Sr Isotopic Fractionation During Calcite Precipitation and Crystal Growth

ANDREW W. KNIGHT[1], JACOB A. HARVEY[2], ANASTASIA G. ILGEN[2]

[1]Storage and Transportation, Sandia National Laboratories, Albuquerque, NM 87123, aknigh@sandia.gov
[2] Geochemistry, Sandia National Laboratories, Albuquerque, NM 87123, jharve@sandia.gov
[3]Geochemistry, Sandia National Laboratories, Albuquerque, NM 87123, agilgen@sandia.gov

Carbonate minerals are abundant phases in the environment. Specifically, calcite (calcium carbonate) is a dynamic phase that readily dissolves and precipitates in response to changing conditions. Exogenous cations incorporate into calcite during precipitation can act as tracers for various environmental processes, most commonly Mg^{2+} and Sr^{2+} cations are incorporated are due to their similar chemistries to Ca^{2+}. The Sr/Ca ratio and Sr isotopic fractionation are one of the most useful tracers to identify specific geochemical processes regarding the chemical environment of calcite formation. Although Sr isotopic fractionation can provide valuable information, its incorporation and fractionation processes are not well understood, and few studies have investigated Sr isotopic fractionation during calcite precipitation and crystal growth.

In this study, we systematically investigated Sr incorporation and isotopic fractionation by evaluating the changes in the $^{86/88}Sr$ and $^{87/86}Sr$ ratio prior to and following calcite precipitation and crystal growth, as well as the impact of aqueous Mg^{2+} on the system. In these studies, calcite was prepared by direct mixing of Na_2CO_3 and $CaCl_2$ with 0 - 5 mol% Sr^{2+} and 0 or 5 mol% Mg^{2+} in the system. These samples were allowed to equilibrate for 3 weeks with periodic sampling to assess the average particle size and evaluate the Sr/Ca ratio along with $^{88/86}Sr$ and $^{87/86}Sr$ ratios as a function of equilibration time. Our results demonstrate that Sr rapidly incorporates into calcite, and the $^{88/86}Sr$ and $^{87/86}Sr$ ratios are dependent upon the initial amount of Sr in the system. During the calcite crystal growth, the ratios $^{88/86}Sr$ and $^{87/86}Sr$ evolve and start approaching the ratio observed in natural calcite, demonstrating the transition to equilibrium through dissolution and reprecipitation of calcite. Additionally, the presence of Mg^{2+} and Sr^{2+} has an impact on the Sr/Ca ratio and crystal growth rates, but does not appear to alter the Sr isotopic ratios.

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