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Substantial colloidal iron supply from resuspension events at the West Antarctic Peninsula

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Southern Ocean primary productivity is often limited by scarcity of the essential micronutrient iron (Fe), and sediment-derived Fe from the Antarctic shelf has been linked with downstream productivity. However, the magnitude of this shelf-derived bioavailable Fe flux and the mechanisms involved are poorly understood. Glacial meltwater along the West Antarctic Peninsula delivers significant volumes of potentially bioavailable Fe-rich glacially weathered material to shelf sediments, and recent work suggests that resuspension flux of sedimentary Fe oxides may be significant in this region [1]. We investigated resuspension of nearshore peninsula sediments at three fjords where glaciers are rapidly retreating. In our experimental incubations, addition of oxic glaciogenic surface sediments to bottom waters enriched dissolved Fe by 4–12 nM and total dissolvable Fe by 30–100 µM. This sustained increase in dissolved Fe could not be accounted for by pore water addition alone, suggesting a rapidly dissolvable solid phase contributing up to 93%. Critically, the release of dissolved Fe to seawater was driven by the colloidal phase.

Data from short-lived radium isotopes show greatly enhanced sediment-water interaction over sills and proximal to glacier grounding lines, indicating energetic physical resuspension in glacial bays. We estimated glacial sediment resuspension flux of highly reactive Fe (oxyhydr)oxides at 2.4–4.0 µmol cm^{-2} per event, exceeding previous [1] outer shelf estimates of 0.7 µmol cm^{-2}, and demonstrating the higher potential flux of reactive Fe oxides derived from fresh glacial sediments. Using XANES to determine Fe speciation, we show that fresh glacial material is rich in bioavailable Fe(II), and mixed-valence Fe particles in surface seawater are stabilised by organic carbon in the colloidal phase. Taken together, our data indicate resuspension is an important Fe supply mechanism that is largely overlooked by the paradigm of reductive dissolution driven primarily by sinking organic carbon. Oxic nearshore sediments therefore contribute an important source of colloidal and reactive particulate Fe to the Antarctic shelf water column, the export of which can supply bioavailable Fe to Fe-limited Southern Ocean waters.

[1] Burdige, D.J. and Christensen, J.P. (2022) Iron biogeochemistry in sediments on the western continental shelf of the Antarctic Peninsula, Geochimica et Cosmochimica Acta, 326:288-312.