

## PROPOSAL FOR A THEMATIC ITINERARY ON GEOMORPHOLOGICAL SITES ALONG THE WESTERN COAST OF THE SALENTO PENINSULA, SOUTHERN ITALY

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**ABSTRACT:** G. Palmentola & M. Lazzari, *Proposal for a thematic itinerary on geomorphological sites along the western coast of the Salento peninsula, southern Italy*. (IT ISSN 0394-3356, 2005).

Researches carried out on the Quaternary coastline modifications along the western Salento Peninsula of Apulia, permitted to survey a succession of well-preserved geomorphological sites. These sites testify the events which interested the studied coastal sector during the Quaternary time from mid-late Pleistocene (MIS 9?) to Holocene (MIS 1). The coastal sector of great landscape value, along which geomorphosites are exposed, is wide some kilometres from Gallipoli town toward north as far as the Punta d'Alto Lido promontory (locally known as the "broken mountain"). In particular, a series of landforms is exposed there, shaped by the sea and by sessile organisms which live along the sea cliffs, as well as by aeolian accumulation and deflation landforms. The variety of well-preserved and easy accessible landforms and their concentration in a not wide coastal sector constitute a good opportunity for both didactic and popularization of the processes which characterize the coastal dynamics, as well as the relative diagnostic elements.

**RIASSUNTO:** G. Palmentola & M. Lazzari, *Proposta per un itinerario tematico attraverso siti geomorfologici lungo la costa occidentale della Penisola Salentina*. (IT ISSN 0394-3356, 2005).

*Nel corso di ricerche sulle modificazioni quaternarie della linea di riva lungo la fascia costiera della Puglia, in corrispondenza della costa occidentale della Penisola Salentina è stata rilevata una successione di siti geomorfologici nei quali sono conservate chiare testimonianze degli eventi che, nel corso del Quaternario dal Pleistocene medio-superiore (MIS 9?) all'Olocene (MIS 1), hanno interessato quel settore costiero. Il tratto di pregio paesaggistico lungo il quale sono esposti i geomorfositi che si intende descrivere si estende per alcuni chilometri dalla città di Gallipoli verso nord, fino al promontorio della Punta d'Alto Lido (localmente nota come "Montagna spaccata"). In particolare, lì è presente una serie di forme modellate dal mare e dagli organismi sessili che ne popolano le falesie, e di forme prodotte dalla deflazione e dall'accumulo eolico. La loro varietà, il buono stato di conservazione e la loro concentrazione lungo un settore poco esteso e facilmente percorribile fanno sì che tali siti costituiscano una opportunità per la didattica e la divulgazione dei processi che caratterizzano la morfogenesi costiera, come anche per l'individuazione dei relativi elementi diagnostici.*

**Keywords:** Southern Italy, Salento Peninsula, Late Pleistocene, Holocene, Coastal geomorphology, Sea-level change, Geomorphosites.

**Parole chiave:** Italia meridionale, Penisola Salentina, Pleistocene superiore, Olocene, Geomorfologia costiera, Variazione del livello del mare, Siti geomorfologici.

### 1. INTRODUCTION

During researches partly supported by the Italian Ministry of Scientific Research (MURST COFIN 1998 and COFIN 2000) about sedimentological and morphological evolution of Italian beaches, a revision of data previously surveyed (Palmentola & Fiore, 1985) has been realized concerning middle and late Pleistocene - Holocene sea level highstands along the western coast of Salento Peninsula (southern Italy).

Due to both its relative tectonic stability from late Pleistocene to the present, and its well-preserved lithostratigraphic and geomorphological features specially along its rocky coastal cliffs, Salento Peninsula represents a good area for the study of past sea level changes. A series of interesting features can be observed in a small area between Gallipoli town and Punta d'Alto Lido promontory along the Ionian coast of the Peninsula, where some sea-level high stands and some associated dune belts are exposed. Because of their cultural, scenic and scientific attributes these features can be identified as "geomorphosites", as well as because

of their good state of preservation, peculiarity and patrimonial value (as evidence of the landscape regional evolution and climate variations), the studied area could constitute an example-locality for coastal geomorphology and dynamics studies in southern Italy.

Intense human activity, in addition to weathering, is presently threatening these sites and hindering their use for scientific and educational purpose. So that, this paper represents a preliminary step for protection of geomorphological sites through a proposal to incorporate them into the Italian inventory of geosites, and propose them as a didactic thematic path for educational aims. In this way geomorphological assets become a patrimonial and cultural asset easily comprehensible, accessible and useful for both specialists and general public.

### 2. GEOLOGICAL SETTING

The Salento Peninsula is the southernmost part of the Apulian foreland of both the Apennines and Dinaric

orogenic systems (Fig. 1). The foreland is represented by the outer Apulian platform consisting of a Variscan crystalline basement covered by approximately 6 km of Mesozoic carbonate sediments. Between the Oligocene and Miocene the foreland was affected by extensional tectonics (Cristofolini *et al.*, 1985; Sella *et al.*, 1988), due to its progressive deformation connected with the lithospheric subduction (Doglioni *et al.*, 1994), which produced a landscape characterized by a set of carbonate ridges ("Serre") alternating with depressed areas. Discontinuous Pliocene and lower Pleistocene transgressive deposits (Calcareni di Gravina and Calcareni del Salento Formations) accumulated on Mesozoic substratum into structural depressed areas.

