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Temporal changes in chemosynthetic community distribution and biogeochemical processes at the Amon mud volcano (Nile Deep Sea Fan)

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Mud volcanoes (MV) are important emission sites of hydrocarbons and hot spot ecosystems in the deep ocean with respect to biogeochemical activity and biodiversity of benthic communities. They are geologically shaped by eruption events and periods of low activity or dormancy, which affects the establishment and distribution of chemosynthetic communities. These are fueled by upward flow of fluid and gas from deep subsurface sources and thus affected by spatial and temporal variations in fluid and mud flow. One of the key processes is microbial sulfate reduction (SR), which can be coupled to anaerobic oxidation of hydrocarbons such as methane. The produced sulfide is used either by free-living or symbiotic associated thiotrophic bacteria. The free-living bacteria can form dense bacterial mats at the sediment surface, which is a good indication for high SR in the sediment below. However, only little is know about the temporal dynamics of these ecosystems due to changing geological subsurface processes.

Temporal variations of biogeochemical processes and the development of specific chemosynthetic habitats at the Amon deep sea MV (1100 m water depth) were investigated during the BIONIL (2006) and HOMER (2009) cruise in the framework of the ESF and EU projects MEDIFLUX, HERMES, and HERMIONE. Our studies focused on in situ quantification of benthic oxygen uptake and methane emission as well as SR measurements by ex situ radiotracer incubations.

Based on our investigations four different habitats can be distinguished at the Amon MV: (I) highly disturbed center, (II) central dome with bacterial mats, (III) biogenic mounds, and the (IV) sulfur band at the MV rim. The inner part of the center (I) had a very rough surface showing many cracks and steep hills in 2006 but topographic structures were smoothened in 2009 and first small bacterial mat patches were found as well as much higher abundances of megafauna. Pore water analyses indicated that the uprising fluids are not only highly enriched in hydrocarbons but also in sulfate (3-times seawater concentration), and that a more active hydrocarbon oxidizing community developed over the three years of observation. In the outer center zone (II), high dissolved oxygen consumption rates (maximum 52 mmol m^{-2} d^{-1}) and sulfide concentrations were measured at mats of sulfide oxidizing bacteria covering small hummocks. Indications for a reduced gas and fluid flow were also found in this area. Succession of the chemosynthetic communities was also observed at the sulfur band bacterial mat (IV) in 2009, where sulfate consumption (maximum 1770 nmol mL^{-1} d^{-1}) were not only higher compared to the center mat (II) but also up to two orders of magnitude higher compared to rates measured in 2006, indicating a development of hydrocarbon oxidizing communities.

Our data give clear evidence that the Amon MV is in a succession phase, changing from an eruption/high fluid and gas flow state towards a period of lower fluid and mud flow, associated with more stable conditions permitting a higher benthic activity. Changes were not only visible during ROV surveys but also by replicate biogeochemical measurements at the four habitats.