Deep Mantle Carbonate

Understanding the deep-mantle's role in the global carbon cycle requires measurements of the high pressure-temperature properties of carbon-bearing minerals. Dolomite—$CaMg(CO_3)_2$—is a major constituent of subducted carbonates, therefore its phase stability and equation of state at high pressures and temperatures is important to understanding Earth's deep carbon cycle. Previous experimental studies have shown that dolomite decomposes into magnesite plus aragonite at pressure-temperature conditions relevant to the Earth's upper mantle. As a result, dolomite is normally not considered a potential carrier to transport carbon to the Earth's deep interior.

However, dolomite's role in the mantle must be reconsidered following a recent study by Mao et al. [1]. They demonstrate that the addition of minor amounts of iron can stabilize dolomite carbonate in a series of polymorphs that are stable in the pressure and temperature conditions of subducting slabs, thereby providing a mechanism to carry carbonate into the deep mantle.

The researchers used synchrotron-based X-ray diffraction techniques in a laser-heated diamond anvil cell (up to 83 GPa and 1700 K) to study high-pressure and temperature dolomite polymorphs. They started with a natural Fe-bearing dolomite from Windham, Vermont with a composition of $Ca_{0.988}Mg_{0.918}Fe_{0.078}Mn_{0.016}(CO_3)_2$. They observed two phase transformations: 1) to dolomite-II at ~17GPa and 300K, and 2) to a new monoclinic phase (dolomite-III) between 36 and 83 GPa. Both high-pressure polymorphs were stable up to 1500 K, indicating that the addition of minor Fe stabilizes dolomite under the intense conditions akin to the deep mantle, suggesting Fe-dolomite as a vehicle for delivering carbon to Earth's deep interior. Additional experiments are required to determine the structure of dolomite-III, examine the potential effects of Fe substitution on the phase transitions, and determine the redox properties of Fe-bearing carbonate in Earth's mantle.

[1] Mao, Z., M. Armentrout, E. Rainey, C.E. Manning, P.K. Dera, V.B. Prakapenka, and A. Kavner (2011), **Dolomite III: A new candidate lower mantle carbonate**, *Geophys. Res. Lett.* **38**, L22303, doi: 10.1029/2011GL049519