

Miocene Os and Tl isotopes in the Indian Ocean: Implications for Antarctic water export and the residence time of Os

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We completed a high resolution profile of osmium and thallium isotopes in a ferro-manganese crust from the Indian Ocean, Antipode 109D-C. The best estimate for the age at the base of this crust is ~15Ma [1]; our Os isotope stratigraphy does not produce a reasonable chronology for this crust.

Application of this [1] age model reveals that the Indian Ocean had a significantly more radiogenic Os isotope composition than the Atlantic and Pacific Oceans in the middle and late Miocene. This isotopic difference can most readily be explained by high continental run-off supplied by rapid erosion of the Himalayas combined with a significantly lower flux of Antarctic bottom water (AABW) into the Indian Ocean in the middle Miocene. The lower AABW influx during the middle Miocene was most likely caused by the inferred warmer climate and more sluggish ocean circulation at that time. Modelling of the marine residence time (RT) of Os shows a minimum RT of ~8kyrs for the middle Miocene, but there is no evidence to suggest that the Miocene RT was significantly different than the best estimates for the present day RT of 20-50kyrs [2-3].

The Tl isotope record obtained for the Indian Ocean crust strongly resembles those recently obtained for the Pacific Ocean [4] and we conclude that the global ocean has remained homogenous for Tl isotopes over the last 15Myrs. During the last ~8Myrs, the Indian and Pacific Oceans have recorded a small Tl isotope increase, which was most likely caused by a change in the ratio of the two output fluxes (scavenging by authigenic phases of pelagic clays and uptake of Tl during low temperature alteration of oceanic crust) of ~30%. This shift is consistent with an equivalent synchronous increase in ocean crust production inferred by recent reconstructions of seafloor spreading rates [4-5]. However, because of the lack of consensus among estimates of past ocean crust production this connection is tentative.

[1] Frank *et al*, *GCA*, 1999; [2] Levasseur *et al*, *EPSL*, 1999; [3] Sharma *et al*, *GCA*, 2007; [4] Cogne & Humler, *GGG*, 2006; [5] Kaiho & Saito, *Terra Nova*, 1994

Biogeochemical signatures of the anaerobic methane oxidation in a south alpine lake (Lake Lugano)

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High amounts of biogenic methane are produced in anoxic fresh water systems, which significantly contribute to the atmospheric methane budget. In the present study, we combined biogeochemical, lipid biomarker and stable carbon isotope analyses to investigate potential modes of methanotrophy in the water column of the northern basin of Lake Lugano. This basin features a meromictic mixing behaviour with a permanent anoxic hypolimnion (90 – 286 m water depth) and bottom water methane concentrations of about 50 µM. However, methane concentrations decrease exponentially to < 5 µM at 200 m water depth, in association with a pronounced ¹³C enrichment within the residual methane pool. Our data provide conclusive evidence for an anaerobic mode of methane oxidation (AOM) in the water column of Lake Lugano. This was further substantiated by the dominance of monoenoic fatty acids in bottom waters with δ¹³C-values as low as -94‰ (C16:1ω6), indicating the incorporation of methane-derived carbon into bacterial biomass well below the redoxcline. Surprisingly, no compounds typically associated with anaerobic methanotrophic archaea (e.g. archaeol) could be detected, suggesting that archaea are not involved in AOM in Lake Lugano. The identity of the terminal electron acceptor for AOM in Lake Lugano needs further evaluation, yet sulphate appears to be an unlikely candidate. A relatively small fraction of the total methane is consumed by aerobic methanotrophic bacteria (possibly type I) at the oxycline. Nevertheless, methane concentrations in mixed surface waters were supersaturated with respect to the atmospheric equilibrium, pointing to a methane efflux to the atmosphere.