

Pulsed sedimentation in the Arctic Ocean: implications for the preservation of organic matter

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The boundary that marks the transition from oxic to anoxic conditions in marine sediments is not located at a fixed distance below the sediment-water interface. Rather, it fluctuates in response to temporal changes in bottom water properties and to pulses in the arrival and burial of organic matter travelling through the water column. A fluctuating redox boundary creates a situation whereby a sediment layer undergoing burial is alternately exposed to oxic and anoxic conditions before becoming permanently anoxic. This resembles the situation in many shallow marine environments where anoxic sediments are periodically re-exposed to oxygen through erosion and redposition, a process that appears to be responsible for the low organic carbon content of such sediments (Aller, 1998). Hartnett *et al.* (1998) have proposed that the burial efficiency of organic carbon is inversely related to the time that organic matter is exposed to oxygen. Here we argue, based on analysis of sediment cores, that a fluctuating redox boundary is an important characteristic of Arctic Ocean sediments, and that it promotes the degradation of sedimenting organic matter and influences the diagenesis of calcium carbonate and ferromanganese minerals.

We have detected acid volatile sulphide (AVS) within 3–6 cm of the sediment surface in seven box cores collected at 2275–4230 m depth on a trans-polar transect in the Arctic Ocean. Assuming that the depth below the sediment-water interface where AVS was first detected lies immediately below the penetration depth of oxygen at the time of sampling, and using well established relationships to estimate the instantaneous flux of oxygen into the sediment, we obtained fluxes corresponding to 0.78–3.2 g C m⁻² yr⁻¹ if all the oxygen is used to oxidize carbon. These values are 2–25 times greater than the current

best estimate of the annual organic carbon flux through the water column in the Canada Basin of the Arctic Ocean (Macdonald and Carmack, 1991), suggesting that the AVS based estimate of oxygen uptake is too high. However, the discrepancy can be understood in terms of the instantaneous as opposed to the average AVS distribution by considering that the delivery of organic carbon to the sediment is strongly seasonal. The cores were collected during summer and likely reflect the situation soon after the arrival of the spring pulse of organic carbon. The high biological activity that would follow would move the sediment redox boundary higher and allow sulphate reduction to take place relatively close to the sediment surface.

This interpretation is supported by our observations. Thus, we could not detect pyrite in any of our cores, indicating that the AVS is ephemeral and periodically reoxidized rather than preserved and buried. Furthermore, the occurrence of maximum concentrations of solid-phase Fe and Mn in the top 0–5 mm sediment layer is exactly what one could expect when the redox boundary fluctuates and the amplitude of the fluctuation reaches the sediment surface layer (Gobeil *et al.*, 1997). Finally, the exponential decrease we observe in the CaCO₃ concentration is what one would expect in a sediment dominated by oxic degradation of organic carbon (which produces acidity and leads to carbonate dissolution) as opposed to anoxic degradation (which produces alkalinity and favours carbonate precipitation).

The organic carbon content of these cores decreases sharply with depth from 0.6–1.1% in the surface layer to 0.2–0.3% at 10–30 cm depth. This sharp decrease suggests rapid and efficient degrada-

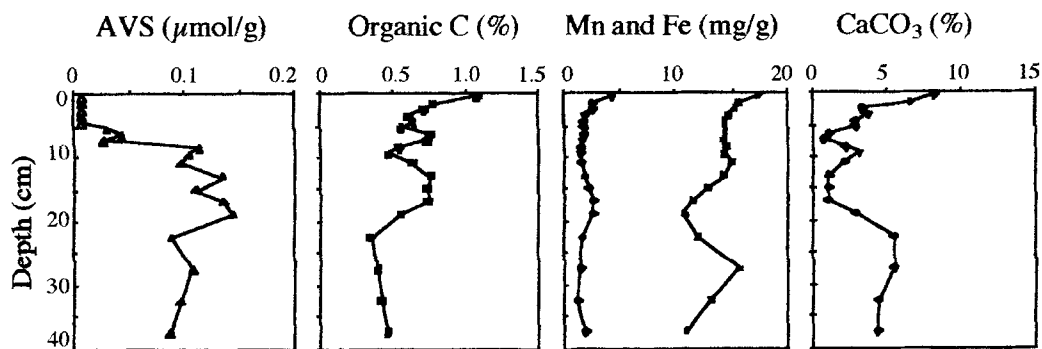


FIG. 1. The distribution of acid volatile sulphide (AVS), organic carbon, reactive manganese and iron, and calcium carbonate in a core from 4000m depth in the Arctic Ocean.

tion of organic carbon in the upper sediment layer. The hypothesis that a fluctuating redox boundary promotes the degradation of organic matter thus seems to have merit.

References

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