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Submerged depositional terraces off the Carini Embayment (Northwestern Sicily)

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INTRODUCTION

High resolution sequence stratigraphy tools have been applied to the study of the regressive shelfal deposits found scattered off the Carini Embayment, a small sector of the northwestern Sicily continental margin (Fig. 1).

Such sedimentary successions, whose development is related to the Late Pleistocene eustatic fluctuations, have been widely recognized off several mediterranean continental shelves (LECCA *et alii*, 1983; MARANI *et alii*, 1988; CHIOCCI *et alii*, 1989; TRINCARDI & FIELD, 1991; CORREGGIARI *et alii*, 1992; AGATE & LUCIDO, 1995).

In the Carini Embayment, these prograding wedges represent the stratigraphic record of subequent sea level falls and lowerings. Terraced features, characterizing the outer shelf, reflect the late costructive stage of the sea level lowering and the first erosive stages of the subsequent rise, when the top of shelf margin units was cut off by shoreline landward shift and accompanying wave action.

Purpose of this paper is to describe the internal geometries and areal extension of the regressive sedimentary succession of the Carini Embayment in order to derive their geological history during the last glacial maximum.

MORPHOLOGICAL AND GEOLOGICAL SETTING OF THE CONTINENTAL SHELF AND UPPER SLOPE.

The northwestern Sicily continental shelf extends along the southern margin of Tyrrhenian Sea (Fig. 1), characterized in Pleistocene times by a high rate of subsidence, up to 1mm/y, in its eastern sector (KASTENS & MASCLE, 1988).

The structural setting of the investigated area has been inherited from a complex pre-late Miocene compressive tectonics, related to the continental collision between the Corsica-Sardinia microplate and the Sicilian continental margin (CATALANO *et alii*, 1985, AGATE *et alii*, 1993).

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The subsequent extensional tectonics, occurred during Tyrrhenian Sea opening, determinated the occurring of alternate morphostructural highs and deep Plio-Pleistocene basins, forming a NNE-SSW trending belt.

The Carini Embayment is bounded to the West by the Castellammare Gulf and eastward by the offshore prolongation of Palermo M.ts (La Barra High).

The continental shelf forms a narrow platform, approximately 10 km wide (Fig. 1), sleeply sloping seaward to the shelf break located to -140 m / -160 m of depth. A paleoshoreline, found between -100/-110 of depth (LUCIDO, 1992), divide the shelf in an inner smooth sector and an outer rought area, where incised paleoriver valleys occur near the main streams.

The shelf is composed by a set of Pleistocene seaward prograding units, upward truncated by the unconformity related to the last glacial sea level fall and lowstand (δO_{18} = 2; Fig. 2). The upper slope is cut by several canyons and display a number of instability features, like slump scars and mass wasting deposits (AGATE & LUCIDO, 1995).

DATA BASE AND METHODS

The analysed data base (Fig. 3) consists of a network of 80 nautical miles of single-channel seismic lines (Sparker and 3.5 kHz S.B.P.) having a different vertical resolution (to few meters), more some gravity core samples.

The seismic survey positioning was based on a hyperbolic Loran C system and, since 1991, on G.P.S. system.

These peculiarities allow the application of high resolution sequence stratigraphy analysis to depositional sequences of limited thickness and areal extension.

SEISMIC STRATIGRAPHY OF THE CONTINENTAL SHELF

The stratal pattern of the Upper Quaternary sedimentary succession has been subdivided into seismically definable depositional packages, bounded by estensive laterally continuous surfaces, both on the shelf and upper slope: seismic sequences have been named from top to bottom I, II and III (Fig.4).

The surfaces are characterized by high amplitude reflections and define sequence boundaries. The upper sequence (I) is considered Late Pleistocene - Holocene in Age and consists of a group of three different seismic units: Ic, Ib and Ia.

Unit Ic is characterized by basinward progradational convex upward reflections of variable amplitude and frequency; it is interpreted to represent a Forced Regressive Systems Tract (FST; HELLAND-HANSEN & GIJELBERG, 1994).

Unit Ib is wedge shaped and is characterized by high to medium amplitude and low frequency. Evidence of mass wasting or seismic facies change, from layered to chaotic or to semitrasparent, on the shelf edge has been recognized. This unit corresponds to shelf perched lowstand wedge or lowstand prograding complex (LPC; POSAMENTIER & VAIL, 1988).

Unit Ia is sheet shaped, onlaps landward at -100/-90 m of depth and can be divided into two subunits, the upper one with a high frequency layered seismic facies and the lower one with a trasparent seismic facies, separated by a continuous reflector corresponding to the maximum flooding surface. According to our interpretation the Unit Ia includes the distal component of Transgressive Systems Tract (TST) and the Highstand Systems Tract (HST; POSAMENTIER & VAIL, 1988).

CONCLUSIONS

Our study, focused in a shelfal area on the continental margin off the NW Sicily, has defined a succession of sedimentary processes triggered by Late Quaternary relative sea level changes (Fig. 6). During the sea level fall and the lowstand following the d O^{18} = 5e, the litoral depositional systems prograded onto a narrow shelf and a steep upper slope; the resulting seaward thickening wedges are

more than 80 ms (t.w.t.) in localized areas (Fig. 5). Stacking pattern of deltaic lobes demonstrate overall progradation from South to North. Three ancestral streams were the fluvial feeders of these shelf deltas.

