The impact of ocean deoxygenation on the marine iron cycle: Evidence from the paleo-record

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Iron (Fe) is the limiting micronutrient for primary productivity in the ocean's High-Nitrate-Low-Chlorophyll regions, including the Peru/Humboldt Current system and the adjacent eastern equatorial Pacific. In the highly productive upwelling waters off Peru, most of the bioavailable Fe derives from reducing continental margin sediments. Bottom water oxygenation plays a vital role in defining the magnitude of this seafloor Fe source. It is therefore anticipated that large-scale fluctuations of upper ocean oxygenation on glacial-interglacial timescales were accompanied by changes in Fe supply from the seafloor with potential impact on primary productivity as well as carbon sequestration in the deep ocean.

Here, we report a 140 ka record of nitrogen isotopes, trace metal proxies for oxygenation and sedimentary Fe concentrations for the Peru upwelling system. We observe a close coupling between the globally consistent trend of upper ocean oxygenation (as revealed from nitrogen isotopes), sediment redox conditions and sedimentary Fe concentrations with periods of reduced ventilation (chiefly interglacials and warmer periods) being characterized by increased Fe retention in the sediment and a lower Fe flux into the water column. Efficient Fe retention under more reducing conditions is attributed to widespread sulfidic conditions in the surface sediment and concomitant Fe sulfide precipitation. Our results demonstrate that Fe release from continental margin sediments is most effective in a narrow 'redox window' where neither oxygen nor sulfide is present. We therefore anticipate that oceanic patterns of micronutrient limitation are unlikely to respond in a uniform manner to global oxygenation trends. Fully oxic ocean regions may experience an increase in seafloor Fe supply upon deoxygenation whereas oxygen-depleted ocean regions may experience an expansion of sulfidic conditions and therefore a reduction in seafloor Fe supply.