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Supporting Information for

Neodymium Cycling and Water Mass Structure in the Indian Sector of the Southern Ocean

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Text S1. Closing the data gap: Nd isotopes in the Indian sector of the Southern Ocean

Neodymium isotopes (εNd) are a powerful tracer of ocean circulation and water mass provenance, complementing classical hydrographic parameters. In the Southern Ocean, εNd has been extensively studied in the Atlantic and Pacific sectors, where distinct signatures reflect regional inputs and mixing processes (e.g., *Jeandel*, 1993; *Stichel et al.*, 2012a; *Rickli et al.*, 2014). In contrast, the Indian sector remains poorly constrained, particularly for seawater REE distributions and εNd systematics. Despite recent RV Polarstern expeditions, significant data gaps persist east of Prydz Bay, limiting the assessment of boundary exchange processes (Fig. S1). We present new εNd and Nd concentration data from this previously undersampled region, helping to close this gap and improve constraints on water mass mixing and boundary exchange in the Indian sector of the Southern Ocean.

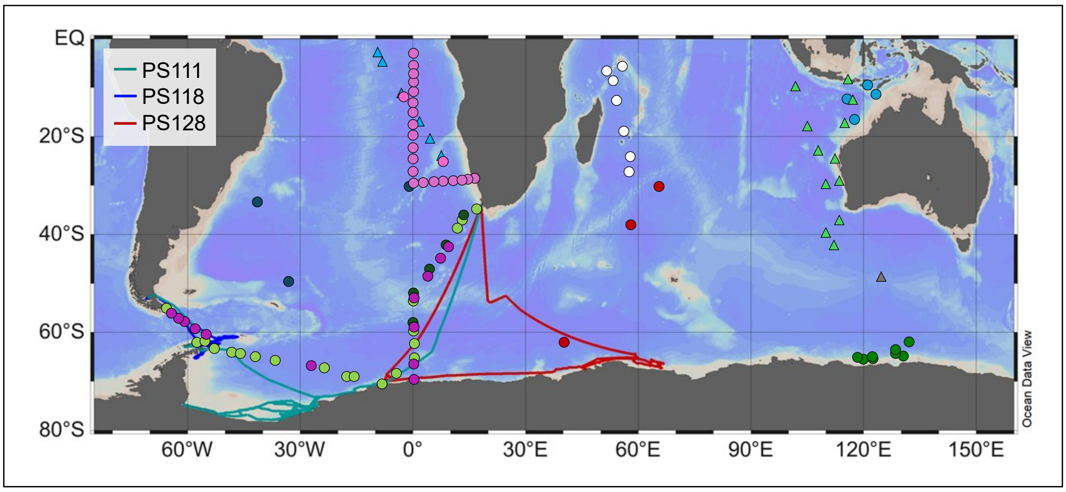

Figure S1. *Sites of previous studies reporting neodymium isotope composition and concentrations in seawater across the southern Atlantic and Indian Oceans. The Indian sector of the Southern Ocean, particularly east of Prydz Bay, has remained a major data gap until recently and is addressed by this study. Dots (full water-column): Red:* Amakawa et al. *[2019]; white:* Bertram & Elderfield *[1993]; light green:* Stichel et al. *[2012b]; grey:* Garcia-Solsona et al. *[2014]; yellow:* Jeandel et al. *[1998]; purple:* Stichel et al. *[2012a]; dark blue:* Jeandel *[1993]; dark green:* Griffiths et al. *[2024]; pink:* Rickli et al. *[2009], light blue:* Rahlf et al. *[2020]. Triangles (only surface water): light grey:* Amakawa et al. *[2000]; blue:* Rickli et al. *[2010], dark grey:* Tazoe et al. *[2011]. Coloured lines indicate RV Polarstern cruise tracks from previous expeditions.*

Text S2. Physical Properties (θ, salinity, O_2)

Potential temperature and salinity distributions reveal a clear north–south gradient, with warm, saline surface waters in the north transitioning to cold, fresh Antarctic Surface Water (AASW) toward the south (Fig. S2). A prominent feature is a southward shoaling Circumpolar Deep Water (CDW) tongue, characterized by a subsurface temperature maximum (UCDW) and a deeper salinity maximum (LCDW). Surface freshening ($<$34.3 psu) in the southern sector reflects sea-ice melt, while more saline waters in the north indicate subtropical influence. Oxygen saturation is highest in surface waters (≈70–100%) and exhibits a pronounced minimum (~50%) within UCDW at intermediate depths, marking older, poorly ventilated waters. Below ~1000 m, oxygen increases again toward the seafloor, consistent with the presence of recently ventilated Antarctic Bottom Water (AABW).