The geological history of Salento Peninsula ends with the deposition of middle and upper Pleistocene sandy-clayey calcarenite deposits and aeolianites either on the Mesozoic basement or on Plio-Pleistocene units. The more recent deposit diffusely outcropping in the Peninsula is the "Sabbie a Brachiopodi" Formation referred to an indeterminate post-Sicilian age (D'Alessandro & Palmentola, 1978; Palmentola, 1987; D'Alessandro *et al.*, 1994). Subsequently, other eustatic oscillations produced small and not much wide transgressions along the Salento Peninsula coastline leaving depositional evidences above all along the western slope.

### 3. GEOMORPHOLOGICAL SITES AND THEMATIC ITINERARY

The thematic itinerary from Gallipoli town as far as to Punta d'Alto Lido cape towards north (Fig. 2) permits to observe six different well-preserved sea level highstands. This last will be described according with an itinerary easy practicable along the main coastal route,

starting from Punta d'Alto Lido cliff and running towards Gallipoli.

The start-point (1<sup>st</sup> stop) is on the top of Punta d'Alto Lido, on the left of the road to Gallipoli, where 70m above s.l. an abrasion surface cut into Mesozoic bedrock during early and middle Pleistocene, is exposed. This surface is diffusely covered by "post-Sicilian" sediments with *Terebratula scillae* Seguenza ("Sabbie a Brachiopodi" Formation, D'Alessandro & Palmentola, 1978; D'Alessandro *et al.*, 1994) not older than MIS 11, which represent the last wide marine transgression on the Salento. With the subsequent regression the coastal zone of the Peninsula reached approximately its present day contour being only partially modified, especially along its western side, by the following sea level fluctuations.

The itinerary continues going down along a path until to 45-50 m above s.l. (2<sup>nd</sup> stop) where a successive sea level highstand is testified by a band of *Lithophaga* boreholes and by thin well-cemented remains of a pebbly-sandy beach, in erosive contact on Mesozoic limestone (Melissano Formation). Chronostratigraphic position of this highstand can only be deduced from stratigraphic data: it is more recent and altimetrically lower than the "Sabbie a Brachiopodi" Formation and older as well as higher than some calcarenites with *Strombus bubonius* Lamarck (MIS 5e), both outcropping in the same area, along and near the same cliff. This means that this highstand is younger than MIS 11 or 9 and older than MIS 5e.

Coming down along the same cliff the 3<sup>rd</sup> stop can be observed along a road trench, the "broken mountain" trench (Fig. 3). The walls of this road cutting show morphological and geological evidences of two other sea level highstands. The first is testified by a well-preserved notch with an associated some meters wide wave-cut platform at 15 m above s.l.. The second,

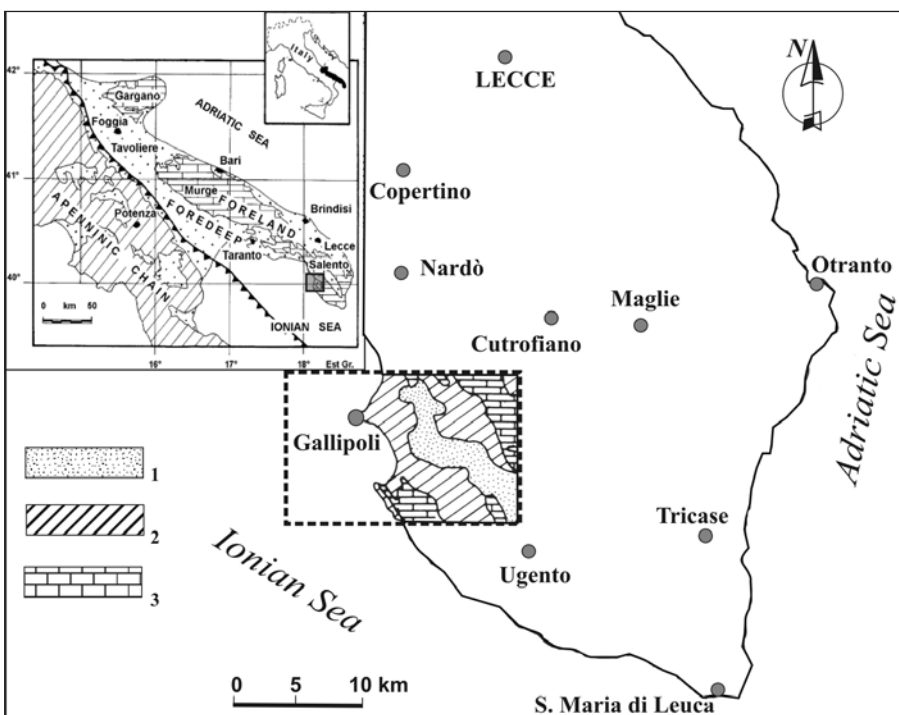


Fig. 1 - Geographic location and schematic geologic map of the studied area. Legend: 1) Sands and clays locally alternated with bioclastic deposits (Pleistocene); 2) Calcarenites (Plio-Pleistocene); 3) Cretaceous limestones of Mesozoic basement (Melissano Formation).

Ubicazione geografica e carta geologica schematica dell'area di studio. Legenda: 1) sabbie ed argille localmente alternate a depositi bioclastici pleistocenici; 2) Calcareni (Plio-Pleistocene); 3) calcari cretacei del basamento Mesozoico (Formazione di Melissano).

