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Diffusion of Ca and Mg in calcite

DIANA K. FISLER* AND RANDALL T. CYGAN†

Geochemistry Department, Sandia National Laboratories, Albuquerque, New Mexico 87185-0750, U.S.A.

ABSTRACT

The self-diffusion of Ca and the tracer diffusion of Mg in calcite have been measured experimentally using isotopic tracers of ^{25}Mg and ^{44}Ca. Natural single crystals of calcite were coated with a thermally sputtered oxide thin film and then annealed in a CO_2 gas at 1 atm total pressure and temperatures from 550 to 800 °C. Diffusion coefficient values were derived from the depth profiles obtained by ion microprobe analysis. The resultant activation energies for Mg tracer diffusion and Ca self-diffusion are, respectively: E_a(Mg) = 284 ± 74 kJ/mol and E_a(Ca) = 271 ± 80 kJ/mol. For the temperature ranges in these experiments, the diffusion of Mg is faster than Ca. The results are generally consistent in magnitude with divalent cation diffusion rates obtained in previous studies, and provide a means of interpreting the thermal histories of carbonate minerals, the mechanism of dolomitization, and other diffusion-controlled processes. The results indicate that cation diffusion in calcite is relatively slow and cations are the rate-limiting diffusing species for the deformation of calcite and carbonate rocks. Application of the calcite-dolomite geothermometer to metamorphic assemblages will be constrained by cation diffusion and cooling rates. The direct measurement of Mg tracer diffusion in calcite indicates that dolomitization is unlikely to be accomplished by Mg diffusion in the solid state but by a recrystallization process.