THE SEISMOFAULTS PROJECT: FIRST SURVEYS, PRELIMINARY RESULTS, AND THE BORTOLUZZI MUD VOLCANO, IONIAN SEA, SOUTHERN ITALY

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The SEISMOFAULTS Project (www.seismofaults.it) was set up in 2016 by Consiglio Nazionale delle Ricerche, Istituto Nazionale di Geofisica e Vulcanologia, and Sapienza University of Rome, with the main aim of exploring the seismicity of marine areas with deep seafloor observatories and further techniques. The activity of the first year (Seismofaults 2017) consisted of installing a geophysical-geochemical temporary monitoring network over the floor of the Ionian Sea, southern Italy (Figs. 1 and 2). During the Seismofaults 2017 survey (May 2017), eight seafloor seismometers (OBS/H) and two seafloor geochemical-geophysical multiparametric observatories were actually deployed over the Ionian seabed (Fig. 2) with the main aims of (1) identifying seismically-active faults, (2) discovering potential geochemical precursors of earthquakes, and (3) understanding possible cause-effect relationships between earthquakes and submarine slides. Moreover, five gravity cores were collected from the Ionian seabottom and 2204 nm of new geophysical data including multibeam and single channel

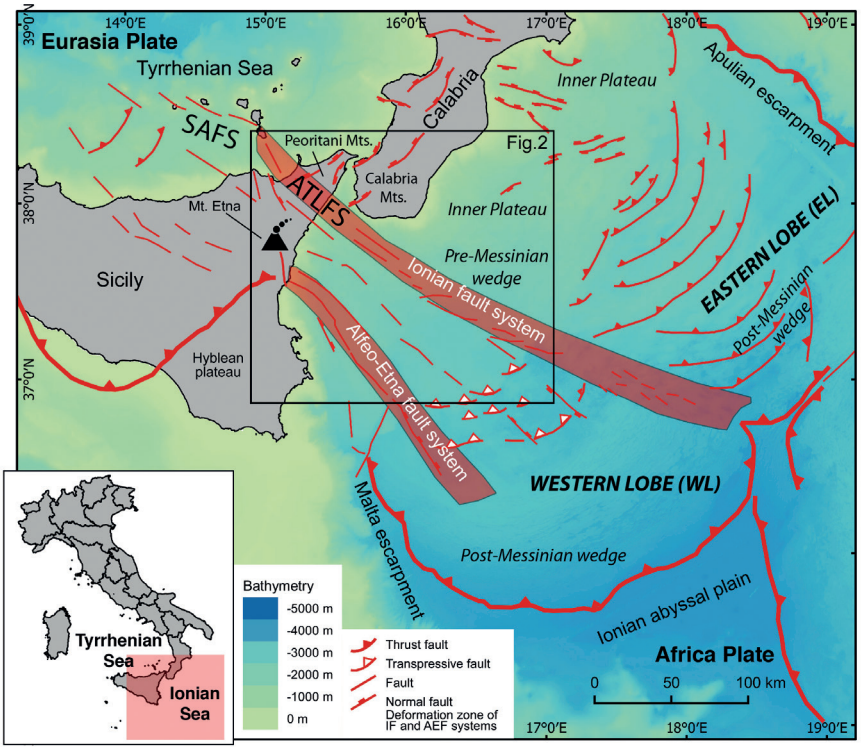

Fig. 1 - Geological and tectonic setting of the Ionian Sea, southern Italy.