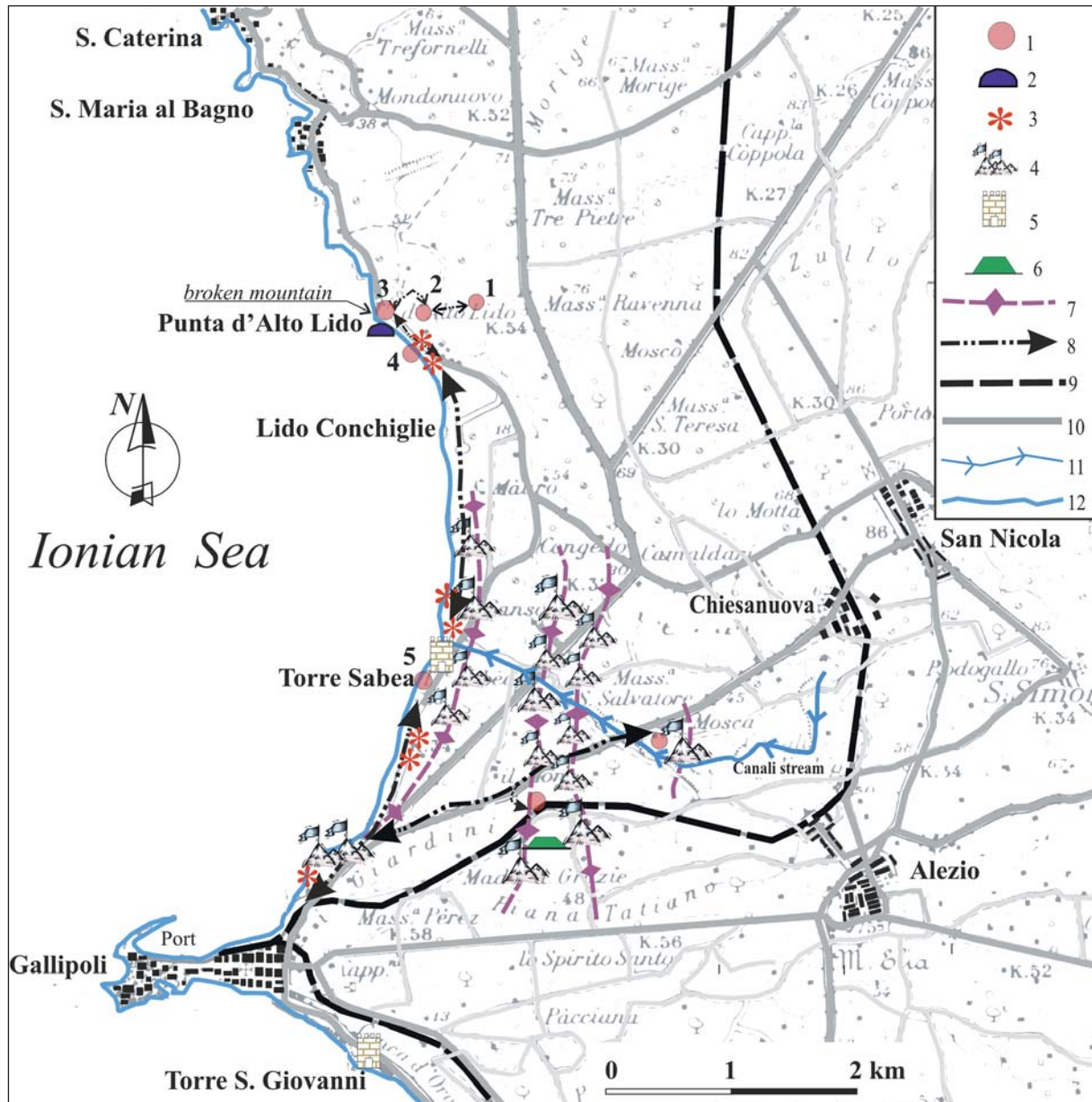


Fig. 2 - Thematic itinerary map along the geomorphological sites. Legend: 1) main stops; 2) sea cave; 3) outcrops of calcarenite with *Strombus bubonius* Lamarck.; 4) dune belts; 5) Saracen Tower; 6) active quarry into dunes; 7) dune belts ridge; 8) itinerary; 9) railway; 10) main roads; 11) Canali stream; 12) coastline.

Carta dell'itinerario tematico lungo i siti geomorfologici. Legenda: 1) stops principali; 2) grotta marina; 3) affioramento di calcareniti con *Strombus bubonius* Lamarck.; 4) cordoni dunari; 5) Torre saracena; 6) dune in cava attiva; 7) dorsale del cordone dunare; 8) itinerario; 9) ferrovia; 10) strade principali; 11) torrente Canali; 12) linea di costa.

by sediments accumulated during a brief successive sea-level rise, which buries all the signs of the previous one. This sediments, topping at about 22 m above s.l., are constitute by pebbles and calcarenite mudstones with marine fossils (*Patella* sp.), and are bored by *Lithophaga*. Some continental clinostratified coarse breccias, about 1.5 m thick, interbedded with a dark-pink, silty-sandy deposit cover all the marine deposits. Because of the altitude this last palaeo-sea level is cor-relable to a hardy eroded and degraded dune belt (Fig. 4), which base is at about 35 m above s.l., outcropping in the hinterland of Gallipoli on the orographic right of

the Canali stream (Fig. 2).

Both the two sea-level highstands of the 3<sup>rd</sup> stop seem to be referable to two main oscillations of MIS 7, where the younger one (MIS 7a) is more elevated than the older (MIS 7c), as occurs in other places of Mediterranean countrys (Zazo *et al.*, 1993; 1994) and as is also suggested by the oxygen isotopic curve of Shackleton *et al.* (1990).

