The igneous floor of the Marsili Deep Plain : how did the "Oceanization" propagate in time and with which products ?

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The numerous example of back-arc, arc volcanic systems which are located in different structural settings are frontally bordered either by oceanic crust or by orogenes; this second case being particulary widespread in and around the Mediterranean Sea. The new igneous crust of the interarc-arc complexes of the Tyrrhenian shows a wide composition spectrum due to the highly different nature of magma sources, as are, on one side, the MORB producing mantle diapir of the Vavilov basin (ODP Site 373 and 655) and, on the other side, the supra-subduction wedge of the Marsili basin (Site 650) and the northern part of Vavilov basin (Site 651).

In the Southernest Tyrrhenian Sea a sequence of volcanic islands and seamounts form the concave arc of the Eolie. The Marsili deep basin borders the internal side of this arc. The basin central area is occupied by a big volcano, (from 3400 to 485 m bsl). The rilief divides the basin area roughly in two parts, western and eastern with maximum depths of respectively 3500 and 3400 m.

Figure 1 shows that the magnetic field related to the deep basin, according to the aeromagnetic survey commissioned by AGIP, is made up by a series of positive and negative anomalies which do not have the linear, correlatable patterns of the mid-oceanic ridges. The physiographic high of the seamount is associated with an elongated positive magnetic anomaly of high intensity which likely belongs to the Brunhes because of the state of freshness of the magmatic products distributed over a wide depth range and the young K/Ar age (not greater than 0.2 Ma) of some eruptions from the summit. The negative magnetic anomalies which flank the positive axial zone can be roughly correlated with the two small side-reliefs situated to the northeast (from 3400 to 2550 m waterdepth) and to the southwest (from 3350 to 3000 m) of the seamount, respectively.

In the west margin of the bathyal plain at a distance of 40-45 Km from the Marsili physiographic axis, an overall round-shaped high of the magnetic field with maximum intensity of about 170 nT is present. To the east-southeast, at an approximate distance of 35 Km from the seamount axis another round-shaped positive anomaly occurs which has an intensity up to about 60 nT. ODP Site, 650, located in the western margin of the Marsili basin, bordering the positive widespread anomaly (170 nT) mentioned above, succeeded in its aim of ascertaining nature and age of the deep-seated igneous floor: volcanic manifestations having (altered) basaltic andesite composition took place around 1.9-1.7 Ma ago.

Chronological data now available clearly indicate a diachronous activity, that is the interarc volcanism of the Vavilov and Marsili abyssal plains developed after the magmatic activity ceased in the adjacent remnant arc to the west and before it started in the new one to the east. Also in the Mariana arc-backarc sequences, during the early stages of interarc basin opening, arc-related volcanism is absent both on the remnant arc and the migrating forearc plate. Despite the significant differences concerning the crustal basement and the rispective geological frameworks, the Tyrrhenian basin and the above-mentioned region share fundanlelltal analogies, in terms of timing of tectono-magnetic events.

Specific questions to address in the Marsili region include: - Where did the early stages of the oceanization occur?

- Which were the composition, serial affinity, distribution and evolution of the rocks as the back-arc basin widened and foundered?
- Which were they as the basin ridge grew in height?
- To what extent was the composition of late-stage magmas which erupted at greater depth of the axial zone arc-like? Was the arc signature less pronounced than at shallower depth?

In the Marsili basin a first objective of drilling would be in the site of a positive roundsh.lped magnetic anomaly located in the eastern margin of the plain. It is expected that this site should provide valuable information on the age, petrochemical character and distribution of the early stage of the igneous crust formation, and hence on the decoupling mechanism of the subducted segment of the Adria-African plate apart from the overriding Tyrrhenian lithosphere.

A second objective of drilling would be in the site of negative magnetic anomaly located in intermediate position between the positive anomalies of the Olduvai and Brunhes. As mentioned above, the products associated to the positive magnetic anomalies of Brunhes and Olduvai occur, respectively, in the axial zone and the western margin of the Marsili basin. This site could be located in the area of the lateral relief to the WNW of Marsili volcano. It is expected that the site should ascertain whether the magmatic products related to this anomaly are intermediate in age (late Matuyama) or not, with respect to the adjacent igneous bodies.

A third objective of drilling would be in the site of the intense positive magnetic anomaly. Its location could be at the southern axial edge of Marsili volcano where deepseated basement of the late stage is expected to be present. One of the major objectives of this site is to study the nature of the volcanites with respect to the greater depth of the axial zone. Products from greater axial depth should have composition with less pronounced volcanic arc sigllature and maybe MORB-like characteristics.

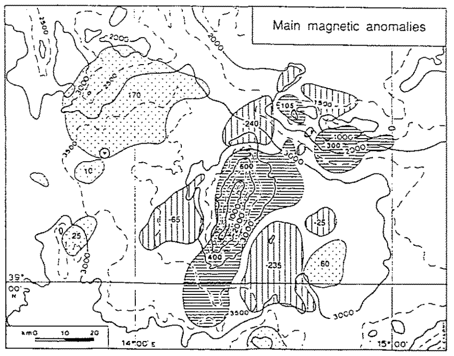

Fig. 1 - Main magnetic anomalies and bathymetry of the bathyal plain of Marsili (SE Tyrrhenian Sea). Bathymetry intervals of 1000 and 500 m (dashed lines). Marsili smt. is located about 45 nm to the NW of the islands of Salina and Lipari (Aeolian arc).
Stippled = positive anomalies of the Olduvai event, or presumed to belong to the Olduvai; circle and triangle = ODP Site 650; north-south stripes = negative anomalies presumed to belong to the late Matuyama (post-Olduvai); east-west stripes = positive anomalies of the Brunhes.