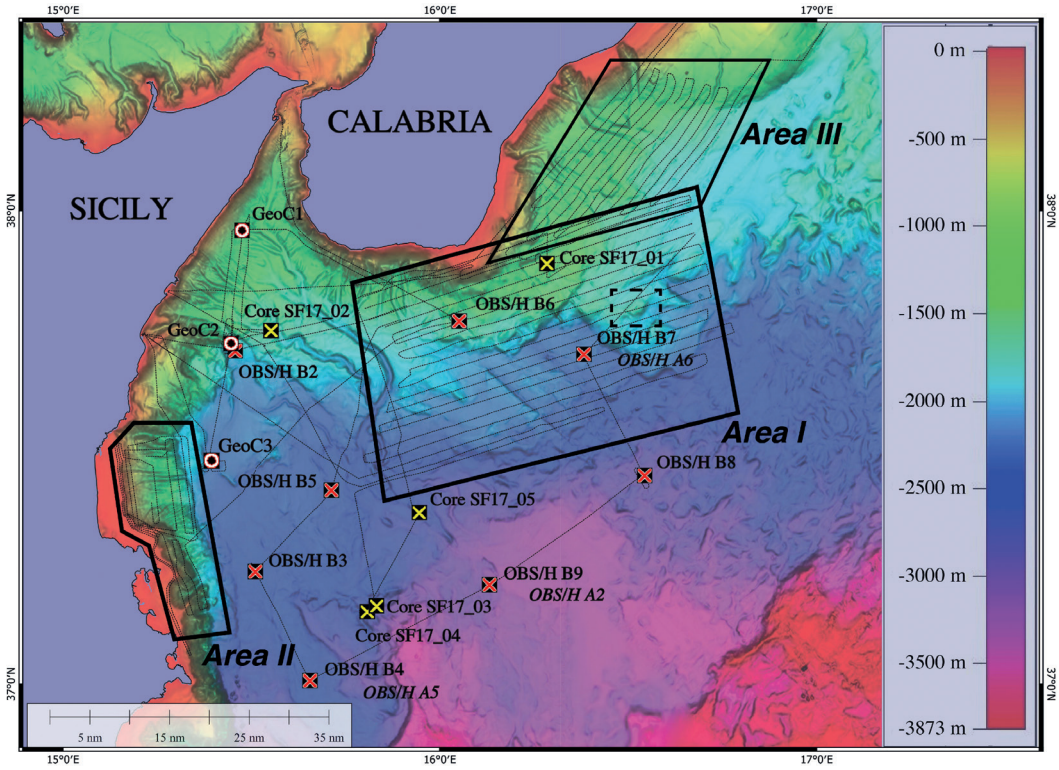

Fig. 2 - Workplan of the Seismofaults 2017 and 2018 scientific cruises in the Ionian Sea. Red crosses are the deployment locations of eleven seafloor seismometers (three OBS/H version A deployed in 2018 and eight OBS/H version B deployed in 2017). Open circles are the deployment locations of two seafloor multiparametric geochemical-geophysical observatories. Yellow crosses are locations of five gravity cores. Samples for the seawater column analyses were collected above the GeoC1, GeoC2, and GeoC3 sites, and above the location of Core SF17_01. Solid boxes correspond to location of the geophysical acquisition working areas, whereas the dashed box is the calibration patch test area. Dashed lines are the GPS navigation tracks of the Seismofaults 2017 scientific cruise.

seismic reflection data were acquired for a total of 4970 km^2 of new high resolution multibeam bathymetry (Fig. 2). Eight Conductivity-Temperature–Depth (CTD) casts were performed along the sea water column. Using Niskin bottles, four water column samples were collected: two corresponding to the two multiparametric observatories, one corresponding to a newly-discovered mud volcano, and a last one far away from these latter three sites and located along a fault zone (Fig. 2). The deep marine devices were recently (May 2018) recovered during the Seismofaults 2018 survey, when three further OBS/H were deployed to keep monitoring the seismicity of the Ionian region (Fig. 2). While the deep marine data are being downloaded and processed, we have focused our attention on a mud volcano located off southern Calabria. Mud volcanoes are the emergence over the Earth's surface of shallow-to-deep conduits for the ascent of endogenous overpressured geofluids. As such, these volcanoes are used, for instance, to study fluids squeezed up from petroleum plays, but have been also hypothesized as being suitable structures for identifying geochemical precursors of earthquakes or for tracking the seismic cycle. Operational systems in this latter sense are still inexistent or very rare and related preliminary studies to improve the feasibility of mud volcanoes as suitable tools for earthquake precursor identification are therefore necessary. A contribution to this future feasibility is one of the main aim of this project. The Ionian Sea in southern Italy is at the center of active interaction and convergence between the Eurasian and African-Adriatic plates in the Mediterranean. This area is seismically active with instrumentally-historically-recorded M > 7.0 earthquakes and it

is affected by recently-discovered long strike-slip faults across the active Calabrian accretionary wedge (Fig. 1). Many mud volcanoes occur on top of the wedge. A recently-discovered one (here named Bortoluzzi Mud Volcano, BMV) was surveyed during the Seismofaults 2017 cruise (May 2017). Bathymetric-backscatter surveys, seismic reflection profiles, geochemical and earthquake data as well as a gravity core are here used to geologically, geochemically, and geophysically characterize this structure. The BMV is a circular feature ~22 m high and ~1100 m in diameter with steep slopes (up to a dip of 22°). It sits atop the Calabrian accretionary wedge and system of flower-like oblique-slip faults that are probably seismically active as demonstrated by earthquake hypocentral and focal data. Geochemistry of water samples from the seawater column on top of the BMV shows crustal-derived (i.e., evaporite-type) mineralized waters rich in CO_2 and CH_4, hence attesting for the occurrence of an open crustal conduit through the BMV down to at least the Messinian evaporites at about -3000 m. This evidence is also substantiated by Helium isotope ratios. Based on these results, conclusions are drawn on the origin of the BMV and on the potential of this type of structures for geochemically tracking the seismic cycle of active faults. Due to the widespread diffusion of mud volcanoes in seismically active settings, this study and similar ones may indicate a potential and feasible future path for the use of these ubiquitous structures in favor of the mitigation of natural hazards.

Summarising:

(1) The BMV on the Ionian Sea is, as previously hypothesized, a mud volcano.
(2) Although evidence to support an ongoing robust and paroxysmal fluid circulation through the BMV are missing, the geochemistry of the water column above the BMV shows a clear contribution from crustal geofluids.
(3) This geochemical evidence support the hypothesis of a cause-effect relationship between the BMV, the underlying active faults, and crustal-scale fluid circulation.
(4) It follows that the BMV and perhaps similar structures elsewhere could be selected in the future to geochemically tracking the seismic cycle of active faults as already done elsewhere in onshore localities.