Starting from "broken mountain" and running about one hundred meters towards Gallipoli until to Lido delle Conchiglie, the fourth stop (Fig. 5) can be reached where, to the bottom of Punta d'Alto Lido cliff

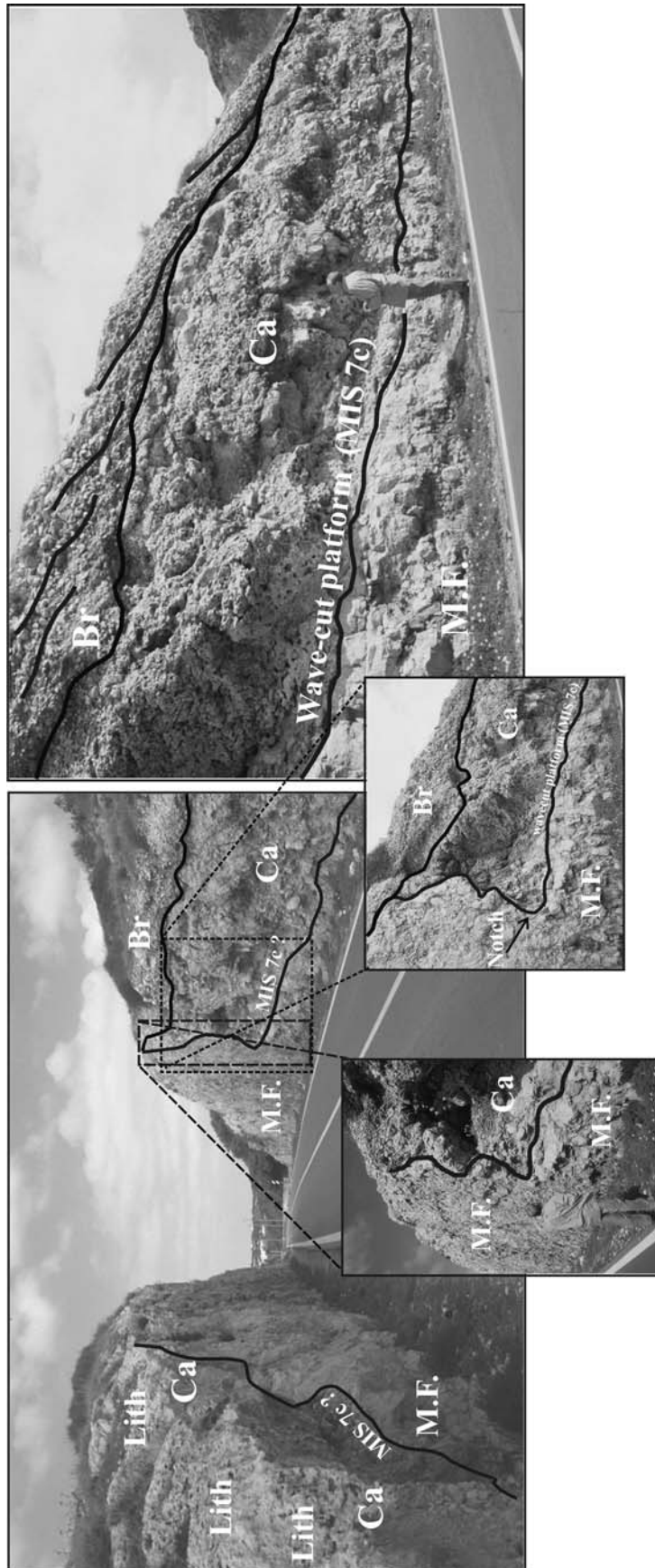


Fig. 3 – Road cutting transversal to Punta d’Alto Lido cliff, where marine calcarenitic mudstones (Ca) outcrop in erosive contact on the Mesozoic limestones of Melissano Formation (M.F.). The palaeo sea level, probably referable to MIS 7a, is evidenced by a *Lithophaga* band (Lith) to the top of pebbly calcarenitic mudstones (Ca), observable on the left of picture. These deposits cover a lower and not well preserved notch and the associated wave-cut platform (thick black line) testifying an older sea level highstand (MIS 7c?). All the succession passes upward to clinostratified continental breccias (Br).

*Trincea stradale trasversale alla falesia di Punta d’Alto Lido, dove affiorano fanghi calcarenitici (Ca) in contatto erosivo sul substrato Mesozoico dei calcari di Melissano (M.F.). Il paleo livello del mare, osservabile sulla sinistra della figura, è probabilmente riferibile al MIS 7<sup>a</sup> ed è evidenziato da una fascia di fori di *Lithofagi* posta al top delle calcareniti ciottolose (Ca). Tali depositi coprono un solco di battigia e la relativa non ben conservata piattaforma di abrasione marina (linea nera) più bassa e più vecchia, testimoniando così un più vecchio alto stazionamento del livello del mare (MIS 7c?). tutta la successione passa verso l’alto ad una breccia continentale clinostratificata (Br).*

