

The effect of thermal decarbonation on stable isotope compositions of carbonates

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ABSTRACT

Oxygen and C isotope compositions of CO₂ gas released by thermal decomposition of siderite, calcite, and dolomite were measured using a new “real-time” continuous-flow technique to determine whether fractionation associated with simple thermal decarbonation could explain the large isotopic variations and mineralogy such as those found in the ALH84001 meteorite.

Oxygen and C isotope fractionation between calcite or dolomite and evolved CO₂ gas during thermal decarbonation in a 3 bar He pressure environment is very small. The δ¹³C and δ¹⁸O values of evolved CO₂ gas are nearly identical to those of the carbonate, very different from the calculated equilibrium Δ¹⁸O_{calcite-CO₂ value of -4 to -5‰ at 800–900 °C or from previous experimental results of decarbonation in vacuum. The kinetic Δ¹⁸O_{siderite-CO₂ values are ~-2‰, whereas Δ¹³C_{siderite-CO₂ values increase logarithmically with time, from ~1‰ for the earliest stages of decarbonation to >5‰ in the final stages. Incomplete siderite decomposition produces both magnetite (δ¹⁸O = 3.5‰ SMOW) and minor graphite. CO and O₂ were detected during the decarbonation process. The data can be explained by simultaneous oxidation and reduction by the reaction:}}}



where x and y are between 0 and 1. Siderite decomposition in the presence of H₂ gas produces wüstite and Fe metal in place of oxidized Fe minerals.

The experiments in this study are not a perfect analog for possible decarbonation conditions that might have occurred to the carbonates in ALH84001. Nevertheless, the large δ¹³C and δ¹⁸O variations observed in ALH84001 (>10‰ for O) are significantly larger than those expected by thermal decarbonation, suggesting instead a low-temperature mechanism for their formation.