AMOC reconstructions applying $^{231}Pa/^{230}Th$ and ε_{Nd}

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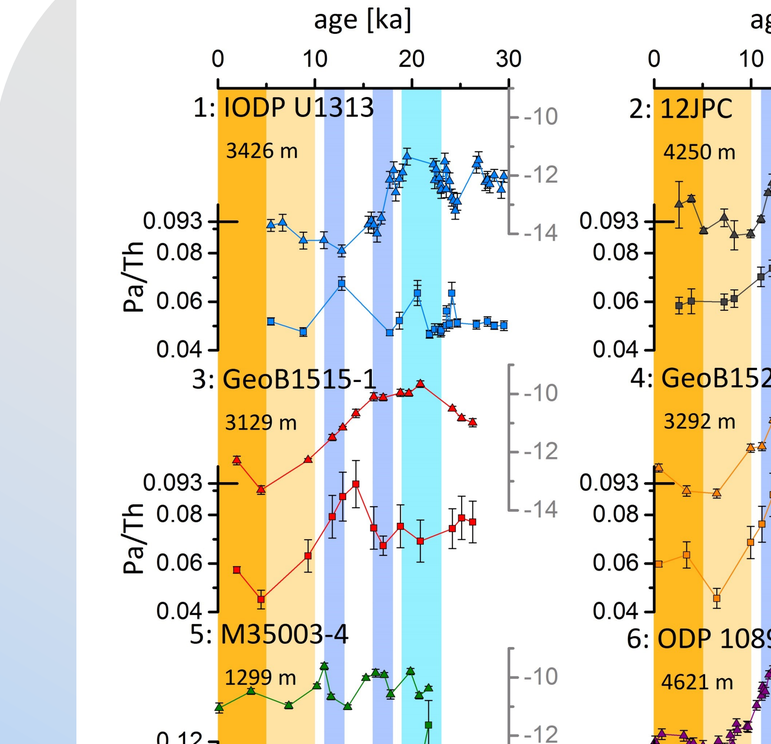
Methods

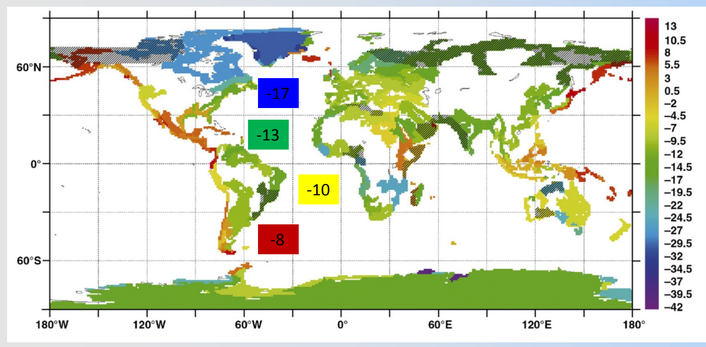
^{231}Pa and ^{230}Th are uniformly produced by alpha decay of ^{235}U and ^{234}U dissolved in the ocean. Both are produced at a constant production ratio of 0.093 and are rapidly removed from seawater.



Due to it's longer residence time in ocean water compared to ^{230}Th, ^{231}Pa can be laterally transported by ocean circulation before deposition.

As a function of circulation strength more ^{231}Pa (weaker AMOC) or less ^{231}Pa (stronger AMOC) is deposited relative to ^{230}Th, providing a measure of past AMOC conditions.

Old continental crust is depleted in ^{143}Nd (very negative ε_{Nd}), while young mantle-derived rocks are enriched in ^{143}Nd (higher ε_{Nd}). Continental weathering transfers low ε_{Nd} from Northern Canada and Greenland into the North Atlantic. Thus, ε_{Nd} leached from sedimentary ferromanganese coatings can be used as a chemical water mass tag indicating bottom water provenance and direction of circulation independent of nutrient cycling.



Map of the Nd-signatures at the ocean margins (Jeandel, 2007) and typical Holocene deep-water ε_{Nd} values in the Atlantic Ocean.

$$\varepsilon_{Nd} = \left[\frac{^{143}Nd/^{144}Nd_{sample}}{^{143}Nd/^{144}Nd_{CHUR}} - 1 \right] \times 10^4$$

Combined $^{231}Pa/^{230}Th$ and ε_{Nd} down-core profiles

Colour bars indicate the time periods (from left to right) of the late Holocene, early Holocene, Younger Dryas, Heinrich Stadial 1, LGM, Heinrich Stadial 2.

