soldiers to farm.

The ancient Main Street was included in via Appia coming from Rome to Brindisium.

In Imperial Time since to VI century A.C. in the country was dominant the big property called *Latifundium*, leaded by strong senatorial families. We know at the moment very extended roman villas near Santa Teresa Farm (Ith creek of Mare Piccolo), Buffoluto, Nasisi, San Pietro, Le Lamie, Ferrara farm.

During the sixth century A.C., Greek Gothic War signs the passage from Late Antiquity and Early Medieval period: all villas seems to be disappeared in the half of century, while the settlements were placed more far to the coast and small ravine were used to excave cave houses and chapels.

Near San Pietro Marrese Farm, for example, to the roman villa near the sea succeded a village placed some hundreds of metres more to North, where the church was built in X century A.C.

During Byzantine domination landscape shown open village and cave village in ravine, linked by radiate street that it's possible to see still now. Most important owner at that time were most important monasteries, whether following Greek rite, or Latin liturgy. After 1060, with the Norman conquest, largest part of these churches became Latin and catholic. Among them, the most important was Imperial St. Peter's, now St. Dominic's in the Old Town. We have still now a group of rural churches reminding more ancient Abbeys and churches: Santa Maria del Galeso, founded in 1169 by Cistercian monks, clever to farm swampy countries, San Pietro Marrese (1126), in which Greek and Latin liturgy living together, Battendieri, where Capuchin tunic were made. We conclude this short note remanding Taranto's town planning history shows a time in which, in Old Town, the local calcareous stone has been excavated to have some environments since from Late Antiquity.

High coast over Mare Piccolo made a so called "Salto di quota" and was used to excave some underground cemeteries and catacombs, like the Palazzo delli Ponti one, recently found.Along via Di Mezzo, between scaletta Calò e Postierla via Nuova we know more of ten cave rooms. Exploitation of calcareous stone go on for all Middle Age.

Sites

1) San Pietro Marrese or sul Mare Piccolo or di Mutata

The site is called in the first way by the name of ancient owners, and "*of mutata*" because *mutatio* is a Latin word signifying the fortified site where by order of Dioclezianus Emperor were assembled wheat for Roman Food Admninistration (Fig. 3.22).

1.1) Roman Villa

Along the SP Circummarpiccolo, where the road to the farm begins, there is a large bench facing Mare Piccolo. It was filled by a roman villa dating back I and V century A.C.In the ground it's easy to see a lot of late Hellenistic pottery concerning a previous Greek farm, to which big pit made in calcareous stone, found in archaeological excavations, belonged. Along the actual road it's possible to see the *basis villae* made by bricks, some walls in *opus coementicium* with re-employment blocks. Villa seems to be deserted about around V century A.C., when settlement brought itself near the actual farm.Although particularly ruins don't survive, it's clear its ancient monumentality. Roman villa had two different functions: to be a farm and to be a rich residence of a Lord. In this case, too, the complexity of the settlement is suggested not only by the ruins of the walls, but by a series of utility structure collected, like the waterworks now under st. Peter's, all digged in the stone

1.2) The next areas

a) So as it was wrote previous, to the east of the farm it's possible to locate some sites of ancient Neolithic Age (VI/V Millennium B.C.) and Bronze Age (II Millennium B.C.).
b) Concerning this last one village many holes of wood pile, tracing plan of sub circle or elliptic cabin.
c) To East of the farm it's possible to see some ruins of Greek Necropolis with contertrench grave covered by a double sloping cover. A large part of these graves was destroyed in the IV century B.C. when stone was cut to take off blocks used for urban walls of Taranto.
d) Little ravine to west of the farm in Early Middle Age was a rock village in which since thirty years ago a small apse with painted saints was possible to see
e) The site was a strategic point for ancient and medieval road network:

Along the road bringing to the farm and to the Abbey's church you can see, on the right side, a long plastered wall with a lot of ancient re employed block. In inside part many graffito crosses and other holy symbol there are: it shows that there was a medieval road bringing from the North of Taranto's country to the via Appia out of the city. St. Peter's was probably a site to have a stay. An other ancient road runs to the north of the farm, along the contour line of 25/30 m. on sea level, going in Le Lamie Farm, where it forks: a line goes to North, going to the settlement of Aiedda and Le Corti since to Monte Castello near Montemesola. Second branch follows the coast to go to St. John's farm near San Giorgio Ionico where it meets Appia road coming from East gate of Taranto.

2) Le Lamie Farm

At South of farm it's easy to find Neolithic pottery with handle in Diana – Bellavista style.
Site is famous to finding Greek graves and, unfortunately, for illegal archaeological excavations too.Next to the trees it's easy see some cover of Greek graves. In National Archaeological Museum of Taranto a calcareous stone metope is kept (IG 16800). In 1971 was founded a Latin inscription of a gravestone datable to III century A.C. In 1983 was found an incuse coin of Metapontos (Cippone, 1981).

3) Palombara Farm

Between farm and Aiedda channel it's possible find stone manufacture and pottery dating to Bronze and Iron Age. In the same place there is an Hellenistic necropolis (Cippone, 1981).

