Seasonal and spatial dynamics of sulfide production and pore water gradients in intertidal surface sands of the southern North Sea

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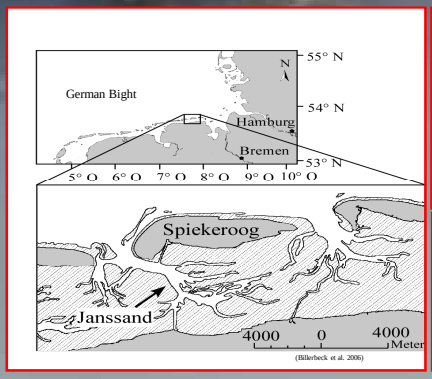
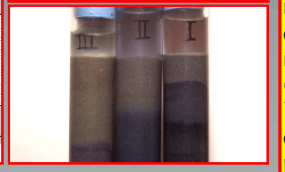
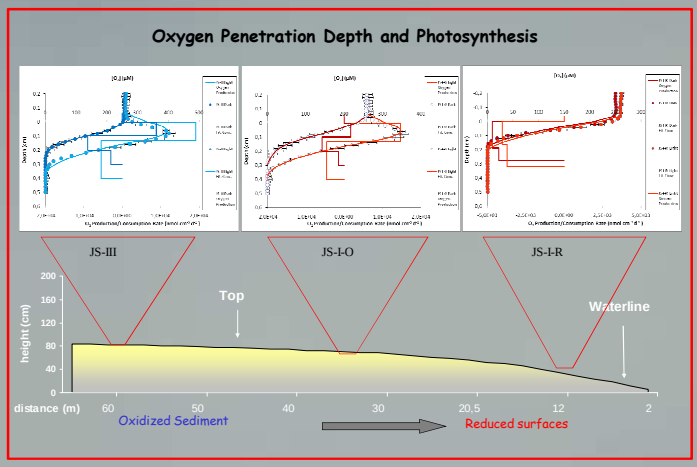
Introduction

Organic matter is mineralized in marine sediments by microbial activity using predominantly oxygen, sulfate, and Fe(III) and Mn(IV) (oxyhydr)oxides as electron acceptors. In intertidal surface sediments, the development of steep compositional and physico-chemical gradients is a common phenomenon. Typically oxygen is consumed rapidly within the upper few mm of marine sediments. In permeable sediments, however, oxygenated bottom waters may flow through the upper part of the surface sediments leading to enhanced participation of oxygen in element cycling. Additionally, black anoxic surface sediments, so-called 'black spots', are locally formed, indicating a disturbance in the balance of the biogeochemical processes, and may act as windows for the liberation of reduced substances into the bottom water or the atmosphere .

In the present study, the pore water composition below oxic and anoxic surfaces of intertidal sandy sediments is investigated using a number of different techniques in the frame of the DFG-research group 'BioGeoChemistry of the Wadden Sea'.





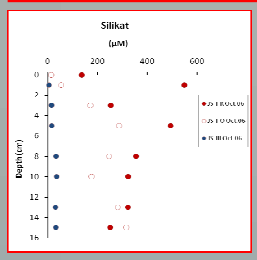


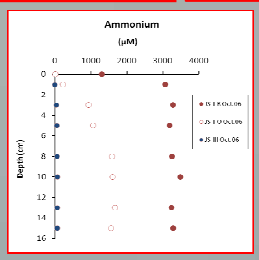
Methods

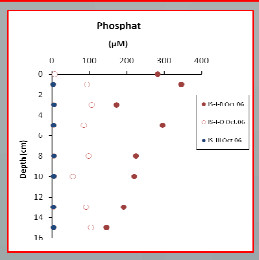
Pore waters are sampled down to 40 cmbsf (cm below surface) using pore water lances, diffusion samplers, centrifugation of sediment core sections, and lander-based microsensors. Water samples are analyzed for microbial sulfate reduction rates, salinity, dissolved O_2, pH, SO_4^{2-}, H_2S, Cl^-, Fe^{2+}, Mn^{2+}, TA, PO_4^{3-}, NO_3^-, NH_4^+, H_4SiO_4, Ca^{2+}, and microbial gross sulfide production rates have been analyzed using intact sediment cores. Additionally, sediments are investigated for the geochemical composition of a number of sedimentiray components.

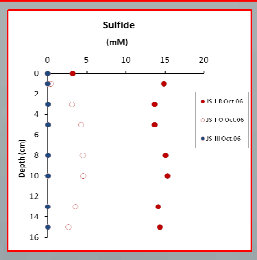
Analytical methods include ^{35}S-radio tracer incubation (whole core incubation method), ion chromatography, ion-selective electrodes, spectral photometry, titration methods, isotope ratio monitoring mass spectrometry (C-irmMS).

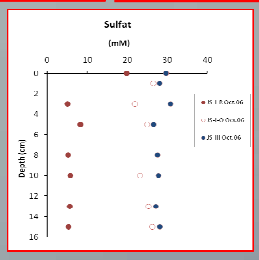
Results are discussed in terms of microbial, geochemical, and hydrodynamic processes.

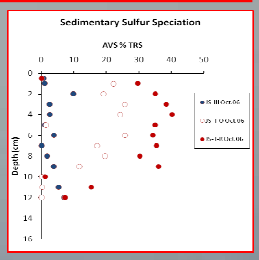


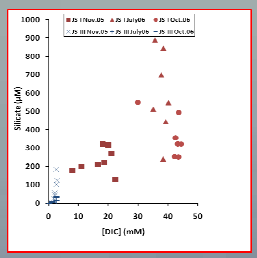


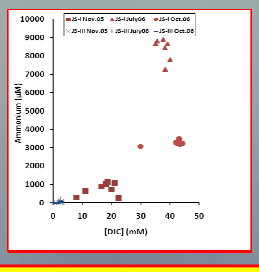


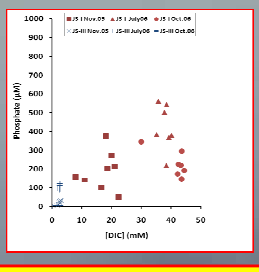


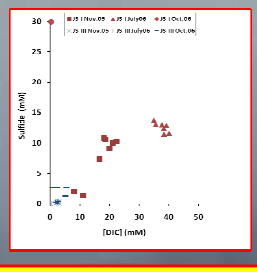


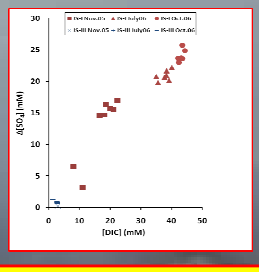


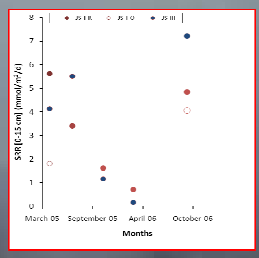












Results

The intertidal surface sediment with both oxic and anoxic surfaces are characterized by high microbial sulfate reduction rates exhibiting maxima between about 5-10 cm. Depth-integrated rates show a maximum during summer time. Net rates are higher below anoxic sediment surfaces associated with decreased oxygen penetration depths, and proton activities. Anaerobic metabolic activity in pore waters below reduced surfaces leads to significantly enhanced concentrations and steep gradients (enhanced fluxes) of sulfide, ammonium, DIC, phosphate, silica, and a net consumption of sulfate. Abundant methane is observed here even close to the sediment surface. The black surfaces may act as windows for reduced substances to surface waters (and the atmosphere).

Acknowledgements

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