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CALABRIAN ARC TECTONICS FROM SEISMIC EXPLORATION

Abstract. Interpretation of a detailed seismic exploration dataset of the Tyrrhenian, Ionian Sea and Messina Strait areas, integrated with geological and useful boreholes stratigraphic informations, allows us to reconstruct in a fairly controlled manner, the complex tectonic setting of the Calabrian Arc. This paper limits its investigation to the young Neogene-Quaternary deformation process. The seismo-structural analysis indicates that there is fully reliable evidence of dominant active thrusting deformation in the Ionian side of the arc and off the southern extremity of the Aspromonte, while in the Messina Strait, Gioia and Paola troughs, distensive faults and lateral strike-slip motions are evident. The Tyrrhenian opening process has determined in the Calabrian Arc region a complex orogenic system, for the most part submerged, where thrusted blocks coming from the Apulian Platform, the paleo-deep basin of the Ionian west-graben (Lagonegrese), the Apennine platform, the Tyrrhenian basin and the SE European plate margin are piled up. The uppermost overthrusting blocks system of Calabrides is limited to the N by the left-lateral strike-slip fault of Palinuro, and to the S by the more important right lateral transcurrent fault of the Southern Tyrrhenian (Taormina fault). The Palinuro fault has affected in the Calabria area only the E-moving thrusts. The southern Tyrrhenian transcurrent fault seems of lithospheric dimension in the Tyrrhenian area and of difficult interpretation in the Ionian Sea, where it is intersected by the active Vulcano right lateral strike-slip, here evidently limited to the thrusting blocks.

FOREWORD

The Calabrian Arc is the orogenic complex that connects the Southern Apennines with the Sicilian-Maghrebian Chain. Authors today, in general, favour the hypothesis that this is a region formed by nappes, thrusted in different compressional tectonic phases (Barone et al., 1982; Messina et al., 1991; Bonardi et al., 1992; Minzoni et al., 1992; Vai, 1992). But there are various schemes for the geodynamic evolution and the origin of the various units of the arc.

The geology is characterized by blocks composed of crystalline-metamorphic basement rocks and Mesozoic-Tertiary sequences. According to the literature the basement is originated by a Paleozoic Hercynian complex with several late-Hercynian intrusions and covers. The different fragments of basement are marked by different methamorphic histories. In the northern part of the arc, during the Tertiary, the Hercynian units overthrusted the southern Apennine constituted by a Mesozoic platform, locally weakly metamorphosed, overlain by Oligocene-Lower-Middle Miocene sediments. In this part of the arc, ophyolite units outcrop and show W-ward eo-Alpine structures, partially masked by a later E-ward compressive phase and Quaternary uplifting.

In the central-southern Calabrian Arc the lowest unit is the Longi-Taormina outcropping along the southern margin of the Peloritani mountains with a methamorphic basement and a Mesozoic-Cenozoic sedimentary cover (Bonardi et al., 1992). In the central part of the Peloritani, the Mandanici unit outcrops, overlain by the Aspromonte unit (Pezzino et al., 1990), largely

