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The role of sediments in shelf ecosystem dynamics

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In shallow marine ecosystems there is a tight two-way coupling between processes in the water column and in the sediments. Part of the organic material produced in the water column may sink to the seafloor to fuel biogeochemical processes in the sediments. Deposited materials are transformed (i.e. degraded or dissolved) in the sediments and either returned to the water column or removed from the shelf ecosystem by burial. Algae and bacteria in the water column can then use the transformation products returned to the water column (e.g. nutrients) again. The intensity of this benthic-pelagic coupling primarily depends on water depth.

We will present numerical simulations using coupled benthic-pelagic biogeochemical models for oxygen, nitrogen and carbon cycling in continental shelf areas. These models will be used to evaluate the role of (1) muddy, depositional sediments, (2) sandy, permeable sediments and (3) sediments with significant phototrophic production in carbon and nutrients budgets. These models will also be used to evaluate the role of shelf systems in the shelf carbon and nutrients cycles. We argue that continental-shelf budget studies ingnoring the sediment compartment provide a biased, incomplete picture.

References

[1] Middelburg, J.J and K. Soetaert. The role of sediment in shelf ecosystem dynamics. Chapter 12 in Vol. 13 of The Sea, edited by A. Robinson and K. Brink, Harvard University Press (in press).

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Microbial processes in gassy sediments: Linking rates, organisms and environments

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The subsurface seabed is a gigantic bioreactor and would also be a substantial source for methane on earth, if rising gases were not efficiently utilized by microbial methanotrophic guilds. More than 90 percent of the methane rising from the subsurface ocean is oxidized anaerobically with sulfate as electron acceptor. It is a striking fact that this process of unknown functioning, carried out by very few phylogenetic groups of archaea, substantially effects atmospheric concentrations of methane.

The process of anaerobic oxidation of methane (AOM) results in the production of sulfide and carbonate in anoxic sediments. The sulfide formed by AOM nourishes chemosynthetic communities on the seabed, including giant sulfide-oxidizing bacteria, and symbiotic mussels and tubeworms. The carbonate often precipitates and may form large cements, chimneys and crusts causing a permanent removal of the methane-derived carbon. So far, all anaerobic methanotrophs (ANME) mediating this process are Euryarchaeota, their closest relatives being methanogens. Three different phylogenetic clusters of ANME have so far been found in a variety of gassy sediments: above hydrate, at mud volcanoes, in hydrothermal sediments but also in coastal subsurface environments. They occur mostly in consortium with sulfate reducing bacteria of different phylogenetic clades forming symbiotic aggregations of unknown functioning.

This contribution presents an overview on recent results from the studies of the MUMM project, which focused on methane cycling at the ocean floor by using combinations of field and lab experiments as well as modern and classical tools of microbiology.