

Tracing vital effects in biogenic carbonates via triple oxygen isotope systematics

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Carbonate $\delta^{18}\text{O}$ and Δ_{47} are used to reconstruct paleotemperatures. Because biogenic carbonate does not form in full equilibrium with seawater, species-specific temperature calibration curves are required for accurate temperature estimates. Apparent growth temperatures derived from corals, however, are generally inaccurate due to large and variable kinetic isotope effects, often termed “vital effect”. Triple oxygen isotope systematics can help identify if an organism forms carbonate in equilibrium with ambient water or not and thus if the $\delta^{18}\text{O}$ and Δ_{47} values provide accurate paleotemperatures. In addition, the chemical nature of the “vital effect” can be identified, because individual kinetic effects fall on characteristic trajectories in triple oxygen isotope space.

To examine these concepts a series of cold water and warm water corals as well as brachiopods are analysed for $\delta^{18}\text{O}$ and $\delta^{17}\text{O}$ (expressed as $\Delta^{17}\text{O}$) using the CO_2 spectrometer (TILDAS; Aerodyne Research) installed in Göttingen. Samples formed in equilibrium are expected to fall on the equilibrium curve. Most samples fall below the curve providing evidence that their oxygen isotope composition is biased by kinetic effects. We suggest that the “vital effect” in corals is dominated by a CO_2 absorption effect which seems to follow a different slope in triple oxygen isotope space than proposed in the literature.

Similar conclusions are derived from dual clumped (Δ_{47} and Δ_{48}) isotope analyses of the same samples [1]. These authors suggested to correct for kinetic effects by back extrapolation to the “dual clumped” equilibrium line. The same concept can be applied in triple oxygen isotope space by back-extrapolation to the “triple oxygen isotope” equilibrium line.

[1] Davies et al. (2022). *GCA* **338**, 66–78.