



Integrated oxygen isotope and Mg/Ca analysis of benthic foraminiferal species: the last 30 Myr

B.D.A. Naafs (1,2), H.L. Stap (1), E. Thomas (3,4), L. Lourens (1), G.J. Reichart (1), D.A. Hodell (5)

(1) Faculty of Geosciences, Department of Earth Sciences, Utrecht University. Budapestlaan 4, 3584 CD Utrecht, The Netherlands, (2) Alfred-Wegener-Institut for Polar and Marine Research, Columbusstrasse, 27568 Bremerhaven, Germany, (3) Center for the Study of Global Change, Department of Geology and Geophysics, Yale University, New Haven CT 06520-8109, USA, (4) Department of Earth and Environmental Sciences, Wesleyan University, Middletown CT 06459-0139, USA, (5) Department of Geological Sciences, University of Florida, 241 Williamson Hall, P.O. Box 112120, Gainesville, Florida 32611, USA

We used samples from ODP Site 1264 (Leg 208, Walvis Ridge, southeastern Atlantic Ocean; present depth ~ 2500 m) spanning the last 30 Myr in an integrated study of oxygen isotopes ($\delta^{18}\text{O}$) and Mg/Ca in *Cibicidoides* spp. and *Oridorsalis umbonatus*. We aimed to obtain records of deep-ocean temperature, carbonate ion saturation and continental ice volume at a time resolution of about 150 kyr. From our temperature records we conclude that there is no consistent relation between ice volume increase and deep-sea cooling, but decreasing temperatures commonly led increasing ice volumes, suggesting that high latitude decrease in temperature was one but not the only driving force behind the growth of continental ice volume. Assuming modern day seawater Mg/Ca, bottom water temperatures at Site 1264 ranged between 6 and 11 °C for the last 30 Myr. Temperatures based on the Mg/Ca from *Cibicidoides* spp fluctuated around a mean of 7 °C during the last 15 Myr, during which time the $\delta^{18}\text{O}$ record of seawater (δw) increased by ~ 1 ‰. Temperatures based on the Mg/Ca from *O. umbonatus*, on the other hand, show an overall decrease of around 5 °C over the last 20 Myr and an increase of ~ 1.5 ‰ in the δw record. Both the δw records shows periods of major ice volume increase over the last 30 Myr, some coinciding with previously reported climate events such as the Oligocene/Miocene boundary. Differences between

the Mg/Ca records of the infaunally living *Oridorsalis umbonatus* and the epifaunally living *Cibicidoides* are suggested to be related to the carbonate ion saturation state (ΔCO_3^{2-}) of the water column. The differences between *Oridorsalis umbonatus* and *Cibicidoides* Mg/Ca seem to be the largest during the last 4 Myr, possibly related to large changes in ΔCO_3^{2-} during the Plio-Pleistocene ice ages. Therefore, Mg/Ca of *Cibicidoides* during that period might be biased.

Our data suggest that Mg/Ca data can be used as paleotemperature proxies during the late Paleogene and Neogene if combined records of differently-living benthic species are used, so that the combined record of carbonate ion effect, paleotemperature, and ice volume can be deconvolved.