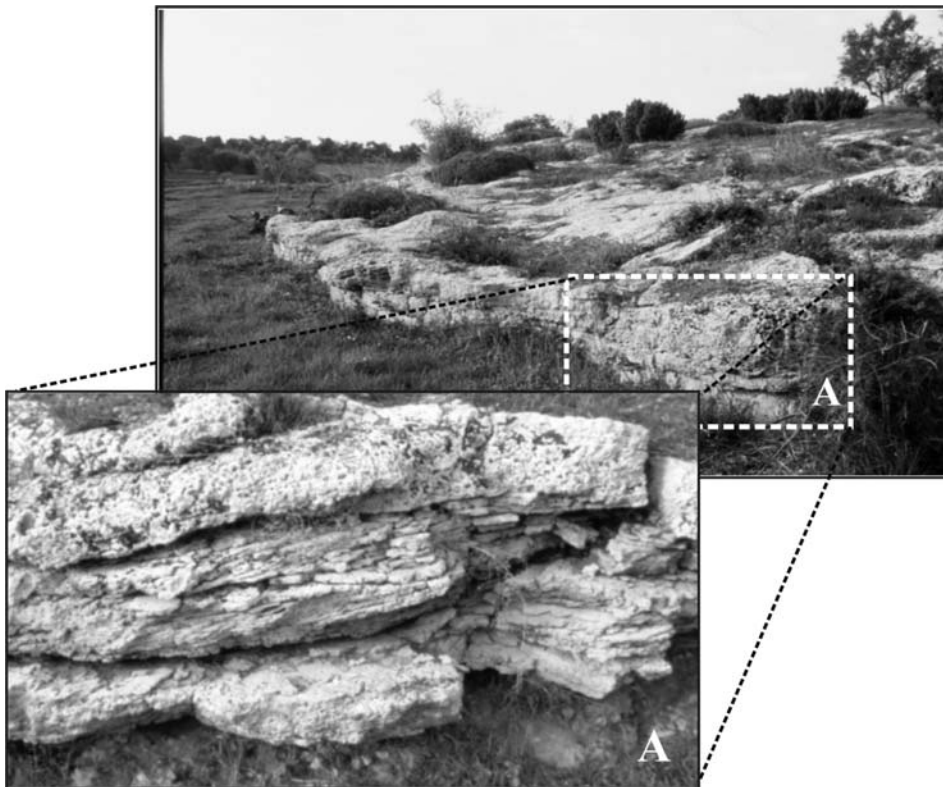


Fig. 4 - Higher and older very degraded dune belt outcropping in the hinterland of Gallipoli.

*Cordone dunare degradato più alto e più vecchio affiorante nell'hinterland di Gallipoli.*

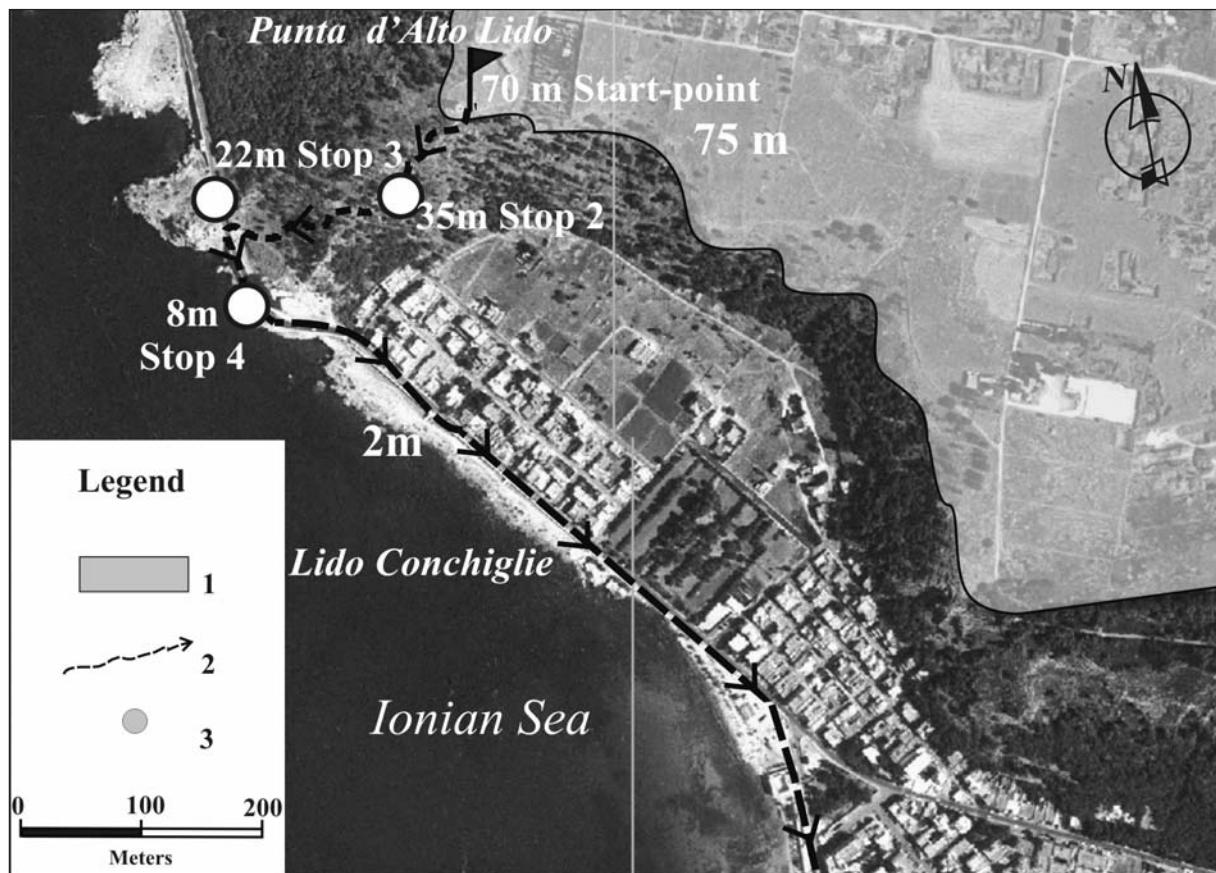


Fig. 5 - Aerial photo of Lido delle Conchiglie - Punta d'Alto Lido area. Legend: 1) top abrasion surface with remains of "Calcareni del Salento Formation" (early Pleistocene); 2) itinerary; 3) stops with meaningful outcrops of morphological and geological evidences of middle-late Pleistocene sea level oscillations.

