The Phanerozoic record of global temperatures and sea water $\delta^{18}O$ as recorded by marine phosphates

A.R. WALDECK[1,2] AND A.S. COLMAN[1,*]

[1]Dept. of the Geophysical Sciences, University of Chicago, Chicago, IL 60637, USA (*asc25@uchicago.edu)

[2]Dept. of Earth and Planetary Sciences, Harvard University, Cambridge, MA 02138 (waldeck@g.harvard.edu)

Stable isotope-based climate reconstructions spanning the Phanerozoic are controversial. Low $\delta^{18}O$ values in well-preserved carbonate shells and limestones suggest (a) Cambrian temperatures could have been ca. 30°C warmer than today if sea water $\delta^{18}O$ was similar to modern, or (b) temperatures were similar to today, but sea water $\delta^{18}O$ values were 6 to 8 ‰ lighter. Both explanations are contested, and it has been argued that the oxygen isotope compositions of carbonates have been increasingly altered through time, and are unreliable as a proxy for ancient environments.

Phosphate $\delta^{18}O$ values are generally thought to be more resistant to diagenetic alteration than carbonates. We have compiled over 2500 published phosphate $\delta^{18}O$ measurements on marine phosphatic fossils spanning the Phanerozoic. These include measurements on conodonts, shark teeth, inarticulate brachiopods, and phosphorites. We address variations in measurement technique and standards over the past four decades in assembling this data set. We compare analyses of each category of phosphatic record against the overall composite trend, examining the preservation potential for each material and the environment in which mineralization originally took place (e.g., upper water column vs. benthic vs. early diagenetic environments).

We have extended the record to the early Cambrian with measurements on phosphatic fossils known as small shelly fossils (SSF). SSFs from several regions were sampled and analyzed: (1) the Pioche Formation, Nevada, United States; (2) the Dengying Formation, Shaanxi Province, China; and (3) the Bayan Gol Formation, Orolgiin Gorge, Mongolia.

The overall phosphate $\delta^{18}O$ record, including that from well-preserved SSF, is very similar to the Phanerozoic record from well preserved carbonates compiled in Veizer et al. (1999) and Veizer and Prokoph (2015). The record of a secular trend in both phosphate and carbonate $\delta^{18}O$ from Cambrian to present is robust. We compare these records, carbonate Δ_{47} measurements, and geologic evidence for intervals of major continental glaciation, concluding that the secular trend is mainly the result of a significant shift in sea water $\delta^{18}O$ rather than much warmer temperatures in the Cambrian than at present or diagenetic alteration.