Geophysical Research Abstracts
Vol. 16, EGU2014-8108-1, 2014
EGU General Assembly 2014

Carbon fluxes from hydrothermal vents off Milos, Aegean Volcanic Arc, and the influence of venting on the surrounding ecosystem.

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The island of Milos, in the Aegean Sea, has extensive hydrothermal fields to the east and southeast of the island with additional venting areas near the entrance to and within the central caldera. A calculation of the total area of the vent fields, based on ship and aerial surveys, suggested that the hydrothermal fields occupy 70 km^2, twice the area previously estimated. The vents ranged in water depth from the intertidal to 300 m. As a result of the low depths there was abundant free gas release: in places water boiled on the seabed. The stream of gas bubbles rising through the sandy seabed drove a shallow re-circulation of bottom seawater. The majority of the water released with the gas, with a mean pH of 5.5, was re-circulated bottom water that had become acidified in contact with CO_2 gas and was often diluted by admixture with the vapour phase from the deeper fluids. The major component of the free gas, 80%, was CO_2, with an estimated total flux of 1.5-7.5 x 10^{12} g a^{-1}. The methane flux, by comparison, was of the order of 10^{10} g a^{-1} Using methane as a tracer it was shown that the major gas export from the vents was below the thermocline towards the southwest, in agreement with the prevailing currents. Areas of hydrothermal brine seepage occurred between the gas vents and occasional brine pools were observed in seabed depressions. Under relatively calm conditions, many of the brine seeps were covered by thick minero-bacterial mats consisting of silica and sulphur and surrounded by mats of diatoms and cyanobacteria. The minerals were not deposited in the absence of bacteria. Storms disrupted the mats, leading to an export of material to the surrounding area. Stable isotope data from sediments and sediment trap material suggested that exported POM was processed by zooplankton. The combined effects of the geothermal heating of the seabed, the large gas flux, variation in the venting and the effect of the brine seeps had a dramatic effect on the surrounding ecosystem. The infaunal biomass and diversity were greatly reduced in the vicinity of the vents (up to approximately 8 m away from the vents) and seagrass cover was absent from the brine seeps. These changes were a consequence of high sediment temperatures, hydrogen sulphide concentrations, high or low salinities and sediment cementation. In contrast, the species diversity of the hard substrate epibiota surrounding the vents was over twice as high as that at nearby areas of equivalent water depth, even though vent-obligate fauna were absent. Sediment cementation, caused by reactions with the minerals in the vent fluids, decreased the habitat for sediment infauna, but enhanced bioconstruction by coralline algae and corals, and hence habitat provision for epibenthic organisms. Since the water column was typical of the oligotrophic Aegean, with low chlorophyll and phytoplankton production, the diverse and enhanced benthic primary production, by cyanobacteria, diatoms and chemoautotropic bacteria and archaea, in the mats over the hot seeps was believed to provide a large diversity of nutritional niches for the epibenthos.