

Carbonate-silicate-metal reactions in the mantle

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Carbonates are important carbon-bearing phases in the mantle. While their role in upper mantle petrologic processes has been well studied, their importance in the lower mantle is less understood. The stability of carbonates in the lower mantle is greatly debated and depends on a host of factors including pressure, temperature, oxygen fugacity, and reactions with surrounding mantle phases. The stability of carbonates is additionally complicated at higher pressures by the change in coordination of carbon from triangular to tetrahedral. We performed X-ray diffraction experiments in the laser-heated diamond anvil cell on carbonate-metal and carbonate-silicate-metal reaction experiments on the Fe-Si-Ca-Mg-C-O system to 124 GPa and 3200 K to understand the stability of carbonates in the presence of lower mantle phases. We find that carbonates react with iron alloys and silicates to form silicates, oxides, iron carbides, and carbonatite melts. However, the temperature at which this reaction occurs increases with pressure, indicating that along a geotherm in the lowermost mantle, carbonates are the stable carbon-bearing phase, even in the presence of metallic iron that may be produced by disproportionation of Fe²⁺ in the lower mantle. Additionally, we find that the Mg endmember carbonate (MgCO₃) is more stable than the Ca endmember carbonate (CaCO₃) in the presence of silicon. Pairing X-ray diffraction results with EDS analysis on recovered samples and *ab initio* calculations, we evaluate the implications of carbonate reactions for the chemistry of carbon in Earth's mantle.