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Neodymium Isotopic Evidence for Late Glacial and Holocene Millennial-Scale Variations in North Atlantic Deep Water Export to the South Atlantic

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Major glacial-interglacial variations in the export of North Atlantic Deep Water (NADW) to the Southern Ocean have recently been confirmed by interstadial Nd isotope shifts in the dispersed Fe-Mn oxide component of sediment cores (Rutberg et al., in press). Nd isotope ratios in seawater and marine precipitates can be powerful paleoceanographic tracers because they are distinct in different oceans and are not measurably fractionated by biological or physical processes, only retaining the signature of the source waters. Nd isotope compositions of the same component in globally distributed core tops have been shown to record the present-day isotopic compositions in deep-water. We have generated a more detailed record of NADW export over the last glacial termination and through the Holocene, and our preliminary data show significant millennial-scale variations.

The leached Fe-Mn component of RC11-83, from the Cape Basin in the SE Atlantic (41.07ºS, 9.72ºE, 4718 m depth) records more Pacific-like Nd isotope ratios during cold Marine Isotope Stages (MIS) 2 and 4 than compared to the Holocene and MIS 3. The cold stage values are also more Pacific-like than present-day Circumpolar Deep Water, indicating that less NADW was reaching the Circum-Antarctic than today (Rutberg et al., in press). Our new samples have emphasized intervals of important late Quaternary climate changes such as Termination I and the mid-Holocene Cool Period (~7-9 ka). Downcore Nd isotope variations show short-term excursions, confirming that the method resolves millennial-scale thermohaline circulation changes. The existence of these excursions in the down-core record shows that any remobilization of Nd has occurred over <10 cm. The Fe-Mn leachates have seawater Sr isotope ratios (~0.7092), much lower than the detrital components of the same samples (0.717-0.723). Because even a small amount of detrital Sr would be detectable, it is clear that no leaching of detrital clays has occurred.

A striking feature of the record is an excursion to more Pacific-like Nd isotope ratios at 7,000-9,000 calendar years B.P. The timing is contemporaneous with the mid-Holocene Cool Period, a global event recognized in climate records such as the GISP2 and Taylor Dome ice cores in Greenland and Antarctica (Alley et al., 1997; Stager and Mayewski, 1997). It has been suggested that a possible trigger for this cold interval was the rapid drainage of Laurentide lakes, which freshened Labrador Sea surface waters, leading to a disruption of NADW production (Barber et. al., 1999). If vigorous production of NADW had continued during this period, a large influx of Canadian shield-derived Nd into the North Atlantic would have lowered the Nd isotope ratio of NADW, making it less Pacific-like, opposite to the change observed in the Southern Ocean record. Therefore, the excursion to higher Nd isotope ratios indicates that, however triggered, thermohaline circulation was severely weakened during the mid-Holocene Cool Period.

Another focal point is the last glacial termination. Charles and Fairbanks (1992) found a short-lived excursion toward more North Atlantic-like benthic foraminiferal $\delta^{13}C$ at ~15 ka in the same core, which they interpreted as signifying a "false start" of NADW export, occurring ~1000 years prior to the true termination. However, there has been some question as to whether the $\delta^{13}C$ shift is a thermohaline signal or part of the noise in the benthic foraminiferal $\delta^{13}C$ signal. Our Nd isotope record shows a contemporaneous excursion toward more North Atlantic-like values, confirming that NADW export increased for a short period directly preceding the termination.

The Nd isotope ratios offer a means of quantifying thermohaline circulation changes. During the "false start", the NADW signal strength increased about 2/3 of the way from LGM towards full Holocene conditions, while during the Mid-Holocene Cooling Period the NADW signal decreased by ~1/3 from its full Holocene value.

In summary, Nd isotope ratios of Fe-Mn leachates confirm a short-lived false start of NADW export to the Southern Ocean prior to the main glacial meltwater spike during the last glacial termination, and a reduction in conveyor strength during the mid-Holocene Cool Period at ~7-9 ka. The data underscore the power of this technique as a monitor of thermohaline circulation changes on both interstadial and millennial time-scales.