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Earths Mg-Ca Cycles Trace the Mesozoic–Cenozoic Reorganization of The Carbonate Factory and Climate

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Magnesium ($\delta^{26}Mg$) and calcium ($\delta^{44}Ca$) isotopes in seawater provide an integrative view of how carbonate burial, silicate weathering, clay formation, and hydrothermal exchange reshape ocean chemistry over geologic time. Yet existing reconstructions differ in both magnitude and long-term evolution across proxy archives. Here we present new $\delta^{26}Mg$ and $\delta^{44}Ca$ data from dolomites (n=760) spanning the Mesozoic through the present, combined with a compilation of published dolomite data (n=589). We focus on dolomites interpreted to have formed under fluid buffered conditions, where dolomite records parent fluid chemistry with relatively consistent fractionation, reducing sensitivity to local environmental variability.

Despite variability within individual stratigraphic intervals, dolomite compositions define a coherent long term trajectory in which $\delta^{26}Mg$ became progressively lighter while $\delta^{44}Ca$ became progressively heavier, producing a persistent negative covariance through time. Using fractionation factors calibrated from youngerw, seawater derived dolomites, we translate this archive into a coupled history of seawater $\delta^{26}Mg$ and $\delta^{44}Ca$ composition.

To interpret these coupled trends, we use an ocean box model that tracks magnesium, calcium, and strontium isotope budgets while exploring first order changes in global boundary conditions. Model results link the Mesozoic to Cenozoic reorganization of the carbonate factory and climate to secular changes in Earth's magnesium and calcium cycles. This work demonstrates that carefully screened diagenetic dolomite can provide a powerful constraint on seawater chemistry through deep time.