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Reconstructing the Late Pleistocene Southern Ocean biological pump using the vertical gradient of Cd/Ca in planktic and benthic foraminifera

Miros Charidemou (1), Ian Hall (1), and Martin Ziegler (2)

(1) School of Earth and Ocean Sciences, Cardiff University, United Kingdom, (2) Climate Geology, Geological Institute, ETH Zürich

The Southern Ocean is a particularly important region in the global carbon cycle because its wind-driven upwelling regime brings CO_2-rich deep waters to the ocean surface. However, outgassing of CO_2 to the atmosphere is ultimately determined by the efficiency of the soft-tissue biological pump which transfers carbon back into the deep sea. Biological productivity in the Southern Ocean on glacial-interglacial timescales is thought to be influenced by the availability of iron from terrestrial dust sources (Martin, 1990). However, the exact nature of the relationship between productivity and dust flux is still debated (Ziegler et al., 2013; Martinez-Garcia et al., 2014) and remains unclear for earlier times such as during the Middle Pleistocene Transition (MPT).
Changes in the strength of the soft-tissue biological pump can be reconstructed with relative ease by measuring carbon isotopes in planktic and benthic foraminifera and quantifying the vertical gradient between them (Ziegler et al., 2013). Our ultimate aim is to use this technique to reconstruct changes in the biological pump in the Southern Ocean during the MPT, when a sharp rise in dust flux is observed in the sedimentary record (Martinez-Garcia et al., 2011). This will allow us to assess the contribution of changes in the Southern Ocean biological pump to the climatic reorganisation that occurred during the MPT.
However, before the $\Delta\delta$13C record is constructed for the MPT it is vital to confirm that this method is indeed a reliable proxy for the soft-tissue biological pump. Records of $\Delta\delta$13C can be influenced by changes in the whole ocean inventory of δ13C, changes in circulation and changes in the degree of fractionation between the ocean and the atmosphere. The impact of inventory and circulation changes can be minimised by careful selection of study sites and by targeting foraminifera that live within specific water masses. However, deviations of $\Delta\delta$13C from the biological signal could certainly arise due to δ13C fractionation between the ocean and the atmosphere.
Due to the similarity in the distribution of phosphate and cadmium (Cd) in the ocean and the incorporation of this trace metal into the calcite tests of foraminifera, Cd/Ca ratios can provide an additional proxy for reconstructing the vertical nutrient distribution in the ocean in the same way as δ13C. We present downcore records of Cd/Ca in the deep-dwelling planktic species, Globorotalia truncatulinoides (s) and the benthic species, Cibicidoides wuellerstorfi from sediment core MD02-2588. A new core a core-top calibration of Cd/Ca in G. truncatulinoides, combined with the established calibration for benthic species allows us to estimate seawater Cd within intermediate and deep water masses that bath the study site and to reconstruct the vertical seawater Cd gradient (ΔCdsw) over the past 150,000 years. Comparison of ΔCdsw to $\Delta\delta$13C from the same samples from core MD02-2588 in the Southern Ocean indicate a very similar downcore variability which supports the use of the $\Delta\delta$13C method to reconstruct the biological pump during the MPT.