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Active tectonics and mud diapirism in the Gulf of Squillace (Crotone Basin, Calabrian Arc, Italy)

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The Calabrian arc is a prominent accretionary prism in the Mediterranean sea that contains alpine metamorphic rocks and connects the southern Apennine chain of Calabria, to the north, with the Maghrebian chain of Sicily, to the southwest. Recent active deformation inside the prism is testified by the earthquakes records and by submarine mud volcanism. The latter, not yet well defined within the accretionary prism, is generally associated to deeper active tectonic structures. In order to unravel the relationships between mud volcanoes and deeper deformations a study has been carried out in the Gulf of Squillace, located in the central portion of the backstop zone of the Calabrian arc and inside the Crotone basin. The deeper tectono-stratigraphic frame has been defined by using 10 well logs, 330 kms of public seismic reflection lines and three CROP seismic lines (the project for deep crust of Italy) recently processed with prestack depth migration. The study has been carried out within the Italian PRIN 2006 Project: “Tectonic and Sedimentation in the Accretionary Complex at the Front of the Calabrian Arc (Ionian Sea)”.

Three major tectonic units could be distinguished; from the top to the bottom, they are: 1) a metamorphic basement nappe (Alpine/Calabrian units); 2) a complex and east-verging Apenninic-Maghrebian prism, that can be subdivided in an outer prism sealed by middle Eocene(?)/Oligocene deposits and an inner prism sealed by middle/late Miocene deposits; 3) a deeper Mesozoic to Neogene relatively undeformed block interpreted as a thinned block of continental crust that preserves Mesozoic extensional fault. Subsurface mapping of Alpine/Calabrian and Apenninic-Maghrebian units show that their leading edges are oriented NNE-SSW and their tectonic stack was completed at least in the late Miocene; since then, WNW-ESE trending Catanzaro-Squillace transcurrent faults system and out-of-sequence thrusting started to locally reshape the backstop. The Cantanzaro-Squillace fault system is an array of faults that belongs to a right-lateral transcurrent zone. In fact, the faults’ array is given by extensional/trans-tensional faults oriented NW-SE and by either transpressive or inverted extensional faults oriented WNW-ESE; then, this faults system displaces with a right-lateral movement of about 4 kilometres the above and older tectonically stacked units.

The Catanzaro-Squillace system cut through deep tectonic units up to the shallower Plio-Pleistocene and Recent sedimentary units of the Crotone Basin, deposited on continental shelf, slope and basin plain. The mud volcanoes and shallow deformations affecting the Crotone basin in the Gulf of Squillace have been investigated by means of higher resolution and partially processed seismic profiles (Sparker lines “J”, ISMAR CNR, 1971-75). A new interpretation of these seismic profiles evidenced that major deformations reaching the sea floor depend on different processes and mechanisms of activation: 1) the WSW-ENE seismic profiles crossing the WNW-ESE trending Catanzaro-Squillace transcurrent system show a wide basin, which is confined to the South by faults with normal dip-slip component of movement and, to the North, a conjugate line flattens on high reflective layers interpreted as Messinian evaporites and Tortonian clays. This deformation is widespread from the basin to the upper slope; 2) the displacement along the master extensional fault is associated to a southward increase in sediment accumulation during the late Neogene, arranged in a growth geometry on the hanging wall; this geometry is partially hidden by mud diapirism. 3) The seismic profiles oriented WNW-ESE, as the Catanzaro-Squillace transcurrent system, allow to bound the late Neogene basin toward the middle-upper slope, where other normal faults, oriented SW-NE and dipping toward the basin plain, occur near parallel to the coastline. These latter faults account for hundreds of meters of displacement and for gravitative processes in the slope where they are marked

by incised canyon. Furthermore, this deformation is also widely associated to mud diapirism. 4) Toward the North, the Late Neogene succession, which is bounded by the conjugate normal fault of the Catanzaro-Squillace system, is also widely dissected by SW-NE normal faults.

In this frame, the occurrence of mud diapirs is related at least to two favorable conditions: 1) overpressure of unconsolidated mud; 2) faults network actively forming. Mud diapirs, also generating mud volcanoes at the sea-floor, are mainly located in the southern part of the Squillace Gulf, where the late Neogene transtensional activity of the Catanzaro-Squillace system is responsible for the asymmetric sediment accumulation which, in turn, accounts for an increased burial and a consequent overpressure of underlying unconsolidated mud. The same fault system then becomes the main pathways for the development of mud diapirism. The source layers for mud diapirs are not clearly identified, even if they appear originated in Miocene sequences, which include evaporite layers largely folded during the Pliocene.

A different case is the SW-NE trending faults that are mainly developed along the slope; in this case, propagation of mud diapirs drives the formation of these faults. Slope failures and gravitative processes are strictly associated to the activity of these latter faults and, at the sea-floor, they are also marked by incised canyons.