PARTICULATE AND ORGANIC FLUXES IN A COASTAL HYDROTHERMAL AREA OFF MILOS, AEGEAN SEA

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Abstract

Two moorings were deployed from June to September 1996 along the SE Coast of Milos in an area known for its extensive area of geothermally active seabed. Moorings were fitted with current meters and sediment traps to measure particulate fluxes at 60 m over a bottom of 90 m depth. The vertical particulate fluxes were integrated over periods of 12 days. Surface currents were relatively high but at the trap depth rarely reached 5-10 cm s^{-1}. Vertical mass fluxes were extremely variable at both sites, ranging from 7 mg $m^{-2}d^{-1}$ to 5.9 g $m^{-2}d^{-1}$, with mean fluxes over one order of magnitude higher at the vent site, increasing to as much as 200 times higher during periods of maximum flux. Carbon and nitrogen fluxes showed a similar pattern whereas pigment fluxes had a completely different variability over time. The high POC fluxes measured were not related to phytoplankton biomass but were likely related to the export of organic material produced at the vent sites.

Key-words: thermal vents, particle flux, sediments, Aegean Sea

Introduction

The Aegean Sea is an area of high seismic activity (1) associated with important geothermal gas venting (2). The island of Milos, located on the Hellenic volcanic arc, is noted for extensive areas of submarine vent fields with some 35 km^2 of geothermally active seabed in shallow waters which vent large volumes of free gas as well as phosphate and manganese (3, 4). Venting typically consists of diffusive seepage of warm water and chemicals from fractures in the seabed. In close proximity to these vents, a vent ecosystem based upon thermophilous bacteria and chemosynthesis is normally present. Fluids from the vents, bacteria and particles produced in the vent ecosystem are advected by currents and create a plume that spreads laterally at a level of neutral buoyancy. The geochemical cycling and biological production based on chemosynthesis in these shallow hydrothermal vents is still largely unknown, particularly the importance of vents in the production and export of particulate organic material. The present communication reports the first results on vertical fluxes of material associated with these vent fields.

Material and Methods

In summer 1996 two moorings were deployed along the SE coast of Milos off Paleohori Bay in an area known for its numerous shallow water vent fields (site C, Fig. 1) and off Provatas Bay in an area presumed to be free of any major vent influence (site A, Fig. 1). Both moorings were located about 1 nautical mile offshore in a water column of 90 m depth, and were 3.5 nautical miles distant from one another. They included sediment traps (Technicap cylindro-conical model PPS3 with an opening of 1/8 m^2) for collection of particles and flocs sedimenting through a depth of 60 m, and current meters (Aanderaa RCM7, InterOcean S4 and RDI ADCP sentinel) located closer to the bottom (85 m) and the surface (12 m) in order to obtain three-dimensional current measurements. Current meters were calibrated at the factory prior to deployment and were set to sample every 30 minutes. Prior to deployment, the trap sampling cups were filled with a 2% buffered formaldehyde solution in filtered local sea water (0.22 μm) to prevent *in situ* microbial degradation and grazing by swimmers. Moorings were deployed on June 19 and recovered on September 25. At each site 8 trap samples covering 12 days each were obtained to study temporal changes on downward particulate fluxes over the 3 month-period.

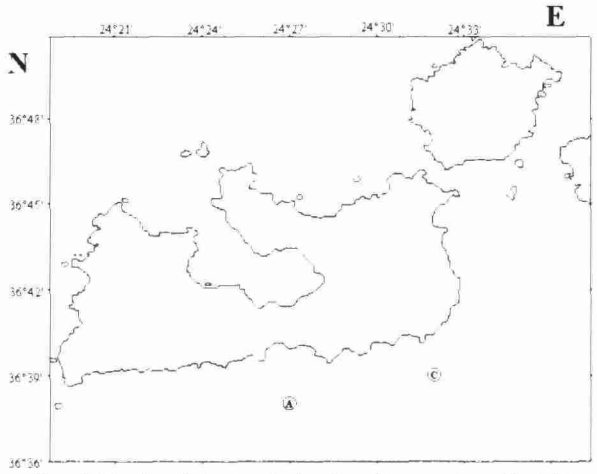

Fig. 1. Map of Milos island showing the location of the moorings. Site A is located off Provatas Bay (area without submarine geothermal vents) and site C is located in the vent zone off Paleohori Bay.

Trap samples were analyzed in the laboratory following standard methodologies (5). Swimmers were first separated by sieving through 1500 μm and 600 μm to remove larger species, and then the remainder was "hand-picked" under a dissecting microscope. Liquid subsamples of the trap material were taken for the analysis of pigments and particle composition. The remaining sample was desalted and freeze-dried for further analyses and estimation of mass flux. Carbon and nitrogen were analyzed by high temperature oxidation using a Heraeus CHN elemental analyzer. The organic carbon fraction was measured in samples treated with a one molar phosphoric acid solution for removal of carbonates (6). Chlorophyll a and phaeopigment were measured spectrophotometrically in 90% acetone extracts and quantified as Chl.a-equivalents using the equations of Lorenzen (7).

Results and Discussion

Currents in surface waters at both sites were strong and mainly directed towards the southwest. At the vent site they reached 50 cm s^{-1} and displayed some peaks oriented in a northerly direction. Current speed decreased rapidly with depth and, in the vicinity of the traps (60 m), they were generally less than 5 to 10 cm s^{-1} flowing in a southwesterly direction (Fig.2). Current speeds closer to the bottom were very low and at the vent site (C), they were often below the threshold of the RCM7 Aanderaa. Furthermore, the bottom currents at the vent site were oriented in a southwesterly direction, whereas at the control site (A) they formed a clockwise vortex shear. Therefore, despite strong surface currents, the traps were located in a relatively calm environment in terms of water mass transport.

At both sites mass fluxes were highly variable and, at least during some periods, quite high. Mean mass flux was one order of magnitude higher at the vent site than at the control station, however during the period of maximum sedimentation, the flux was over 200 times higher at the vent site (Fig. 3). Only during August were fluxes comparable at the two sites or higher at the control area. Total mass fluxes at the vent site were extremely variable ranging between 7 mg m^{-2} d^{-1} and 5.9 g m^{-2} d^{-1}. The range of mass flux at the control station was less, *i.e.* 11 to 1000 mg m^{-2} d^{-1}. During periods of low sedimentation, sinking particles at both sites were composed of plankton debris and marine snow, whereas large flocs of biogenic material and elongated ellipsoidal fecal pellets comprised the bulk of the particles during periods of maximum flux. POC and N fluxes presented similar trends over time and between stations indicating that there were two periods of pulsed sedimentation of organic material at the vent site and one period of much smaller magnitude at the control site. Maximum POC and N fluxes at the vent and control site were 1359 and 115 mg POC m^{-2} d^{-1}, and 238 and 21 mg N m^{-2} d^{-1}, respectively. The C and N content of the sedimenting particles was high and similar at both sites throughout the study except in September when concentrations sharply decreased and the C/N ratios increased, a consequence of a significant