MUD VOLCANOES ON THE MEDITERRANEAN RIDGE SEAFLOOR MAPPED BY SWATH BATHYMETRY AND ACOUSTIC IMAGERY: PRELIMINARY RESULTS FROM THE MEDEE AND PRISMED II CRUISES.

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Abstract

Bathymetry and acoustic imagery data of the MEDEE (1995) and PRISMED II (1998) cruises bring further insights into the distribution and properties of mud volcanoes on the Mediterranean Ridge Accretionary Prism. An inner belt of mud volcanoes is traced on the summit and inner flank of the ridge, throughout its western and central parts, between longitudes 20°30'E and 25°30'E. This inner belt includes the Pan di Zucchero, Prometheus 1 and 2, Olimpi, and United Nations mud dome fields. Mud volcanoes of this inner belt have grown in an area of maximum contraction of the prism against the rigid backstop. A distinct line of small mounds, tentatively interpreted as a second belt of mud volcanoes, is traced over a distance of 70 km, on the outer flank of the central part of the Mediterranean Ridge. In contrast to the mud domes of the inner belt, mounds of the outer belt do not exhibit a high backscatter, thus suggesting different properties of the erupted muds.

Keywords: Mud volcanoes, bathymetry, swath mapping, Mediterranean Ridge

One major acoustic feature of the Mediterranean Ridge seafloor, in the Eastern Mediterranean Sea, is the occurence of sharply defined patches of high reflectivity. These patches, with subcircular or elongated shapes and lateral dimensions of several hundred meters to a few kilometers, were first observed during four cruises of the RRS *Discovery* (1971, 1973, 1977, 1979) by means of 6.5 kHz GLORIA long-range sidescan sonar (1). Further highbackscattering patches were discovered south of Crete in 1993 during Leg-2 of the Third Training Through Research cruise of R/V *Gelendzhik* by means of both 9.5 kHz OKEAN and 30 kHz MAK-1M (2,3). A multibeam bathymetric survey during *Meteor* Cruise 25/4 in 1993 by means of the Hydrosweep echosounding system supplemented the sidescan sonar records in the latter area (4). Additional sidescan sonar records during the Fifth and Sixth Training Through Research cruises of R/V *Professor Logachev* in 1995 (5) and R/V *Gelendzhik* in 1996 (6) detected several new highbackscattering patches in the Eastern Mediterranean Sea. Recently, two cruises of L'Atalante operating an EM12-D echosounding system, MEDEE in 1995 and PRISMED II in 1998, have produced bathymetric maps and seafloor acoustic images of broad areas of the Mediterranean Ridge, thus providing for the first time with a ridge-scale view of the areal distribution and associated morphological characteristics of highbackscattering patches in those surveyed areas.

Proposed interpretations (1) of the high backscattering patches on the Mediterranean Ridge include outcrops of hard rocks (such as Messinian evaporites), fold crests, debris flow deposits, mud volcanoes or mud diapirs. The presence of mud breccia at or near the seafloor is one simple explanation for the highbackscattering of mud volcanoes in the Eastern Mediterranean Sea (2, 7). A combination of bathymetric data and seafloor acoustic images from the MEDEE and PRISMED II cruises clearly shows that a large number of highbackscattering patches on the Mediterranean Ridge are associated with conical or elongated mounds, often several tens of meters high. Also, areas of highbackscatter are not strictly limited to those areas covered by the mounds but extend into seafloor depressions at their base. Our current interpretation of most of the highbackscattering patches on the Mediterranean Ridge is that they express the presence of mud volcanoes and mud breccia flows.

The high backscattering patches define a belt, approximately 30 km wide, of mud volcanoes at the prism-backstop boundary. This belt is traced throughout the western and central parts of the ridge, approximately from 20°30'E to 25°30'E. It includes the Pan di Zucchero, Prometheus 1 and 2, Olimpi and United Nations Rise mud volcano fields. Mud volcanism along this belt appears to be controlled by the ridge deformation in relation with the Africa-Aegea convergence. In the westernmost part (Prometheus 1), mud volcanoes follow a linear transpressive structure interpreted as the result of a dextral shear that partly accomodates the obliquity of the Africa motion with respect to the backstop. In the Pan di Zucchero area, the eastward escape motion of the prism produces a wide senestral shear band associated with N110°E to N150°E en-echelon folds along which mud volcanoes have grown. Further east, the Olimpi and United Nations Rise fields are associated with intensive deformation ahead of two backstop promontories.

A second belt of mounds, which we suggest are also mud volcanoes, was discovered during the PRISMED II cruise. This second belt (outer belt) is traced over 70 km in the central part of the Mediterranean Ridge, south of the Olimpi mud volcano field. The mounds of this second belt are located at a constant distance, approximately 40 km, from the front of the prism. They are of smaller lateral dimensions. They do not exhibit the high backscattering characteristics of most of the mud volcanoes of the first belt (inner belt), presumably because the erupted materials are different.

The PRISMED II data brings further information on the Olimpi mud dome field (8). The Olimpi field, sensu stricto, contains 9 principal mud domes over an area of approximately 20 km by 15 km. The Napoli, Milano, Bergamo, and Hilo domes are the prominent ones, with diameters between 1 and 4 km and elevations between 40 and 80 meters above the mean seafloor level (8, 4, 3). Napoli, the largest dome, has a flat top and a 100 deep circular moat at its base. Napoli and Hilo exhibit a low backscatter in strong contrast with Milano, Bergamo and Monza which exhibit a high backscatter (3). The PRISMED II data shows that areas of high backscatter for these three domes form a single elongated patch , extending 1-2 km onto the seafloor away from their flanks in all directions. The low backscatter of Napoli and Hilo suggests a different nature of the subseafloor, possibly the presence of a larger amount of gas (9). Not all the parts of Napoli are acoustically characterized by a low backscatter: its very axial part is a spot of high backscatter. The PRISMEDII data also suggest the presence to the north of Napoli of a broad, shallow furrow, over 20 km long, along which fluid muds or brines, erupted from the dome, could have flowed to the Pline trough.

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