Dominance of deeply sourced iron in the Pacific Ocean

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Iron (Fe) is the most abundant transition metal in marine phytoplankton, reflecting its importance for a range of biochemical processes such as photosynthesis and nitrogen fixation. The high cellular requirements for Fe, coupled with its low solubility and concentrations in seawater, render Fe a limiting nutrient in vast regions of the global ocean, which in turn makes Fe a potential controlling factor for changes in atmospheric $p\mathrm{CO_2}$ and thereby major oscillations in global climate. Dissolved Fe in seawater is primarily sourced from sparingly soluble continental mineral dust, submarine hydrothermalism, and sediment dissolution along continental margins. However, the relative importance of surface dust deposition, compared to the deeper marine Fe sources to the open ocean remains contentious. By exploiting the Fe stable isotopic fingerprint of these sources, it is possible to trace distinct iron pools through marine environments in sedimentary records through time.

We have reconstructed the dominant central Pacific Fe sources over the past 76 Myr using Fe-isotopic measurements of Fe-Mn crust CD29-2. We find that dust is not the dominant Fe source in the central Pacific Ocean, as almost all of the data lies outside of the Fe-isotopic ranges defined by continental aerosol. Further, our record demonstrates that the average long-term Fe supply to the central Pacific has remained relatively constant over the past 76 Ma. We hypothesize that the overall Fe-isotopic variability must reflect the influence of distant Fe sources, with distinct Fe-isotopic compositions, that have been transported over large distances (> 3, 000 km) within the ocean interior.

These distal sources—most likely hydrothermal venting and sediment dissolution along continental margins—ultimately control the Fe budget of the deep Pacific Ocean. As such, the importance of continental aerosol dissolution to marine Fe budgets may be significantly overestimated. This has important implications for the proposed feedbacks between the hydrological cycle, Fe supply, and global climate over Earth's major climatic transitions, as our data suggest that the oceans' Fe inventory depends on ocean stratification and redox state, rather than the 'dustiness' of the prevailing climate.