Implications of Highly Reactive Iron Distributions in Long-Range Transport of Aeolian Dust

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Dissolved iron is an essential micronutrient for marine phytoplankton, and its availability has controlled patterns of primary productivity and carbon cycling throughout Earth history. In many open-ocean regions, the input of new iron to the surface waters is dominated by atmospheric deposition of soluble iron in aeolian dust.

Dust from the Sahara reaches across the Atlantic Ocean. In this study, we explore distributions of potentially bioavailable Fe, the soluble fraction required by phytoplankton for photosynthesis and nitrogen assimilation, in deep-sea sediments in the North Atlantic Ocean. Within this framework, we analyzed a total of four IODP cores across the North Atlantic Ocean. A state-of-the-art Fe speciation technique was applied to characterize Fe inputs to address the patterns and their implications across spatial gradients and glacial-interglacial time scales.

To date, we have found no systematic pattern in the reactivity of the dust-associated Fe across glacial-interglacial time scales. We have also analyzed a range of sediment grain sizes and found no size effects in the distribution of bioavailable iron. There is, however, a trend of decreasing ratios of highly reactive (oxide iron that is/was potentially bioavailable) to total iron (Fe_{HR}/Fe_T) with greater distance from the source region. This trend might reflect increased reactivity (likely through prolonged atmospheric/cloud processing) during long-range transport and subsequent loss of soluble Fe in the water column. This lost iron could have simulated primary production in the surface ocean even (or preferentially) at great distances from the source region. If correct, these data suggest lower dust fluxes but with proportionally more reactive iron with increasing distance from the source. Similar Fe relationships have been observed in ancient loess deposits and could explain the downwind distribution of sites of intense biological activity. Remaining challenges include a better understanding of the role of deep-water dust dissolution and enhanced solubility linked specifically to low oxygen conditions in the water column and sediments. The latter could be a positive feedback tied to high primary production and associated oxygen demand.