*Ripresa aerea dell'area del Lido delle Conchiglie-Punta d'Alto Lido. Legenda: 1) superficie d'abrasione marina con lembi della Formazione delle Calcareni del Salento (Pleistocene inferiore); 2) Itinerario; 3) stops con i principali affioramenti di evidenze geologiche e geomorfologiche delle oscillazioni del livello del mare del Pleistocene medio-superiore.*

at 8 m above s.l., remains of a fourth highstand are well preserved (Fig. 6). They are represented by a band of *Lithophaga* boring the Cretaceous limestones of the cliff, and by remains of a proximal pebbly beach deposit, laterally passing to sandy-calcareenite deposits with nests of *Strombus bubonius* Lamarck. This calcarenite, corresponding to MIS 5e ("Tyrrhenian phase", Mirigliano, 1956), can be altimetrically correlated with a thick and well-preserved sandy dune belt, with the base at 15-20 m above s.l., outcropping in the hinterland of Gallipoli (Fig. 2). These dunes are well exposed in a quarry and along a railway cutting (Fig. 7) easily reachable running the road from Gallipoli to Alezio.

The morphological effects of a successive 5<sup>th</sup> highstand can be studied along the coastal road between Punta d'Alto Lido and Gallipoli (5<sup>th</sup> stop) represented by a seaward surface wave-cut at about 2 m above s.l. into the calcarenites with *Strombus bubonius* Lamarck. The age of this abrasion event has been assigned to MIS 5a (Cotecchia *et al.*, 1971) by means of a sample of *Cladocora coespitosa* (Linnè) found in some coastal sediment over the calcarenites, which showed a radiometric age of 85 ka. This datum was afterwards corroborated by Dai Pra & Hearty (1988; 1989) by means of isoleucine epimerization ratio of some *Helix* sp. (70 ka) collected in a thin red soil level between the abrasion surface and an overlying Holocene yellowish

dunes. This last situation is still exposed in the neighbourhood of Torre Sabea (6<sup>th</sup> stop), 1.5 km north of Gallipoli, where a beautiful Saracen watch-tower built of XI century is also observable (Fig. 8).

After the abrasion of the surface of 2 m a.s.l., a cold climatic phase (about 20 ka) induced a regression of sea-level towards the Quaternary eustatic minimum of -120 m below its present position. This retreat was followed by a rapid transgression, shown also in the Holocene sea-level fluctuation curves reconstructed by Dai Pra & Hearty (1989) and Dini *et al.*, (2000) for the coasts of southern Apulia. The transgression ended about 6000-7000 years BP with the sea-level highstand corresponding to the peak of MIS 1 (Versilian transgression). This stage corresponds to the so-called "Climatic Optimum" (Bertolani Marchetti, 1985; Rossignol-Strick *et al.*, 1992; Yan & Petit Maire, 1994) and has been characterized by the warmest and most humid climatic conditions during the Holocene (Atlantic chronozone).

The Holocene yellowish dunes elongated roughly parallel to the present coast line, contain several pulmonate gastropods *Helix* spp., radiometrically dated 6700-5300 yr B.P. (Cotecchia *et al.* 1969; Hearty & Dai Pra, 1989; Dini *et al.*, 2000), have their base here and there submerged and are in many places partially covered or flanked by subactual dunes.

