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Southern Ocean summer sea ice and snowpack are not significant reservoirs of dissolved rare earth elements despite substantial atmospheric contributions inferred from stable oxygen isotopes

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Sea ice plays a central role in shaping the seasonal dynamics of the Southern Ocean and influences various processes critical to ecosystem health, climate modulation, and global circulation. The western Weddell Sea has one of the thickest perennial sea ice covers on Earth, which is significantly altered by ice degradation and snow metamorphism during summer thaw-freeze cycles. These processes affect the bioavailability of nutrients and trace elements essential for primary producers, but their dynamics have only been studied to a limited extent so far. One of the objectives of RV Polarstern expedition PS118 from February to April 2019 was, therefore, to investigate the effects of end-of-summer ice conditions on marine biology and biogeochemistry in this evolving sea ice landscape. Here, we present dissolved rare earth element (REE) concentrations analyzed in different sea ice and snow types, gap layers, and the underlying seawater together with stable oxygen isotopes ($\delta^{18}O$) and salinity, providing crucial insights into water, ice, snow, and trace element sourcing. Despite considerable variation in $\delta^{18}O$, indicative of contributions from both atmospheric and marine sources, our results reveal consistently low REE concentrations across all snow-ice reservoirs, typically remaining below 2 pmol/kg for Nd. Notably, elevated REE concentrations, reaching up to ~9 pmol/kg for Nd, were detected in the gap layers, but did not reach the concentrations observed in the underlying seawater, which varied from ~10 to ~18 pmol/kg for Nd. In contrast to the exceptionally high REE concentrations found in nearby deposited continental snow [1], the snowpack covering the sea ice during PS118 thus proved to be an insignificant REE reservoir. We will relate our results to thaw-freeze processes affecting REE content as well as to the nutrient and chlorophyll-a distributions to clarify the effects of sources and processes on the marine and sea ice biology and biogeochemistry of this evolving region.

[1] Kim, Kim & Choy (2015), *Polar Research* 34(1), 24289.