Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36145

Marine ice: a sleeping giant source of iron for coastal Antarctica and the Southern Ocean

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Micronutrients such as iron (Fe) are essential for marine phytoplankton growth and play a key role in regulating ocean carbon sequestration. As the second-largest ice shelf on Earth, the Filchner-Ronne Ice Shelf (FRIS) has strong potential to supply bioavailable Fe to the Southern Ocean through iceberg calving and basal melt. However, its marine ice layer – a hundreds-of-meters-thick layer formed by refreezing of Ice Shelf Water beneath the ice shelf [1]– has not been well characterized with respect to its Fe content, creating a major uncertainty in Fe supply estimates from FRIS. Using an ice core (B13) recovered from FRIS that contains a 62 m thick marine ice layer [2], this study combines measurements of dissolved and particulate Fe with state-of-the-art imaging (scanning and transmission electron microscopy) and Laser Ablation ICP-MS, alongside biogeochemical model simulations, to quantify Fe supply from marine ice and assess its large-scale impacts on Southern Ocean productivity. The marine ice layer contains dissolved Fe ranging from 13 to 83 nmol kg^{-1} – several orders of magnitude higher than typical surface Southern Ocean concentrations. This elevated dissolved Fe occurs as Fe nanoparticles, particularly concentrated along ice boundaries, suggesting enhanced stability and transport potential toward offshore waters. Particulate Fe reaches up to 83 μmol kg^{-1} and is dominated by lithogenic glacial flour, which can release significant dissolved Fe even at low solubility. Model simulations using observed Fe concentrations from the marine ice, along with iceberg transport, indicate substantial Fe input from FRIS marine ice, generating significant surface Fe anomalies and enhanced net primary productivity across both coastal Antarctica and the open Southern Ocean. These findings provide the first high-resolution characterization of Fe in marine ice and highlight marine ice as a previously underappreciated driver of Southern Ocean biogeochemistry and ecosystem dynamics.

References:

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