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THE IONIAN CRUST AND THE CALABRIAN ACCRETIONARY WEDGE

Catalano R.*, Doglioni C.**, Merlini S.° & Sulli A.*
* Dipartimento di Geologia e Geodesia, Università di Palermo, via Archirafi 26, Palermo
** Dipartimento di Scienze della Terra, Università "La Sapienza" di Roma, P.le A. Moro 5, Roma
° ENI-AGIP, San Donato Milanese (MI)
E-mail: rcatal@unipa.it (corresponding author)

Introduction

The interpretation of deep seismic lines has revealed the structure of the Pelagian passive continental margin and the related Ionian ocean (Catalano et al., 2000), highlighting the evolution of the Mesozoic continental rifting and oceanic spreading (Catalano et al., 2001). Crustal pattern and geometries of the continental margin-to-ocean transect is an important constraint to study subduction processes of the Ionian lithosphere beneath the outer Calabrian Arc (Fig. 1).

The unmigrated crustal lines were calibrated by using geological and geophysical data. Interpretative techniques attempted to distinguish several seismic facies to estimate the lithology and geometry of the reflecting units and to discriminate between sedimentary and crystalline units. Previously published magnetic, heat flow, gravity and bathymetry, as well as seismic reflection and refraction data (ESP, DSS, EGT and WARR) were used to constrain, at a regional scale, the crustal structures interpreted from the seismic reflection lines.

General setting

The passive continental margin and the related Ionian ocean

The passive continental margin extends from the Iblean-Malta shelf, through the Malta Escarpment, to the Western Ionian Sea. Rifting events started in pre-Late Triassic time, but major extensional features appear to dissect the top of the Triassic carbonate platform and the late Jurassic-early Cretaceous pelagic deposits.

The continental margin crust becomes progressively thinner eastwards. In addition to early Mesozoic block-faulting of both the basement and sedimentary cover, the interpreted large igneous intrusions (Catalano et al., 2000) support the "transitional" nature of the crust flooring the Malta slope and the western Ionian sector. Several Triassic to Neogene mafic volcanic levels, sandwiched in the 6 to 9 km thick sedimentary strata (Antonelli et al., 1991), and a magnetically postulated major mafic body, located in the upper crust east of the Malta Escarpment, support the hypothesis of a magmatic underplating of the thinned continental crust (volcanic continental margin) previously postulated by Della Vedova & Pellis (1992), Bonatti & Seyler (1987).

The lateral continuity of the sedimentary facies across the Malta Escarpment and the depositional relationships between the carbonate platform and basinal deposits enable the locating of the original edge of the Mesozoic continental margin in the western Ionian well beyond the Escarpment (Scandone et al., 1981; Catalano et al., 2000). The Malta Escarpment owes its morphogenesis to the reactivation caused by more recent vertical and/or transtensional tectonics (Casero et al. 1984; Doglioni et al., 2001).

The Iblean-Malta continental margin has recently been described by Cantarella et alii (1997), Catalano et alii (2001) as the conjugated margin of the Apulian swell in the other side of the Ionian, which is considered as a remnant of the Mesozoic Tethys ocean.

The Ionian abyssal plain and its eastern side are floored by a crust already interpreted as oceanic (Finetti, 1982; De Voogdt et al., 1992; Catalano et al., 2000, 2001) or thinned continental (Cernobori et al., 1996). The seismic characteristics of the Ionian crust strongly differ from the adjacent western and eastern sectors.

When correlated to the sedimentary body lying on the thinned continental crust, the “oceanic” sediments appear to be more recent than the lower Mesozoic carbonate platform: one could argue that the age of initial oceanic spreading cannot be further than Late Jurassic.

Despite the fact that tectonic subsidence analysis, deep sea floor (>4000 m in the abyssal plain), low heat flow values (Della Vedova & Pellis, 1992) support a late Jurassic-early Cretaceous age, the absence of borehole stratigraphy impedes the possibility of defining the true age of the ocean formation.

The study area

The Ionian subduction zone and the Calabrian accretionary wedge

A CROP seismic line crossing the Ionian abyssal plain towards the southern Calabria offshore images a well developed SE vergent accretionary wedge and the NW dipping oceanic basement (Fig. 2).

The most impressive signature of the Ionian abyssal plain is a couplet in the form of a highly reflective layered body and a transparent and unstratified band with overlapping hyperbolae (Catalano et al., 2000); the oceanic Moho deepens northward from 9 to more than 10 s/TWT in few kilometers (Fig. 2). The resulting sharp lateral discontinuity is here interpreted as the result of a near WNW-ESE transform (?) paleofault offsetting the Ionian crust. The crystalline crust is still coupled with the oldest sedimentary layers. The younger sedimentary layers are deformed and chaotically arranged along a decollement plane overlying the oldest sediments. They lack a coherent tectonic bodies organization.

In the intermediate sector the crust progressively deepens with a complex trajectory appearing offset by a WNW-ESE lateral (?) discontinuities (Fig. 2). Moho develops at about 11 s/TWT. The sedimentary cover is still deformed in its upper part appearing as coherent thrust ramps corresponding to the tip of the socalled External Calabrian Arc (Morlotti et al., 1982; Cernobori et al., 1996).

Towards the North the deformation reaches the lower and older sediments that form a 4 s/TWT thick tectonic wedge detached from its crust. Moreover the crystalline crust, well seismically imaged at 9 to 12 s/TWT depth interval is a gently arched body offset by reverse faults with variable fold wavelength.