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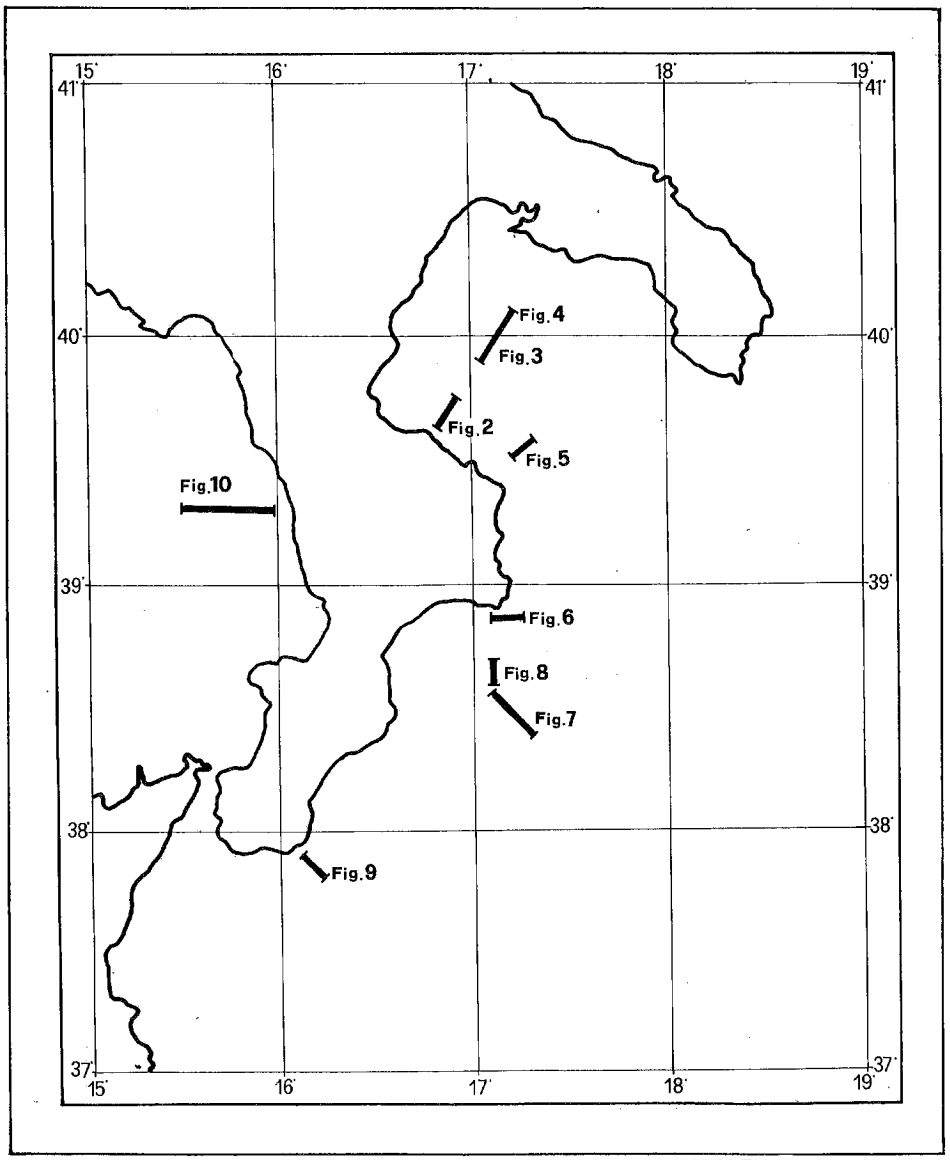

Fig. 1 - Location map of the studied area and seismic sections shown.

evident in the northern Peloritani and Aspromonte area. Blocks of this sector would show W-ward thrusting until Middle Miocene and only in post Early Miocene time does it seem to become homogeneous with the N-Calabrian Chain, and both sectors verged E-ward.

This paper describes the results obtained from the interpretation of a large dataset of seismic lines from the offshore of the Tyrrhenian and Ionian sides of the Calabrian Arc and in the Messina Strait.

SEISMO-STRUCTURAL ANALYSIS OF THE DEFORMATION

In the Ionian offshore of the Calabrian Arc, compressive structures generated by the Tyrrhenian opening process (Plio-Quaternary) and E-ward migration of the Apennine-Calabrian

