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Constraining the Shuram $\delta^{13}C$ Excursion with the $\delta^{44/40}Ca$ – $\delta^{88/86}Sr$ multi-proxy

NILOU LILLY SARVIAN[1], ANDREW D JACOBSON[1], TIA CHUNG-SWANSON[1], MATTHEW HURTGEN[1], MAGDALENA R OSBURN[1] AND KRISTIN BERGMANN[2]

[1]Northwestern University

[2]Massachusetts Institute of Technology

Presenting Author: nilou@earth.northwestern.edu

The Shuram Excursion is the largest negative carbon isotope excursion (CIE) in Earth's history. Major questions surround whether the CIE resulted from primary or secondary processes, and whether those processes were local, global, or some combination thereof [1,2]. We address these questions by employing the novel $\delta^{44/40}Ca$-$\delta^{88/86}Sr$ multi-proxy, which is sensitive to variable mass-dependent isotope fractionation, fluid buffered early diagenesis, and temporal shifts in the isotopic composition of seawater due to end-member mixing.

Utilizing high-precision TIMS techniques, we apply the multi-proxy to the Shuram CIE recorded in carbonate rocks of the Huqf Supergroup, Oman, which was deposited ~574 – 567 Ma [3]. Minerology varies by unit and includes primary aragonite that has neomorphized to calcite, primary calcite, and very early dolomite. We analyzed 30 samples spanning the Khufai, Shuram, and Buah formations. Recrystallized aragonites show lower $\delta^{44/40}Ca$ and higher $\delta^{88/86}Sr$, whereas calcites and dolomites show higher $\delta^{44/40}Ca$ and lower $\delta^{88/86}Sr$. Calcites from the nadir of the CIE display among the lowest $\delta^{88/86}Sr$, as well as the highest $^{87}Sr/^{86}Sr$. The trend between $\delta^{44/40}Ca$ and mineralogy appears to fit a diagenetic model where aragonite transforms to calcite and dolomite in the presence of seawater. However, such a model does not explain the complementary $\delta^{88/86}Sr$ trend. No evidence suggests aragonite could initially incorporate heavier Sr isotopes, nor does a mechanism exist to decrease $\delta^{88/86}Sr$ through fluid-buffered alteration, as carbonates are well-understood to lose Sr during diagenetic transformation. Carbonates kinetically incorporate lighter Ca and Sr isotopes. Therefore, application of kinetic mass-fractionation laws points to a rapid decrease in seawater $\delta^{88/86}Sr$ during the Shuram CIE, which appears superimposed on a longer-term increase in $\delta^{88/86}Sr$ up-section. End-Ediacaran seawater likely had high $\delta^{88/86}Sr$ [4], whereas continental runoff has low $\delta^{88/86}Sr$ [5]. Our initial results raise the possibility that seawater-freshwater mixing was a characteristic of this near shore setting, consistent with observations that the onset of the Shuram CIE coincides with a major marine transgression [6].

[1] Busch et al., 2022 [2] Geyman and Maloof, 2019 [3] Rooney et al., 2020 [4] Sawaki et al., 2010 [5] Vollstaedt et al., 2014 [6] Osburn et al., 2013