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The evolution of the Atlantic-Mediterranean Gateways during the Neogene and Quaternary

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The Mediterranean is a semi-confined basin with a mean depth of around 1500 m separated from the Atlantic by a narrow sill, the Straits of Gibraltar, which is only 10 km wide and 300 m deep. Its reduced dimensions impose a low heat exchange by marine advection with the open Ocean and, therefore, local climatic conditions (strong evaporation in relation to precipitation) become very important.

The main factors governing the Atlantic-Mediterranean water exchange are: a) Atlantic water properties, b) local Mediterranean climate (the evaporation-precipitation balance E-P) and c) the geometry of the thresholds (BETHOUX, 1984). However, these parameters did not remain constant through time and therefore the Atlantic Mediterranean water exchange was very variable throughout the Neogene and Quaternary with the subsequent influence over the Mediterranean and global ocean history. After the closure of the Mediterranean-Indian Ocean connection, the only communication of the Mediterranean with the Global Ocean was through the Betic-Rifian corridors throughout the Miocene, and the Alboran-Gibraltar strait during the Pliocene and Quaternary. These regions did have a very important interest for paleoceanographic studies.

The climatic and oceanographic evolution throughout the Miocene was characterized by repetitive episodes of expansion and retreat of the antarctic ice sheets, causing global sea level changes. For a particular interval of time and a specific geometry of the North Betic Corridor, the global sea level rises and falls will determine different sections of the upper and lower Atlantic-Mediterranean flows and therefore different patterns of water exchange between them. The depth and width of the sills is also related to the tectonic and sedimentary evolution of the gateway (uplift, subsidence, olistostrome sliding, overthrusting, sedimentary filling, etc.). On the other hand, the global climate evolution and particularly the local climatic response, led the Mediterranean to modify the patterns of exchange with the open Ocean.

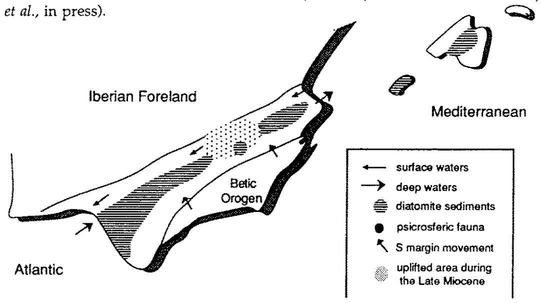
From the Paleoceanographic point of view, the Mediterranean evolved during the Miocene from being a region of the Open Ocean to becoming a marginal sea with important implications for its hydrography and its biotic communities.

During the Lower Miocene, both foredeeps were large and deep enough to allow the deep Atlantic waters to enter into the Mediterranean. Psychrospheric microfaunas of that age were found by BENSON (1976) in different places of the Betic Foredeep. During the Middle and Late Miocene the foredeeps became pregressively narrower and shallower and the deep communication restricted, leading the Mediterranean to become a marginal sea. Specially at the Langhian-Serravallian boundary an important reduction in the section of the Betic corridor occurred, causing the restriction of deep communication and conditioning the evolution of the deep Mediterranean ecosystems from that time to the present day related to an increase in the residence time of Mediterranean waters (VERGNAUD GRAZZINI, 1983).

During the Middle to Upper Miocene, diatomite sediments accumulated mainly in the southern margin of the Betic passage from the Atlantic coast to the Balearic Islands. The micropaleontologic and sedimentary features of these siliceous sediments, along with their preferred location in the southern part of the basin, strongly suggest that they were related to the coastal upwelling of deep Atlantic waters during a period of estuarine circulation between the Atlantic and the Mediterranean (SIERRO *et al.*, 1989, 1990). Deep microfaunas and diatomite sediments are found at least to the Middle Tortonian (approx. 8 to 7 Ma), supporting the hypothesis of a deep communication until that time through this gateway.

During the high sea level periods of the Upper Tortonian the hemipelagic sediments of the Guadalquivir basin were affected by bottom currents. These sediments were compared to recent sediments of the Gulf of Cadiz winnowed by the Mediterranean outflowing Waters (MOW) (SIERRO & FLORES, 1989; FLORES, SIERRO & BARAZA, 1991).

Immediately prior to the Tortonian Messinian boundary a large volume of olistostromes coming from the South partially filled the basin, causing a fast change in the geometry of the basin The coincidence of this event during a period of low *sea level* probably determined a restriction or closure of the Northbetic strait near the Tortonian-Messinian boundary. At the same time some anomalies were described in the calcareous plankton assemblages of the Mediterranean in relation to those of the Atlantic (FLORES, SIERRO and GLACON, in press; SIERRO *et al.*, in press).



On the other hand, BENSON *et al.* (1991) recognized an Atlantic Mediterranean water reversal near the Tortonian-Messinian boundary based on the occurrence of psychrospheric faunas in the South Rifian Gateway. During the Messinian the South Rifian Basin evolved almost parallely to the Guadalquivir Basin, but probably, the last episodes of water exchange immediately before the Salinity Crisis occurred through the South Rifian Corridor.

After the Messinian salinity crisis the Atlantic-Mediterranean water exchange probably took place through the Gibraltar-Alboran Corridor. The tectonic and sedimentary evolution of this area have conditioned the exchange dynamics since the Pliocene. The sea level rise approximately isochronous with the Micene-Pliocene boundary which reestablishes the communication is recorded in the Guadalquivir Basin by a condensed section related to a downlap surface.

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