Changes in North Atlantic deepwater circulation during the past 4 Myr

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Abstract

Changes in northern North Atlantic deep water circulation during the past 4 million years (Ma) were studied at a suite of five IODP/ODP sites at water depths from 2400 to about 5000 m. Benthic $\delta^{13}C$ records at these sites oscillate in parallel around values lower than today by ~0.2 ‰ during interglacials and by ~0.7 ‰ during pronounced glacials of the late Pliocene warm period. However, Pliocene Mg/Ca-based deep-water temperatures were 2 to 3 °C higher than today during interglacials and near modern levels during glacial periods. The coeval changes in ventilation at a lower level than today may indicate a weaker difference between these warm water masses than today, which is probably caused by water mixing in the northern North Atlantic. This is corroborated by ε_{Nd} bottom seawater values near -9 to -10 at all sites, which differs markedly from the modern situation characterized by clear differences in ε_{Nd} signatures between the water masses at these sites. Accordingly, the lesser ventilated, warm, and mixed water masses are most likely the result of the weaker overturning in the northern North Atlantic during that time of global warmth [1].

After 1.6 Ma, benthic $\delta^{13}C$ records show a gradually improving ventilation, with pronounced glacial/interglacial oscillations, which came close to the modern-to-late-Pleistocene levels. This ventilation change in deep water masses was coeval with a clear divergence in ε_{Nd} of bottom water masses between the different sites towards modern signatures. This is apparently linked to a significant change in the sources of circulating deep waters in northern North Atlantic. Accordingly, the first reorganization of the deep circulation in northern North Atlantic towards the modern situation appears to have started only after ~1.6 Ma, most likely as a response to increases in the amplitude of the Earth's obliquity cycle during that time [2].

[1] Haywood & Valdes (2004) *Earth and Planetary Science Letters* **218**, 363-377. [2] Laskar *et al.* (1993) *Astronomy and Astrophysics* **270**, 522-533.