Modeling vertical excursions of the redox boundary in sediments: Application to deep basins of the Arctic Ocean

Katsev, Sergei, Bjørn Sundby, Alfonso Mucci

Limnol. Oceanogr., 51(4), 2006, 1581-1593 | DOI: 10.4319/lo.2006.51.4.1581

ABSTRACT: A diagenetic reaction-transport model was used to simulate how the sediment redox boundary migrates in response to persistent or episodic changes in the deposition flux of degradable organic matter and the concentration of oxygen in the overlying bottom water. The position of the redox boundary is represented by the depth of oxygen penetration. The simulations reveal that the position of the redox boundary in organic-poor sediments, such as those in the deep basins of the Arctic Ocean, is highly sensitive to the flux of organic matter: relatively small and/or brief increases in that flux can cause the redox boundary to migrate rapidly from deep within the sediment to within a few centimeters of the sediment-water interface. Reoxidation of the sediment column after such an event can take years. Redox fluctuations can redistribute solid-phase manganese within the sediment column and produce multiple concentration peaks in its depth profile on a decadal time scale. Manganese peaks observed in sediment cores from the deep basins of the Arctic Ocean do not necessarily correspond to the position of the redox boundary during previous climatic periods or reflect historical changes in manganese deposition rates. The model supports the hypothesis that the recent decrease in the Arctic ice cover has increased the flux of organic matter to the seafloor and moved the redox boundary close to the sediment-water interface. The presence of iron sulfides at depths significantly below the bioturbated layer suggests that either the Arctic sediments have been anoxic for millennia, or iron and sulfate are reduced at these depths by dissolved organic matter diffusing downward from the bioturbation zone.

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