sediment cores collected at three soft bottom stations; two brackish-marine and one freshwater. One of the marine stations was reduced and azoic, whereas the freshwater and the other marine station had well oxygenated conditions in the bottom waters. Positive redox-turnovers, including anaerobic incubation followed by reaeration, were generated in the cores and the supernatant water.

In cores from the oxygenated freshwater and marine stations, dissolved phosphate and ferrous ions were released from the sediment during the anaerobic incubation. At the positive redox-turnover, the concentration of dissolved phosphate in the supernatant water decreased sharply due to scavenging by rapidly formed colloidal ferric hydroxide. Dissolved phosphate was also released during the incubation of the marine sediment from the reduced station. However, in these cores the concentration of iron in the supernatant water was low throughout the experiment and after the redox-turnover phosphate remained dissolved. In a parallel experiment in which iron was added to the supernatant water, dissolved phosphate was scavenged by ferric hydroxide at the positive redox-turnover in a similar way as observed for the two oxygenated stations. The low abundance of dissolved iron in the reduced marine system could be due to a rich supply of sulphide.

In freshwater systems the concentration of dissolved phosphate is effectively diminished after a positive redox-turnover due to interaction with iron. In marine systems, which have had prevailed reduced conditions in the bottom waters, iron is immobilised. Consequently, a potent retention mechanism for phosphorus is eliminated. Our results imply that the cycling of phosphorus, in this aspect, differs in fresh and saltwater systems. This difference might have large effects on the availability of phosphorus as a nutrient.

Manganese showed a consistent redox-dependent behaviour in all systems, but it did not interact with iron or phosphorus.

The phosphorus cycle in coastal marine sediments

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The concentration of dissolved phosphate in sediment box-cores from the Laurentian Trough in the Gulf of St. Lawrence increased sharply across the sediment-water interface from 2.0 μmol/PO_4/l in the bottom water to 6 ± 3 μmol PO_4/l in the top cm, remained almost constant at this value down to 5–15 cm depth, and then increased rapidly with further depth. In the region of constant concentration, phosphate is buffered by sorption equilibria with the sediment. The production rate of phosphate, the sorption capacity of the sediment, and the thickness of the diffusive boundary layer at the sediment-water interface appear to control the shape of the pore water profile. Even though the buffering places an upper limit on the concentration gradient across the sediment–water interface, and hence on the flux, the phosphate flux to the overlying water is controlled by the production rate of phosphate within the sediment. A model is proposed to relate sediment chemistry to phosphorus fluxes.

Approximately half of the net sedimentation flux of phosphorus is not buried but is mobilized within the sediment and returned to the water column. The phosphorus mobilized in this way from the suspended sediment load carried by the St. Lawrence River adds 40% to the load of dissolved phosphate carried by this river to the ocean, demonstrating that phosphorus diagenesis in coastal sediments can increase significantly the flux of dissolved phosphate from the continents to the ocean.