Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36434

Synchrotron characterization of particulate iron delivered to the Amundsen Sea via the meltwater pump

KATHERINE MATEOS[1], PHOEBE LAM[1], SAMUEL M. WEBB[2], KYOUNGLIM KANG[3] AND MATTHEW A MARCUS[4]

[1]University of California, Santa Cruz
[2]SLAC National Accelerator Laboratory
[3]University of Minnesota
[4]Lawrence Berkeley National Laboratory

The rapid melting of the West Antarctic Ice Sheet is causing significant changes in biogeochemical cycling in marginal Antarctic Seas, including the Amundsen Sea (AS). Here, relatively warm, modified Circumpolar Deep Water (mCDW) drives a buoyancy-driven "meltwater pump," supplying iron (Fe) from both glacial melt and the sediment-water interface to the surface, where it can be used by local Fe-limited phytoplankton. Particulate iron (pFe; >1μm) delivered through the meltwater pump may be bioavailable, depending on its physical characteristics, chemical speciation, and mineral identity. For example, Fe(II)-bearing minerals may be particularly bioavailable [1]. Increased glacial melt may cause export of pFe from marginal seas to the Southern Ocean, stimulating primary production in this climatically important region.

In this work, we combine synchrotron techniques to characterize Fe-containing particles from six samples along the path of the meltwater pump in the AS. Scanning transmission X-ray spectroscopy (STXM) provides images of individual particles and spatially resolved maps of Fe and carbon at nanometer-scale resolution. Previous studies using STXM suggest that glacial Fe(II) is stabilized by C-Fe associations; while we observe similar colocation of Fe(II) spots and C, these Fe particles appear to be small, crystalline, and not necessarily chemically associated with the nearby C. Instead, where C and Fe appear to be chemically associated, Fe is more diffuse and of mixed valence. We also use hard X-ray microprobe and mesoprobe spectroscopy to identify Fe-containing minerals and to quantify Fe speciation. We find that pFe is dominated by Fe(III), though mixed valence Fe occurs in all samples. Particulate iron from glacial outflow of the Dotson ice shelf, influenced by both sedimentary and glacial sources, was most reduced (14% Fe(II)) and contained the highest diversity of Fe(II) containing minerals, while pFe near the sediment-water interface was more oxidized (0-4.5% Fe(II)). These results suggest that glacial outflow may supply potentially bioavailable Fe(II) minerals to the upper water column. Together, these complementary techniques provide both qualitative and quantitative characterization of these biogeochemically important Fe-containing particles.

[1] Shoenfelt et al., (2017) *Sci. Adv.* 3. e1700314