Indian Ocean circulation and productivity during the last glacial cycle

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The Indian Ocean is affected by inflow of Atlantic-derived deep water and by upwelling and surface ocean return flow from the Indo-Pacific; thus is an ideal location to reconstruct thermohaline circulation (THC)-forced changes to primary productivity and deep water nutrient contents. We present a Nd isotope record from the equatorial Indian Ocean which shows that deep ocean circulation was decoupled from nutrient content changes on glacial-interglacial timescales.

Fe-Mn leachate ε_{Nd} and benthic $\delta^{13}C$ records from core SK129/CR02 in the deep equatorial Indian Ocean (3°N, 76°E, 3800 mbsl) [1] span the last 150 kyr. The ε_{Nd} record shows that an increased proportion of NADW reached the Indian Ocean during interglacials (MIS 1 and 5) and also exhibits changes during major MIS 3 interstadial-stadial events. The magnitude and timing of deglacial and interstadial-stadial shifts are very similar to those in the RC11-83/TNO57-21 South Atlantic deep Cape Basin Nd isotope record [2] suggesting that Atlantic MOC changes were effectively propagated into the central Indian Ocean via the Southern Ocean.

The SK129/CR02 benthic $\delta^{13}C$ record shows glacial-interglacial pattern of changes which is similar to the ε_{Nd} record, with the exception of a prominent decoupling during early MIS 5. If the ε_{Nd} record reflects changes in the strength of the THC, then the decoupled $\delta^{13}C$ is indicative of either a change in mean ocean $\delta^{13}C$ or nutrient regeneration during the last interglacial. A shift in productivity is supported by benthic $\delta^{13}C$ gradients along Indian and Pacific Ocean deep water flow. A concurrent warming in planktonic Mg/Ca during MIS 5 at the site is consistent with changing thermocline temperature and may indicate a link to surface ocean hydrographic changes.

[1] Banakar (2005) *Indian Journal of Marine Sciences* **34**, 249. [2] Piotrowski *et al.* (2005) *Science* **307**, 5717, 1933.

Tracing Zn biogeochemical cycle using the $\delta^{68/66}$Zn of the coccolithophore *Emiliania huxleyi*

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The use of non-traditional stable isotopes of Fe, Zn has been proposed as proxies for biological processes. We have evaluated the potential of Zn isotopes as a proxy for marine biocarbonate formation. We have monitored Zn incorporation into coccoliths of the widespread coccolithophore (*Emiliania huxleyi*) during cell growth in laboratory cultures under surface water conditions. Cultures of *E. huxleyi* were set in f/50 artificial seawater medium (0.2ppb of Zn) or Zn-enriched (2-20ppb) f/50 media. Coccolithophores and artificial seawater aliquots were regularly sampled during the log to stationary phase. Zn was extracted from coccoliths or artificial seawater by anion-exchange separation with 100% yields. Zn concentrations and $\delta^{68/66}$Zn were determined by Q-ICP-MS and MC-ICP-MS, respectively.

Cells incorporated 100% of the Zn available when grown in artificial seawater f/50 medium. Only 2 to 25% was incorporated when grown in Zn-enriched media. The $\delta^{68/66}$Zn of *E. huxleyi* grown in f/50 decreased with time from +0.07 to -0.02‰, indicating a Rayleigh distillation with a $\approx$ 0.1‰ positive fractionation between cells and seawater. The constant $\delta^{68/66}$Zn (+0.2‰) observed for cells grown in Zn-enriched media are coherent with this model. This unexpected positive fractionation could be attributed to adsorption of Zn on the coccoliths surface and/or to a vital effect during active incorporation of trace metals by coccolithophores.

Our results indicate that in ocean surface waters where strong Zn depletion occurs Zn isotopic composition is not a good proxy for biological activity. However, it is a good proxy for surface water composition, since coccoliths should record the $\delta^{68/66}$Zn of the surrounding seawater.