Large ^{34}S depletions of reduced sedimentary sulfides at low sulfate concentrations in an iron-rich lake dominated by anaerobic methane oxidation

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The sediment of Lake Ørn (Denmark) is characterized by a high reactive iron content and a strong methane consumption in the deep sulfate-containing zone reaching ~15 cm depth. Radiotracer studies (^{14}C-methane and ^{35}S-sulfate) confirmed anaerobic oxidation of methane (AOM) and microbial sulfate reduction (SR) and demonstrated the highest AOM rates (up to 40 nmol cm^{-3} day^{-1}) at 10-15 cm depth with very low sulfate concentrations (5-10 μmol L^{-1}). We further used stable sulfur isotope analysis and incubation experiments to investigate the interactions of iron, sulfur and methane with particular focus on a hypothetical cryptic sulfur cycle. Isotope analyses revealed substantial ^{34}S depletion in reduced sulfur species with $\delta^{34}S$ values of down to -15‰ for acid volatile sulfides (H_2S and FeS) and -25‰ for chromium reducible sulfides (S^0 and FeS_2) accumulating in the AOM zone. Anoxic slurry incubations demonstrated $\delta^{34}S$ values of up to 40‰ in sulfate in the incubations with methane and S^0 respectively, indicating that large sulfur isotope fractionations can be established by a combination of sulfate reduction, sulfide oxidation, AOM and microbial sulfur disproportionation. RNA stable isotope probing was applied to identify key players of the cryptic sulfur cycle.

The cycling and transport of glacially derived iron in Arctic fjord sediments

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Iron is an essential nutrient for primary production and is strongly connected to glacial-interglacial variations in atmospheric CO_2 concentrations. Glacial runoff rapidly delivers large volumes of potentially bioavailable Fe, produced by mechanical and microbially enhanced chemical weathering in glacial environments, to high latitude oceans. Little is known about the fate of this Fe pool in adjacent coastal marine waters, particularly fjord systems. We investigated the concentration and speciation of Fe in the sediments of three Western Svalbard fjords with the aim of quantifying and understanding the biogeochemical processes of the sedimentary Fe cycle. Results of porewater and solid-phase analyses show that the input of glacially derived Fe plays an important role in the biogeochemical processes in fjord sediments by controlling sulfur and manganese cycling and by providing a large Fe-oxide pool for dissimilatory iron reducers (DIR). Extreme sedimentation rates in the fjords result in elevated Fe accumulation but dilution of the organic carbon pool. From this combination, the sediments show a strong signature of DIR, leading to high dissolved Fe concentrations of up to 800 μM in the porewaters of Kongsfjorden and Van Keulenfjorden and correspondingly enhanced benthic Fe flux from the sediment to the water column. Our data point to extensive benthic Fe cycling in Svalbard fjord sediments likely promoted by bioturbation and physical disturbance via iceberg calving. Thus, recycling of iron in fjord sediments may facilitate the transport of this important micronutrient across the fjords while maintaining its bioavailability for fertilization of primary productivity on the adjacent continental shelf. This work complements recent studies on the bioavailability and concentration of Fe in glacial runoff and contributes to the emerging picture that glacially derived Fe may constitute an important component of the global Fe cycle, particularly in high-latitude ocean regions.

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