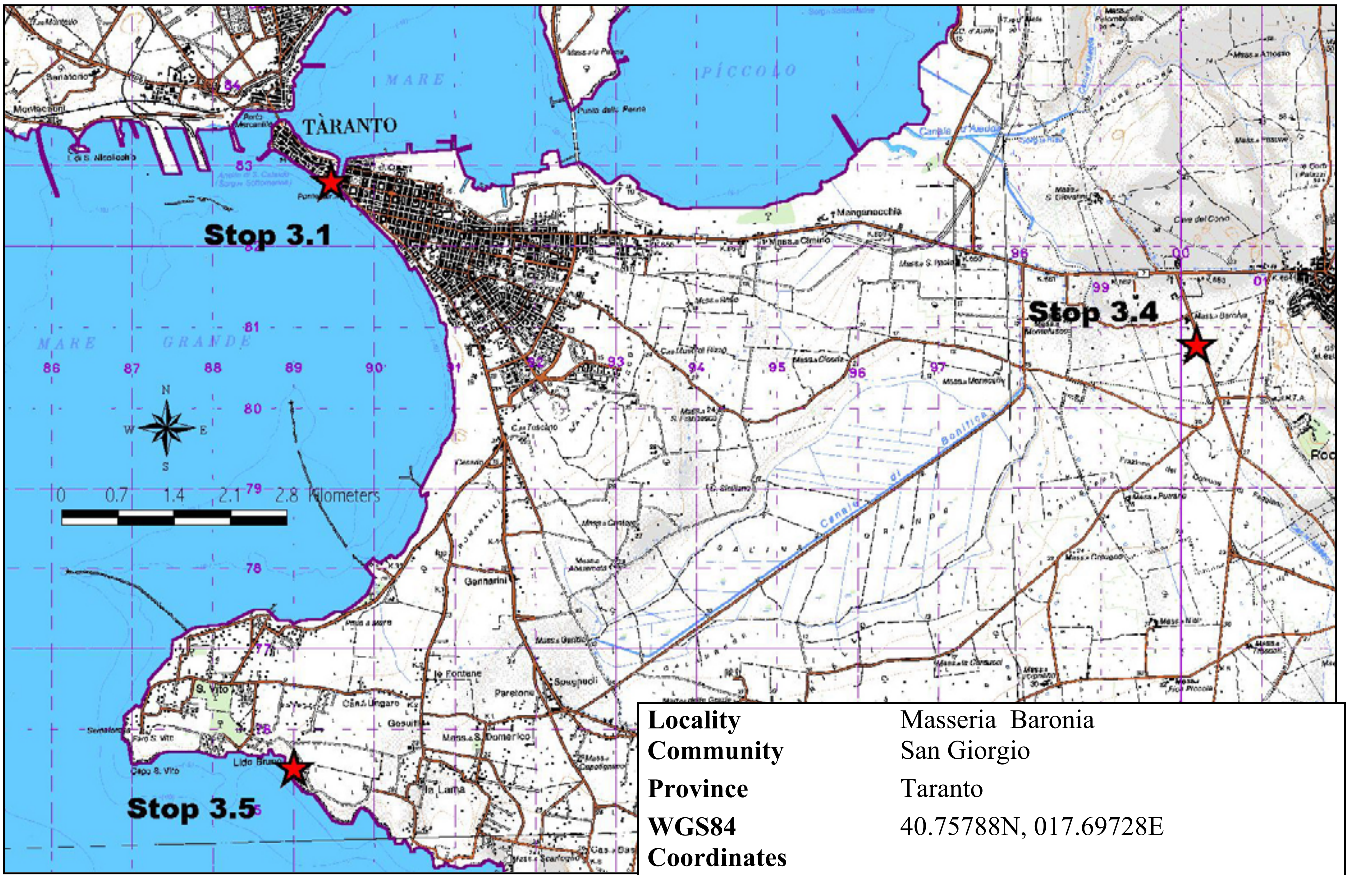
4) Palombarella Farm

Hellenistic necropolis (Cippone, 1981).

5) Ferrara Farm

Farm with next oil press is directly above II creek of Mare Piccolo. It's a very important settlement by presence of an Hellenistic farm covered by imperial villa, archaeologically excavated in 1995. After the Roman period, in Late Antiquity a village survived since to VI century A.C.

Site 3.4



Locality	Masseria Baronia
Community	San Giorgio
Province	Taranto
WGS84 Coordinates	40.75788N, 017.69728E
Keywords	OIS 5 deposit, Dune belt, Inner margin

Stop 3.4.1 - The dune belt of San Giorgio
(G. Mastronuzzi, P. Sansò, P. Tuccimei, P. Vesica)

A continuous dune belt, about 4 m high, is recognisable between Masseria Baronia and Massera Ruina, at the foot of the graben of Monte Sant'Elia, near San Giorgio (Taranto).

It is made of bioclastic sands (less than 15 % is represented by terrigenous grains). At the base about 1.5 m of low-angle laminated, well-cemented, medium-coarse calcarenites with rare shells of bivalves represent foreshore sediments belonging to the Last Interglacial terrace. It grades upwards into fine calcarenites, very well sorted and medium cemented, showing high-angle cross lamination.

No elements are available to date directly the dune belt which marks the inner margin of a very large marine terrace, about 9 km wide, stretching from Taranto to San Giorgio. However, since this terrace is diffusely characterized by senegalese fauna (Fig. 3.25), the dune belt could be referred to the Last Interglacial period.

San Giorgio (Taranto) Masseria Baronia – Masseria Ruina	Elevation (m a.p.s.l.)		References
inner margin – foot of dune belt	24	-	Mastronuzzi, 2001
Strombus bubonius	11	(1)Masseria Abateresta	"
"	20	(2) Casino Massarotti	"
"	16	(3) Casino Salinella	"
"	19	(4) Casino Manzo	"

Table 3.6 – *Place and elevation of finding of S. bubonius seaside of the dune belt of San Giorgio*

