Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16575

A multiproxy reconstruction of the Antarctic Circumpolar Current over the past million years

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The Antarctic Circumpolar Current (ACC) is the largest oceanic current system on Earth. Changes in ACC dynamics thus have strong implications for the air-sea partitioning of CO_2 and thereby modulate the efficiency of the Southern Ocean to act as a carbon sink. Documenting the sensitivity of the ACC to past climate variability could thus provide useful constraints for better predicting the evolution of climate in the face of anthropogenic forcing. However, past changes in ACC strength remain poorly constrained both temporally and geographically. Here we investigate variations in the ACC strength based on terrigenous grain-size, magnetic and geochemical properties in the Indian sector of the Southern Ocean over the past million years. We find that sortable silt mean grain size (SS, 10−63 μm) and magnetic properties show consistent patterns with coarser grain sizes during glacial intervals and smaller sizes during interglacials, reflecting coherent glacial-interglacial changes in ACC flow speed, with a stronger abyssal circulation during glacials and weakened current strength during interglacials. Compared to physical proxies, X-ray fluorescence scanner–derived zirconium and rubidium (Zr/Rb) ratios reveal anti-phased patterns on orbital timescales, with higher Zr/Rb ratios during interglacials and not as might have been expected during glacials at our study site. The Zr/Rb ratios show a positive correlation with chemical weathering index, which indicates changes in Zr/Rb ratio on orbital timescales and may thus have been primarily controlled by the chemical weathering intensity rather than by the ACC flow speed. Enhanced ACC strength may be directly related to intensified Southern Hemisphere westerly winds during glacial times. Moreover, a generally more equatorward position of the Antarctic frontal system during glacials may have obstructed the Agulhas leakage into the South Atlantic and intensified the Agulhas Return Current, which might thus have contributed to reinforce the strength of the ACC in the region during past ice ages.