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Cryogenian postglacial climate revealed by dolomite triple oxygen isotopes

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Quantitative paleotemperature estimates from the Precambrian are rare due to the scarcity of well-preserved sediments and uncertainties about the isotope composition of ancient oceans. Carbonate triple oxygen isotope measurements ($^{17}O/^{16}O$ and $^{18}O/^{16}O$), however, can be used to overcome these challenges and estimate climate conditions in deep time [1].

In this study, we investigated interglacial carbonates from the Cryogenian Oodnaminta Reef Complex in Australia, deposited between the Sturtian and Marinoan Snowball Earth events. According to petrological and sedimentary analyses, dolomitization of originally aragonitic reef components occurred immediately after deposition, along with the precipitation of primary dolomite cements. Debris flow transported undolomitized blocks into deep water, where they were sealed off from seawater by mudstones, resisting further dolomitization. Later, post-depositional diagenesis recrystallised the limestones while dolomites resisted alteration and retained their original fabric [2].

The limestone samples do not fall on any reasonable triple oxygen isotope equilibrium curve. In contrast, the dolomite cements and reef components fit a range of curves that could represent equilibrium with ambient Neoproterozoic water. One endmember water composition that matches the samples has a $\delta^{18}O$ of −6‰ and a $\Delta'^{17}O$ of −11 ppm. This water composition is compatible with some seawater models [3, 4], but it could also result from the mixing of meteoric water and seawater. The other endmember has a $\delta^{18}O$ of -3‰, which is more in line with the theory of low-$\delta^{18}O$ oceans, yet it has a low $\Delta'^{17}O$ of −20 ppm, only found in modern oceans at very low depths.

If the triple oxygen isotope composition of all the analysed dolomite samples accurately reflects water temperatures, they indicate a range of approximately 30 °C, possibly reflective of an interglacial hothouse climate. Depending on the endmember water taken, the lowest temperature estimates are around 16 °C and 27 °C, respectively.

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