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Spatial variability of physico-chemical gradients and biogeochemical processes at hydrothermal vents and cold seeps and their effects on community structures

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Cold seeps, hydrothermal vents and other anoxic environments are shaped by a complex interplay of biological, geochemical, and geological processes. Biogeochemical processes are highly variable and physicochemical gradients are very steep in these ecosystems. At cold seeps the expulsion and venting of hydrocarbon-rich fluids fuel a variety of geomicrobial processes such as carbonate precipitation and the growth of chemosynthetic communities. Bio-geochemical reactions take place along sharp gradients below the sediment surface (often on cm-scale). At hydrothermal vents communities thrive around diffuse fluid emanations when mixing of hydrothermal fluids with seawater in the subseafloor, is cooled down to temperatures tolerable for microbial and invertebrate life. However, still little is known on the spatial and temporal distribution of fluid and gas flow around diffuse hydrothermal vents or in sediments around seep structures. The effects of small-scale spatial and temporal fluid-flow variability on biological production and biogeochemical processes are largely unknown. These effects may even gain particular importance where habitat structuring organisms influence fluid flow and geochemical gradients, such as e.g. hydrothermal vent mussels do in mussel beds.

The major flow and energy pathways in these deep sea ecosystems are highly complex and require interdisciplinary and multiphase approaches to quantify fluid and gas emission and the related bio-geochemical processes. This can only be achieved by a combination of ROV-operated *in situ* studies to measure and sample at targeted habitats. So far, very few geochemical and microbiological investigations have been carried out based on *in-situ* studies of methane seeping sediments and diffusive vent

habitats.

Here we report on strategies and results how seep and vent ecosystems can be investigated on a mesoscale to understand the distribution of habitats for microorganisms and fauna, and their relation to fluid flow and geo-activity - geosphere-biosphere link. Additional targeted sampling and microscale analysis of geochemical gradients further enables us to recognize patterns and to quantify fluxes which then can be used to upscale them to geosystem dimensions. Novel data from hydrothermal vents (Mid Atlantic Ridge) and from different hydrocarbon seeps (e.g. Gulf of Mexico, Eastern Mediterranean and Norwegian Shelf) will be shown: In-situ microsensor measurements of O_2, pH, H_2S and T were used to investigate the links between the geochemical energy supply and the communities at vents and seeps. 2D imaging of the O_2 distribution in seep sediments was applied to study the spatial variability. Furthermore, benthic chamber and tracer injection methods allowed the quantification of fluxes and turnover rates.