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# Reactive-transport model on Arctic shelves: a focus on subsea permafrost affected sediments

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## Abstract

Arctic sediments are expected to contain a large quantity of methane and to be underlayered by subsea permafrost, a carbon stock whose extent is unknown and whose biogeochemical properties have not been explored yet. High methane concentrations (up to 500 nM) have been measured in the waters corresponding to the East Siberian Arctic Shelf [1], but its origin is still debated [2, 3], whether originating from methanogenetic degradation of organic matter stored in thawing subsea permafrost or from the destabilization of gas hydrates occurring below the Arctic shelves [4].

While some purely geophysical simulations of subsea permafrost vertical and lateral extent are available, no diagenetic biogeochemical model has been developed so far. Here we present the first setup of such a model: a version of the Biogeochemical Reaction Network Simulator (BRNS) [5] specifically tailored to simulate Arctic shelves and its typical processes. Our simulations aimed at describing such an environment: a sediment column threaded by an upgoing flow of water rich in methane nourishing a microbial community that is able to perform Anaerobic Oxidation of Methane (AOM). This last process, unlike the Aerobic Oxidation of Methane (AeOM) [6], increases alkalinity and, in an iron rich environment as the Arctic shelves, triggers a biogeochemical reaction network, which may lead to pyrite and authigenic carbonate precipitation. The latter is a distinguishing feature associated with methane seepage and can provide an indication of temporal dynamics of the AOM which, upon comparison with field samples, could serve as a proxy to reconstruct sediment diagenetic history or to validate the model itself. The version of BRNS we implemented goes beyond the simplification which describes AOM as a second order reaction, but envisages a kinetic as well as thermodynamic constraint on it [7].

We focused our attention on the effects that the presence of methane has on the biogeochemistry of the sediment column, assessing the efficiency of the AOM filter on oxidizing dissolved gas and testing how the explicit bioenergetic limitations affect the process. We will present how a methane release, *e.g.* as aftermath of thawing subsea permafrost, alters the benthic exchange fluxes of quantities like DIC and alkalinity. Transient and equilibrium states will be also presented to show the time scale needed for the microbial community to develop and adapt to change in methane flux from below.

**Keywords:** subsea permafrost; sediments; methane; AOM; reactive-transport model

## References


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