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North Atlantic Deep Water expansion during Northern Hemisphere Glaciation: evidence from neodymium isotopes

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The Atlantic Meridional Overturning Circulation (AMOC) is a major component of Earth's climate system and plays an important role in heat transport and carbon storage. During the transition from the warm Late Pliocene to the cooler Early Pleistocene (2.58 million years ago), large northern ice sheets developed in the circum-Atlantic region across an interval known as the intensification of Northern Hemisphere Glaciation (iNHG). Such a major change in Earth's boundary conditions can be expected to have changed the structure and strength of both the AMOC and the global overturning circulation. However, neither existing carbon isotope records nor modelling studies agree on the spatial extent of North Atlantic Deep Water (NADW) in the Pliocene compared to the Pleistocene [1-3].

To better constrain changes in Atlantic Ocean circulation across the iNHG, we present a suite of high-resolution neodymium isotope records measured on fossil fish teeth in a depth transect of three sites in the equatorial Atlantic Ocean. Published data from other locations provide evidence on water mass endmember values [4,5], enabling an assessment of spatial gradients from the new data, and aiding interpretations of circulation changes. Our main finding is a persistent latitudinal and depth gradient in the Nd isotope composition in the deep Atlantic Ocean during the Late Pliocene, but not during the Early Pleistocene, which provides strong evidence for an expansion of NADW over the iNHG. In addition, the records span multiple glacial-interglacial cycles, which enables us to assess NADW extent under glacial and interglacial boundary conditions of both the Late Pliocene and Early Pleistocene.

Overall, our results demonstrate that deep-water circulation in the Atlantic Ocean was markedly different during the warm Pliocene climate state, with potential implications for how AMOC stability will evolve in future.

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