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Unlocking the bio-essential metal supply from marine ice at the Filchner-Ronne Ice Shelf

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Micronutrients such as iron (Fe) and manganese (Mn) are crucial for marine phytoplankton growth and play an important role in regulating air-sea CO_2 exchange. This is particularly significant in the Southern Ocean, where macronutrients like nitrate are abundant, but micronutrients are regionally depleted due to their low solubility in seawater and limited external sources. Despite this, seasonal phytoplankton blooms are observed in the Weddell Sea, so far attributed to external Fe inputs from deep-water upwelling, continental shelf sediments, melting of sea ice, icebergs, and glacial ice. As the second-largest ice shelf on Earth, the Filchner-Ronne Ice Shelf (FRIS) has substantial potential to supply bio-essential metals to the Weddell Sea through iceberg calving and basal melt. However, its marine ice layer—a layer formed by the refreezing of supercooled seawater beneath the ice shelf, had so far not been characterized with respect to its micronutrient contents. This study examines its dissolved and particulate trace metal composition—using an ice core (B13) recovered from FRIS in the 1990s. The 62 m thick marine ice layer in core B13 contains dissolved Fe and Mn ranging from 13 to 83 nmol kg^{-1} and 21 to 165 nmol kg^{-1}, respectively. These concentrations are several orders of magnitude higher than those reported in the surface Southern Ocean, highlighting the potential role of FRIS marine ice as a micronutrient source. Additionally, particulate Fe and Mn concentrations reach up to 83 and 1.4 µmol kg^{-1}, respectively. Elemental ratios (metal/Al) indicate that most of the particulate Fe and Mn originate from lithogenic sources, potentially derived from subglacial crustal erosion. Further scanning electron microscope-EDX elemental analysis will provide insights into the mineralogical composition of marine ice particles, while ongoing solubility experiments aim to investigate the release of Fe and Mn from particle dissolution. This study presents the first high-resolution profile of bio-essential trace metal composition in the marine ice layer and underscores the potential significance of marine ice in shaping marine ecosystem dynamics and biogeochemical cycling.