Carbonate Formation in the Samail Ophiolite, Oman: A Case Study for CO_2 Sequestration Through Alteration of Mantle Peridotites

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The observation that anthropogenic CO_2 can influence global warming has focused attention on carbon capture and storage as a mitigation strategy. One proposed option for carbon sequestration is to increase the conversion of CO_2 gas to stable, solid carbonate minerals, such as calcite ($CaCO_3$) and magnesite ($MgCO_3$), in rocks from Earth's mantle (called peridotites) that have been tectonically exposed. Peridotites are easily weathered to hydrous silicates, Fe-oxides, and carbonates. These alteration reactions occur naturally at low temperatures when peridotite is exposed to water. However, the rates at which these reactions occur are poorly quantified, but are essential in order to evaluate the viability of using artificially-enhanced *in situ* weathering of peridotite to capture and store atmospheric CO_2.

Figure 1: A. Evelyn Mervine samples a recently formed carbonate precipitate in a highly alkaline stream bed at Qafeefah Travertine, Oman. B. Old white carbonate veins exposed on a new roadcut through peridotite near the town of Fanja, Oman.

In this project, Evelyn Mervine focused her Ph.D. research on investigating the rates of natural formation of carbonate in peridotite in the Samail Ophiolite, Sultanate of Oman – one of the largest and best "ophiolites" (an uplifted fragment of oceanic crust and upper mantle now exposed sub-aerially) in the world. Our approach was to use a combination of field mapping, and two different age dating techniques (carbon-14 and uranium-series dating) to determine carbonate formation ages. We dated two types of carbonates: subsurface veins that form within the peridotite, and calcite-rich travertines that precipitate from highly alkaline surface waters.

Many of the veins within the peridotite that are now exposed at the surface formed 29,000-43,000 years ago. However, half of the veins sampled along recent roadcuts are older than 50,000 years and are up to 350,000 years old, indicating formation over a considerably longer time period than previously

estimated. Surface travertines range in age from actively precipitating today to having formed 45,000 years ago, indicating unusually long-term deposition and preservation.

Based on our data, we calculate that approximately 1-3 x 10^6 kg CO_2/yr is sequestered in surface travertines, and approximately 10^7 kg CO_2/yr is sequestered in the subsurface veins. Comparison of these values with our estimated erosion rate of 10^5-10^6 kg CO_2/yr indicates that the mantle peridotites of the Samail Ophiolite are indeed a natural sink for CO_2. However, the rate that CO_2 is sequestered by this mechanism is small relative to the ~3.5 x 10^{13} kg CO_2/yr of anthropogenic emissions to the atmosphere. Hence, the rates of CO_2 uptake in peridotite would have to be greatly enhanced in order to significantly offset anthropogenic emissions.

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