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Electric currents couple spatially separated biogeochemical processes in marine sediment

Lars Peter Nielsen[1], Nils Risgaard-Petersen[2], Henrik Fossing[3], Peter Bondo Christensen[4], Mikio Sayama[5*]

[1]University of Aarhus, [2]University of Aarhus, [3]University of Aarhus, [4]University of Aarhus, [5]AIST

Some bacteria are capable of extracellular electron transfer, thereby enabling them to use electron acceptors and donors without direct cell contact. Beyond the micrometer scale, however, no firm evidence has previously existed that spatially segregated biogeochemical processes can be coupled by electric currents in nature. Here we provide evidence that electric currents running through defaunated sediment couple oxygen consumption at the sediment surface to oxidation of hydrogen sulphide and organic carbon deep within the sediment (Fig. 1). Altering the oxygen concentration in the seawater overlying the sediment resulted in a rapid (<1 hour) change in the hydrogen sulphide concentration within the sediment more than 12 mm below the oxic zone, a change explicable by transmission of electrons and not by diffusion of molecules. Mass balances indicated that more than 40% of total oxygen consumption in the sediment was driven by electrons conducted from the anoxic zone. A distinct pH peak in the oxic zone could be explained by electrochemical oxygen reduction, and not by any conventional sets of aerobic sediment processes. We suggest that the electric current was conducted by bacterial nanowires combined with pyrite, soluble electron shuttles and outer-membrane cytochromes. Electric communication between distant chemical and biological processes in nature adds an entirely new dimension to our understanding of biogeochemistry and microbial ecology.

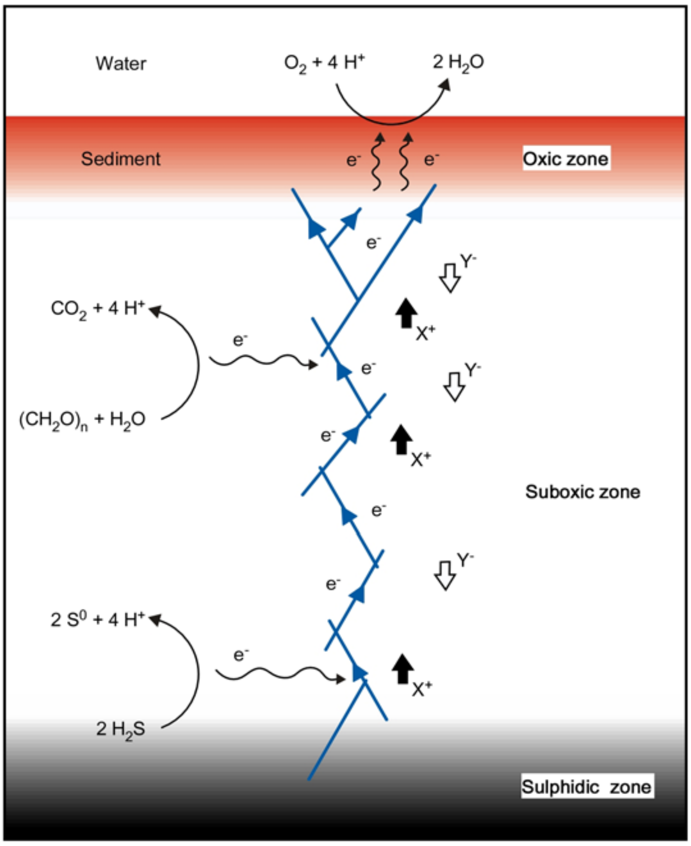

Fig. 1. **Electric currents in sediment.** Conceptual illustration of the electric communication between oxygen reduction in the oxic zone and oxidation of hydrogen sulphide and organic carbon in the suboxic and sulphidic zones. Electrons (e^-) are transmitted in a conductive network (blue arrows), and the circuit is completed by migration of ions (X^+ and Y^-) in the porewater.

Keywords: Electric currents, biogeochemical processes, marine sediment, Bioelectrochemical systems