Sulfate reduction and methanogenesis at a freshwater-seawater interface in a Shallow Aquifer, Skansehage, Denmark

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ABSTRACT

The freshwater-seawater interface was studied in a ~9-m thick anaerobic aquifer located in marine sand and gravel with thin peat lenses. Very limited amounts of iron-oxides are present. Consequently, the dominating redox processes are sulfate reduction and methanogenesis, and the groundwater is enriched in dissolved sulfide, methane and bicarbonate. Under normal conditions the seawater-freshwater interface is found at a depth of 4 m at the coastline and reaches the bottom of the aquifer 40 m inland. However, occasional flooding of the area occurs, introducing sulfate to the aquifer.

Groundwater chemistry was studied in a 120 m transect perpendicular to the coast. Cores were taken for radiotracer rate measurements of sulfate reduction and methanogenesis.

In the saline part of the aquifer 35 m inland, sulfate reduction was the dominant process with rates of 0.1-10 mM/year. In the freshwater part 100 m inland, the sulfate was depleted and methanogenesis consequently the dominating process with rates of 0.1-0.7 mM/year, with the bicarbonate pathway dominating over acetate fermentation.

H₂ concentrations were measured under natural flow conditions using a newly developed sampling device. Concentrations between 0.5 and 46 nM were found with values around 2 nM dominating. The peak values correspond to a transition state from sulfate reducing conditions towards methanogenesis. During the transition, the fermentation step continues to produce H₂, which is not consumed, as sulfate is limited, and methanogenesis has not yet taken over.

Keywords: Geochemistry, radiotracer rate measurement, hydrogen

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