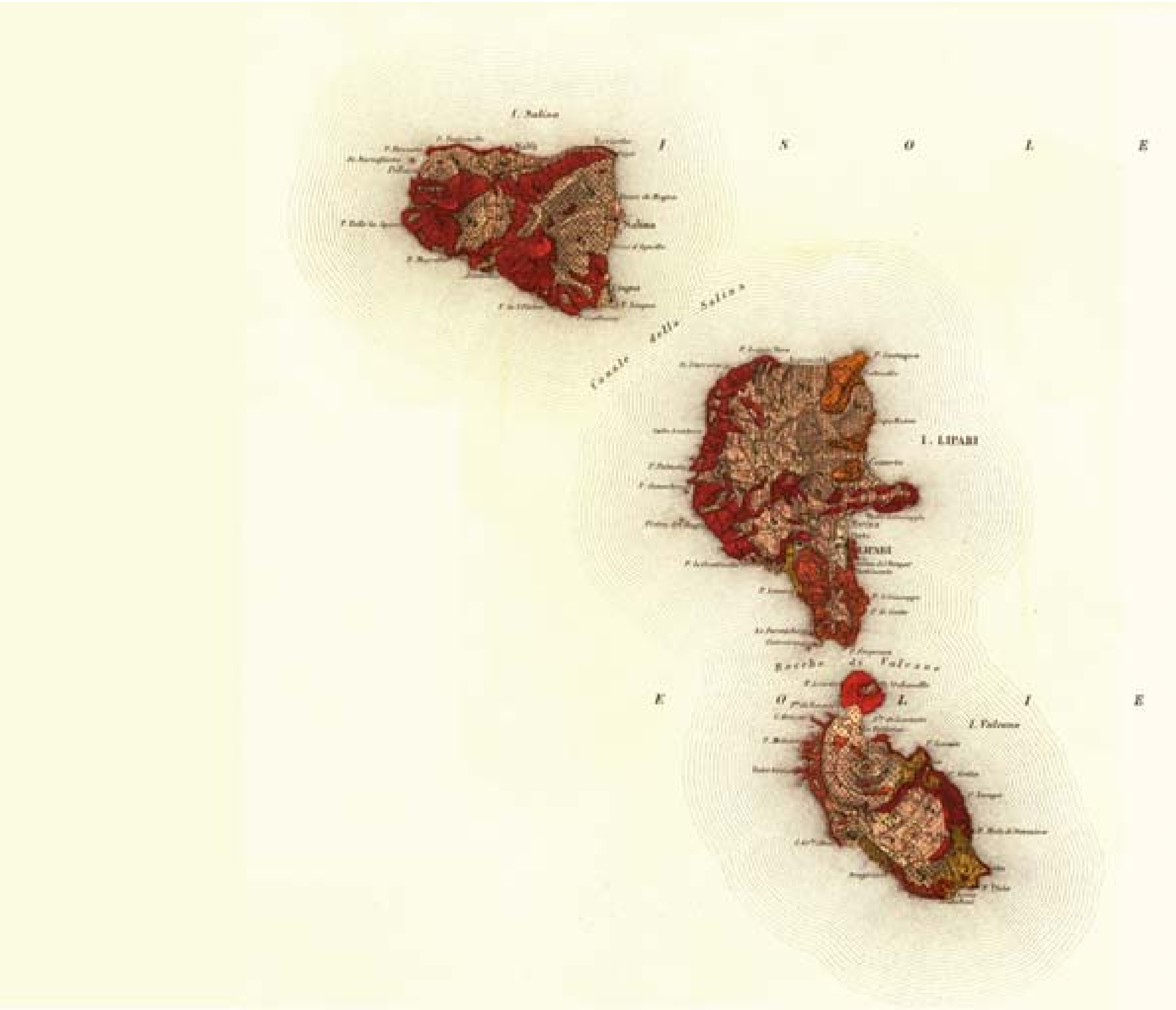
CASE HISTORIES OF THE ITALIAN COASTS



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Submerged depositional terraces in the Tuscan Archipelago (Eastern margin of the Corsica Basin)

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GEOLOGICAL FRAMEWORK

Submerged depositional terraces are a common feature along the eastern margin of the Corsica Basin, particularly between Capraia Island and Scoglio Africa; in this paper we show examples from the shelf area extending from Capraia to Pianosa Island (Fig. 1), for which a large seismic profiles and core database is available.

