Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09974, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09974
EGU General Assembly 2008

Quantification of methane-driven biogeochemical processes at cold seeps: Implications for local and global scales

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Concentrated around ocean margins, the focused emission of cold and often hydrocarbon-laden fluids from subsurface reservoirs into the oceanic hydrosphere is creating highly dynamic cold-seep ecosystems at the seafloor. These systems are shaped by a complex interplay of biological, geochemical, and geological processes. Associated with fluid outflow at seeps are chemosynthetic communities that utilize the chemical energy of reduced components such as H_2S, CH_4, and other hydrocarbons. The production of biomass by these communities can be several orders of magnitude greater than at non-seep sites on the nearby ocean floor. These chemosynthetic communities are nourished by the chemical energy – mostly methane rising from subsurface sources and forming the basis of cold-seep ecosystems. In addition to these unique and highly specialized ecosystems, cold seeps are recognized by several morphological features, like pockmarks, hydrocarbon seeps on top of salt diapirs, asphalt volcanoes, cold seeps induced by plate subduction, mud diapirs, and mud volcanoes. These geostructures are characterized by specific chemical environments, e.g. oxygen depletion within the first few millimeters of the sediment surface, high sulfide fluxes, mineral precipitates (e.g., authigenic carbonate, barite, and gas hydrates), and diagnostic stable-isotope signals in inorganic and organic phases.

Here we present flux and turnover rates from different cold seep systems including mud volcanoes, pockmarks, gas and asphalt seeps from the Arctic region (Hakon Mosby Mud Volcano), the Eastern Mediterranean (Amon Mud Volvano, Central Pockmarks), the Golf of Mexico (Chapopote), the Japan Trench (*Calyptogena* accumulations). We compare in situ oxygen consumption rates as an indicator for the (micro-)biological and chemical activities, as well as methane discharge and subsurface consumption. Our data show that cold seeps are heterogeneous ecosystems in which abiotic as well as biotic processes are strongly influenced by fluid and gas flow intensities often varying in space and time. *In situ* measurements are necessary for tracking such changes and to better characterize seep systems, especially processes influencing the methane release. By scaling our measured rates from local to global scales, we evaluate the ecological importance of cold seeps, which is crucial to understand the role of methane in the global carbon cycle.

This study contributes to the DFG/BMBF Geotechnologien program “Methane in the Geo-Bio-System”, project MUMM_2, the DFG Research Center Ocean Margin – “Seepage of fluid and gas” and EU 6th FP HERMES.