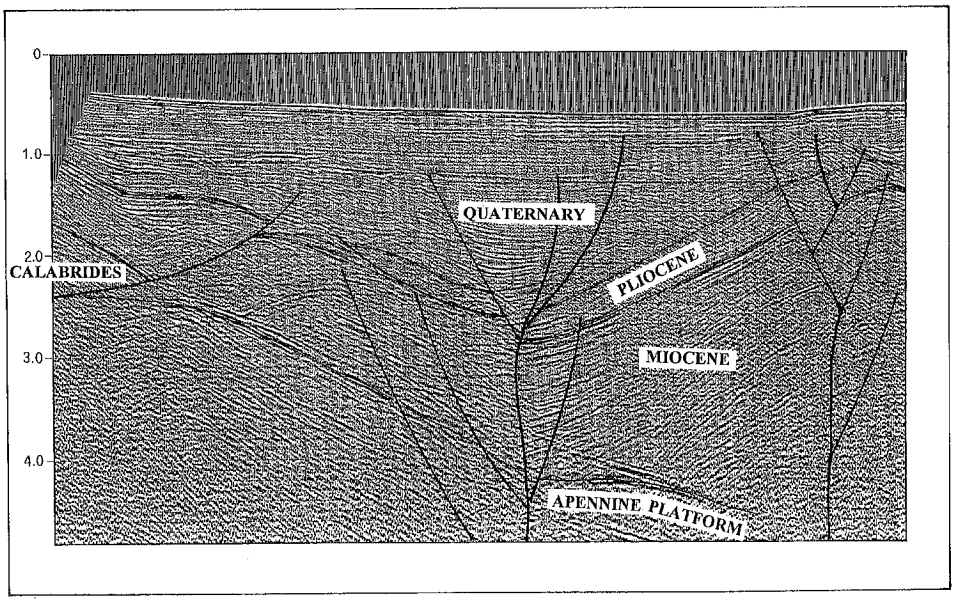

Fig. 2 - Example of Interpreted Seismic Section in the NE Ionian Sea near Calabrian coast: the Flower structure of the Palinuro strike-slip fault is evident. In the left part the thrust of Calabrian unit is confirmed by boreholes.

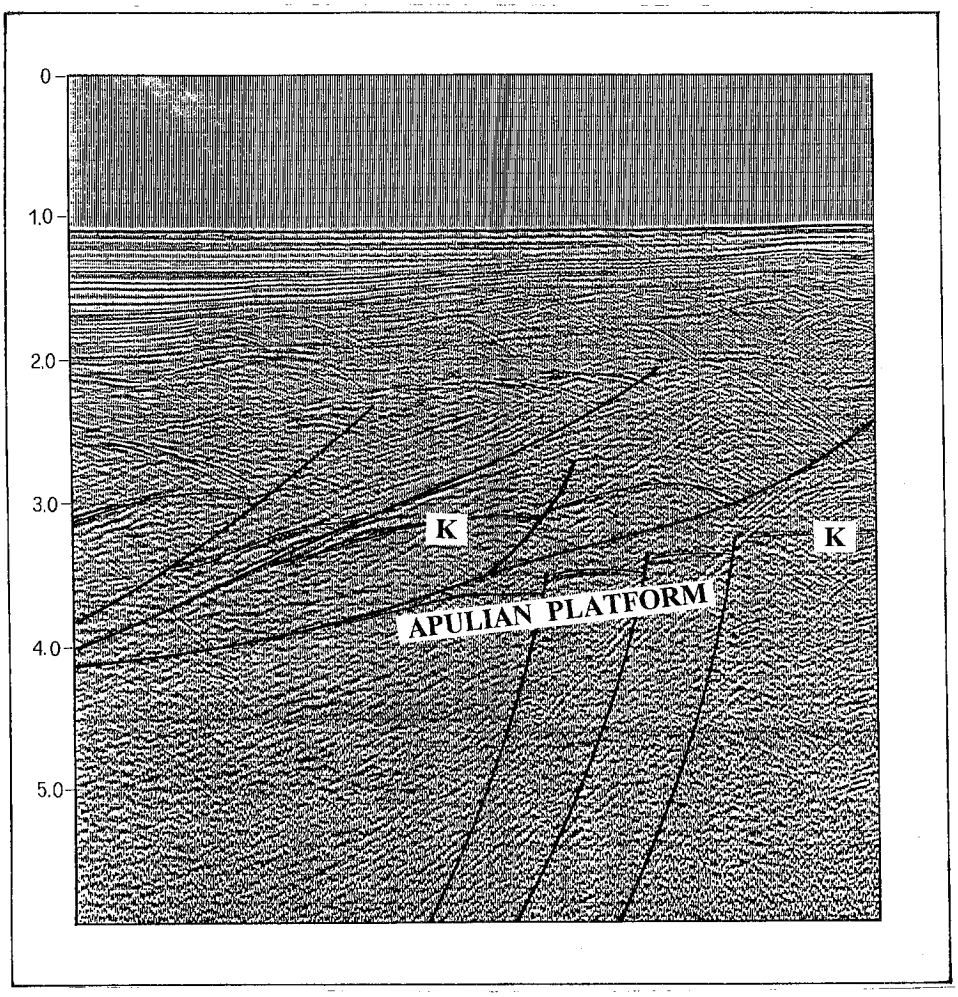

Fig. 3 - Example of Interpreted Seismic Section: compressive tectonic has produced thrusts also in Apulian Platform.