The Corsica Basin is one of the main Tyrrhenian sedimentary basins (VIARIS DE LESEGNO, 1978; BACINI SEDIMENTARI, 1979; ZITELLINI *et alii*, 1986); the basin fill is represented by a thick post-Oligocene succession (more than 4000 m; GABIN, 1972); sediments were accumulated during the Oligocene to Miocene compressional phases and mostly during the following extensional one, related to the late Miocene Tyrrhenian Sea opening (SELLI & FABBRI, 1981; ZITELLINI *et alii*, 1986; KASTENS & MASCLE, 1990; BARTOLE *et alii*, 1991).

The extensional phase is characterized since the Tortonian by magmatic activity (FERRARA & TONARINI, 1985); the intrusion of magmatic bodies led to the formation of several parallel ridges, elongated in a N-S and NNW-SSE direction and representing the structure of the Tuscan Archipelago. The small basins between ridges were progressively filled during Plio-Pleistocene time starting from the east; during the Late Quaternary a complex shelf area is formed, extending from the coast of Tuscany to the Corsica and Capraia Channel.

The outermost structural high (the so called Elba or Pianosa Ridge) delimits the shelf to the west; it is elongated in a N-S direction from Scoglio Africa to Pianosa Island and in a NNW-SSE direction from Pianosa to Capraia Island.

Miocene to Pliocene sedimentary units uplifted by intrusive bodies crop out along the ridge axis, both on the sea floor and at the surface (e.g. Pianosa I; COLANTONI & BORSETTI, 1973; VIARIS DE LESEGNO, 1978). High-angle extensional faults of Plio-Pleistocen age trending in a NE-SW and NW-SE directions cut the ridge between Elba and Capraia I. and between Capraia and Gorgona I.; thus, shelf areas, characterized during Pliocene and early Pleistocene time by different morphological and depositional features, can be recognized.

The peculiar structural framework of the shelf area to the east of the Corsica Basin, played an important role in trapping terrigenous sediments deriving from the growing Apennine Chain; for this reason the eastern margin of the Corsica Basin appears to be relatively starved with respect to the western one, abundantly fed by the Corsica Island.

The different sediment input is reflected by basin asimmetry (both of the external form and of the

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fill geometry) and by the progressive eastward migration of basin axis (VIARIS DE LESEGNO, 1978). This situation is particularly evident during Pliocene time; since the late Pleistocene, after the filling of the Tuscan extensional basins, a slow reversal trend is observed.

Anyway, the Elba Ridge remains a morphologic high, thus limiting the sediment input along the eastern margin also during the late Quaternary sea-level lowstand; this fact has great impact on the morphologic and sedimentary setting of both shelf and slope areas and, as a consequence, on the geometry and composition of sedimentary bodies.

During this time interval several deltaic lobes and small turbiditic systems characterize respectively the shelf and base of slope areas of the western margin of the basin (STANLEY *et alii*, 1980; BELLAICHE *et alii*, 1994), while along the eastern one only small terraced bodies formed at the shelf edge.

DATA AND METHODS

This work is based on 1000 km of GPS positioned seismic profiles and 50 cores collected during cruises ET91 (N/O BANNOCK), ET93 and ET95 (N/O URANIA), carried out by CNR Istituto di Geologia Marina of Bologna, as part of a research project concerning the study of active sedimentary processes and of Plio-Quaternary morphologic and sedimentary evolution of the eastern margin of the Corsica Basin. Seismic profiles were acquired in a regular grid (< 2km); they are represented by single channel 1 kJ Sparker profiles digitally recorded; 3.5 kHz sonar profiles (ET91) and 300 J UNIBOOM profiles (ET95) were also acquired. The good quality of the positioning allowed the integration of the three cruises data, making easier the interpretation and calibration of seismic data with cores.

Sparker profiles are not the best tool for the detailed study of shelf sedimentary bodies, due to the limited vertical resolution. Anyway, the overall good quality of the available seismic profiles, allows the individuation and study of depositional terraces; sometimes also internal geometries are recognizable. Digital record allows the processing of data; as a consequence a significant improvement of the signal/noise ratio have been obtained together with the possibility to change vertical exaggeration.

