Drilling Submarine Hydrothermal Sites in the Tyrrhenian Sea, Italy, during Meteor cruise M73/2

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Hydrothermal systems in submerged island arc settings differ greatly from those studied on normal mid-ocean ridges. They occur in shallow water (<1000m to 20 m) and show enrichments in base (Cu, Zn) and precious metals (Au, Ag) but also contain high amounts of toxic trace elements such as As, Hg, Pb, Sb, and Tl. One of the key factors controlling the metal inventory in these island arc related systems is possibly the profound influence of gases (SO_2, CO_2) and metals that can be delivered from an underlying magmatic system into the hydrothermal fluids. Island arc related hydrothermal sites are mainly known from the Pacific region, but few such systems also occur in European territorial waters such as those in the Tyrrhenian Sea north of Sicily or in the Aegean Sea of Greece.

During Meteor cruise M73/2 in August 2007 a team of 22 scientists and 7 technicians from 6 countries (Australia, Canada, China, Great Britain, Italy, and Germany) successfully deployed the British Geological Survey (BGS) Rockdrill 1. The instrument was used in order to investigate the third dimension of three known hydrothermal sites on volcanoes of the Tyrrhenian Sea: Palinuro volcanic complex, Marsili Seamount and Panarea. These hydrothermal systems were previously only poorly characterized with respect to their local geological setting, size and metal content. Key questions to be addressed during this cruise included the role of boiling and/or magmatic degassing on the unusual metal content of these sites, the source of sulphur, as well as the influence of the toxic metals on the microbiology. This drilling allowed, for the first time, a documentation of the third dimension of massive sulphide and sulphate occurrences forming at shallow water depths in arc environments.

The cruise started on March 14th 2007 when the vessel left Genoa and sailed for the first working area at the Palinuro volcanic complex which was reached on August 16th (Fig. 1). Here, research focused on a sulphide occurrence located in a small topographic depression (610 to 645 m water depth) at the summit of a volcanic cone in the western part of the volcanic complex. Shallow drilling proved the occurrence of massive sulphides underlying unconsolidated sediments of variable thickness. Eleven successful holes were drilled and recovered 12.7 m of semi massive to massive sulphide/sulphate. One hole returned 4.9 meters of continuous massive sulphide/sulphate core. The mineralization is crosscut by a network of late veins containing abundant native sulphur indicating the presence of magmatic volatiles derived from a degassing magma chamber at depth.

Vibro- and gravity-coring was performed in sedimented areas in order to investigate the pore water chemistry and sulphur isotope chemistry. TV-guided grab sampling at Palinuro retrieved warm (maximum temperature of 60°C measured on board) native sulphur cemented sediments and crusts as well as associated macro fauna. This sample shows that the Palinuro volcanic complex, despite the sedimentary cover, is still hydrothermally

active although hot fluid venting and smoker activity has not been observed during a ROV diving campaign in 2006 with RV Poseidon.