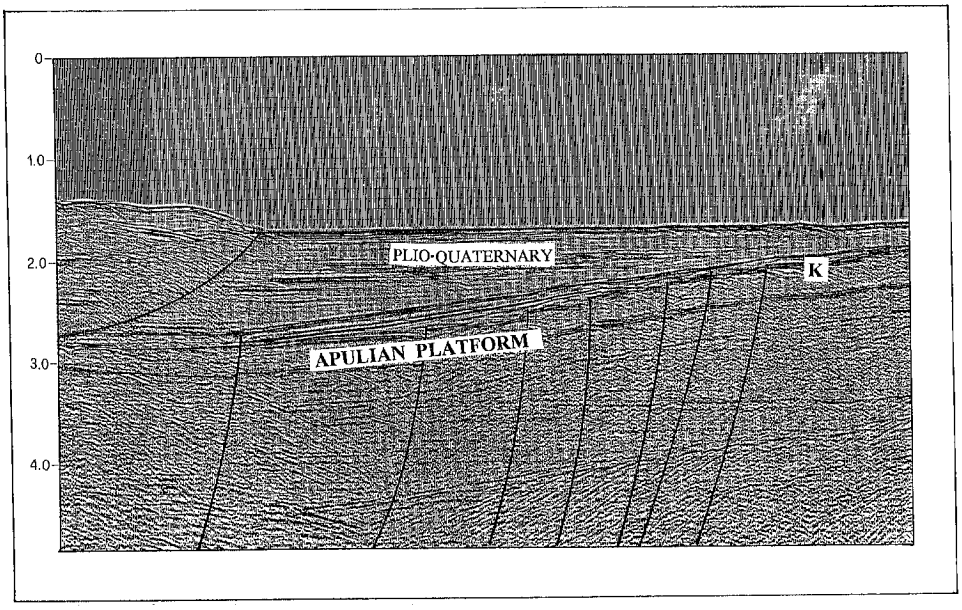

Fig. 4 - Example of Interpreted Seismic Section: the compressive active tectonic has deformed and thrusted also the old foredeep of the chain. The underthrusting and deformation of the Apulian Platform is evident.

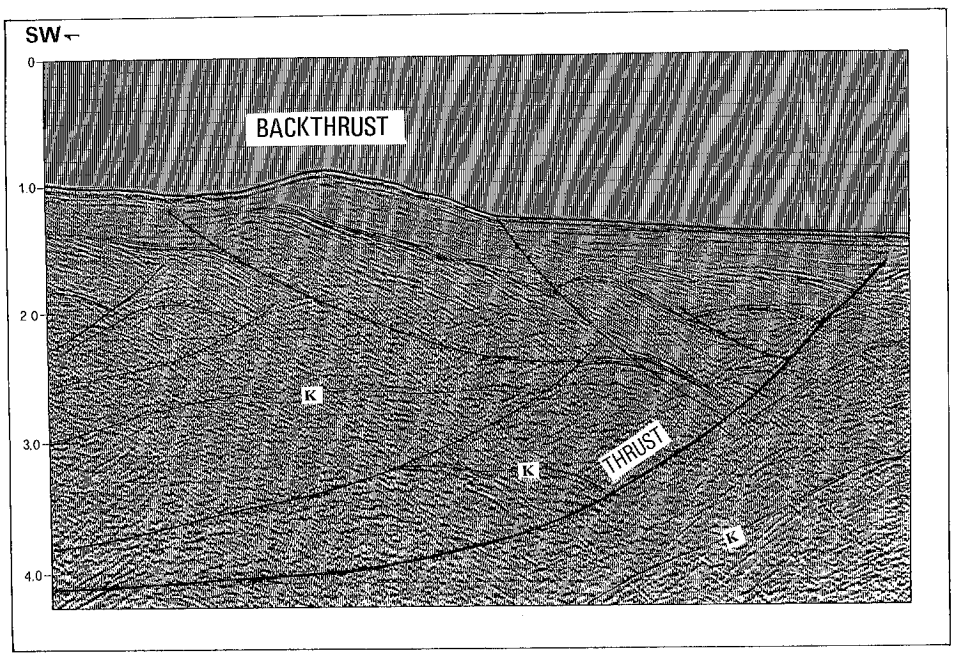

Fig. 5 - Example of Interpreted Seismic Section near Crotone Peninsula coast: the compression has determined back-thrust structure.