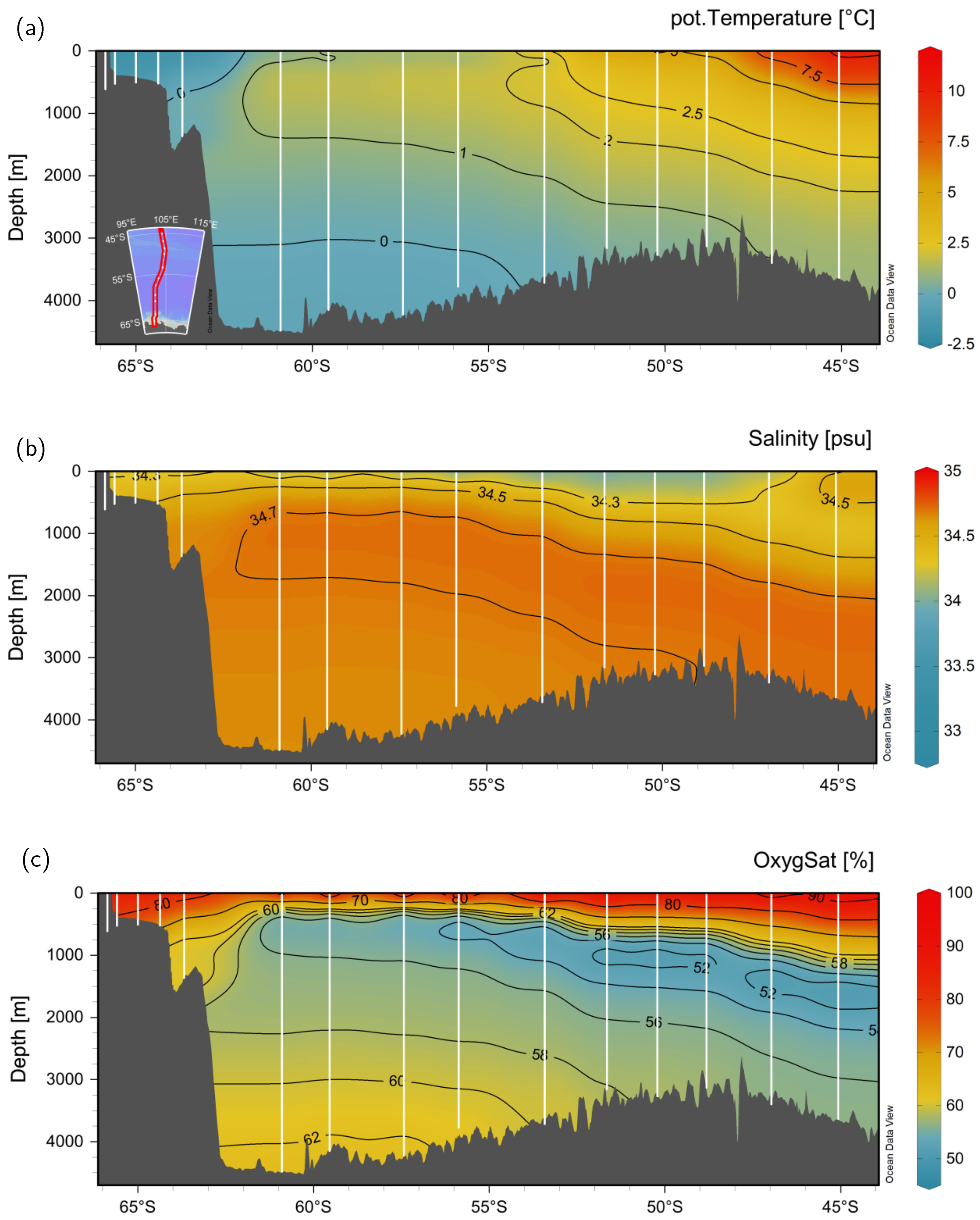

Figure S2. Sections of (a) potential temperature, (b) salinity, and (c) oxygen saturation along the investigated transect at ~100°–105°E. Sample locations are depicted as white lines.

Text S3. Samarium concentration results

Dissolved Sm closely follows Nd, showing nearly identical vertical and lateral distributions with increasing concentrations toward depth and higher values in southern bottom waters (AABW). A distinct enrichment at intermediate depths near the continental margin suggests additional boundary or shelf-derived inputs, while low concentrations in northern surface and intermediate waters reflect the nutrient-type behaviour of REEs (Fig. S3).

