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Changes in the South Pacific deep water Nd isotope composition over the last 140 ka

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The Southern Ocean plays a central role in the global overturning circulation of the ocean through the formation of intermediate and bottom waters and the import and redistribution of deep waters from all major ocean basins that make up Circumpolar Deep Water (CDW). The South Pacific is an ideal location to study the evolution of CDW over the last glacial-interglacial cycles with little direct overprint by fluctuating North Atlantic Deep Water (NADW) input.

Here were present a 140ky-long record of neodymium isotope ratios (^{143}Nd/^{144}Nd, expressed as ε_{Nd}) analyzed on fossil fish teeth and debris from sediment core PS75/056-1 (55˚09.74 S, 114˚47.31 W, 3581 m water depth) in the open South Pacific that is bathed today by Lower Circumpolar Deep Water (LCDW) with a small contribution from Pacific Deep Water. The Late Holocene and Marine Isotope Stage (MIS) 5 ε_{Nd} values of -7.5 to -7.7 are close to the modern seawater isotopic composition near the core site [1]. Glacial ε_{Nd} of about -6 is observed during MIS 2 and 6. The decrease in the ε_{Nd} record during the penultimate deglaciation is more gradual compared to that during the last deglaciation and the most negative values of the last interglacial are reached during MIS 5c. The transition from MIS 5 into MIS 4 is characterized by a shift towards more negative ε_{Nd} (-6.5) but full glacial values are not reached. The change to more positive ε_{Nd} at the MIS 4/3 transition is followed by a long-term increase to maximum values reached during the last glacial maximum.

The timing of the observed transitions is comparable to a nearby δ^{13}C record (core E11-2) [2] and to published ε_{Nd} records from the deep South Atlantic and Indian Oceans [3, 4]. We observe consistently more positive absolute ε_{Nd} values in the South Pacific compared to the Atlantic. The offset is around one ε_{Nd} unit during cold periods (MIS 2, 4, 6) and 1.5 ε_{Nd} units during the interglacials. During MIS 3, on the other hand, there is little difference in absolute ε_{Nd} signatures between Pacific, Atlantic, and Indian Ocean sites. Pronounced differences in ε_{Nd} between the oceans are consistent with lower direct NADW influence in the South Pacific compared to the other sites during warm periods, when North Atlantic overturning was strong. Previous studies from the South Atlantic and Indian Oceans interpreted the positive ε_{Nd} values in the deep Southern Ocean during glacials in terms of reduced NADW supply to CDW. While our record confirms that this change is required to explain the larger part of the glacial-interglacial ε_{Nd} amplitudes in the south, the timing of the last deglaciation in our record hints at processes in the Southern Ocean that must have contributed to the observed changes and have likely played a role in the older part of the record as well.

[1] Basak et al., submitted. [2] Ninnemann & Charles, 2002. EPSL 201, 383. [3] Piotrowski et al., 2005. Science 307, 1933. [4] Piotrowski et al., 2009. EPSL 285, 179.