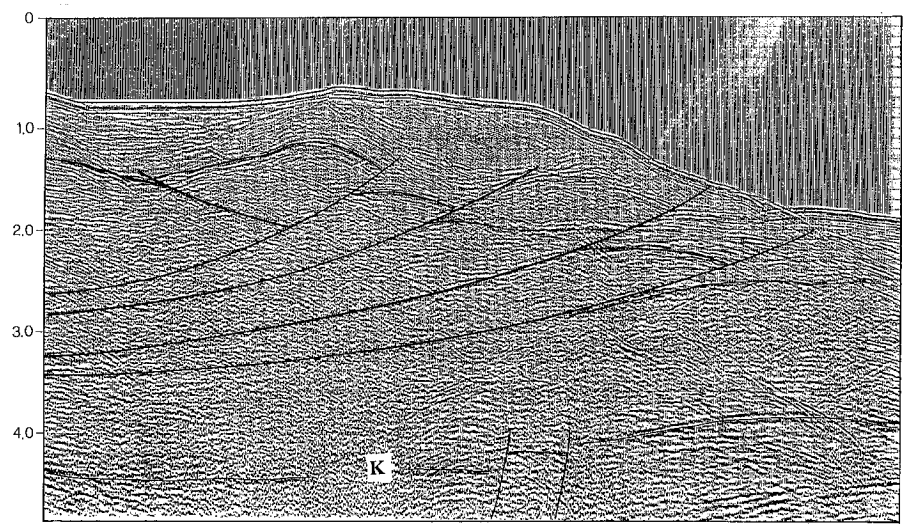

Fig. 6 - Example of Interpreted Seismic Section near Crotone Peninsula coast: evidence of an active thrust; the deep reflector "K" represents the top of carbonate block.

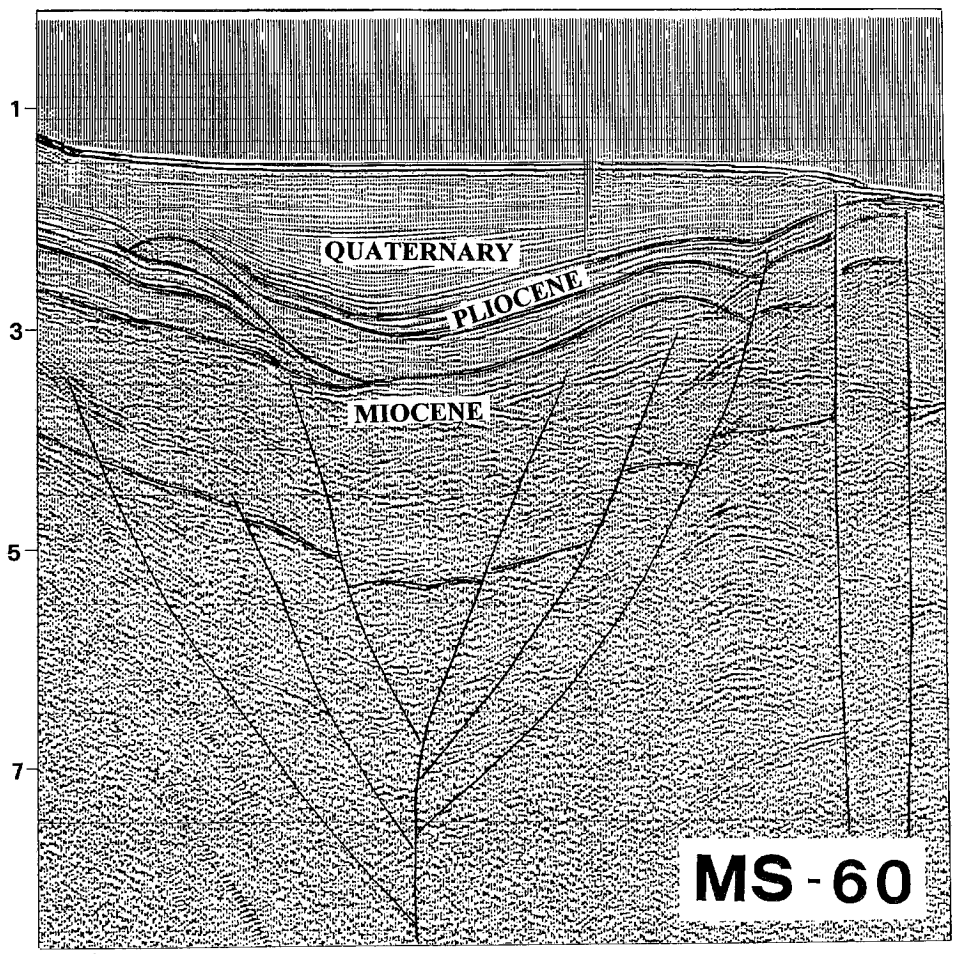

Fig. 7 - Example of Interpreted Seismic Section in the offshore Catanzaro Trough: Negative Flower structure is evident, produced by the Catanzaro strike-slip fault system.

