## STRUCTURAL FEATURES OF MUD VOLCANOES AND FOLD SYSTEM OF THE MEDITERRANEAN RIDGE, SOUTH OF CRETE

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New information about the geometry of mud volcanoes, folds, and fractures located in the central part of the Mediterranean Ridge is provided by images from long-range and deep-towed sidescan sonar systems, profiles from high resolution seismic and deep-towed subbottom profiler, and by gravity cores obtained during the 1993 UNESCO-ESF Training Through Research cruise of R/V Gelendzick. Mud volcanoes are formed by domes of intercalated pelagic sediments and mud breccias containing clasts as old as Upper Cretaceous. The mud breccias are extruded mainly from point sources, although some fissural emissions are also observed. Mud volcanoes have an irregular to elliptical shape with diameters up to 16 km. The distribution of the mud volcanoes in the area is irregular, but there appear to be local concentrations along the ridge crest. Our survey was restricted to the area around the Olimpi Field.

The Pliocene-Quaternary sediments in this area, and probably also the Messinian sediments, are deformed by symmetrical very open folds, with mean wavelength of 750 m. The hinge lines of the folds are curved around the area where the mud volcanoes are concentrated. Some of the folds show an intrusive nucleus and, in some cases, mud breccia is inferred from the sidescan sonar images to be flowing from the limbs of the folds into the synclinal areas in between.

Fractures in the uppermost part of the Mediterranean Ridge are rare. Most of the faults are normal and subparallel to fold limbs. Furthermore, subvertical fractures with orientations of N20E and N100E are found controlling the shape of the mud volcanoes.

In most areas of the Mediterranean Ridge, fold hinge lines are subparallel to the elongation of the ridge. In the study area, however, mud volcano emplacement may modify the regional stress and strain field related to the NNE-directed subduction of the African plate below the Eurasian plate along the Hellenic arc, resulting in the arcuate fold system observed. Elongated mud volcanoes can grow from anticlinal folds. In the first stages, mud breccia intrudes the axis of the folds, and later, flows of mud breccias develop where the sides of the anticlines are breached.

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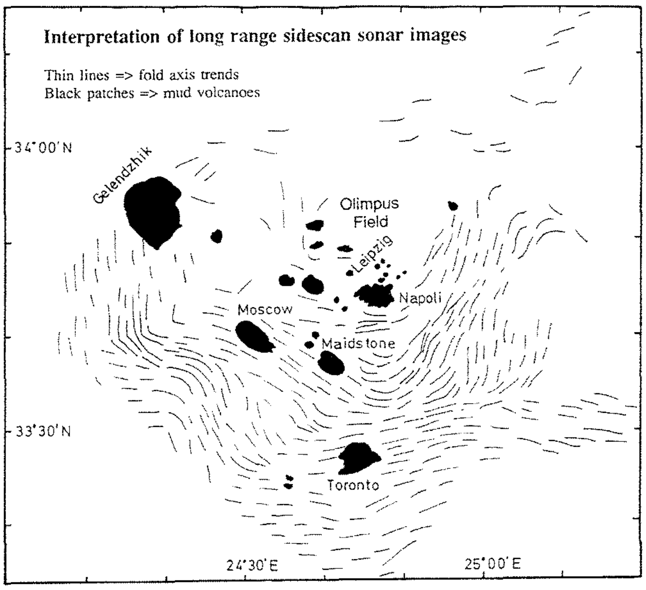


## STRESSES AND CRUSTAL STRUCTURE IN THE NORTHERN BOUNDARY OF THE ALBORAN SEA

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Alpine deformation in the Betic-Rif Cordilleras and in the Alboran sea is active up to today. The present-day boundary between the Euroasiatic and African plates is located in this region. This boundary is not sharp, and it is composed by a broad band of distributed deformation and seismicity in the Betic-Rif Cordilleras and in the Alboran sea.

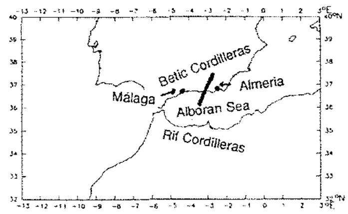
The NW-SE convergent character of this boundary produce a progressive decrease in the size of the Alboran sea from Neogene up to present times. The marine neogene sediments that crop-out in the internal basins of the Betic Cordilleras show that most of the uplift of the Internal zones was made in Miocene to present-day times. Simultaneously, the Alboran sea underwent subsidence.

