

Dissolved silica-catalyzed disordered dolomite precipitation

YIHANG FANG^{1,†} AND HUIFANG XU^{1,*}

¹NASA Astrobiology Institute, Department of Geoscience, University of Wisconsin–Madison, 1215 West Dayton Street, Madison, Wisconsin 53706, U.S.A.

ABSTRACT

There is a great abundance of sedimentary dolomite in the Proterozoic and Lower Paleozoic, but examples of primary dolomite are scarce in the Cenozoic. This discrepancy suggests a poorly understood but dramatic shift in the geochemical system that inhibited dolomite formation. Previous research on microbial-mediated dolomite formation demonstrated that microbial activity could promote disordered dolomite precipitation through the catalytic role of polysaccharides. However, the microbial-mediated model cannot explain some of the Precambrian dolomite for which there is no evidence of microbial origin. Here, we present an abiotic mechanism with dissolved silica catalyzed dolomite precipitation that provides new insight into this long-lasting “dolomite problem.” In this study, we demonstrate that the presence of 1–2 mM of aqueous $\text{Si}(\text{OH})_4$ in high Mg:Ca ratio solutions at room temperature will promote disordered dolomite precipitation (with up to 48.7 mol% MgCO_3) and inhibit aragonite formation. Dissolved silica in solution also promotes Mg incorporation into the Ca-Mg carbonates. Dissolved silica possesses low-dipole moment and dielectric constant similar to hydrogen sulfide, dioxane, polysaccharide, and exopolymeric substances (EPS), which are catalysts in previously established room-temperature dolomite synthesis. The molecules with low-dipole moment adsorbed on the dolomite surface can lower the dehydration energy barrier of a surface Mg^{2+} -water complex and promote dolomite nucleation and growth. This study provides a new model for abiotic sedimentary dolomite formation, which is likely to be responsible for the significant amount of primary dolomite in Earth history.

Keywords: Disordered dolomite, dolomite problem, sedimentary dolomite, dissolved silica