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Enhancing CO_2 Mineralization in Ultramafic Systems: Flow-Through Experiments Using Simulated Seawater and CO_2 Injection

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The thermodynamic instability and reactive nature of terrestrial ultramafic rocks make them theoretically ideal sites for carbon storage. Extensive fracture networks facilitate the subsurface flow of meteoric water, ultimately leading to the precipitation of Mg and Ca carbonates. Enhancing the rate of these subsurface reactions via the injection of CO_2 rich fluids could provide a significant pathway for atmospheric CO_2 capture.

Mineral carbonation occurs through a complex set of water-gas-rock interactions requiring a substantial amount of water. Ocean water presents a promising injection fluid for this process, as it already contains high concentrations of Mg (~1400 ppm) and Ca (~400 ppm), is strongly buffered against pH changes, and is widely available in coastal regions where many ophiolites and ultramafic bodies are located.

This study investigated the potential for CO_2 sequestration and mineralization in ultramafic systems through long term (37-day) flow-through experiments using simulated seawater and crushed ultramafic rock. Experiments were conducted on rocks from two settings: less serpentinized peridotite from The Cedars Ultramafic Mass, USA, and highly serpentinized rock from The Bay of Islands Ophiolite Complex, Canada. An initial set of experiments was performed at reservoir temperature with low pCO_2 and a second set of experiments was performed using reservoir temperatures high pCO_2. Each experiment was performed in two stages (i) a water-rock equilibration stage (0 to 6 days) where simulated ocean water flowed through the columns (ii) water-rock-gas stage (6 to 37 days) where CO_2 was added to the system.

In the low pCO_2 experiments there was a maximum magnesium concentration increase of 1.37×10^{-1} M ± 6×10^{-3} M. Under ideal conditions the conversion of every mol of Mg to Mg-carbonate indicates that 1 tonne of ultramafic rock could mineralize up to 0.05 tonnes of CO_2 for a conversion rate of 4.9%. In the high pCO_2 experiments the maximum Mg value was 2.3×10^{-1} M ± 3×10^{-2} M indicating that up to 0.15 tonnes of CO_2 could be mineralized with a conversion rate of 14.6%.