Experimental investigation of the breakdown of dolomite in rock cores at 100 MPa, 650–750 °C

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ABSTRACT

The kinetics of the breakdown reaction dolomite = periclase + calcite + CO_2 were investigated using cores of dolomitic marble. Two samples of Reed Dolomite from southwestern Nevada were cut into cylinders approximately 4×6 mm in size. The cores were sealed in gold capsules with isotopically enriched water ($H_2^{18}O$ or $HD^{18}O_{0.5}^{16}O_{0.5}$). The samples were heated in a cold-seal hydrothermal apparatus to 650–750 °C at 100 MPa for durations ranging from 2–59 days. The cores were then sectioned and examined by EPMA, XRD, and SIMS techniques. All experiments showed some amount of reaction regardless of duration or temperature. Reaction products occurred mainly along grain boundaries, fractures within grains, and along sample edges. Ion images and isotope-ratio analysis indicated that reaction products exchanged with infiltrating fluids. Reaction rates were calculated from measured extents of reaction, which were determined from automated EPMA modes. At 700 °C, we measured reaction rates ranging from 3.8×10^{-14} to 2.3×10^{-12} mol/mm²·s. The extent of reaction is proportional to the square root of time, suggesting a diffusion-controlled process. A shrinking-core model for the dolomite breakdown reaction fits the grain-size data, suggesting that diffusion of H_2O and CO_2 through the mantle of reaction products controlled the rate. Apparent activation energies for that diffusion are ~283 ± 32 kJ/mol for coarse-grained samples and ~333 ± 36 kJ/mol for fine-grained samples. Initial reaction occurred relatively fast near the surface of dolomite grains, but continued diffusion through the reaction products ultimately controlled the rate of dolomite breakdown.

Keywords: Dolomite, kinetics, H_2O, CO_2