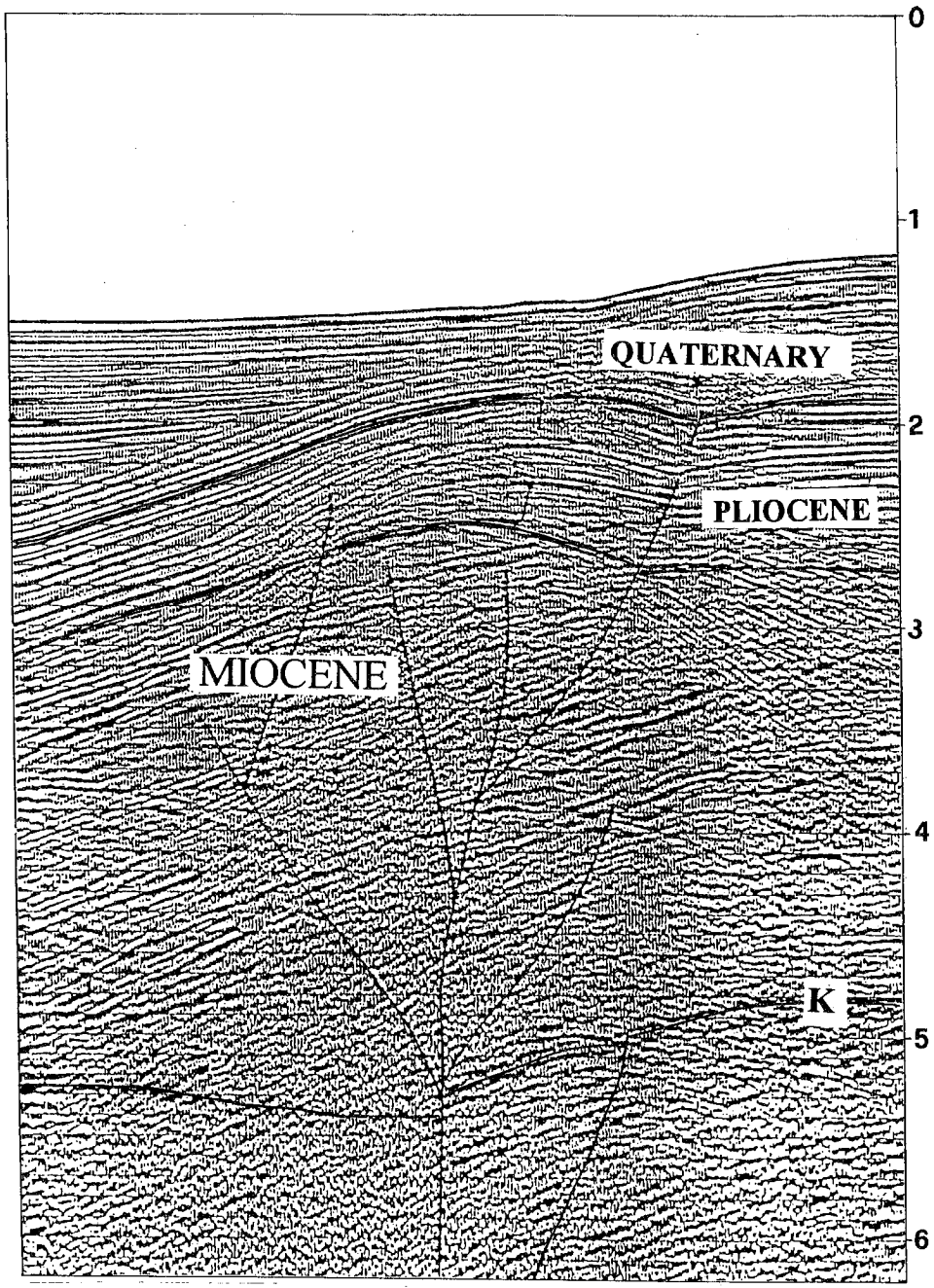

Fig. 8 - Example of Interpreted Seismic Section in the offshore Catanzaro Trough: Positive Flower structure is evident, produced by the Catanzaro strike-slip fault system.