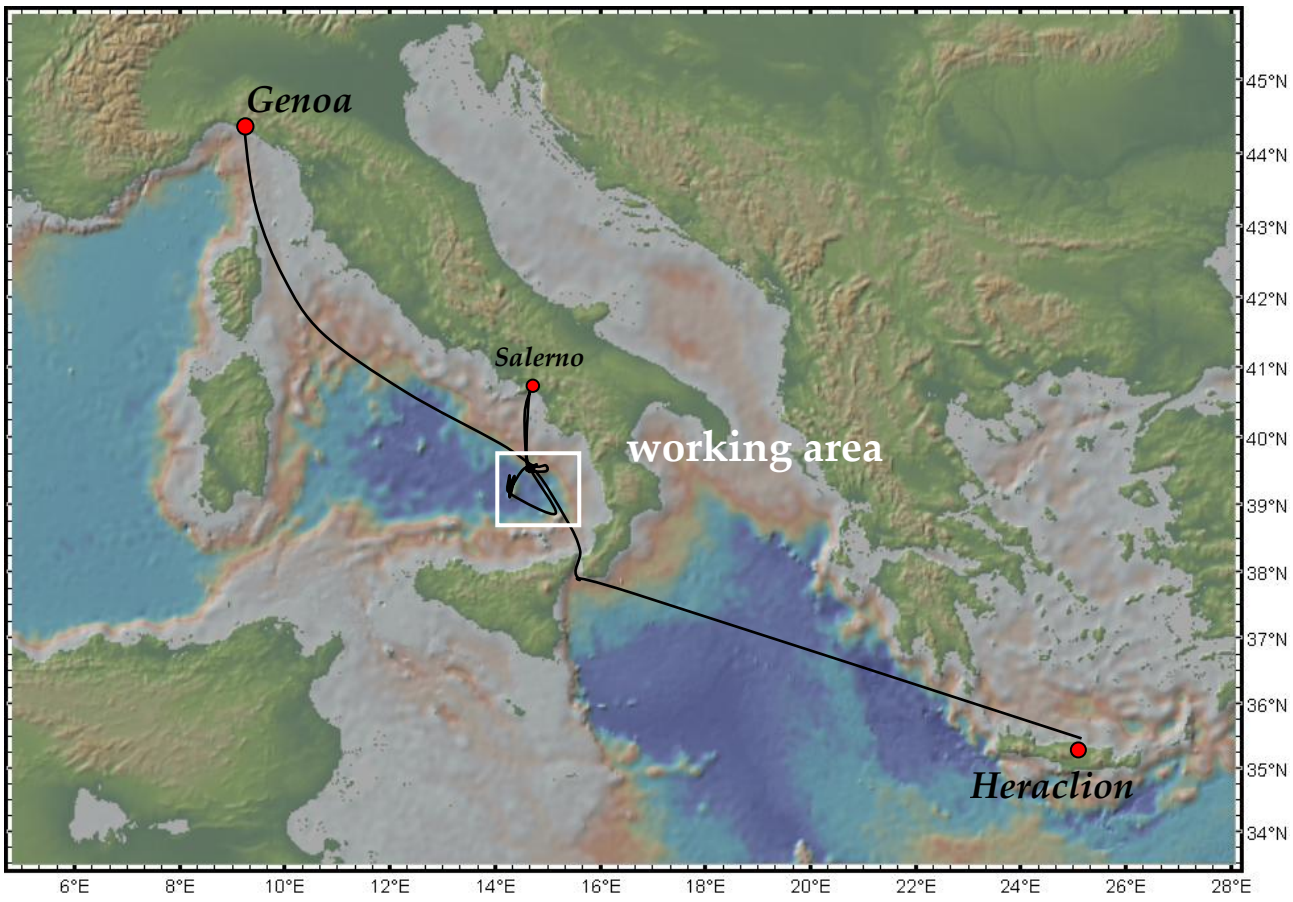

Fig. 1: Ships track during cruise M73/2.

Detailed bathymetric mapping shows that Palinuro represents a complex submerged arc volcano that consists of several coalesced eruption centres located along an E-W trending fault system.

The scientific work at Palinuro seamount was interrupted in the evening of August 16th by a transfer to Salerno because one of the scientists had to be brought onshore for a medical examination. He left the vessel and flew home from Napoli. The reminder of the scientific party and the vessel moved back to Palinuro and continued the work.

Due to technical problems with the winch, work in water depths beyond 600 m had to be postponed on August 20th and the vessel moved to the second working area near the island of Panarea, where we stayed for 4 days working at shallower water depths.

Panarea, the smallest of the Aeolian Islands, forms a small archipelago that emerges from a submarine, near circular platform that represents the flat summit of a submarine stratovolcano that rises more than 1200 m above the surrounding seafloor. Submarine gas venting is widespread around Panarea, but most intense in the area of the central islets [*Esposito et al.*, 2005]. The recent gas discharge is likely related to a regional seismic and volcanic event that started in 2002 indicating a possible connection between Panarea and, at least, Stromboli volcano. A high-resolution bathymetric survey of the study area

performed by our Italian co-workers revealed the presence of numerous circular craters ranging from <10 to over 100 m in diameter, the locations of which are controlled by faults. Overlapping of craters along these structures locally resulted in the formation of elongated channel-like depressions. Because juvenile volcanic ejecta were not observed, the craters are interpreted to have formed by submarine gas explosions. The abundance of craters suggests that these explosions are characteristic of the Panarea hydrothermal system and may, therefore, represent a potential volcanic hazard.

Shallow drilling of 38 holes in water depths ranging from 60 m to 90 m revealed that hydrothermal activity at Panarea leads to the widespread deposition of massive anhydrite/gypsum (calcium sulphate) as well as native sulphur within discrete craters and along the channel. These sulphates are interpreted to represent a cap forming at the interface between seawater and geothermal fluids ascending towards the seafloor. The upwelling hydrothermal fluids are enriched in metals as suggested by the presence of minor sulphides infilling vugs and fractures within the massive anhydrite and gypsum. Several drill holes recovered least altered and altered volcanic rocks allowing the comparison of host rock lithologies on land with those in the submarine environment adding valuable information on the development of the volcanic complex.

Bathymetric mapping was conducted around the small islands in order to add to the existing bathymetric data of this area. All bathymetric data was forwarded to Dr. Marco Anzidei of INGV in Rome.