The digital record system is based on a PC 486 and was realized by IGM; data has been processed with a SUN based software (FOCUS). The most important step was deconvolution which led to a significant decrease of the ringing effect related to the signature of Sparker. In this paper some examples are shown of seismic profiles before and after processing (Figs. 5- 6 and 11-12). Cores, located on specific targets, have been collected using a gravity corer 1.2 T with variable length (2-6 m.).

CAPRAIA SHELF

Capraia Island is sorrounded by a 5 km wide shelf to the west and to the south (Fig. 2); to the east the shelf is linked to the larger Tuscan shelf. The shelf break is a very sharp feature at a constant depth of -150 m; the slope is very steep (14°) and its base is found at -400 m depth. To the south the slope connects the Capraia shelf with the Elba Channel, a NE-SW trending depression related to Pliocene faults cutting the Elba Ridge; the Elba Channel axis is steep (2.5°) in the lower southwestern tract, while the upper northeastern one is very gentle (0.5°) and the transition to the shelf is gradual. The steepness of the southern slope of Capraia decrease to the NE along the Elba Channel together with the depth of its base.

Figures 3 to 6 show the framework of the Capraia shelf; the edge of the shelf and the slope are the frontal part of a polihystory progradational complex, developed all around the island during the Pliocene and the Quaternary, after the formation of the Elba Channel (Fig. 3 shows the progradational complex onlapping against tilted block of the volcanic basement of Capraia Island). The high angle of the slope is due to the coarse-grained nature of the foresets (biocalcarenites and biocalcirudites). The gradual decrease of the base of slope depth and of slope steepness along the axis of Elba Channel is due to two factors: 1) the progressive shallower depth of the base of the progradational complex and 2) the concomitant thickness increase of fine-grained Late Pleistocene deposits onlapping the base of slope; such deposits, genetically linked to the depositional terrace object of this study, completely cover the progradational complex in the Elba Channel head.

The morpho-structural setting of the Capraia shelf was thus already defined at the beginning of the Quaternary and probably since the Late Pliocene. The outermost prograding unit of the complex shows a well developed topset with a flat, smooth and very low-angle top surface, and onlapping against the island basement (Late Miocene effusive rocks); the latter crop out on the sea-floor at depth shallower than -100 m.

A prograding body develops above the Plio-Pleistocene complex; it is characterized by a seismic facies similar to that of the underlying unit. This body is a depositional terrace 15 km long (parallel to the coastline) and 0.5-1 km wide; the maximum width is reached in an area were also the underlying progradational complex attains its maximum expansion; to the west, where the shelf gradient increases up to 2°, the terrace rapidly disappears; to the east, the shelf gradient decreases progressively up to 0.5° at the Elba Channel head and the depositional terrace gradually dies out.

The terrace is a prograding body with an external wedge shape; it opens at variable depths ranging from -105 to -115 m; the topset-foreset transition lies at a constant depth of -120 m and the base is found at -130/-140 m depth (Fig.3). The mean thickness of the body is 15 m. Seismic facies is normally characterized by the absence of reflections; in some instances foresets with an angle of 15° can be seen; the terrace is monocyclic; some reactivation surfaces are rarely observed but the body appears to be developed during a single progradational phase.

Cores (Fig.4) show that the topset of the Plio-Pleistocene progradational complex is made up of biocalcarenites and biocalcirudites with calcareous algae; the base of the depositional terrace has been cored near the closure of the body: it is composed of fine bioclastic sands with glacial Mollusks; fine clayey sands with glacial Mollusks also characterize the unit found in the Elba Channel. AMS radiocarbon datings on Mollusks show that such deposits are related to the Last Glacial Maximum (ca. 18 kyr BP).

The depositional terrace formed on the Capraia shelf during the falling or lowstand stages of the Late Quaternary glacio-eustatic fluctuation. At the present moment no core data are available for the upper part of the foresets and the topset; for this reason it is very difficult to define sedimentary facies and to relate the prograding body to a specific depositional setting. Anyway, the depth of the foreset-topset transition (-120 m) is consistent with the Last Glacial Maximum sea-level recognized along the continental margins (FAIRBANKS, 1989); this suggests that the depositional terrace could represent a beach s.l. formed along a high-energy and relatively high-gradient coastline.

THE SHELF BETWEEN ELBA AND PIANOSA ISLANDS

The shelf area extending from Elba to Pianosa Islands has a linear edge at a constant depth of -120 m; the slope is complex, steep to very steep and severely affected by bottom current ACTIVITY(ROVERI, *et alii*, 1994; TONI, 1995; MARANI *et alii*, 1993). The base of slope is placed at depths ranging from -500 m to the north and -600 m to the south.