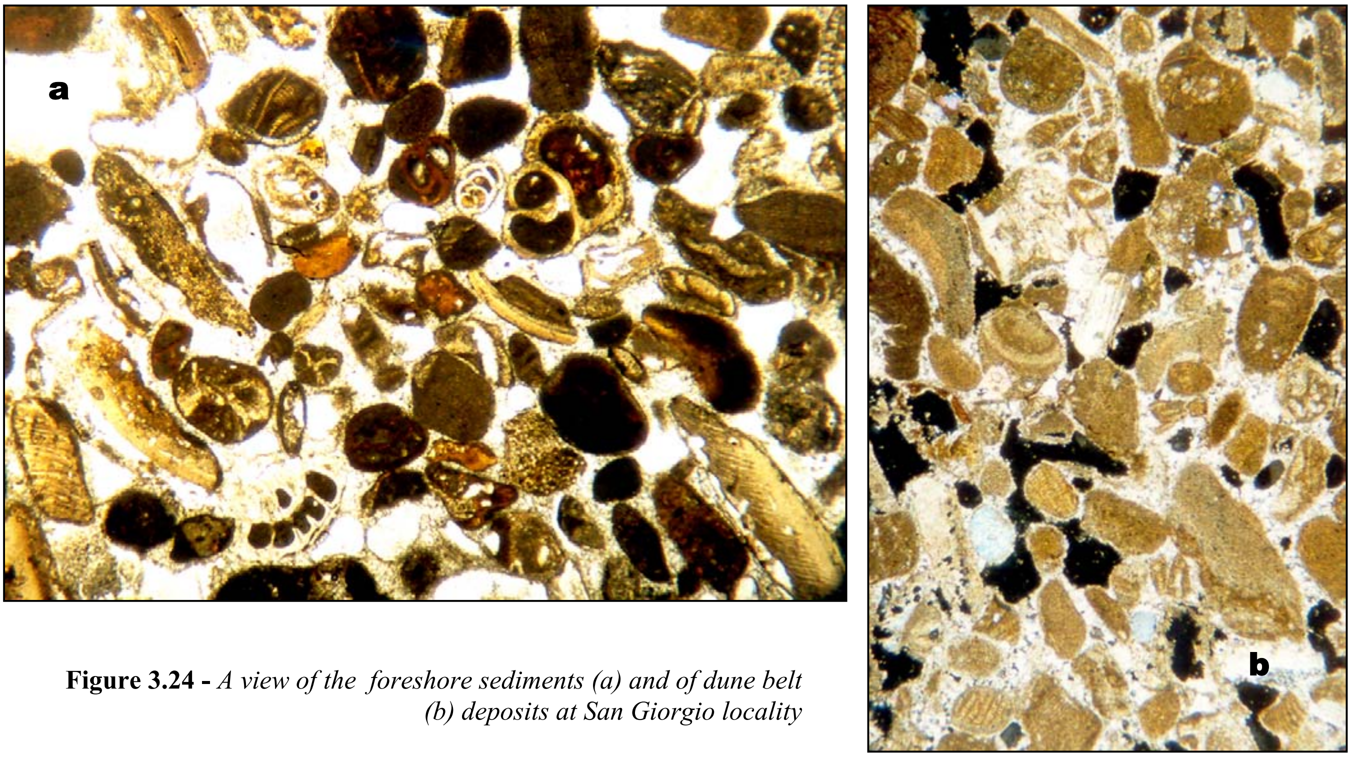
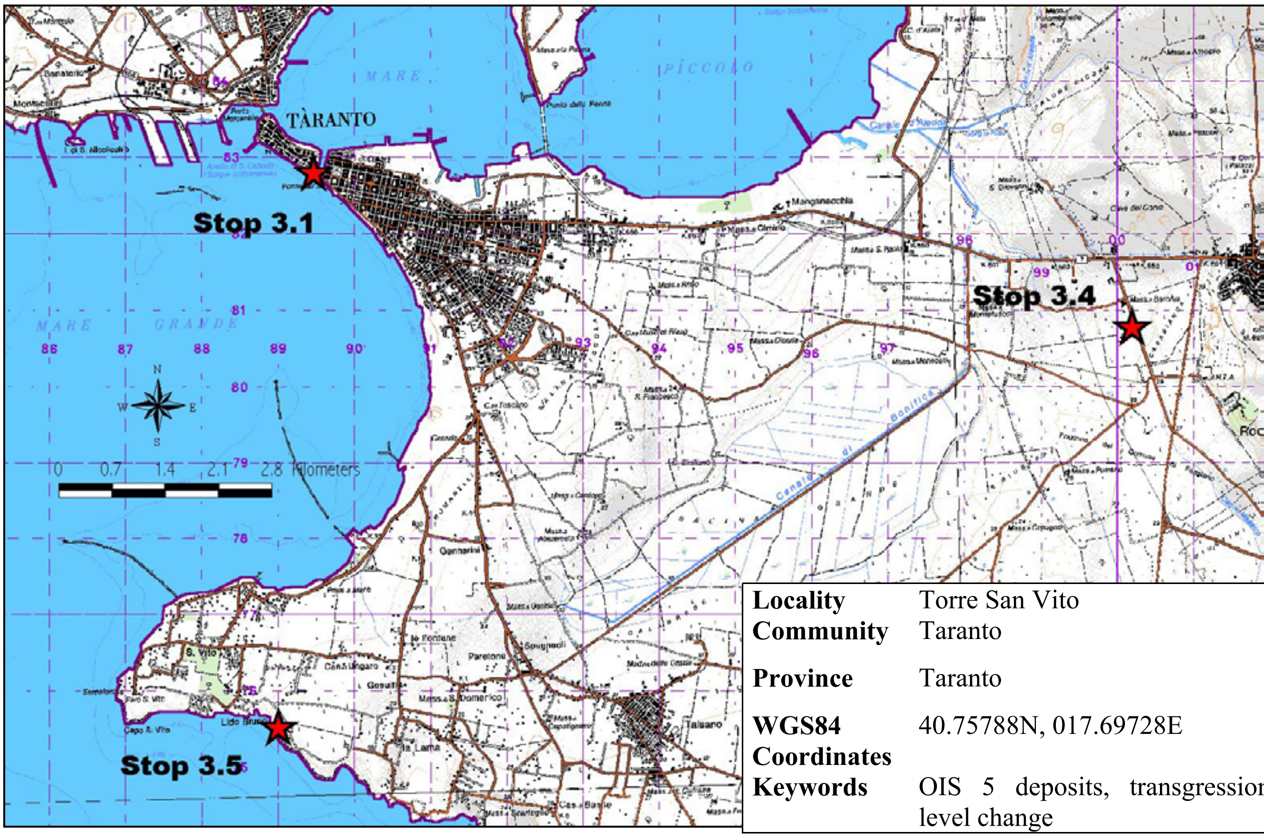


Figure 3.24 - *A view of the foreshore sediments (a) and of dune belt (b) deposits at San Giorgio locality*

Figure 3.25 - *A specimen of S. bubonius sampled at about 11 m a.p.s.l. near Masseria Abateresta.*

Site 3.5



Locality	Torre San Vito
Community	Taranto
Province	Taranto
WGS84 Coordinates	40.75788N, 017.69728E
Keywords	OIS 5 deposits, transgression, Sea level change

Stop 3.5.1 - The coast to the south of Taranto (G. Mastronuzzi, P. Sansò, P. Tuccimei, P. Vesica)

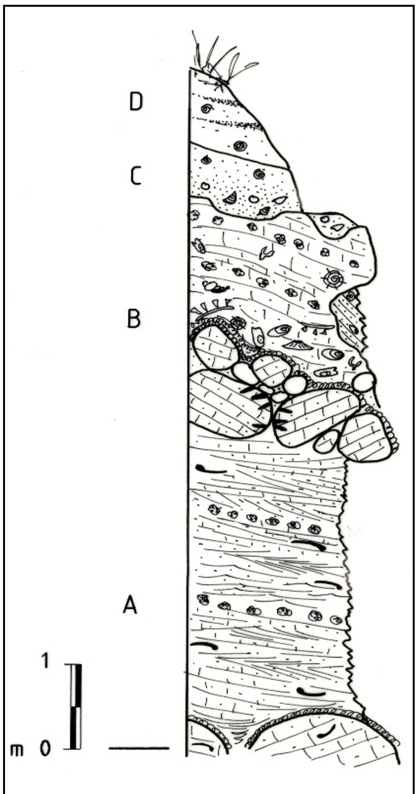


Figure 3.26 - *Stratigraphic section near Torre San Vito (legend in Fig. 3.8).*

The coast to the south of Taranto is generally made of gently sloping rocky coasts. However, 10m high cliffs formed where the shoreline intersects narrow relict valleys. Along the cliff face the Last Interglacial deposits crop out; they lack of specimens of *S. bubonius* whereas a typical fauna of DC and Coralligenous environment (sensu Peres and Picard, 1961) is recognisable. It is characterised by large specimens of *P. ferruginea, S. gaederopus, A. rugosa, A. noe, Caronia sp., M. brandaris* and *T. trunculus*.