The analyses of the earthquake focal mechanisms allow to determine the present-day stresses. Around the Betic-Rif Cordilleras, the maximum compressive stress is nearly horizontal and has a NW-SE direction, related with the convergence in the same direction of the Euroasiatic and African plates. In the external zones of the Betic Cordilleras, the maximum compressive stress has a low plunge toward the NW. In the internal zones of the Betic Cordilleras and in the Alboran sea, the stresses are very similar and show an extensional setting. The extension is variable in character, from radial extension in the Alboran sea and in the Malaga region, with the maximum compressive stress nearly vertical or highly inclined towards the NW, up to triaxial extension in Almeria region.

The field analysis of Neogene to Quaternary brittle deformations shows that the paleostresses were generally compressional in the external zones of the Betic Cordilleras, with a NW-SE compression direction, and extensional in the internal zones that constitute the basement of the Alboran sea during the Neogene.

The deep reflection seismic profiles in the Betic Cordilleras and the gravimetry data allow to determine the structure of the crust in the boundary between the Betic Cordilleras and the Alboran sea in the region between Malaga and Almeria. The gravimetric model across this area (Fig. 1.) shows that the boundary between the thick crust of the Betic Cordillera and the thin crust of the Alboran sea is located in a zone near the coast line. In this zone, the Moho dip is very high. The gravimetric data show that this boundary is located along a narrow band, E-W oriented and parallel to the coast line between Malaga and Almeria.

The crustal structure and the recent deformations in the northern boundary of the Alboran sea, mainly in the region between Malaga and Almeria, can be related to the convergence between the Eurasian and African plates. The movement towards the SE of the Iberian crust below the Internal Zones of the Betic Cordilleras, as a consequence of the plate convergence, probably cause the southward migration of the Alboran sea boundary during the Neogene to the present-day, and the progressive closing of the Alboran sea. The crustal thickening in this region produce a fast isostatic uplift of the internal zones of the Betic Cordilleras. In this setting, there are extensional stresses in the uppermost areas (internal zones) and compressional stresses in the deep and in the frontal areas of the Cordillera.



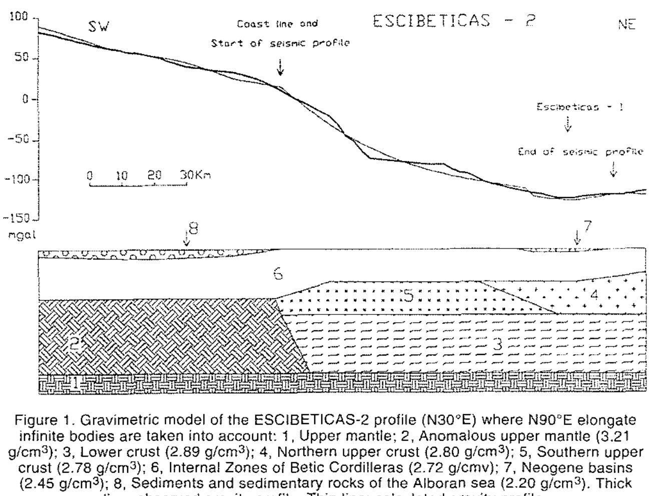




Figure 1. Gravimetric model of the ESCIBETICAS-2 profile (N30°E) where N90°E elongate infinite bodies are taken into account: 1, Upper mantle; 2, Anomalous upper mantle (3.21 g/cm$^3$); 3, Lower crust (2.89 g/cm$^3$); 4, Northern upper crust (2.80 g/cm$^3$); 5, Southern upper crust (2.78 g/cm$^3$); 6, Internal Zones of Betic Cordilleras (2.72 g/cmv); 7, Neogene basins (2.45 g/cm$^3$); 8, Sediments and sedimentary rocks of the Alboran sea (2.20 g/cm$^3$). Thick line: observed gravity profile. Thin line: calculated gravity profile.