Dolomite formation in abyssal peridotite

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Interactions of CO_2-rich aqueous fluids with mantle peridotite have major implications for geochemical budgets and microbial life in oceanic lithosphere through the formation of carbonate minerals and reduced carbon species. However, the underlying mechanisms controlling the transformation of CO_2 to carbonates and hydrocarbons in ultramafic-hosted hydrothermal systems remain incompletely understood.

We present an experimental study investigating carbonate formation pathways during hydrothermal alteration of peridotite under strongly reducing conditions. We reacted powdered harzburgite with a Ca-rich aqueous fluid at 300°C and 35 MPa for 1.7 years. We then injected a CO_2-rich fluid and allowed the system to react for 8 more months. Fluid speciation and mineral analyses suggest that serpentinization of harzburgite led to the precipitation of serpentine, brucite, magnetite, and calcite, in addition to other minor phases including chlorite and sulfur-poor Ni sulfides. Subsequent injection of a CO_2-rich fluid caused dolomite, Ca-dolomite and high-Mg calcite to form at the expense of olivine, calcite and brucite. Replacement textures with dolomite filling mesh centers and forming reaction rims over olivine are strikingly similar to those found in carbonate-altered serpentinites from Atlantis Massif (30°N, Mid-Atlantic Ridge).

Our experimental findings suggest that short-lived CO_2 injections in Ca-bearing serpentinization systems favor the early precipitation of dolomite. Prolonged exposure to $CO_{2(aq)}$-rich fluids is needed to form magnesite as suggested by results from reaction path modeling. Although magnesite formation is possible in hybrid mafic/ultramafic mid-ocean ridge environments, the short-lived supply of CO_2-rich fluids, e.g., due to magmatic degassing during diking events, likely limits magnesite formation. We conclude that dolomite precipitation is favorable even under strongly reducing conditions in subseafloor serpentinization systems, and may contribute to carbon uptake at slow- and ultraslow-spreading ocean ridges.