Molecular evidence for microorganisms in recent and ancient methane-related settings

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A large portion of methane produced in marine sediments is metabolized anaerobically before reaching the water column or the atmosphere. Combined results from field and laboratory studies now strongly suggest that syntrophic consortia of Archaea performing reversed methanogenesis and sulfate-reducing bacteria account for anaerobic oxidation of methane (AOM) in marine sediments (e.g. Hoehler et al., 1994; Hinrichs et al., 1999, Thiel et al., 1999; Elvert et al., 1999; Boetius et al., 2000).

In methane-related deposits, lipid biomarkers, combined with compound-specific stable carbon isotope measurements provide important information on the activity of the distinctive AOM performing consortia. Whereas numerous modern settings have now been explored for the presence of diagnostic, methane-related lipids, only few studies exist on ancient, pre-Quarternary deposits. Little is as yet known about the paleoenvironmental significance of these compounds and both their structural as well as their isotopic preservation potentials. We here provide structural and isotopic information on biomarkers extracted from a set of methane-related environments ranging in age from Recent to Jurassic. Special emphasis is placed on the study of recently discovered methane oxidizing bacterial mats from the anoxic zone of the Black Sea.

Our findings show the diagenetical persistence of both biomarker and isotopic signatures from methane-related settings. In particular, they reveal that the recycling of methane carbon by certain Archaea and their eubacterial associates has been an important subsystem for the turnover of buried organic carbon throughout the geological past.

References

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The study of geochemical processes with X-ray spectromicroscopy

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X-ray microscopy achieves a much higher resolution than light microscopy. This is due to the much shorter wavelength of X-rays compared to visible light. The smallest structures that can be seen in an X-ray microscope at present are about 20 nm in size. X-ray microscopy is also capable of imaging specimens directly in aqueous media. By choosing the wavelength of the X-radiation appropriately, it is possible to perform spectromicroscopy studies. Comprising, it is a very well suited tool to study colloidal structures in geochemical relevant systems. Due to their surface activity colloids are involved in various processes. Substances can be bound and immobilized or transported, colloids can attach to microorganisms building up microhabitats, and organic substances as humics can flocculate due the interaction with metals. A great variety of colloidal structures have been studied using X-ray microscopy. Several examples will be presented: Dispersions extracted from these systems have been imaged with an X-ray microscope to obtain first of all a visual impression of the appearance of the colloids. The effect of changing chemical conditions in the aqueous dispersion media has been studied, too. The change in the appearance of the colloidal structures has been imaged and evaluated. Clay dispersions and microhabitats have been imaged tomographically. Tilt series of images have been obtained with an X-ray microscope; the specimen was then reconstructed from these images. The resulting reconstruction conveys a detailed three-dimensional impression of the specimen structure, as will be shown. Using spectromicroscopy, the distribution of organic substances on inorganic soil colloids has been studied. The obtained spectra have been analyzed for major chemical components. A major fraction of these are humic substances. Spectra have been taken from humic substances with and without a coagulation agent. Different functional groups have been identified and changes due to the influence of iron have been mapped.