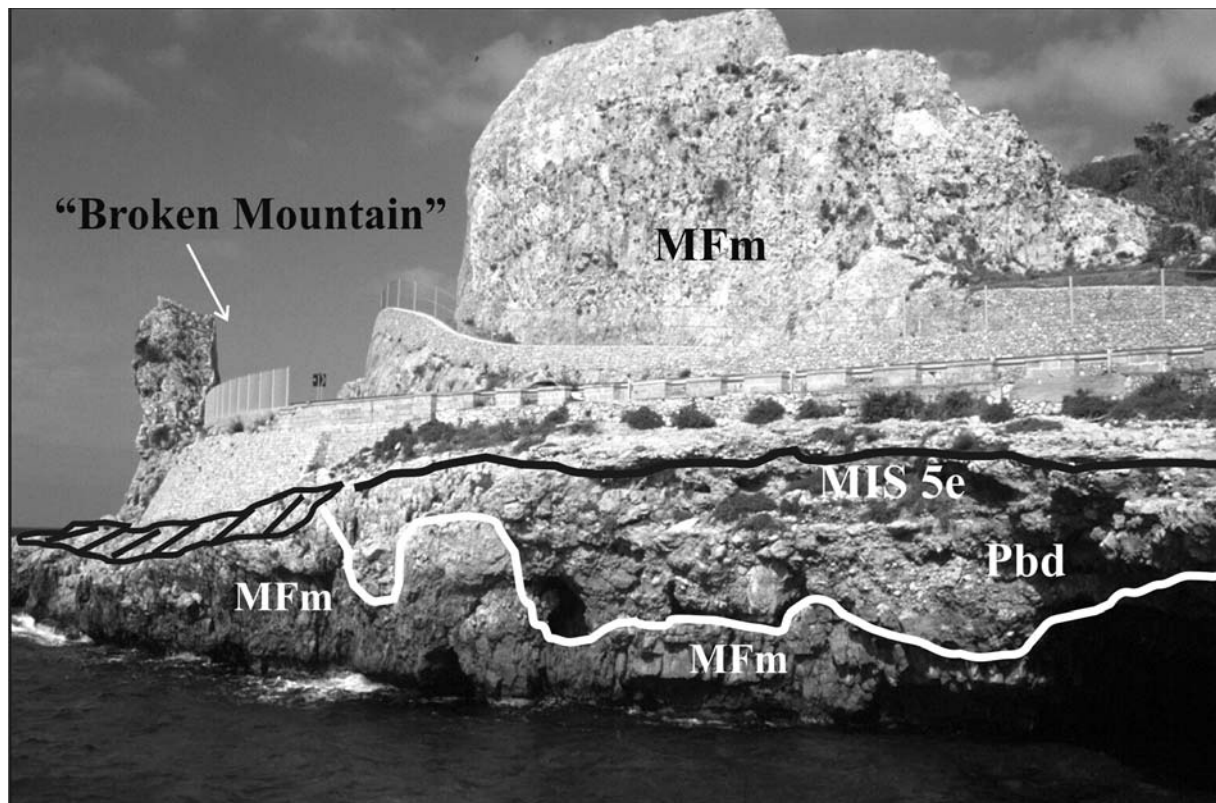


Fig. 6 - Outcrops of pebbly beach and calcarenite deposits (Pbd) at the bottom of the "broken mountain" cliff and in a sea cave, in erosive contact on Mesozoic basement (Melissano Formation, MFm). Laterally this deposit, corresponding to sea level highstand of MIS 5e, grows thin as far as to be replaced by an abrasion marine surface (black striped area).

Affioramenti di spiaggia ciottolosa e depositi calcarenitici (Pbd) nella parte alta della falesia della "montagna spaccata" in una grotta marina, in contatto erosivo sul substrato Mesozoico (Formazione di Melissano, MFm). Lateralmente questo deposito, corrispondente allo stage 5e, si assottiglia fino ad essere sostituito da una superficie di abrasione marina (area tratteggiata in nero).

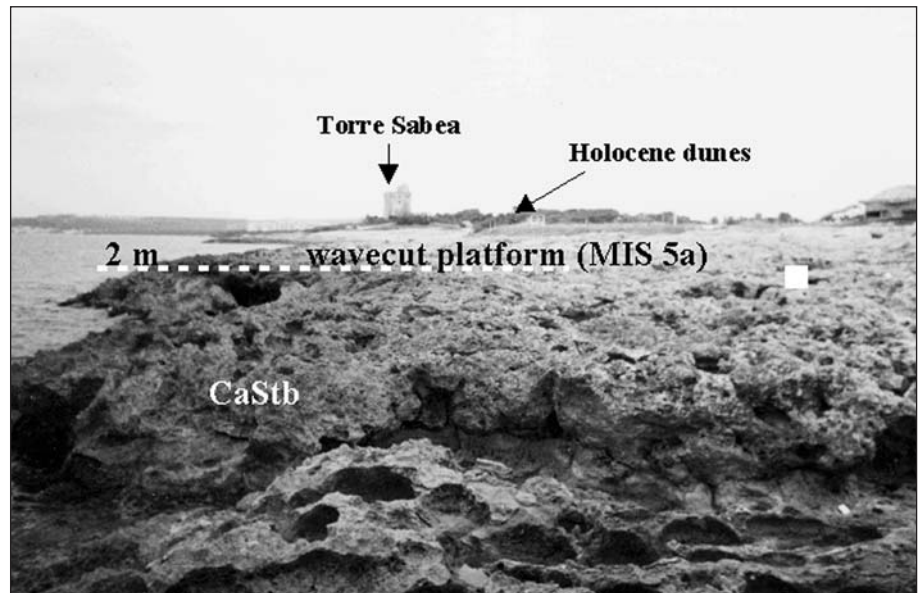
Fig. 7 - Outcrop of sandy dune belt (DB) some meters thick in a railway cutting in the hinterland of Gallipoli. The photo shows also the classic curve shape of the dune belt with the axis elongated perpendicularly to the cutting.

*Affioramento del cordone dunare sabbioso (DB) spesso alcuni metri in corrispondenza di una trincea ferroviaria nell'hinterland di Gallipoli. La foto mostra inoltre il classico profilo curvilineo della duna con l'asse allungato perpendicolarmente alla trincea.*



Fig. 8 - The figure evidences the outcrop of the calcarenite with *Strombus b. Lamarck.* (CaStb) near Torre Sabea, on which an evident and wide wave-cut platform at 2 m a.s.l. was shaped probably during the MIS 5a. Subsequently, a Holocene dune belt with *Helix* sp. was deposited on the same wave-cut platform.

*La figura evidenzia l'affioramento della Calcarenite con Strombus b. Lamarck. (CaStb) nei pressi di Torre Sabea, sulla quale si è modellata una evidente ed estesa superficie d'abrasione marina posta a 2 m s.l.m. e probabilmente riferibile allo stage 5°. Successivamente un cordone dunare con Helix sp. si è depositato su tale piattaforma.*



#### 4. CONCLUSIONS

The sites above outlined seem important to be preserved because of the rare and great value evidences they show. It is not usual to find in a relative small area such an important succession of geological and geomorphological events, testifying sea level variations fundamentally due to climatic changes occurred from the mid-Pleistocene to Holocene.

In figure 9 such events are summarized by means of two ideal geomorphological profiles crossing the different landforms and deposits described in the main five stops.

In short, after the deposition of the post-Sicilian Sabbie a Brachiopodi Formation, six eustatic oscillations produced between 45-50 m and 2 m above s.l. morphological and geological evidences of as many

highstands, referable to mid-late Pleistocene (MIS 11 or 9?, 7c, 7a, 5e and 5a) and Holocene (MIS 1).