Core locations and silicate surface concentrations [µmol/l]

While $^{231}Pa/^{230}Th$ provides quantitative information about the strength and the dynamics of overturning circulation (McManus2004) Nd isotopes allow fingerprinting water mass provenance and therefore constraining flow paths throughout the deep ocean (Frank2002; Piotrowski2004).

Nine combined $^{231}Pa/^{230}Th$ and ε_{Nd} down-core profiles from the Atlantic Ocean (Lippold2016; Jonkers2015; Böhm2015; Roberts2010; Gutjahr2008; McManus2004; SU90-03 unpublished) provide insights on the AMOC mode of the last glacial and last deglaciation.

Both proxies show generally higher values for both proxies during the LGM for most of the core sites. These results provide evidence for a consistent pattern of northward advances of Southern Sourced Waters into the deeper (>3000m) Atlantic Ocean during the last glacial (sites 2,3,4,6,7).

Because of Southern Sourced Water bathing the deeper cores before and during the last glacial termination their $^{231}Pa/^{230}Th$ records may not be interpreted in terms of NADW strength. Instead they indicate sluggish northward transport of AABW.

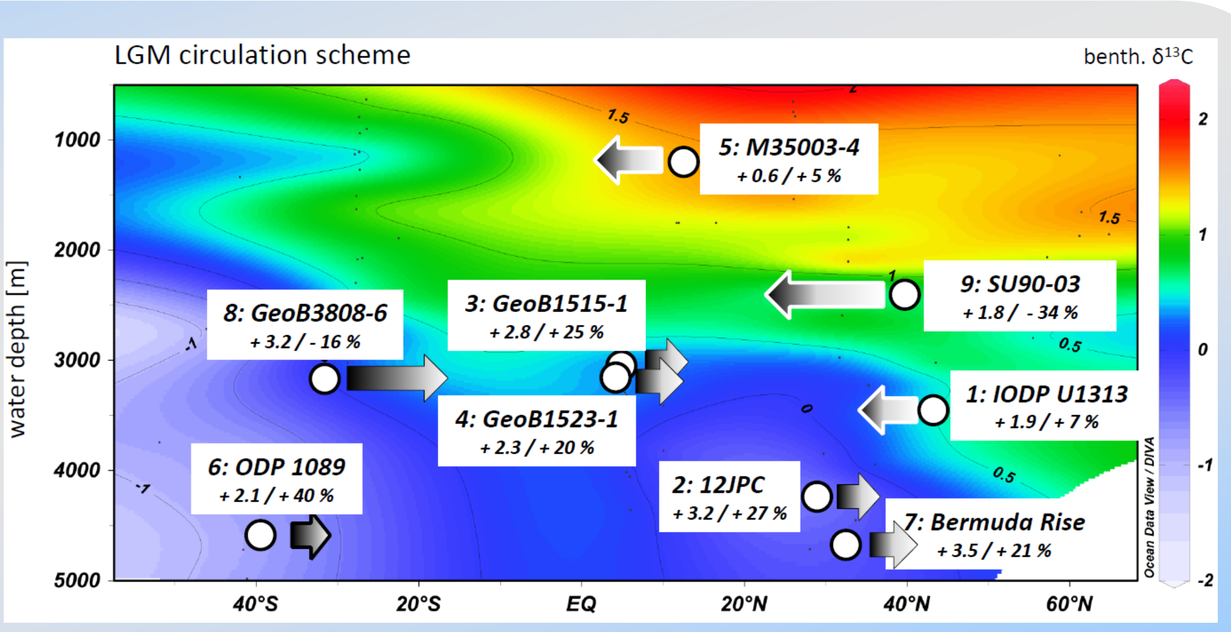
However, core sites located in the north and/or shallower cores show less pronounced changes in both $^{231}Pa/^{230}Th$ and ε_{Nd} (sites 1,5,8,9).

AMOC during the Last Glacial

More radiogenic Nd isotope signatures during the glacial and the deglacial indicate the dominance of Southern Sourced Water in particular in the deeper Atlantic.

Results from shallower core sites support evidence for an active overturning cell of shoaled Northern Sourced Water during the LGM and the subsequent deglaciation (e.g. HS1).

The resulting reconstruction of the AMOC pattern based on both proxies are in very good agreement to carbon isotope data (Curry2005). On the right (overlain on $\delta^{13}C$ data) directions and advection strengths during the LGM are shown. According to the $^{231}Pa/^{230}Th$ records the AMOC situation in the shallow northern North Atlantic was not much different compared to the Holocene.



Numbers underneath the core names indicate the differences in ε_{Nd} and relative increases in $^{231}Pa/^{230}Th$ compared to average Holocene values.

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