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Scientific Merit of Measuring Silicon Isotopes on the US GEOTRACES Pacific Sections

Silicon isotopes arguably are among the most informative of the paleo-nutrient proxies. By combining indices of the relative depletion of surface silicic acid using diatom δ^{30}Si (De La Rocha *et al.*, 1997) with assessments of the silicic acid content of source waters fueling surface production using the δ^{30}Si of sponge spicules (Hendry *et al.*, 2010) estimates of absolute silica production rates can be reconstructed. The promise of obtaining absolute production rates from sedimentary records is unique to Si isotopes and is not currently possible for other nutrient proxies. Realizing this promise requires understanding of the processes controlling Si isotope distributions in the modern ocean to verify the assumptions underlying application of the δ^{30}Si proxies.

The Peru-Tahiti and meridional GEOTRACES sections offer an opportunity to 1) access how Si and N isotope dynamics are coupled in a low Si-HNLC region outside of the Southern Ocean, 2) examine whether hydrothermal inputs affect deep water δ^{30}Si distributions and 3) assess fundamental mechanisms controlling Si isotope distributions at the basin scale. These goals can be accomplished by measuring profiles of $\delta^{30}Si(OH)_4$ on water samples from the super stations on both sections.

1) Comparison of the concentration of nitrate and silicic acid in the surface waters across the Peru shelf show high concentrations of both nutrients in upwelled waters followed by the preferential depletion of silicic acid by phytoplankton resulting in a low-Si HNLC condition (Dugdale *et al.*, 1995)likely as the result of Fe stress (Hutchins et al, 2002). The preferential depletion of silicic acid over nitrate is apparent in the upper 100 m nearly all the way to Tahiti along the proposed section. This decoupling of N and Si dynamics has been observed in the low Fe HNLC waters of the Southern Ocean (Coale *et al.*, 2004; Franck *et al.*, 2000) leading radically different N and Si isotope dynamics in SO surface waters (Varela et al. 2004) and in SO paleorecords (Brzezinski et al. 2002). These contrasting dynamics resulted in the Silicic Acid Leakage Hypothesis with strong implications for paleo- nutrient dynamics and climate (Brzezinski *et al.*, 2002; Matsumoto *et al.*, 2002; Sarmiento et al. 2004). Understanding Si and N isotope dynamics in a low-Si HNLC system outside of the Southern Ocean will further aid in understanding the role of silicic acid and Fe supply in setting limits on ocean productivity.
2) The Peru-Tahiti section also intersects the hydrothermal plumes of the east Pacific rise. Hydrothermal waters are known to have unique $\delta^{30}Si(OH)_4$ values (-0.3 ‰; De La Rocha *et al.*, 2000) compared to deep waters (+1.0 - +1.4 ‰) such that their input may alter local Si isotope distributions.
3) Both proposed sections are ideal for improving our understanding of the processes controlling the first order distribution of Si isotopes at ocean basin scales. Numerical simulations of $\delta^{30}Si(OH)_4$ distributions suggest that the coupling of the biological pump and the meridional overturning circulation (MOC) creates predictable and unique $\delta^{30}Si(OH)_4$ signatures among major ocean basins and water masses. However, many existing measurements of $\delta^{30}Si(OH)_4$ refute model predictions. For example, recent modeling efforts by Reynolds (2009) and others predict a decrease in $\delta^{30}Si(OH)_4$ in deep waters (>2,500 m) along the flow path of the MOC, but measured deep-water $\delta^{30}Si(OH)_4$ values actually increase rather than decrease with increasing $[Si(OH)_4]$ between the Southern Ocean and the Northeast Pacific (Beucher *et al.*, 2008). A hypothesis that explains these results is that the northwest Pacific $Si(OH)_4$ plume (Johnson *et al.*, 2006) exerts a major influence on regional Si isotope distributions. The plume is sustained by a flux of $Si(OH)_4$ of 1.5 Tmol Si a^{-1} from the sediments of the NE Pacific. That efflux is equivalent to nearly a third of the Si supplied to the ocean by the rivers significantly enhancing $[Si(OH)_4]$, and presumable affecting $\delta^{30}Si(OH)_4$, to as far west as 180°E and to as far south as Tahiti (Johnson et al. 2006).

Thus the two U.S. GEOTRACES Pacific sections are well positioned to test hypotheses related to the influence of this feature on basin-scale $\delta^{30}Si(OH)_4$ distributions in the north Pacific.

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