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Geochemistry driven trends in microbial diversity and function across a temperature transect of a shallow water hydrothermal system off Milos (Greece)

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The shallow water hydrothermal vents off Milos Island, Greece, discharge hot, slightly acidic, reduced fluids into colder, slightly alkaline, oxygenated seawater. Gradients in temperature, pH, and geochemistry are established as the two fluids mix, leading to the formation of various microbial microniches. In contrast to deep-sea hydrothermal systems, the availability of sun light allows for a combination of photo- and chemotrophic carbon fixation. Despite the comparably easy accessibility of shallow water hydrothermal systems, little is known about their microbial diversity and functioning. We present data from a shallow hydrothermal system off Milos Island, one of the most hydrothermally active regions in the Mediterranean Sea. The physico-chemical changes from ambient seafloor to hydrothermal area were investigated and documented by in situ microsensor profiling of temperature, pH, total reduced sulfur and dissolved oxygen alongside porewater geochemistry. The spatial microbial diversity was determined using a combination of gene- and lipid-based approaches, whereas microbial functioning was assessed by stable isotope probing experiments targeting lipid biomarkers.

In situ microprofiles indicated an extreme environment with steep gradients, offering a variety of microniches for metabolically diverse microbial communities. We sampled a transect along a hydrothermal patch, following an increase in sediment surface temperature from background to 90°C, including five sampling points up to 20 cm sediment depth. Investigation of the bacterial diversity using ARISA revealed differences in the community structure along the geochemical gradients, with the least similarity between the ambient and highly hydrothermally impacted sites. Furthermore, using multivariate statistical analyses it was shown that variations in the community structure could be attributed to differences in the sediment geochemistry and especially the sulfide content, and only indirectly to shifts in temperature.

Results from intact polar lipid analyses were consistent with the ARISA data and clearly differentiated those samples located close to the vent from those found in less affected areas. Changes from phospho- and betaine lipids within the top layer of the unaffected area to glyco- and ornithine lipids in the hydrothermally influenced sediment layers reflected a change from photoautotrophic algae to a bacteria-dominated community as predominant lipid sources. A clear dominance of archaeal lipids indicated archaea as key players in the deeper, hotter layers of the hydrothermal sediment.

We performed stable isotope probing experiments with 13C-bicarbonate in the dark to investigate if chemolithotrophy, as opposed to phototrophy, plays any significant role for carbon fixation in shallow vent systems. Different amendments revealed that not only chemolithotrophy represents an important pathway for carbon fixation in these ecosystems, but that diverse ways of dark CO_2 fixation exist, with hydrogen being the most effective electron donor under high temperature conditions.