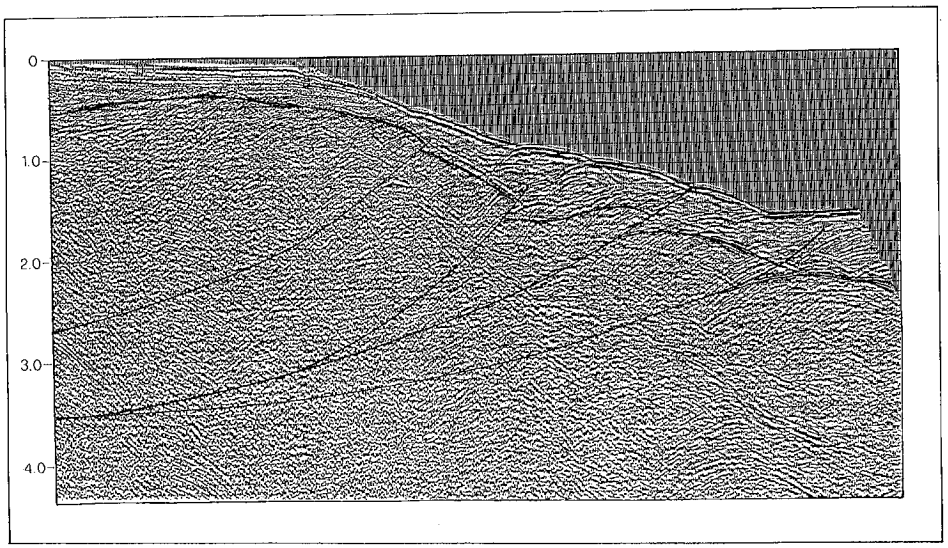

Fig. 9 - Example of Interpreted Seismic Section near the S-Calabrian coast: evidence of an active SE-verging thrust.

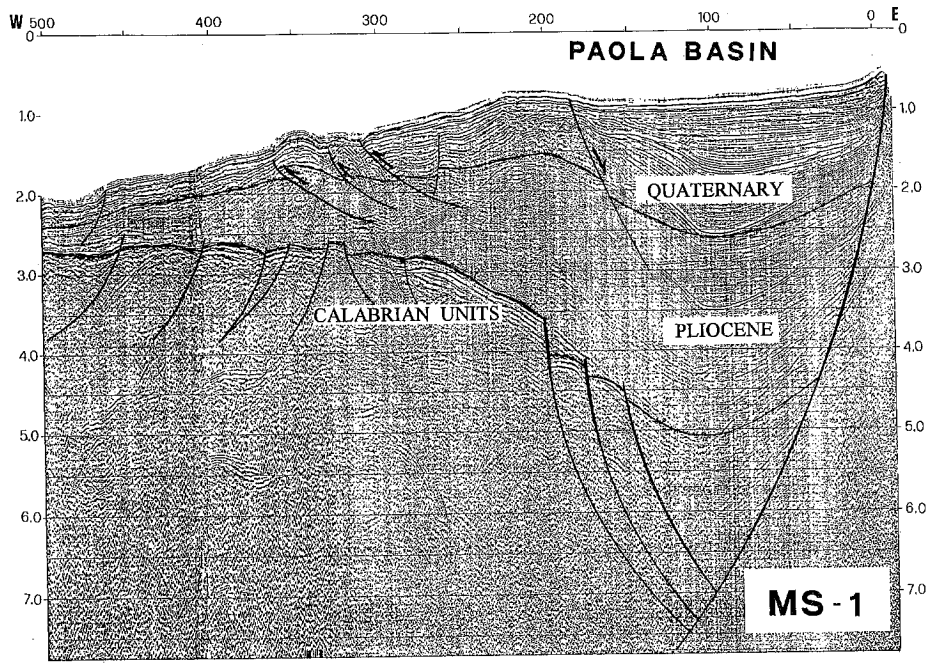

Fig. 10 - Example of Interpreted Seismic Section across the Paola Basin in the Eastern Tyrrhenian Sea.

