Geophysical Research Abstracts
Vol. 14, EGU2012-13085, 2012
EGU General Assembly 2012

Timing of deglacial changes in regional Atlantic benthic δ^{18}O

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Modifications to the Atlantic Meridional Overturning Circulation (AMOC) structure influence global climate but the instrumental record of intermediate to deep Atlantic water mass properties and flow speeds remains insufficient to confidently characterize modern changes to the AMOC beyond intra-annual to annual variability. Longer-term characterization of transitions to reduced North Atlantic Deep Water (NADW) formation is of particular interest because such a reduction is generally expected for the modern global warming.

We attempt to constrain the timing of water mass responses during the pronounced AMOC adjustments of the last deglaciation by dating four regional Atlantic benthic δ^{18}O stacks, which we refer to by water depth (Intermediate = 1000 to 2000 m; Deep = below 2000 m) and hemisphere (North or South). Regional non-glacioeustatic benthic δ^{18}O changes reflect modifications to the physical properties – temperature and salinity – of the overlying water mass(es), from which we infer changes in AMOC. A suite of 515 planktonic foraminiferal ^{14}C dates from 47 of the 197 total records in the stacks provides age control. We define probability distributions for the age model errors that account for both the errors of the individual age estimates and the changing variance of the mean ages along the stacks.

The possibility of variable surface-water ^{14}C reservoir age over the last deglaciation represents an additional source of age model uncertainty. We compare separate high and low latitude age models for the Deep North Atlantic stack using an initial constant reservoir age of 400 yr (reservoir age correction, ΔR = 0 yr) for all dates. We interpret the residual of these two age models as ΔR for the high latitude North Atlantic and observe a maximum of 1,810 $\pm$ 490 yr around 16.5 ka during Heinrich Event 1. Age models for the two North Atlantic stacks include this ΔR correction for cores from $>40°$N. We argue for a constant reservoir age at all sites included in the two South Atlantic stacks (which span $\sim$0 to 44°S).

On these age models, the onset of the deglacial decrease in benthic δ^{18}O occurred at 18.5 ka in the Intermediate South Atlantic stack, 18.0 ka in the Deep South Atlantic stack, and 17.0 ka in both the Intermediate and Deep North Atlantic stacks. To test the statistical significance of our observation that this South Atlantic benthic δ^{18}O response precedes the North Atlantic benthic δ^{18}O change, we use Monte Carlo techniques with samples drawn directly from the probability distributions of the radiocarbon age estimate errors. For every possible combination, we conclude with $>99\%$ confidence that the termination onset occurs earlier in the South Atlantic stack than the North Atlantic stack. This suggests that warming and/or freshening of the intermediate to deep South Atlantic could be an important precursor to the major reduction in North Atlantic Deep Water formation of Heinrich Stadial 1 ($\sim$17 to 14.5 ka) and highlights the importance of monitoring the South Atlantic for early identification of modern AMOC changes.