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Measuring oxygen lattice diffusion in biominerals – Implications for paleotemperature reconstructions

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Biomineral oxygen isotope compositions provide the longest continuous proxy record of paleoseawater temperatures from the Mesozoic to the present. The reliability of this record has been improved by only selecting visually pristine biominerals that show no evidence of dissolution, precipitation, or recrystallization, and therefore are presumed to preserve their original oxygen isotopic composition. In recent years, however, it has become evident[1–4] that the isotopic compositions of visually pristine calcitic biominerals, in particular foraminifera tests, may not necessarily provide unbiased paleotemperatures due to low-temperature oxygen solid-state diffusion. Due to the difficulty in calculating accurate diffusion coefficients in (bio)minerals at low temperatures, the extent of this effect on the paleotemperature record has not yet been fully assessed but has been hypothesized to be substantial even at ambient ocean burial conditions[1].

To constrain the controls on lattice diffusion in biominerals, and to extrapolate lattice diffusion coefficients to the low temperatures encountered during the shallow burial history of most biominerals, we performed oxygen isotope exchange experiments on modern foraminifera tests and other fossilized biominerals at temperatures from 30 to 300 °C. Preliminary results suggest that oxygen lattice diffusion rates in biominerals appear to be influenced by the amount, distribution, and types of inter- and intracrystalline organic molecules distributed throughout the biomineral structure[2]. However, even when the organic matter is removed through roasting or oxidation, calculated diffusion rates in biominerals still exceed rates measured in abiotic minerals by orders of magnitude. Using the diffusion rates calculated from our experiments, we model the potential outcomes of oxygen lattice diffusion on various biominerals following burial at low temperatures and pressures over millions of years.

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[2] Cisneros-Lazaro, Adams, Guo, Bernard, Baumgartner, Daval, Baronnet, Grauby, Vennemann, Stolarski, Escrig & Meibom (2022), *Nature Communications* 13, 113.

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[4] Harrison, Schott, Oelkers, Maher & Mavromatis (2022), *Geochimica et Cosmochimica Acta* 335, 369–382.