Torre San Vito section

The stratigraphic sequence is exposed on about 10 m high cliff (Fig. 3.26). The base is marked by calcarenitic, sub-rounded blocks followed by laminated calcarenites with numerous rhodolites levels; *Glycymeris* sp. debris and traces of *Echinocardium cordatum* (Pennant) activity can be recognised. Aile/lle ratio determinations suggest an age corrisponding to isotope Substage 5c. In this same level, few km to the southeast, U/Th age determinations on *C. caespitosa* sample (139 ka) and the Aile/lle ratio on *Glycymeris* indicate a possible correlation with the isotope Substage 5e (Belluomini at al., 2002).

The sequence continues upwards with large blocks affected by lithophaga boreholes and covered by algal mats which are overlain by calcarenites containing many rhodolites and decalcified valves of *A. noae.* The top surface of this well-cemented layer has been modified by small potholes filled with pinkish/red sands with numerous remains of gastropods and bivalves as in the Apodonia beach, Southwestern coast, Punta La Dogana, Punta Lo Scanno sections on Chéradi Islands and Punta Rondinella section in Taranto. The sequence is locally capped by aeolian sands very rich in *Helix* sp. remains which yielded an uncalibrated 14C age of 6386 ± 70 years B.P. (Dini *et al.*, 2000).

Coast south of Taranto	Elevation (a.p.s.l.)	Aile/Ile	Age	References
Torre San Vito – Torre Castelluccia				
Inner margin	27	-	-	Dai Pra and Stearns, 1977
Strombus bubonius	≈ 25	-	-	"
Glycymeris sp	-	0.28±0.02 – 0.39	-	Hearty and Dai Pra, 1985
Arca sp	-	0.22±0.03 – 0.26	-	"
Astralium sp	-	0.41±0.03 – 0.49±0.03	-	"
Dentalium sp	-	0.45	-	"
Spisula sp	-	0.32±0.04	-	"
Glycymeris sp	0.8 – 1.0 3.5	0.43±0.01 – 0.55±0.01	-	Belluomini *et al.*, 2002
Cladocora caespitosa	-	-	138±14	Dai Pra and Stearns, 1977
"	3.5	-	139.6±4.5	Belluomini *et al.*, 2002
Torre Castiglione				
Strombus bubonius	1	-	-	Hearty and Dai Pra, 1992
Cladocora caespitosa	-	-	156+/- 20	Dai Pra and Stearns, 1977

Table 3.7 – *Synoptic table of OIS 5 deposits and landforms in the area to the southeast of Taranto.*

The age of Late Pleistocene units

The whole set of chronological determinations along with paleontological and stratigraphical data allow us to recognize at least three distinct marine units (Figg. 3.27, 3.28, 3.29).

The oldest unit is made by sands, silty sands, laminated calcarenites and algal calcarenites. Its deposition occurred between 140 ka and 90 ka, as the presence of Senegalese fauna and new age determinations point out in correspondence with substages 5e and 5c of Shackleton and Opdyke (1973) and Imbrie *et al.* (1984). The *S. bubonius* is present only in the lowestlevels corresponding to the isotope substage 5e.

No evidences of land emersion between these two substages have been found in the area most likely because of the relative movements between land and eustatic sea level. Recently Rose *et al.* (1999) pointed out that there is no known geomorphological effect associated with the deterioration of climate recognized in the later part of OIS 5e, either because the change of climate was not sufficient to cause the geomorphic processes to cross critical thresholds of erosion, or because the event was not long enough for sufficient quantities of material to be eroded and deposited.

The second unit lies in transgression both on the Tyrrhenian level and on the local geological basement. It is made up of pebbles, sands and algal calcarenite and is characterized by warm phauna which lacks Senegalese species. This unit formed about 85 ka, during late last interglacial high sea level stand, in corrispondence with substage 5a. It could correspond to an older phase of the Shoreline complex II of Hearty and Dai Pra (1992).

This second unit is covered in several places by a third one which is made of sands, silty sands and silt and retains specimens of *P. nobilis* and *G.glycymeris* in living position. We obtained an age of 48 ka for this unit, so that it could be formed during an high sea level stand which occurred during the OIS 3.

Conversely, aminoacids analyses and U-series age determinations on samples collected at about 1 m a.s.l. at Isola di San Pietro (ISP5 samples) suggest the occurrence of a marine deposit formed about 48 ka (OIS 3) well separated from the older deposits by a major unconformity. With regard to this, in analogous stratigrafic sequences Hearthy and Dai Pra (1992) reports the presence of a beach sand, consisting of a reddish calcarenite and containing a "banal" fauna. The analyzed Glycymeris are characterized by D/L values between 0.30 and 0.25. The APK model (Mitterer and Kriausakul, 1989) applied by Hearty and Dai Pra (1992) suggest an age of 75-50 ka (Late 5a,4 and 3). The resulted large spread in age could be attributed to the fact that the extrapolation of rates beyond the calibration range is likely to lead to large errors because the estimated ages will be strongly model-dependent (Mitterer and Kriausakul, 1989; Goodfriend, 1991). It is our opinion that an age younger than 50 ka is the most plausible age for these stratigraphic sequences. Evidences of marine deposit in Mediterranean basin related to stage 3 are reported by other Authors. On Crotone peninsula (Calabria, Southern Italy), along the coast of Ionian sea, marine deposits as *"panchine"* - ranging from 220 m of elevation to present sea level, have been referred to stages 9, 7 and to substages 5e, 5c and 5a by Belluomini *et al.* (1988) and by Palmentola *et al.* (1990).

Recently, luminescence analyses on these *"panchine"* suggest to refer the deposits previously ascribed to OIS 5a to OIS 3 (Mauz and Hassler, 1998; 2000). Besides that, in Belluomini *et al.* (1986; 1999), some D/L ratios (from 0.21 to 0.25) suggest the presence of an OIS 3 above present sea level, in a tectonic stable region (Sardegna Island), with thermal conditions similar to those of Taranto area.