The upper portion of Late Pleistocene wedges is extensively eroded, primarly by subaerial erosion and, to a lesser extent, by subsequent transgressive truncation. The scenario of high sediment supply fluvial systems, incising the morphological shelf breack, is suggested by sequence stratigraphy model for type 1, 4th order depositional sequence, could be apply for these particular progradational regressive lithosomes and their associated "submerged depositional terraces".

FIGURE CAPTIONS

Fig. 1 - *Location of the studied area (depth contour in meters) (Fig.2). Extension of the shelf margin submerged terrace is shown. The terrace extends 20 km along the coast and it is to 3.5 km wide between Torre Muzza and Isola delle Femmine.*

The depositional terrace edge (D) is coinciding with the morphological shelf break (F), except in the "La Barra" sector, were the continental shelf atteins the maximum extension and the depositional terrace wholly lies above the continental shelf.

Fig. 1B - *Schematic section of the shelf margin, not in scale. Morphological and depositional features mapped on Fig. 1A are shown.*

A: edge of scarp; B: landward boundary of the forced regression deposit; C: landward boundary of the shelf margin wedge (LPC) D: terrace edge coinciding with shelf break; E: seaward boundary of the depositional terrace; F: shelf break.

Fig. 4 - *Location of recorded during Sicilia '88, Sicilia '89 and Sicilia '90 oceanographic cruises seismic profiles. Boldfaces are the profiles shown in this paper. a) profiles of Sicilia '88 cruise: S.B.P. 3.5 kHz and Sparker 0.5 and 1.0 kJ; b) profiles of Sicilia '89 cruise: Sparker 1 kJ.*

Fig. 5 - *Seismic profile (Sparker 16 kJ) crossing the shelf margin and the upper slope (location on Fig. 3). The Plio-Pleistocene sedimentary succession unconformably overlies the meso-cenozoic deformed substrate. The succession shows free reflection seismic facies evolving upward to high amplitude and continuity reflectors. Above the continental shelf the unit shows a progradational reflection pattern (modified from* AGATE & LUCIDO*, 1995).*

Fig. 6 - *Sparker profiles 1 kJ (4A, 4B, 4C and 4D) and profile S.B.P. 3.5 kHz (4E) crossing the Carini Embayment continental shelf (location in Fig. 3). Seimic stratigraphic analysis of the seismic sequence I allowed us to distinguish three seismic units.*

- Unit. Ic: consists of high frequency and medium-high amplitude seismic horizons with a prograding reflection pattern; the reflectors dip seaward with oblique-tangential and complex sigmoid-oblique patterns and variable slope (Fig. 4 B); locally seismic facies become mostly like reflection-free, probably because of presence of gas (Figs. 4 A and 4C). Slump scars linked to rotational sliding landslide are present with collapsed deposits at the toe (in the sismic profile they appear as mounded high amplitude reflectors; Figs. 4A and 4B); topward the seismic horizons are truncated.

- Unit 1b: it shows a reflection-free seismic reflection pattern with low amplitude complex sigmoid-oblique reflectors (Fig. 4B).

Unit 1a: consists of medium-low amplitude, high frequency reflectors with parallel reflection configuration. This unit shows a thickness increasing landward (Figs. 4A and 4E).

Legend: 1) seismic sequences and units; 2) seismic sequence boundary; 3) maximum flooding surface (m.f.s.); 4) base of Lowstand Prograding Complex (LPC); 5) base of Transgressive Systems Tracts + Highstand Systems Tracts (TST + HST).

Fig. 7 - A: *Depth of unit Ic lower boundary; B: thickness of unit Ic+Ib unit; C: depth of unit Ib lower boun-*

dary; D: thickness of unit Ib. Values are expressed in ms, two way travel time. Fig. 5B show three main unit Ic+IB depocenters; the thicknest, NE of Isola delle Femmine, could be related to major slope of basal depositional surface. In turn, major extension perpendicularly to coast of units Ia and Ib NW off Isola delle Femmine is related to minor slope an regularity of the basal depositional surface (Fig. 5A; see Fig. 1A too).

Fig. 8 - *Geological evolution of shelf margin during the last glacio-eustatic fluctuation (cartoon not in scale).*

*A) - falling sea level, shoreline seaward putting forward and type 1 sequence boundary generation (*VAN WAGONER *et alii, 1988); - regressive progradational succession deposited above the shelf margin (FST, corresponding to unit Ic).*

B) - Deposition of a prograding complex above the shelf margin (LPC, unit Ib) during lowstand and beginning of the sea level rise. Covered talwegs in the inner sector of the continental shelf between Torre Muzza and Isola delle Femmine, are correlatable to deposits of sequence I (unit Ic and Ib) and suggest these units have been deposited in a deltaic environment. Were a paleo-drainage have not been recognized, presence of litoral deposits has been supposed. Shape, extended parallelly to the coast, of unit Ib (Fig. 5D) suggests strong litoral currents along a narrow and irregular shelf. During sea level fall, deposits of unit Ic underwent subaerial erosion; seaward the erosional surface become a toplap surface at the top of unit Ib.

C) Subsequent sea level rise produced landward shift of litoral facies, generating a transgressive erosional surface at the top of units Ic and Ib. This process is considered as one of the most important for the origin of terraced surface above the progradational deposits (units Ic and Ib).

D) In the inner sectors of the continental shelf, above the transgressive erosional surface, condensed deposits accumulated during the late sea level rise and highstand stages with a reduced sedimentary supply. In the outer sectors of the continental shelf the terraced surface, cut during the sea level rise, outcrops.