In the middle and lower tracts of the slope complex sedimentary bodies are present; they are interpreted as related to bottom current activity; the upper slope is characterized by large scale erosion, somewhere very strong and seismically detectable for the occurrence of truncated reflectors. Upper slope angles range from 2.5° to 14° with a modal value of 5°. A small linear canyon cuts at high-angle the slope up to the shelf edge in the northern sector (Figs. 7, 9).

The shelf is superimposed to the large anticlinalic structure of the Elba Ridge; it has a prevailing erosional character; present day sedimentation is absent, being this area too far from sediment input and continuously reworked by strong surface current that can affects the sea floor up to -80-100 m depth. Along the Ridge axis, Miocene and Pliocene strata crop out on the sea floor generating a higher and rougher belt; the outer western flank is characterized by alternating low gradient and smooth tracts and steep and rough ones.

The shelf stratigraphy is characterized by gently folded Miocene and Pliocene units truncated by an erosional polihistory surface, which formation started probably since the Late Pliocene. Along the western flank of the Ridge (Figs. 10-12) also Pleistocene clinoforms are found below the erosional surface; the youngest phase of erosion was during the Late Quaternary sea-level fluctuation, in two distinct moments: in a subaerial setting during the sea-level fall and in a subacqueous one during the subsequent transgression (ravinement surface); these two moments would generate two distinct surfaces; in this area, for the absence of sedimentary products relative to both the falling and the early rising stages of sea-level the two surfaces are coincident; above this surface a very thin layer (a few cm) of bioclastic sands is found; it represents the time interval corresponding to the late transgressive and high-stand phases of Late Pleistocene-Holocene age. At the shelf edge the two surfaces tend to separate and loose their erosional character; here they envelop a depositional terrace 25 km long and 0.5-1 km wide (Figs. 7-8). It opens at -110/-115 m depth and the closure is at variable depths ranging from -140 m and -200 m; the edge of the body is coincident with the shelf break and is at a constant depth of -120 m. The terrace appears to be more developed in a shelf tract with a low gradient (1°) and relatively smooth which is linked to an upper slope with 3° to 5° angles; the terrace onlap to the north and to the south against shelf tracts characterized by higher gradient (>2°) and linked to very steep upper slope (10°-14°).

The depositional terrace is a wedge shaped prograding body (Fig. 13); the internal geometry is well seen in 3.5 kHz sonar profiles (Figs. 13-14); they show tangential foreset strata with 10°-12° angle and very thin bottomset; in the upper part a clear toplap is seen below the sea floor.

A core cutting the upper part of the foreset strata (Fig. 14a) recovered medium to coarse-grained lithic sands with a strong biogenic component; they rest below a thin cover of fine bioturbated and bioclast rich sediments (TST-HST); sands are clean, not bioturbated and show parallel to low-angle inclined laminae; a second core cutting the lower part of the terrace (Fig. 14b) recovered, below a thin cover of TST-HST fine deposits, fine to coarse-grained, clayey, bioturbated sands with abundant bioclasts showing glacial affinity.

These data suggest, as for the Capraia shelf, that the terrace formed during the lowstand phase of the Last Glacial Maximum.

Cores clearly suggest in this case a beach depositional setting; moreover, considering that the depth of the foreset-topset transition (-120 m) is coincident with the sea-level depth reached during the Last Glacial Maximum, it can be argued that the depositional terrace represents a beach body developed in a relatively high gradient and high-energy coast tract.

CONCLUSIONS

The shelf superimposed above the Elba Ridge shows sectors with variable morphological characters reflecting a different Plio-Pleistocene sedimentary evolution; this is particularly evident when comparing the shelf margin of Capraia with that extending from the Elba Island to Pianosa Island. Nonetheless, in both areas depositional terraces with similar geometric and compositional characters develop at the same depth; these sedimentary bodies appear to be limited in their lateral extension only by the gradient of the shelf above which they develop (values comprised between 0.5° and 1.5°).

The sedimentologic and palaeontologic characters as observed in cores, together with radiocarbon datings, suggest that the depositional terraces present in this area formed as high-energy beach bodies during the Last Glacial Maximum lowstand (18 kyr BP); the edge of the terrace is found at a constant depth of -120 m, according with the mean sea-level reached during the Last Glacial Maximum; a direct consequence is that the study area can be considered, from both a subsidence and morpho-sedimentary point of view, stable, and homogeneous at least since the Late Pleistocene.

