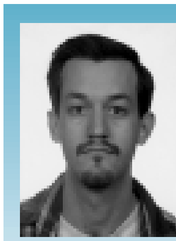
ZINC IN BENTHIC FORAMINIFERA: A NEW PALEOCEANOGRAPHIC TRACER?



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I am investigating ratios of zinc to calcium in benthic foraminifera shells as a potential paleotracer of deep-water circulation. Foraminiferal carbon isotopic values and cadmium-to-calcium ratios are currently used as proxies to infer the past distribution and circulation of deep-water masses, but additional tracers are needed because each has its own particular strengths and weaknesses. A multi-proxy approach offers the best means of unambiguously deciphering the geologic record.

Zinc shows promise as a paleotracer because its dissolved profile in the modern ocean is nutrient-like, with near-zero concentrations in surface waters and maximum values below 1000 m (Bruland *et al.*, 1978). Dissolved Zn closely covaries with dissolved silica, probably because both have similar rates and sites of uptake and regeneration. Deep-water formation and circulation create gradients of Zn and Si in the abyssal ocean. There is a particularly large (~sixfold) increase in Zn between the North Atlantic and Southern Ocean. This difference is much larger than the corresponding Cd gradient, and suggests that Zn may be a sensitive tracer of the interactions between Antarctic Bottom Water and North Atlantic Deep Water.

First, I calibrated the zinc chemistry of bottom waters to foraminifera in the surface sediments. I measured Zn/Ca and Cd/Ca in 29 Holocene coretops (>1500 m depth; including seven DSDP and ODP cores) and compared the results to modern concentrations of Zn in bottom waters. The Zn was estimated from nearby hydrographic stations (GEOSECS) from the Si data and the Zn:Si relationship ($r^2 = 0.98$) below 1000 m. The results from *Cibicidoides wuellerstorfi* and *Uvigerina* spp. are shown in Figure 1A. The Zn/Ca data correlate well with predicted [Zn] ($r^2 = 0.73$), indicating that these two taxa record bottom-water [Zn].

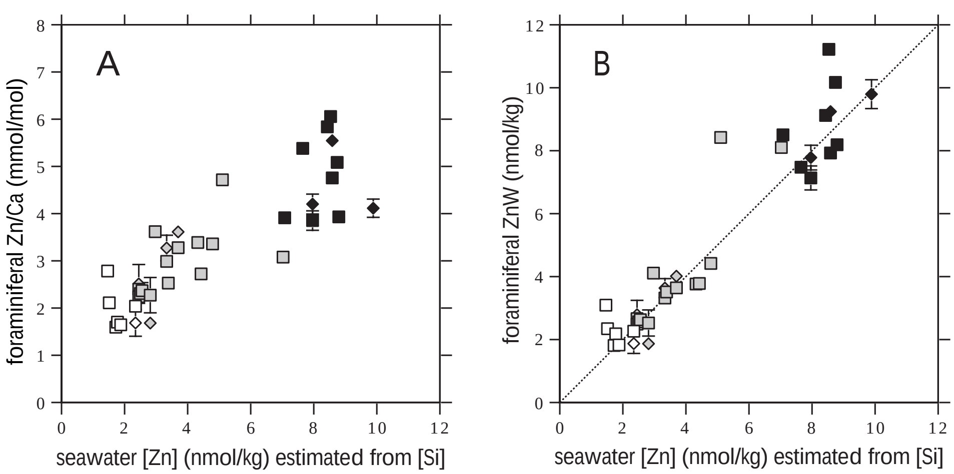
Note, however, that some data fall below the trend suggested by the Atlantic cores. This pattern may be explained by decreased apparent Zn distribution coefficients (D_{Zn}=[Zn/Ca]$_{foram}$/[Zn/Ca]$_{water}$) in waters undersaturated with respect to calcite—an effect that has been observed previously for Cd, Ba, and Sr (McCorkle et al., 1995). Apparent D_{Zn} is strongly correlated with saturation (ΔCO_3) below ~20 µmol mol^{-1} ΔCO_3. These data reflect a simple relationship, allowing me to predict seawater [Zn] (ZnW) from foraminiferal Zn/Ca and seawater ΔCO_3. The resulting foraminiferal ZnW values correlate very well with predicted seawater [Zn] ($r^2 = 0.90$; Figure 1B, confirming that *C. wuellerstorfi* and *Uvigerina* spp. precisely record bottom-water [Zn]. Because calcite undersaturation seems to affect D_{Zn} differently than D_{Cd}, there is hope of using Zn/Ca and Cd/Ca together to deconvolve circulation and apparent ΔCO_3 changes.

Next, I will generate downcore records, from the Holocene to the last glacial maximum (~22 ka) of Zn/Ca and Cd/Ca in the eastern equatorial Pacific (ODP Site 849) and in the South Atlantic.

REFERENCES:

Bruland, K. W., Knauer, G. A., and Martin, J. H., 1978. Zinc in northeast Pacific water. *Nature*, 271: 741-743.

McCorkle, D. C., Martin, P. A., Lea, D. W., and Klinkhammer, G. P., 1995. Evidence of a dissolution effect on benthic foraminiferal shell chemistry: $\delta^{13}C$, Cd/Ca, Ba/Ca, and Sr/Ca results from the Ontong Java Plateau. *Paleoceanography*, 10: 699-714.



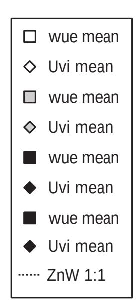


Fig. 1: A) Coretop calibration of Holocene benthic foraminifera *C. wuellerstorfi* (squares) and *Uvigerina* spp. (diamonds) Zn/Ca versus dissolved Zn concentrations in bottom water estimated from Si data. Values increase from the North Atlantic (open symbols), through the tropical and South Atlantic (shaded), and into the Indian and Pacific (filled). B) Bottom water Zn concentrations derived from coretop benthic foraminifera (ZnW) vs. Zn concentrations estimated from Si data. Symbols are as in (A). Dotted line is the 1:1 line.