Approaching SE Calabria offshore the oceanic crust becomes steeper as the faintly recognized Moho discontinuity occurs at more than 14 s/TWT. The upper crust (Layer 2 ?) is strongly deformed in several tectonic slices (Fig. 2). Above it a 2 s/TWT thick imbricated wedge composed of rocks correlatable to the older portion of the sedimentary cover is piled up. It underlies a 3 s/TWT thick seismically transparent to chaotic body physically correlatable with the continental crystalline portion of the adjacent outcropping Calabrian units.

Discussion

The seismics images that both sedimentary and crystalline Ionian crustal bodies are progressively detached from their substrate more deeply and markedly towards NW. As a consequence sedimentary and oceanic crust units appear embricated to form the SE verging accretionary wedge.

The subduction hinge zone is seismically imaged in the area where the Calabrian crystalline units overthrust the deformed oldest sediments deposited on the Ionian crust.

Thickness of the Ionian crust with respect to the adjacent continental areas, petrological-physical characteristics and relic structures could have influenced the geometry of subduction and generated processes in the shallow levels.

Occurrence of oceanic crust certainly favours subduction in this area, generating the Aeolian volcanic arc and the deep seismicity in the southeastern Tyrrhenian, as well as the ascent of the Etna magmas (Doglioni et al., 2001).

The geometry of the downgoing slab recalls articulated topography due to ancient morphostructures as the supposed medioceanic paleoridge (Cantarella et al., 1997; Catalano et al., 2001) and the transform faults formed before the subduction time. These morphostructures can make difficult the subduction and/or complicate its geometry (Font et al., 2001).

The seismic reflection study of the southern Tyrrhenian along the Cefalù basin-Solunto Mount sector (Agate et al., 2001) images a northward inflection of the Sicilian (African) continental crust below the submerged interpreted Kabilian-Calabrian continental crust (Figs. 1, 3), confirming a north-directed continental subduction as suggested by Doglioni et al. (1998).

The comparison with the crustal setting of the Calabria-Ionian sector highlights the importance of the crustal and lithospheric heritage of the downgoing foreland. The convergence of two continental crusts causes more difficulty in the subduction of the Sicilian crust respect to the Ionian sector where major convergence rate facilitates both a southward advancing of the deformation front (arcuate shape of the Apenninic front) and a vertical separation between the Ionian and Sicilian crusts.

The surface expression of this behaviour is the shorter propagation of the Sicilian frontal accretion and the building of a chain with major topographic relief respect to the accretionary wedge of the Calabria-Ionian sector.

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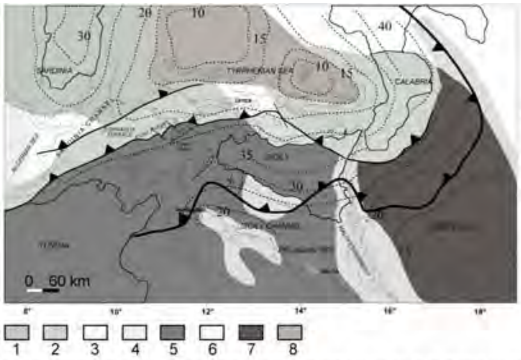

Fig. 1. Schematic map of the study area. 1: Sardinia units; 2: Kabilian-Calabrian units; 3: Thinned Sardinia and Kabilian continental crust; 4: Algerian basin; 5: Sicilian-Maghrebian units and African foreland; 6: African thinned crust; 7: Ionian ocean; 8: Tyrrhenian basin.

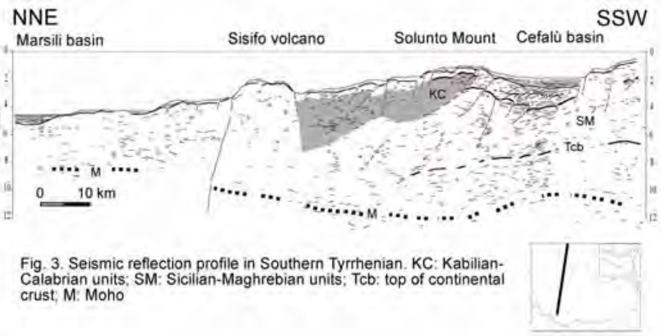

Fig. 3. Seismic reflection profile in Southern Tyrrhenian. KC: Kabilian-Calabrian units; SM: Sicilian-Maghrebian units; Tcb: top of continental crust; M: Moho

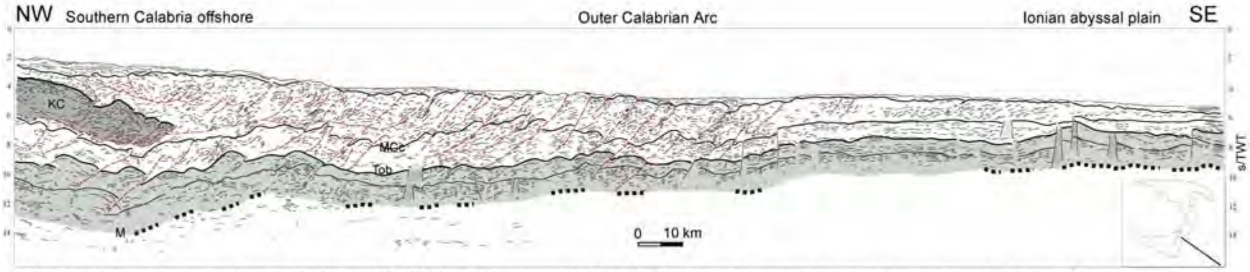

Fig. 2. Seismic reflection profile in the Ionian sea. KC: Kabilian-Calabrian units; MCc: Top of the Meso-Cenozoic Ionian sedimentary cover; Tob: top of Ionian oceanic crust; M: Moho