FIGURE CAPTIONS

Fig. 1 - *Location map of the studied area. Isobaths in metres.*

Fig. 2 - *Detailed map of the Capraia shelf, with the extension of the Last Glacial Maximum lowstand depositional terrace and the cores location.*

Fig. 3 - *1 kJ Sparker analogic profile (vert. exagg. 15x); the Late-Quaternary depositional terrace progrades above the topset of the Plio-Pleistocene progradational complex; the two systems onlap against the faulted basement of Capraia Island.*

Fig. 4 - *Correlation scheme of the cores superimposed on the same profile of Fig. 3. Not to scale to represent all the units. The Plio-Pleistocene complex topset is made up biocalcarenites with calcareous algae. At the base of the late-Quaternary depositional terrace fine sands with glacial fauna are found; these deposits do not reach the shelf margin, where, immediately below a thin cover of trangressive and high-stand sediments, the Plio-Pleistocene complex deposits are found. Below the erosional sea-floor of the Elba Channel fine-grained deposits with glacial fauna crop out; they can be temptatively correlated to the depositional terrace. Towards the NE these deposits are linked to the base of the terrace and completely cover the Plio-Pleistocene progradational complex.*

Fig. 5 - *1 kJ Sparker profile before processing (vert. exagg. 15x). Compared to Fig. 3 profile the slope appears less high and steep, due to the different depth of the base of the Plio-Pleistocene progradational complex and to the thickness increase of the fine-grained deposits at the base of the Late-Quaternary depositional terrace.*

Fig. 6 - *The 1 kJ Sparker profile of Fig. 5 after processing; deconvolution has improved the vertical resolution with the drastic reduction of the ringing effect, making it possible to see the real terminations of reflectors. Vertical exaggeration is reduced at 7x.*

Fig. 7 - *The depositional terrace at the shelf edge in the tract between Elba and Pianosa Islands (nortern tract, see Fig. 1). Isobaths in metres.*

Fig. 8 - *The depositional terrace at the shelf edge in the tract between Elba and Pianosa Islands (southern tract, see Fig. 1). Isobaths in metres.*

Fig. 9 - *1 kJ Sparker profile and its interpretation (vert. exagg. 16x). The depositional terrace progrades within the head of a small canyon reaching the shelf edge; several phases of erosion and deposition within the canyon fill are clearly evident.*

Fig. 10 - *1 kJ Sparker profile not processed (vert. exagg. 15x) across the western flank of the Elba Ridge; the erosional character of the sea-floor is evident; in this section the strata have a monoclinalic attitude; to the east in the rougher and higher relief area the Miocene terms of the succession crop out; to the west in the flat lying and smooth area Plio-Pleistocene deposits crop out; the latter made up a complex prograding unit which outermost term is represented by the Late-Quaternary depositional terrace.*

Fig. 11 - *1 kJ Sparker profile not processed (vert. exagg. 15x) across the Elba Ridge. As in the section of Fig. 10 the Miocene to Pliocene succession crop out in the higher relief sector of the shelf; the Pleistocene progradational complex is here well developed; at its front on the shelf edge, the prograding wedge representing the Late-Quaternary depositional terrace can be seen slightly deeper with respect to the adjacent deposits.*

Fig. 12 - *The 1 kJ Sparker profile of Fig. 11 after processing; the vertical exaggeration is reduced to 7x and the reflector terminations after the deconvolution appears more clear.*

Fig. 13 - *3.5 kHz sonar profile across the depositional terrace (vert. exagg. 12x); location in Fig. 7. Note the internal geometry of the body with tangential foresets.*

Fig. 14 - *a) 3.5 kHz sonar profile across the depositional terrace with the ubication and the sedimentologic log of core ET91-8; below the fine-grained deposits of TST and HST the core recovered the upper part of the foresets, made up of clean sands with parallel and low-angle inclined lamination; b) 3.5 kHz sonar profile showing a detail of the closure of the depositional terrace with the ubication and the sedimentologic log of the core ET91-14: the bottomset is made up of clayey bioturbated sands with abundant glacial-type bioclasts.*

Fig. 15 - *Photographs of fig.14 cores.*