Finally Miller *et al.* (1983) explain the occurrence of some emerged marine units in western Norway with an Atlantic water input in the Norwegian Sea during much of OIS 5 and intermittently during OIS 3.

Eustatic sea level curves proposed by different Authors (i.e. Chappel and Shackleton, 1986; Shackleton, 1987; Bloom and Yonekura, 1990) suggest a low sea stand of 30 to 70 m below present sea level in correspondence of OIS 3. As reported in Mix and Ruddiman (1984), Shackleton (1987) and Vesica *et al.* (1999), these curves do not led to precise determination of sea levels because ocean isotopic composition is not a linear function of ice volume and hence is not a linear function of sea level. In addition to that, sea level changes present a strong regional specificity, in response to hydro- and glacio-isostatic adjustments (Hillaire-Marcel *et al.*, 1996; Pirazzoli, 1996).

Data from many localities support this statement, even if additional data from other coastal areas of the world are needed for better document the evidence of marine deposit related to OIS 3. In fact its occurrence above present sea-level in areas that are considered affected by a low rate of uplift is currently a dilemma.

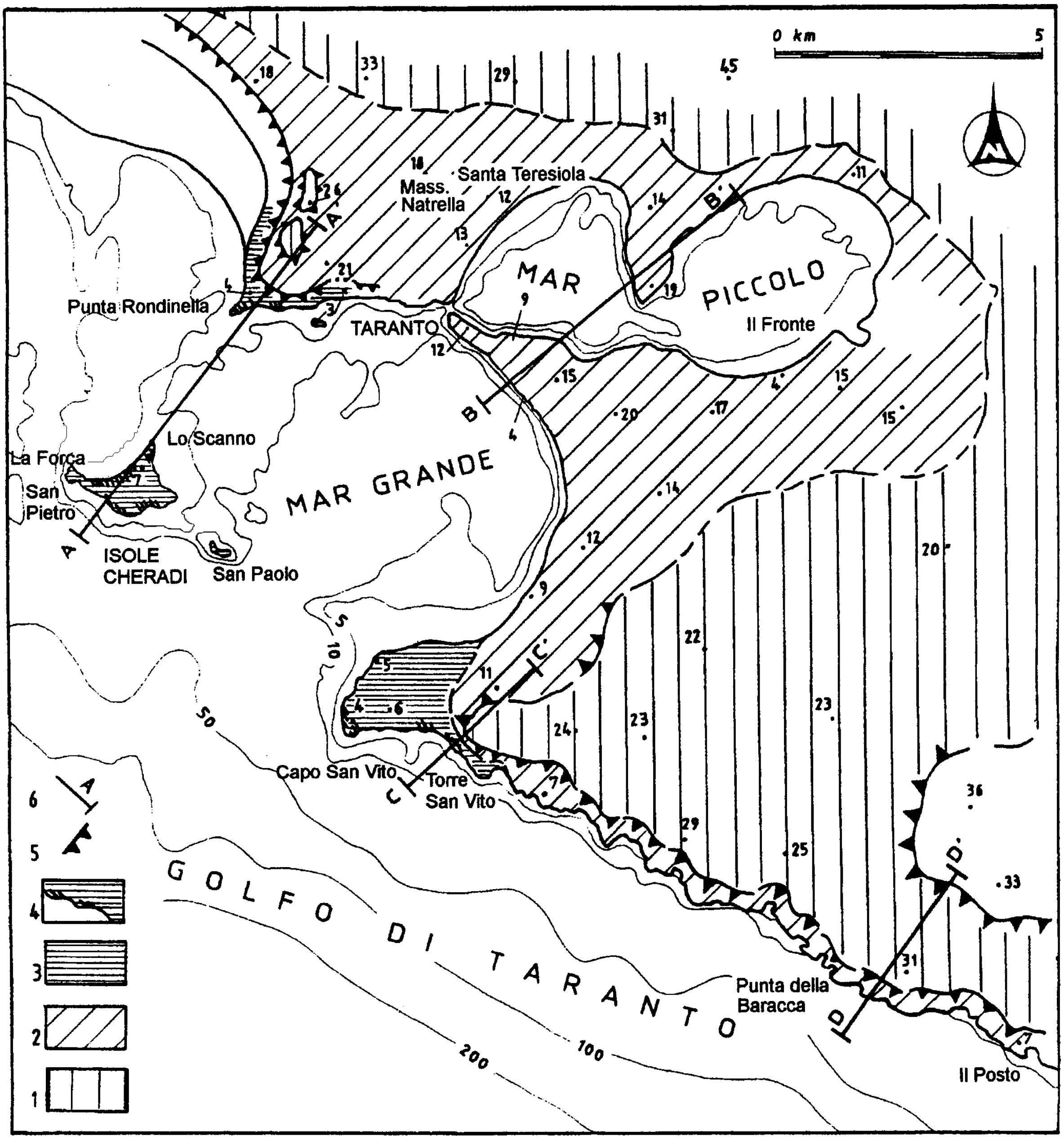


Figure 3.27 - *Late Plesitocene marine deposits outcropping in the Taranto area. 1 – OIS 7 deposits; 2 – substages 5e-c deposits; 3 – substage 5a deposits; 4 – OIS 3 deposits; 5 - relict cliffs; 6 – traces of sections reported in Fig. 3.28/29.*

Morphological evolution and uplift

The chronostratigraphic data along with the geomorphological survey of the area allow the reconstruction of the morphological evolution of the Taranto coastal area during last interglacial/glacial cycle.

This area, characterised by a large bay corresponding to the present Mar Grande and Mar Piccolo, was affected by a rapid, long and wide transgression during substage 5e. OIS 5 which promoted the devolopment of the submerged sandy barrier of Taranto historical centre. Similar characteristics of sea level rise during the first phases of OIS 5 were reported by Hillaire-Marcel *et al.* (1996) in Balearic Islands. During OIS 5e and 5c the relative sea level apparently was placed at about the same position as suggested by the lack of unconformity or soil/continental deposits. This led to the formation of a wide marine terrace which, presently, stretches between about 4 and 24 m elevation. The relative sediments show high variability of facies and are characterized by Senegalese fauna in its lower part.

They partly overlay in transgression the local basement (Mesozoic limestones and/or Plio-pleistocenic clays) and partly the older *"panchine"* deposits referable to OIS 7 and, probably, OIS 9 (Dai Pra and Stearns, 1977; Hearty and Dai Pra, 1992). On the other hand, the presence of only one dune belt indicate a very fast emersion of the coastal area, may be connected to an acceleration of the uplift.

A new relative high sea level stand occurred during the substage 5a, about 85 ka BP.

