

Late Cretaceous Evolution of Southern Hemisphere Seawater Neodymium Isotope Composition

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Background

The predominant source of dissolved Nd to the oceans is the weathering and drainage of subaerially exposed terranes. Nd has become a commonly used tracer of water mass provenance (and hence deep-water circulation patterns) because water masses essentially form with the Nd isotopic signature of the weathering inputs in the region of formation. However, temporal variations in the isotopic composition of the water mass may result from changes in the composition of the weathering inputs.

Studies of modern river dissolved and particulate Nd isotopic composition indicate that fine fraction sediments record the same isotopic signature as the dissolved inventory [1]. Thus, we can reconstruct changes of Nd inputs to a given ocean basin through analysis of the detrital sediments in conjunction with the seawater composition. Here we apply this strategy to reconstruct the history of deep-water formation from 8 sites in the Indian and Atlantic sectors of the Southern Ocean during the Late Cretaceous.

Late Cretaceous Reconstructions

During the Cenomanian to early Campanian, the South Atlantic was divided into several distinct basins [2]. Previous work demonstrated that deep-water production in the Southern Ocean became the primary source of deep water in the South Atlantic during the early Campanian [2]. New seawater and detrital Nd isotope data from DSDP Sites 361, 511, 530 and 690 help constrain the timing of the subsidence of deep water gateways. By 75 Ma all sites in the South Atlantic shared a common water mass.

New data from Indian Ocean ODP Sites 763, 765, 766 and 1138 suggest that variations in the composition of weathering inputs controlled the overall evolution of proto-Indian Ocean water mass composition. Such variations were driven by the emplacement and subsidence of the Kerguelen Plateau and Broken Ridge during the Late Cretaceous. Weathering of subaerially exposed portions of these terranes caused Indian Ocean seawater Nd isotope values to increase, coincident with the peak of the mid-Cretaceous warmth. As the LIPs subsided below sea level, the input of radiogenic weathering products diminished and the isotopic composition of intermediate and deep waters in the region decreased, reflecting the weathering inputs from older terranes. The Indian Ocean sites extend the record of high-latitude deep-water formation back into the Early Cretaceous, prior to the onset of the mid-Cretaceous peak warmth. The growing body of data supports a mode of MOC in part characterized by high-latitude downwelling during the peak of greenhouse warmth of the Mesozoic.

[1] Goldstein and Jacobsen (1988) *Earth Planet. Sci. Lett.* **87**, 249-265.

[2] Robinson et al. (2010) *Geology* **38**, 871-874.

Probing the effects of organic ligands on mercury biouptake

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Introduction

Methylation of mercury (Hg) only occurs after Hg has passed through the bacterial cell membrane [1]; therefore, understanding the mechanisms of Hg biouptake is essential to gain insight into the fate of Hg in the environment. Hg has a strong affinity for organic ligands, which influence Hg speciation and subsequently its transport across the bacterial cell membrane. The relationship between Hg complexation in aquatic systems and its biouptake remains poorly understood, partially due to the difficulty of directly measuring intracellular Hg. One approach for monitoring the biouptake of Hg is to use a luminescent whole-cell biosensor [2]. In this study, we employed a chromosomally-based biosensor to examine the effects of various organic ligands (*e.g.*, EDTA, NTA and three thiol-containing ligands) on Hg uptake by bacteria in presence of 50nM of Hg.

Main results

In the presence of EDTA and NTA, we observed a slight increase in Hg biouptake. On the other hand, we found that biouptake of Hg in the presence of cysteine was highly dependant on the concentration of the ligand, consistent with the results of Schaefer & Morel [3]. From 0.1 to 10 μ M of cysteine, we observed a significant increase in Hg biouptake while 100 and 1000 μ M of cysteine resulted in a dramatic drop in biosensor signal. Both glutathione and penicillamine enhanced Hg biouptake when they were present at low concentrations, with the lowest concentration (0.1 μ M) leading to the highest biosensor signal. As their concentration reached a certain threshold (10 μ M for glutathione and 100 μ M for penicillamine), Hg uptake was severely inhibited.

We calculated the chemical speciation of Hg in the exposure medium using ChemEQL with thermodynamic constants selected from the JESS database [4]. Results show that in most instances Hg was predominantly complexed by the added organic ligands, indicating that Hg-ligand complexes contribute to Hg biouptake.

Significance

This study suggests that Hg biouptake can be promoted by the presence of organic ligands in solution. Our results parallel the findings from Hg biomethylation experiments, indicating a promising application of biosensor for studying Hg biouptake.

[1] Benoit, Gilmour & Mason (1999) *Environ Sci Technol* **35**, 127-132. [2] Dahl, Sanseverino & Gaillard (2011) *Environ Chemistry* **8**, 552-560. [3] Schaefer & Morel (2009) *Nat Geosci* **2**, 123-126. [4] http://jess.murdoch.edu.au/jess_home.htm.