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Carbon mineralization in peridotite: Natural processes, global fluxes, the origin of life & closing the human carbon cycle

Outcrops in Oman, the seafloor, and elsewhere inspire study of alteration and weathering processes that combine atmospheric CO_2 with tectonically exhumed mantle peridotite to form solid carbonate minerals. The mantle is far from equilibrium with the atmosphere and near-surface fluids. Where plate tectonics brings peridotite close to the surface, this giant battery drives surprisingly rapid and extensive reactions that spontaneously form carbonates, while converting chemical potential energy to heat and work. Carbonation of mantle peridotite - during seafloor alteration, serpentinization at the outer rise, and mass transport into the “leading edge of the mantle wedge” above subduction zones - may be an important part of the global carbon cycle. Hydrous alteration of peridotite produces highly reduced fluids, due to oxidation of ferrous iron in mantle silicates to form ferric-iron-rich oxide minerals. These reduced fluids generate H_2 which, catalyzed by FeNi alloy, combines with CO_2 to form hydrocarbon species, in an abiotic synthesis process that may underlie the origin of life on this and other planets. Experiments at elevated temperature and pressure show the way toward one-thousand-fold to one-million-fold acceleration of carbon mineralization rates in peridotite, compared to CO_2 uptake during natural, near surface weathering. Engineered methods that emulate and accelerate natural processes hold the potential to capture and store trillions of tons of CO_2 on a human time scale.