The molar Sm/Nd ratio remains largely uniform throughout the water column (0.183 ± 0.005), with only minor variability in the upper ocean. Slightly lower ratios occur south of ~55°S, whereas higher values are observed further north, indicating subtle effects of water mass mixing and scavenging processes.

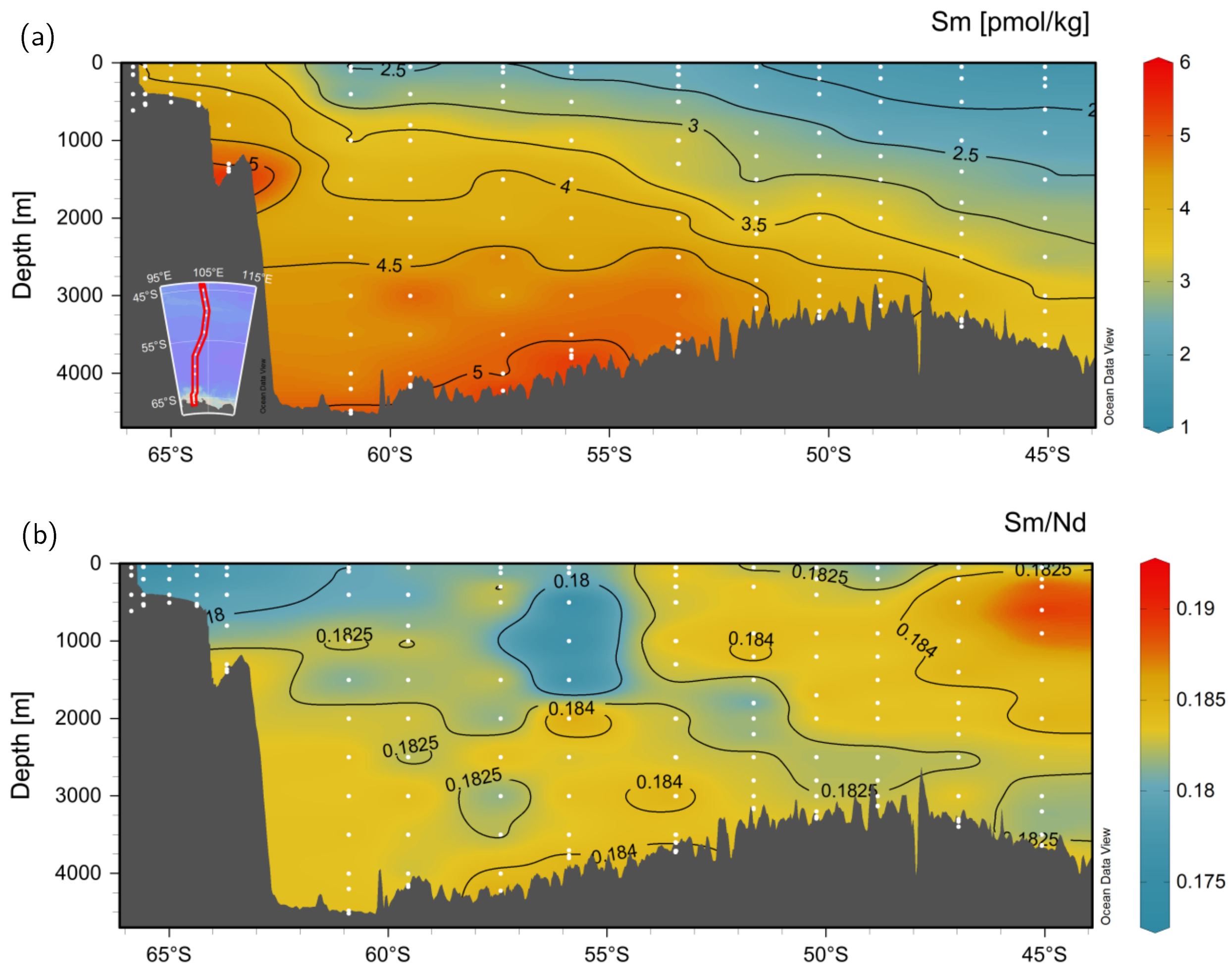

Figure S3. *Sections of **(a)** Sm concentration and **(b)** Sm/Nd ratio along the investigated transect at approximately 100°–105°E. Sample depths are depicted as white dots.*

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