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Pore Water Geochemistry of CH_4-rich Mud Volcano Sediments in the Eastern Mediterranean Sea: Implications for Anaerobic Methane Oxidation, Presence of Gas Hydrates, and Intensive Irrigation

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Submarine mud volcanoes represent an extreme environment for life due to the spontaneous deposition of methane loaded mud which serves as substrate for temporary and highly adapted forms of micro- and macrobiota. Eastern Mediterranean mud volcanoes are widespread and are subject of an interdisciplinary study including organic compound identification and their isotopic signatures (Pancost et al. 2000, this issue), macrobenthic and microbial ecology, and pore water geochemistry.

We will present images and pore water geochemistry results from two expeditions focusing on the Olimpi (south of Crete) and the Anaximander (west of Cyprus) area: In 1998 direct observations and sampling of sediment and biota were carried out from the French submersible 'Nautile' during 20 dives. In 1999 sampling was carried out by means of box, gravity, and piston coring on-bord of R/V Prof. Logachev. Direct observations revealed heterogeneously distributed occurrence of microbial mats and macrofauna such as clams, mussels, tube worms, sponges, urchins, crabs and fish. Often fields of empty (dead) shells were found. Apart from biota, up to decimetre thick carbonate crusts were found on top of the sediment. On Napoli Dome, a mud volcano located in the Olimpi area, discrete brine water seepage induces creek-like downhill flow ending in brine ponds and lakes.

Pore water distribution of conservative tracers (Na, B) display significantly different patterns: In the Napoli area Na and B mostly increase with depth in the upper most sediment and stay constant below. This implies a present-day mixing of sea water and original pore fluid which is brine water enriched in Na and B by a factor of ~10 versus normal sea water. This is in agreement with brine water occurrences and composition west of the Olimpi area, Urania and Bannock Brines, which represent relicts of fossil evaporated sea water entrapped in Late Miocene sediments (Vengosh et al. 1998). In contrast, in the Anaximander area both conservative tracers show sea water concentrations in the upper decimetres. Below, Na is decreasing whereas B is increasing. The decrease of Na can only be explained by the *in-situ* presence of gas hydrates, which dissociate during core recovery and dilute ambient pore water. Correcting for this artefact *in-situ* B is here ~18-fold enriched versus sea water. Since Na has sea water concentration in the absence of gas hydrates, original pore fluid of the Anaximander area is for most constituents similar to sea water. B enrichment originates here from leaching of detrital sediment under high temperature conditions. Homogeneous seawater-like concentrations of B and most other constituents in the top of Anaximander sediments can only be explained by intensive irrigation, possibly by macrofauna which live in symbiosis with CH_4/HS^- oxidising bacteria and feed on gas hydrates. The induced active downward transport of O_2-rich bottom water and reaction with released CH_4 may then also explain a distinctive minima in $\delta^{13}C$ of dissolved inorganic carbon (DIC). Presently, we model pore water profiles from the Olimpi area to reconstruct the time of mudflow emplacement and from the Anaximander area to quantify the intensity of irrigation.

Anaerobic methane oxidation has been proofed in these sediments by means of organic compound identification (Pancost et al. 2000) and is also evident from pore water data. SO_4^{2-} typically becomes depleted in the upper meter, which coincides with depletion of upward diffusing CH_4. Net products of the microbially induced, coupled reactions are the build-ups of HS^- and DIC. The later leads to supersaturation and precipitation of carbonate which explains the observation of abundant authigenic carbonate.

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