Morphological and stratigraphical evidences suggest a definite evolutive scheme. The presence of a relict cliff shaped in Plio-pleistocenie clays and in the uppermost part on calcarenites related to substage 5e/c suggests a very fast transgressive phase, which in turn suggests tectonic activity shortly before the deposition of the 5e calcarenites. We hypothesize a fast drop of sea level superimposed on a gradual uplift as in a model suggested by Pirazzoli (1996). The difference between Punta Rondinella (where there is a relict cliff) and Capo San Vito area (where there it is not) can be explained by different tectonic behaviours. The relict cliff of Punta Rondinella could correspond to a coseismic fault in the hinge zone of "Soglia messapica", the alignment between Taranto and Brindisi, which separes the Murge plateau and the Taranto - Brindisi plain.

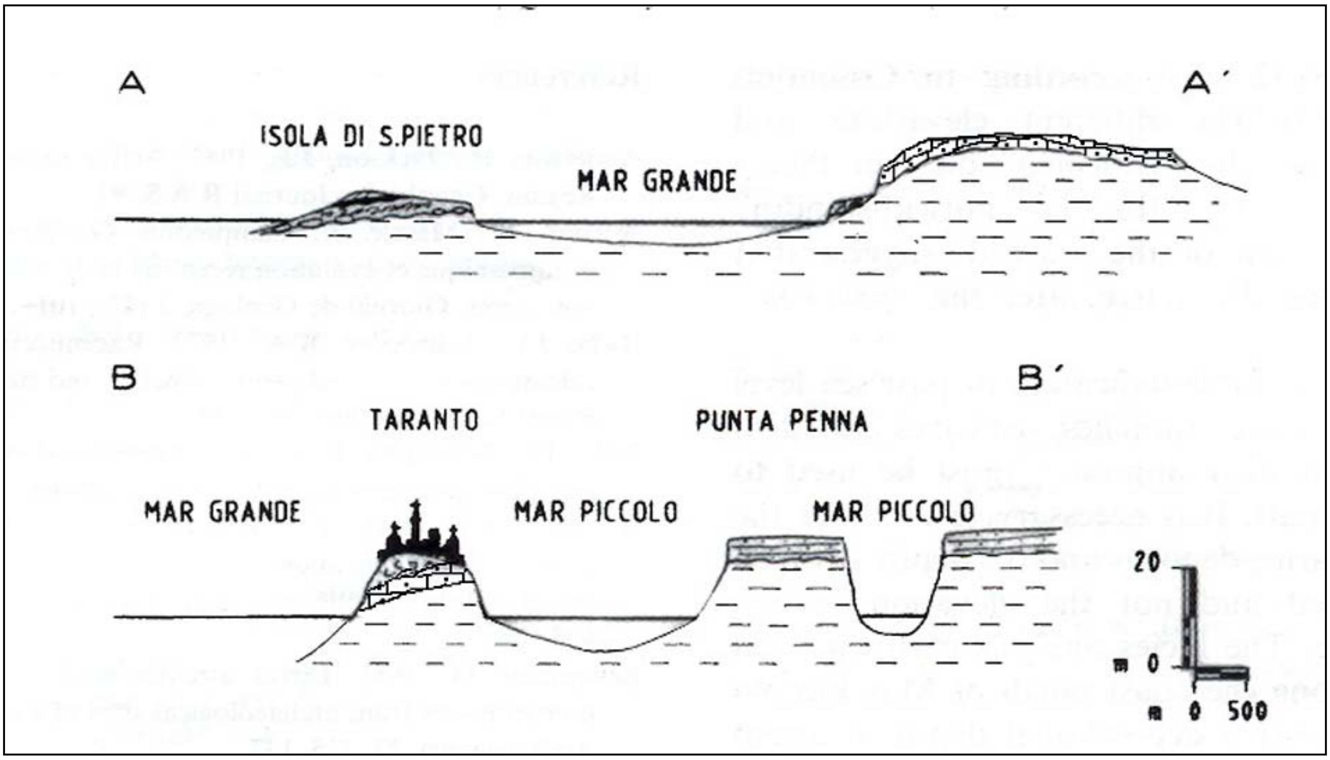


Figure 3.28 - *Geological sections of Fig. 3.27.*

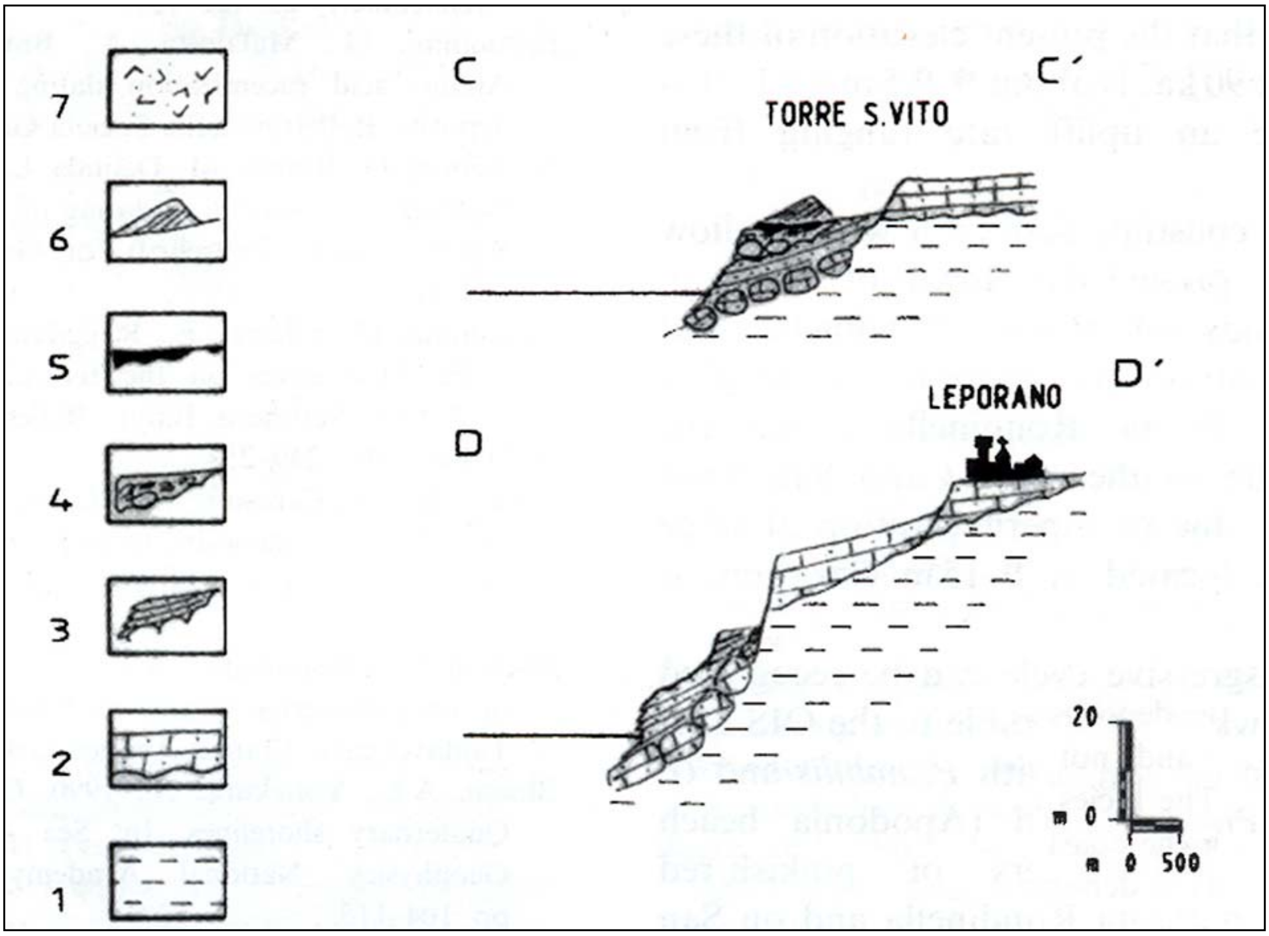


Figure 3.29 - *Geological sections of Fig. 3.27. 1 – Plio-Pleistocene clays/sandy clays; 2 – OIS 7 deposits; 3 – substages 5e-c deposits; 4 – substage 5a deposits; 5 – OIS 3 deposits; 6 – Holocene aeolian deposits; 7 – anthropic filling.*

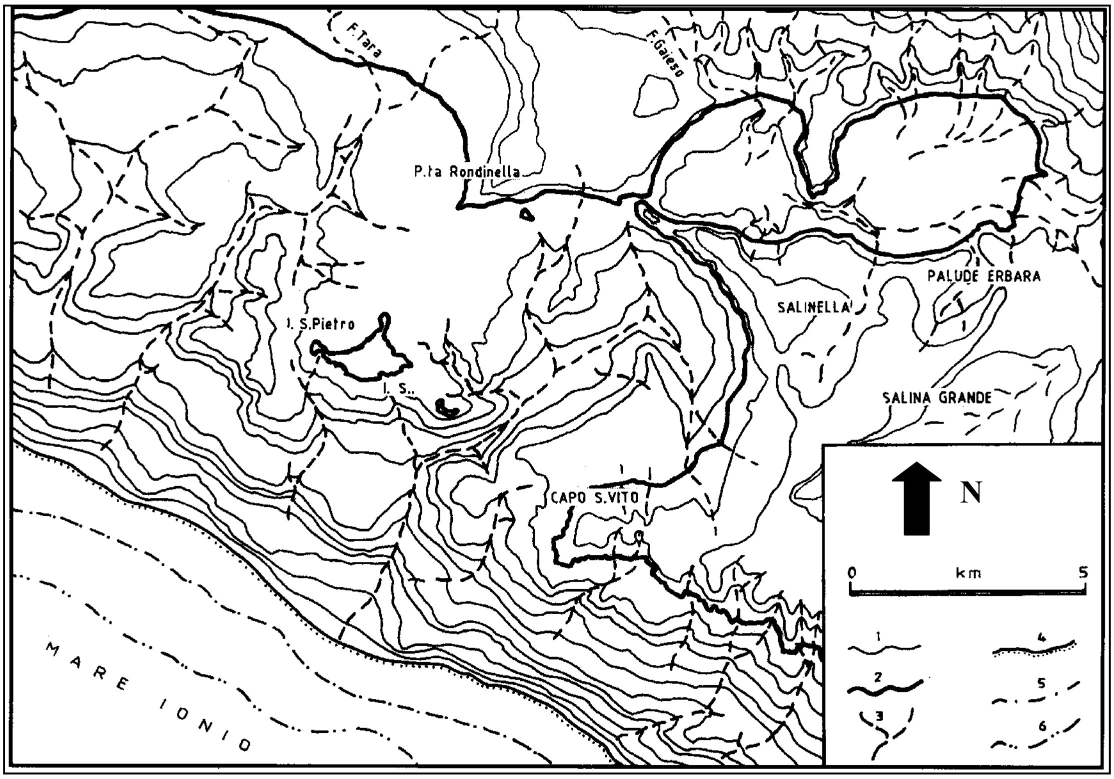


Figure 3.30 - *Landscape of Taranto area about 20 ka BP. 1 – contour lines (every 10 m); 2 – present coastline; 3 – relict fluvial network; 4 – Last Glacial Maximum (LGM) coastline; 5 - present isobath 200; 6 present isobath 300.*

