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High-Resolution Analysis of Dolomite Cation Ordering and Stoichiometry in the Upper Ediacaran Dengying Formation, South China

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Dolomite cation ordering and stoichiometry serve as important proxies for formation conditions, yet high-resolution data from Precambrian dolomites remain limited. This study investigates the crystallographic and geochemical characteristics of Upper Ediacaran dolomites (551–541 Ma) from the Dengying Formation in the Sichuan Basin, South China. We analyzed 442 dolomite samples from three stratigraphic sections (Hujiaba, Yangba, and Wuxi), representing microbial dolomite, sand-bearing dolomite, crystalline dolomite, and silicified dolomite.

Powder X-ray diffraction (XRD) analyses reveal distinct variations in cation ordering (S) and stoichiometry across dolomite types. Kernel density analysis of cation ordering exhibits a "single peak with two shoulders" distribution pattern, reflecting contributions from microbial dolomite (S=0.65), silicified dolomite (S=0.75), and sand-bearing dolomite (S=0.53). Stoichiometry is primarily concentrated within 46–54% $MgCO_3$, with lower-Mg dolomites (43–45% $MgCO_3$) occurring in sand-bearing facies. Correlations with carbon and oxygen isotopes, trace elements, and Sr isotope compositions indicate that diagenetic alteration played a major role in shaping these variations. Elevated $^{87}Sr/^{86}Sr$ ratios and depleted $\delta^{18}O$ values suggest interaction with fluids sourced from continental-granitic lithologies.

Our findings provide the first high-resolution dataset on dolomite crystallographic attributes from upper Ediacaran dolomites and highlight cation ordering as a more reliable proxy for microbial activity than stoichiometry. Additionally, we demonstrate that diagenetic processes significantly influence dolomite characteristics, even in deep and ancient carbonate systems. These results offer new perspectives on the geochemical evolution of dolomitization and its implications for reconstructing Precambrian environmental conditions.