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Strontium and Lithium in planktic foraminiferal shells: a new tracer for surface ocean carbon concentration?

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The oceans are a major carbon reservoir, and the state of carbon in the ocean is a focus of paleoclimate research. Numerous trace elements and isotopes in foraminifera have been proposed as tracers for past ocean carbon chemistry. For example, boron isotopes provide a particularly useful archive of past ocean pH. However, estimating the state of ocean and atmospheric carbon requires knowledge of a second carbon system parameter, such as dissolved inorganic carbon (DIC) concentration or total alkalinity (TA). This second parameter is often constrained from first-order observations of the ocean system (e.g. carbonate compensation depth, CCD) derived from models, or assumed to be approximately constant through the Cenozoic ([1]). Proxies that directly constrain on DIC or TA are lacking. This is, in part, due to the highly correlated nature of the seawater carbon system, which makes it difficult to establish causal relationships between foraminiferal geochemistry and a single parameter of the carbon system.

Here, we present Sr/Ca and Li/Ca from planktic foraminifera (*Orbulina universa*) cultured under conditions designed to decouple seawater carbon chemistry. This method allows us to separate the influences of pH, carbonate ions (CO32-) concentration, and DIC concentration, providing a robust dataset for assessing proxies for past ocean carbon chemistry.

We show that Sr/Ca is strongly positively correlated with DIC concentration, while Li/Ca is strongly negatively correlated with DIC concentration. Both elements also show a consistently weak (non-significant) relationship with pH and CO32- concentration. Consequently, the Sr/Li ratio of foraminifera is linearly correlated with DIC concentration. This relationship is also observed in another planktic species (*Trilobatus sacculifer*) in previously published data ([2]), but not in benthic species.

We evaluate the use of planktic foraminiferal Sr/Li as a potential proxy for surface ocean DIC concentration, and apply it through the Cenozoic.

[1] Rae, Zhang, Liu, Foster, Stoll & Whiteford (2021). Annual Review of Earth and Planetary Sciences 49, 609-641.
[2] Allen, Hönisch, Eggins, Haynes, Rosenthal & Yu (2016). Geochimica et Cosmochimica Acta 193, 197-221.