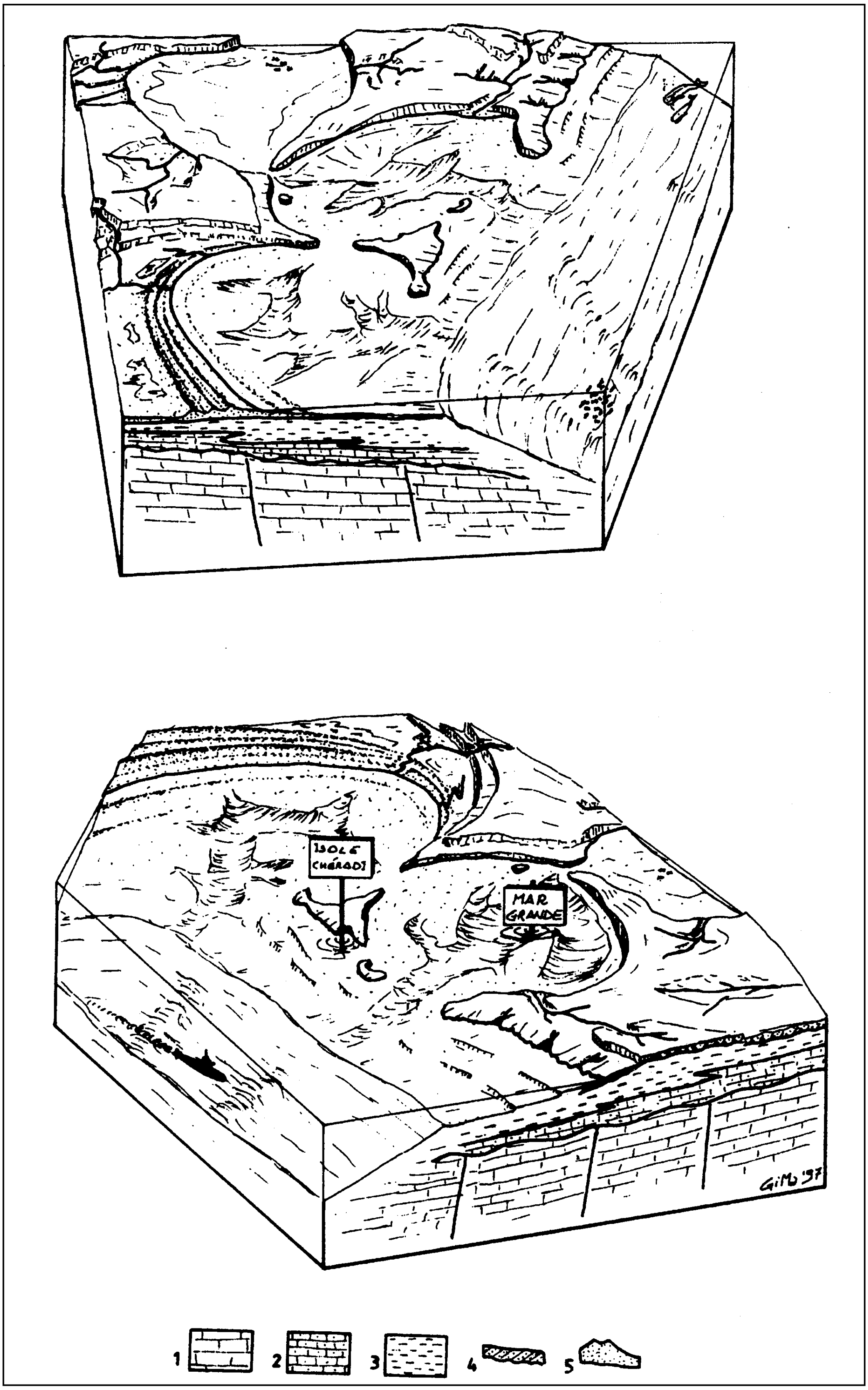


Figure 3.31 - *Geomorphological sketch of Chéradi Islands and Mar Grande - Mar Piccolo system. 1 – Upper Cretaceous limestones (Calcare di Altamura); 2 – Middle Pliocene – Lower Pleistocene calcarenites (Calcareniti di Gravina); 3 – Middle Pliocene – Lower Pleistocene clays (Argille Subappennine); 4 – Middle Pleistocene – Upper Pleistocene marine terraces deposits ("panchine"); 5 – Holocene alluvial, beaches and coastal dune deposits.*

About this aspect, it is important to underline that the inner margin of last interglacial deposits northwestern to the Mar Piccolo is at about 35 m whereas it is at about 27 m to the east. The Taranto area represents the zone where the uplift decreases rapidly from 0.40 mm/yr at Ponte del Re locality to 0.20 mm/yr at Mar Piccolo and further in the coastal area south of Taranto from 0.32 to 0.23 (Cosentino and Gliozzi, 1988; Dai Pra and Hearty, 1988; Hearty and Dai Pra, 1992). The different altimetrical positions and the fracturation of the *"panchine"* on San Pietro Island, here related to the substage 5a, suggest that the area was tectonically active after the "*panchine*" deposition.

The lack of incontestable indicators of past sea level stands in Taranto area (notches, sea caves and algal rims) means that another approach must be used to calculate the tectonic uplift. It is necessary to consider the present height of marine deposits and the depth at which they were sedimented and not only the elevation of supposed coastline. The facies analysis, performed on deposits located along the coast north of Mar Piccolo suggests a depositional depth of about 10-15 metres. Considering that the present elevation of these sediments, aged about 140-90 ka, is about 9-12 m a.p.s.l., it is possible to calculate an uplift ranging from 0.21 to 0.27 mm/yr.

During OIS 5a the coastline formed a wide shallow bay in front of present Taranto town, between the heads of Punta Rondinella and Capo San Vito. On the contrary, along the coast extending to the southeast of Capo San Vito, the shoreline ran roughly parallel to the former one; only a narrow terrace gently sloping seaside due to superimposition of stage 5e/c and 5a terraces, placed 0 - 15 m elevation, is recognizable.

During the OIS 3 the last transgressive cycle occurred. It induced the deposition of sands with *P.nobilis* and *G.glycymeris* on the San Pietro island; the thin layers of pinkish/red sands with *L.lacteus* (L.) at Punta Rondinella and on San Pietro Island; along the coast south of Taranto they filled up circular or elliptic potholes affecting the cemented older unit related to substage 5a or 5e/c. This depositional phase could be related to Shoreline complex II, characterized by *"banale"* fauna with *Corbula gibba* L., as suggested by Hearty and Dai Pra (1992) for the same area. The elevation of these deposits up to 4 m a.p.s.l. could be put in relation to the local uplift. The presence of OIS3 deposits above present sea-level on Isola di San Pietro is matter of debate.

Finally, during the last glacial low sea level stand the entire area of Mar Grande was emerged. It underwent to a phase of river erosion with the development of a poorly developed drainage network characterised by a rettangular pattern because of structural conditioning (Canale D'Aiedda, Fosso Galeso, Valle Erbara, etc.) (Mastronuzzi and Sansò, 1998). These narrow and deep valleys incised the last interglacial deposits and the lower Pleistocene clays. The Chéradi Islands and the peninsula of Taranto represented one of the main watersheds (Fig. 3.31).

These valleys were submerged during the post glacial transgression and enlarged by wave action. Coastal erosion was accompanied by the sedimentation of about 10 meters of sediment in the inner part of Mar Piccolo and Mar Grande.

The particular shape of present shoreline seems to be the effect of the geological structure of this area and wave diffraction. The coast is generally represented by an even sloping surface. It is characterised by slow evolution along the coastal tracts facing the open sea where well-cemented Tyrrhenian calcarenites crop out. These last ones gently slope seaward, sheltering the underlying weak clayey units from wave erosion. Along the Mar Grande and the Punta Rondinella bay, the coast is represented by cliffs, with the foot cut in the Plio-Pleistocene clays, in fast retreat because of effective wave undercutting.

Wave diffraction induced by the narrow openings of bays, which developed along the submerged valleys, and the natural evolution of cliffs which tend to stretch parallel to wave crests are responsible for the characteristic shape of sea bays.