Pacific intermediate and deep water reorganisation during the middle Miocene onset of the "icehouse": Radiogenic isotope evidence

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A major stepwise transition from moderate global climate conditions to the "icehouse" occurred in the middle Miocene. It has been argued that this transition influenced the climate of the entire planet. One of the major changes was an enhancement of ventilation and global ocean circulation including the onset of deep water production around the Antarctic continent.

Water masses in the ocean are labeled with distinct Nd isotope signatures in their source areas (oceanic residence time ~500-1000 years) and are then only modified in the open ocean by mixing with other water masses. Past bottom water Nd isotope signatures can be extracted from early diagenetic ferromanganese coatings of bulk sediments applying a reductive leaching technique and can serve as a tool to reconstruct past water mass mixing. Seawater Pb isotope compositions (oceanic residence time ~50-200 years) provide additional information on local weathering inputs.

We present a new data set of radiogenic Nd and Pb isotope compositions of past seawater combined with ventilation proxies such as stable carbon isotopes in the southeastern Pacific from intermediate and deep water ODP Sites 1236 and 1237 covering the period between 15.5 and 12.8 Myr ago. At this location water masses of Southern Ocean origin (AAIW - εNd ~-7 to ~-9) competed with waters of North Pacific origin (NPIW- εNd ~-2 to ~-5).

The Nd isotope data of site 1236 reveal that prior to about 14.2 Ma colder periods were accompanied by enhanced northward export of AAIW and higher influence of North Pacific intermediate waters during warmer periods. Following major expansion of Antarctic ice sheets between at 13.9-13.8 Myr ago, the data suggest that ventilation at intermediate water depths was improved, most likely as a consequence of enhanced meridional overturning circulation. The Pb isotopes provide complementary information about changes in continental inputs during the onset of the "icehouse".

Millennium scale radiocarbon variations in Eastern North Atlantic thermocline waters: 0-7000 years

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Deep water corals are exceptional archives of modern and past ocean circulation as combined U-series and radiocarbon dating allows to reconstruct seawater radiocarbon. Here we present thermocline water radiocarbon concentrations that have been reconstructed for the past ~7000 years for the eastern north Atlantic, based on deep-water corals from Rockall Bank and Porcupine Seabight. We find that thermocline water radiocarbon values follow overall the mean atmospheric long term trend with an average offset of $\Delta^{14}C$ between intermediate water and atmosphere of -55±5‰ until 1960 AD. Residual variations are strong (±25‰) over the past 7000 years and there is first evidence that those are synchronous to millennium scale climate variability.

Over the past 60 years thermocline water radiocarbon values increase due to the penetration of bomb-radiocarbon into the upper intermediate ocean. Radiocarbon increases by $\Delta\Delta^{14}C$ of +95‰ compared to +210‰ for eastern North Atlantic surface waters. Moreover, bomb-radiocarbon penetration to thermocline depth occurs with a delay of ~10-15 years. Based on high resolution ocean circulation models we suggest that radiocarbon changes at upper intermediate depth are today barely affected by vertical mixing and represent more likely variable advection and mixing of water masses from the Labrador Sea and the temperate Atlantic (including Mediterranean outflow water).

Consequently, we assume that residual radiocarbon variations over the past 7000 years reflect millennium scale variability of the Atlantic subpolar and subtropical gyres.