INVESTIGATION OF HYDROTHERMAL VENTS IN THE AEGEAN SEA USING AN INTEGRATED MASS SPECTROMETER AND ACOUSTIC NAVIGATION SYSTEM ONBOARD A HUMAN OCCUPIED SUBMERSIBLE

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Abstract

In June and July of 2006 a research program was undertaken to investigate areas of suspected hydrothermal venting at the Greek islands of Milos and Santorini. This program utilized the HCMR Thetis research submersible equipped with a navigation tracking system and in-situ chemical sensors. This integrated sensor payload successfully mapped and chemically characterized hydrothermal venting in real-time.

Keywords : Aegean Sea, Chemical Analysis, Instruments And Techniques, Mapping, Hellenic Arc.

The 2006 project PHAEDRA investigated Aegean Sea hydrothermal venting near the islands of Milos and Santorini. In order to conduct field work at these sites, the authors developed novel technologies into the HCMR Thetis human occupied submersible, including an Ethernet communication system, navigation tracking system, and in-situ chemical sensors -including a Gemini in-situ mass spectrometer, CTD, dissolved oxygen sensor, and manipulator arm triggerable Niskin bottles for post-dive gas chromatographic analysis. A total of three dive missions were conducted with Thetis and the payload sensors; two at Milos, and one inside the Santorini caldera. The first dive was an operational test of the instrument systems at a depth of approximately 60 meters in a hydrothermally inactive area near the southern coast of Milos. Submersible sensor data collected during the dive mission did not reveal any anomalous temperature spikes (temperature deviating no more that 0.02 °C about a mean of 14.82 °C) and no mass spectrometer values indicative of hydrothermal venting activity. Visual inspection of the ocean floor by the submersible's crew corroborated the in-situ data. Post-dive gas chromatographic analysis of water samples did not reveal any increases in dissolved gas concentrations associated with hydrothermal venting. The second dive mission was conducted in an area southeast of the Fyriplaka volcano containing hydrothermal vents to depths of 115 meters [1]. Examination of the site revealed filamentous white microbial mats, possibly Thioploca [2], along with sulfurous mineral deposits, and water column chemical anomalies at a depth of approximately 100 meters. In-situ mass spectrometer measurements at the site indicated significant concentrations of sulfides (in the presence of dissolved oxygen) and elevated carbon dioxide. Minor increases in methane were also recorded. Post-dive processing and merging of chemical data with navigation data indicated highly localized hydrothermal venting on horizontal length scales of approximately Â¡ meter (Figure 1).

CTD records indicated temperature increases of up to 0.12 °C in the overlying water column at the venting sites. Gas chromatographic analysis of water samples collected during the dive indicated significantly elevated carbon dioxide, and methane concentrations up to 0.18mM, but did not indicate the presence of sulfides. However, decreased dissolved oxygen of approximately 270mM were measured, suggesting that any sulfide collected in the Niskin bottles may have reacted with the dissolved oxygen. In comparison to the first dive site, the second site exhibited a 104% carbon dioxide concentration increase and a 15.3% dissolved oxygen decrease. Methane concentrations were below the gas chromatograph's detection limits at the first dive site. The increased carbon dioxide, hydrogen sulfide, and methane concentrations correspond well with vent gas composition found at nearby shallow water sites [3], suggesting that they are part of the same vent system.

The third dive mission using the integrated chemical sensor/navigation system was conducted in the Santorini caldera in an area of suspected active volcanic or hydrothermal venting at a depth of approximately 350 meters. Real-time data collected during this dive did not indicate any significant variation in methane, oxygen, or carbon dioxide concentrations, nor any sulfides or other dissolved gases associated with volcanic venting. Despite the absence of apparent venting activity, areas of small (approximately 0.5 m high) flocculent seafloor mounds with yellow-orange coloration were observed, suggesting high concentrations of oxidized iron. Post-dive GC analysis of water samples did not indicate any significant variation in gas concentrations, suggesting that these sites were not hydrothermally active. The authors would like to thank the Hellenic Center for Marine Research and the United States NOAA Office of Ocean Exploration for their support of this research program.

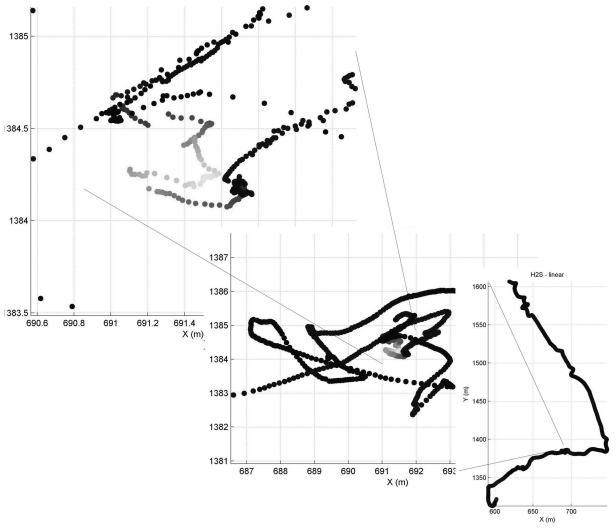

Fig. 1. Map of hydrogen sulfide concentrations measured during Milos Dive #2 using the Gemini mass spectrometer. Lighter coloration indicates increasing sulfides.

References

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