#### 4.1 Protection and valorization of geomorphosites

All the geological and geomorphological evidences represent an irreplaceable scientific, didactic, environmental and cultural heritage and therefore an added value for this territory, which we believe must be preserved. Unfortunately the sites are today seriously threatened by modifications and obliteration due to the anthropic aggression, as quarries in the sandy dune belts, road cuttings, urbanization and other human interventions. Their protection is necessary because, with respect to a cultural asset *strictu sensu*, geomorphosites are not restorable and reproducible.

Different ways to oppose against their irreversible deleting and submitting the sites to active and pas-

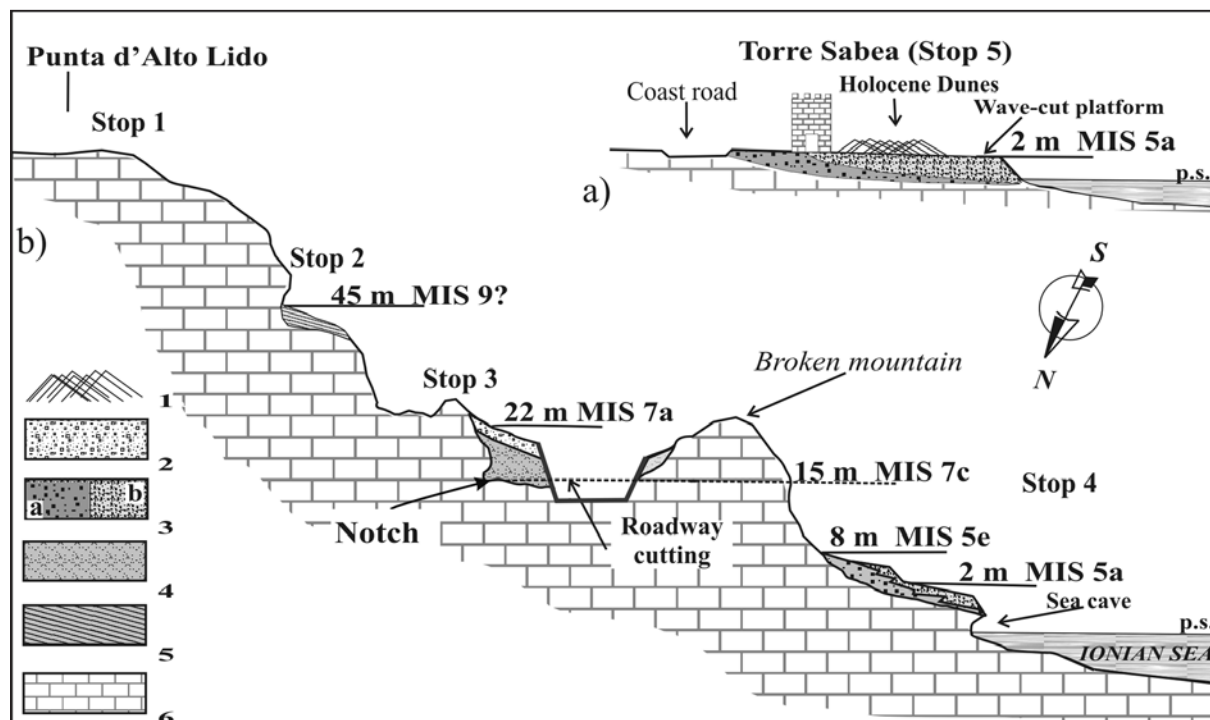


Fig. 9 – Geomorphological schematic profile along the main stops of the thematic itinerary from Lido Conchiglie-Punta d'Alto Lido cliff to Gallipoli-Torre Sabea, in which the more meaningful outcrops of sea level high stands and marine landforms are represented. In a) it is represented the situation of Torre Sabea (stop 5), while in b) the morphological and geological evidences observable in other three stops (projected from south) are shown. Legend: 1) Holocene dune belt (MIS 1); 2) continental clinostratified breccias; 3a) coarse pebbly and calcarenitic beach deposits (MIS 5e); 3b) calcarenites with *Strombus bubonius* Lamarck. (MIS 5e); 4) calcarenitic mudstones with *Lithophaga* band to the top (MIS 7a); 5) Pebbly beach and calcarenites remains (MIS 9?); 6) Cretaceous limestones.

*Profilo geomorfologico schematico lungo i principali stops dell'itinerario tematico dalla falesia di Lido delle Conchiglie-Punta d'Alto Lido a Gallipoli-Torre Sabea, in cui vengono rappresentati gli affioramenti più significativi delle forme marine e degli alti stazionamenti del livello del mare. In a) viene rappresentata la situazione di Torre Sabea (Stop 5), mentre in b) sono mostrate le evidenze geomorfologiche e geologiche visibili in altri tre stops (proiettati da sud). Legenda: 1) cordone dunare olocenico; 2) breccie continentali clinostratificate; 3a) depositi di spiaggia calcarenitici e ciottolosi (MIS 5e); 3b) calcareniti con *Strombus bubonius* Lamarck. (MIS 5e); 4) fanghi calcarenitici con una fascia di *Lithophaga* nella parte superiore (MIS 7a); 5) lembi residui di calcareniti ciottolose (MIS 9?); 6) calcari Cretacici.*

sive protection could be adopted.

A first conservation strategy (*sensu* Reynard, 2003), could be to propose their inserting in an inventory catalogue of the Italian geotopes, binding the sites in order to submit them to active protection limiting the human activity.

The itinerary along the main proposed stops should be insert in a context of tourist and educational flow, valorizing still more their scientific and didactic great value also by means of showcases, in which geomorphological landscape evolution during last different climatic phases would be schematically represented and explained.

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