CLUMPED ISOTOPE EVIDENCE ON THE ORIGIN OF THE MARINOAN CAP DOLOSTONE

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PROJECT OBJECTIVES

- Examine whether reordered dolomite and calcite can preserve the primary oxygen isotopic composition of formation fluids.
- Decipher the formation process of the Marinoan cap dolostone (primary versus diagenetic origins).

PROJECT RATIONALE

The Marinoan cap dolostone (~635 Ma), directly overlying the glacial sediments, is thought to be globally distributed preserving critical climatic and oceanographic information on one of the most extreme climate events in Earth history. In terms of hydrological processes, there are two proposed models, "plumeworld" (Shields, 2005) and "early diagenetic systems" (Ahm et al., 2019). The key distinctions between these two models are the nature of formation fluids and their hydrological processes through the proximal to distal platform. The proposed "plumeworld" model witnesses the mixing of meltwater and seawater following the deglacial period. (Fig. 1A). In contrast, the cap dolostone in the platform margin and upper slope is characterized by fluid-buffered behavior approaching glacial seawater chemistry, while the diagenetic system gradually transfers to the sediment-buffered system preserving the meltwater signal in the inner platform. Correspondingly, the spatial perturbation of geochemical compositions (e.g., carbon, magnesium and calcium isotopes) is observed as a product of interactions by these binary diagenetic systems (fluid- and sediment-buffered) (Fig. 1B).

APPROACH

Natural samples: Samples were collected from five outcrops of cap carbonates located in South China and Namibia. In order to examine the two existing models, the distribution of collected samples ranges from the platform interior to the

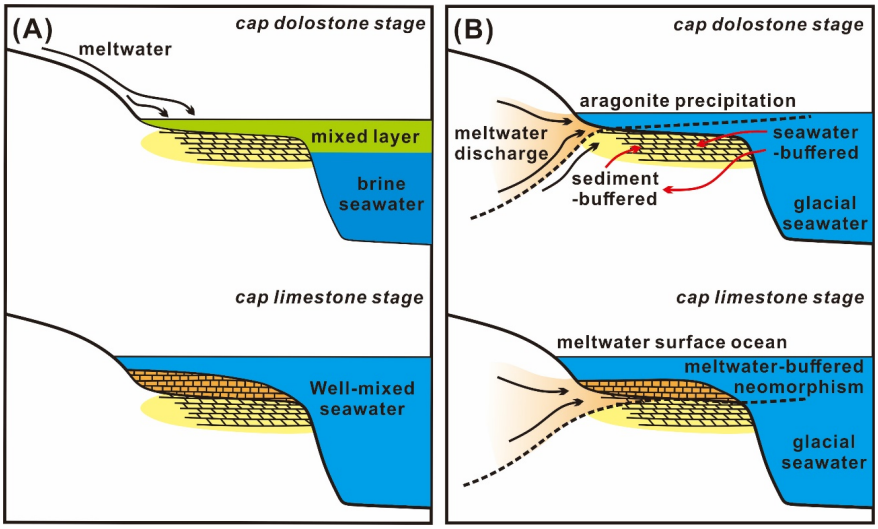

Figure 1: The cartoon graphs for two formation models of cap carbonates. (A) Mixing water-mass model. (B) Binary diagenetic system model.

platform margin. The cap carbonate includes calcite and dolomite minerals, which can be used to decipher whether the alteration is attributed to recrystallization or to solid-state reordering (Lu et al., 2023).

Heating experiments: In order to decipher the solid-state reordering process of clumped isotopes, we performed heating experiments with two dolomites, Bahamas marine dolomite and a dolomite standard (NIST-88b), and compared these data with published data from a hydrothermal dolomite (Lloyd et al., 2018) (Fig. 2). The measured Δ_{47}-temperatures and $\delta^{18}O_{fluid}$ values (calculated by Δ_{47}-temperatures and $\delta^{18}O_{carb}$ values) can illustrate the evolving process deviating from the original composition during solid-state reordering. The comparison of these evolving patterns between natural and heated samples can examine the origin of alteration in cap carbonates as well as tracing the nature of dolomitizing fluids.

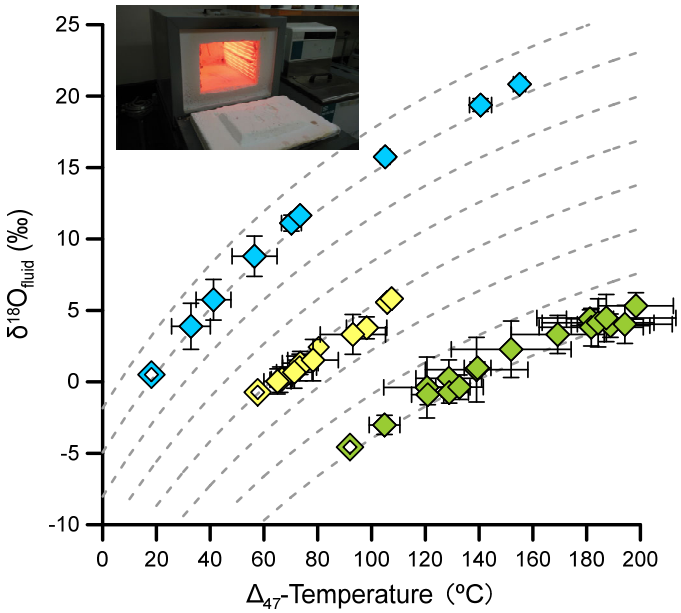

Figure 2: The reordering trajectories simulated by heating experiments for three dolomites. Bahamian dolomites shown in blue. The dolomite standard (NIST-88b in yellow) is from the National Institute of Standards and Technology. The hydrothermal dolomite (green) as reported by Lloyd et al. (2018). The hollow and solid rhombs represent the unheated and heated dolomites, respectively.

SIGNIFICANCE

Our findings will demonstrate the usefulness of the reordered clumped isotopes as a fluid tracer in deep time successions and offers an insight into the enigmatic origin of cap carbonates.

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