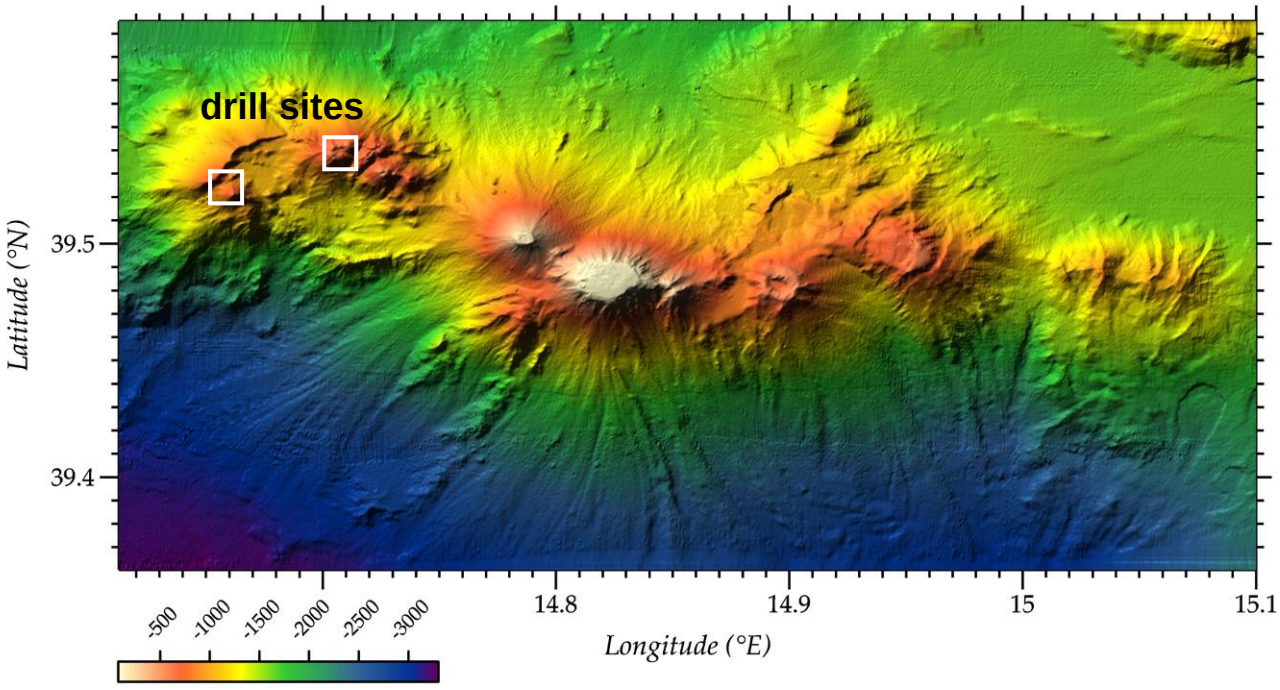

Fig. 2: New bathymetric map of the Palinuro volcanic complex obtained during cruise M73/2. Drill sites were located in the western sector of the volcanic complex.

On August 24th we moved to our 3rd target, **Marsili Seamount**, where we used the Rockdrill and the TV-grab to sample two summits of this elongated volcanic ridge. Fresh basaltic-andesite lava and Fe-oxyhydroxides were recovered from the hill tops. Additionally, a detailed bathymetric map of the entire volcanic edifice was produced showing a complex volcanic structure with multiple volcanic eruptive centres.

The research vessel Meteor left Marsili Seamount in the early morning of August 26th in order to finish the work at Palinuro Seamount for the last two days. Meteor left the working area on August 28th and headed for Heraclion, Greece, where the cruise ended in the morning of August 30th.

Fig. 3: The BGS Rockdrill 1 lowered to the seafloor during M73/2.

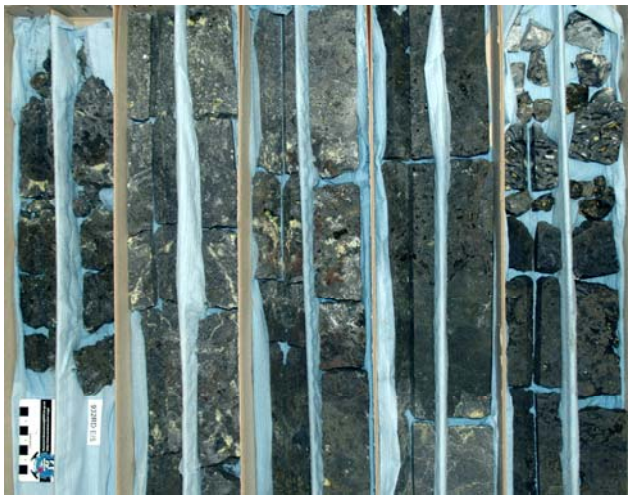

Fig. 4: Selection of drill core recovered from the Palinuro volcanic complex.

References

Esposito, A., G. Giordano, and M. Anzidei (2006), The 2002-2003 submarine gas eruption at Panarea volcano (Aeolian Islands, Italy): Volcanology of the seafloor and implications for the hazard scenario. Mar. Geol., 227, 119-134.