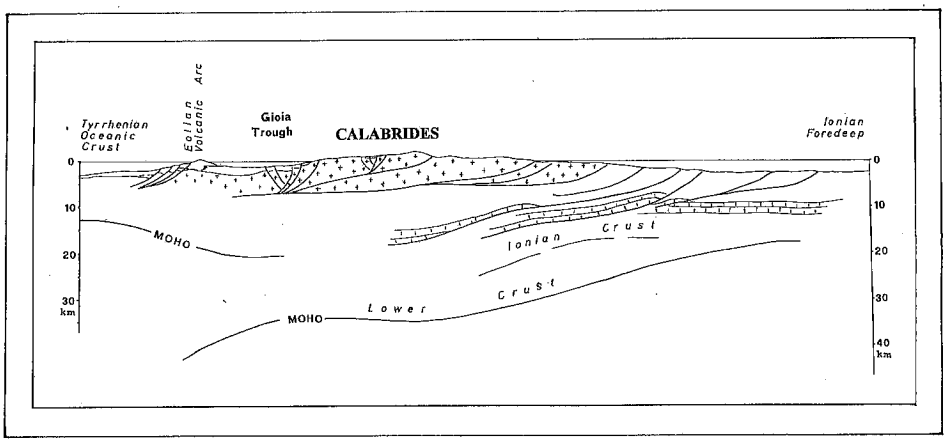

Fig. 11 - Schematic section across the Southern Calabrian Arc illustrating the Calabrian uplifting and the origin marginal basins.

Chain are evident. In the northern sector the Calabrian units, thrusted on the Apennine Platform, seem to consist of not very thick crystalline-methamorphic layers. From the geology it is well known that the Calabrides terminate to the N on the Sibari Plane. Seismic data indicate that this northern limit coincides with the prominent left lateral strike-slip named the Palinuro fault (Finetti and Del Ben, 1986). In the Ionian side this fault determines a transtensive condition characterized by a negative flower feature (Fig.2). At the left extremity of this figure the front of the Calabrides thrust is shown. This is the NE limit of the Calabrides.

On the east outside of Fig. 2, several overthrusts are seismically evident and can be interpreted as detachted carbonate blocks of the Apennine platform, covered by Neogene-Quaternary sediments thrusted on the Lagonegrese-Ionian thrust-blocks. The Apulian platform is underthrusting these imbricated tectonic sequences. In Fig. 3 one can see that compressive stresses have also deformed and thrusted blocks of the Apulian platform. In the advanced front of the Calabrian Arc the compressive tectonics has deformed and thrusted the sediments of the previous foredeep (Fig. 4); normal faults connected to the bending of the Apulian platform on its foredeep area are also evident.

Frequently the thrusting deformation is associated with generally smaller back-thrusts, as can be observed in Fig. 5.

Thrusts offshore the Crotone peninsula are clearly shown in Fig. 6 where reflecting deep seismic horizon (Horizon "K") is evident. According to the seismic velocity analysis, it can be established that the deep sequence below "K" is composed of layers of high velocity attributable to carbonates. They can be interpreted as thrusted units of the Mesozoic carbonate of the Ionian-Lagonegrese sequence. As secondary alternative these thrusts could come from the more internal paleo-position of the Apennine platform. The missing evidence of the Apennine platform units in the onshore eastern Calabrides can be explained by the thick pile of Caladrides thrusts and consequent depth of the carbonate blocks.

The northern and southern sectors of the Calabrain Arc are separated by the Catanzaro trough that is interpreted as a negative structure produced by the Catanzaro strike-slip fault system. Tipically, it is possible to note like in a little distance, this transcurrent system produces two different structures: negative in Fig. 7 and positive in Fig. 8; this is a consequent of the local respectively transtensive and transpressive wrenching along an uneven fault plane. It is clearly evident that the Catanzaro fault espressed its activity in the Quaternary as it is confirmed by the depression produced by this fault which is filled by Quaternary sediments directly lying on Miocene or very thin Pliocene. Offshore southern Calabria (Aspromonte), very young thrusting processes took also place (Fig. 9), confirming that all along the Ionian margin of the Calabrian Arc the compressive tectonic activity has produced thrusted blocks in Quaternary times, simultaneously with the Tyrrhenian opening process. This compressive tectonics is responsible

for the Quaternary uplifting of the emerged Calabria; in fact it is formed by active ramps of a wider thrust complex lying largely in the Ionian Sea.

Behind to the compressive features of the arc, as normally occurs, distensive tectonics takes place with creation of normal faults, grabens, more frequently half-grabens, as such as those of the Crati, Mesima, Messina Strait, Paola and Gioia troughs. The Paola trough (Figs. 10 and 11), the major peri-Tyrrhenian basin, is generated by the faster E-ward motion of the Sila block, disconnected by the left-lateral strike-slip fault of Palinuro and the right transcurrent of Catanzaro.

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