Deep Ocean Exploration Institute
Final Project Report

Project Title: Mineral Carbonation of Abyssal Serpentinite

PIs: Frieder Klein & Henry Dick, in close collaboration with Carlos Garrido and Thomas M. McCollom

What were the primary questions you're trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

The main objective of this study was to unravel the complex interactions of mantle rocks exposed at or near the Earth's surface with carbon-bearing aqueous fluids. Particularly interesting were mineral replacement reactions and changes in fluid chemistry from hydration (i.e. serpentinization) of mantle rocks to mineral carbonation. Such systems are remarkable for several reasons; most notably they might be analogous to hydrothermal systems on early Earth when Mg-Fe rich rocks were more abundant at the seafloor. Moreover such systems might play a significant role in the global carbon cycle by forming carbonate minerals.

What have you discovered or learned that you didn't know before you started this work?

Mineral carbonation is driven by steep chemical gradients and the reactions are incredibly fast – much faster than the formation of hydrocarbons (which is competing for the carbon in such systems).

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

The modeling and experimental results have some implications for engineered in situ carbonation of serpentinized peridotite, but also for our understanding of abiotic processes competing for carbon in seafloor hydrothermal systems.

What is the significance of this research for society?

Mineral carbonation of serpentinite has been considered a possible pathway to convert CO2 gas into solid carbonate minerals. The modeling and experimental results of this study highlight how the chemistry of interacting fluids can be used to monitor chemical reactions during mineral carbonation. Two processes are competing for carbon: precipitation of carbonate and the reduction of CO2 to methane (CH4). Since CH4 is a more potent greenhouse gas than CO2, its formation would promote global warming. However, the experimental results suggest that the formation of carbonate dominates while the reduction of CO2 to CH4 formation is relatively sluggish.

What were the most unusual or unexpected results and opportunities in this investigation?

It was unexpected that mineral carbonation is orders of magnitude faster than the reduction of CO_2 to methane, at least at the experimental conditions.

What were the greatest challenges and difficulties?

The injection of a fluid into an ongoing hydrothermal experiment at elevated temperatures and pressures was probably the greatest technical challenge.

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

The modeling part of this project started out with Carlos Garrido in Granada, Spain. Later on the experiment was conducted in collaboration with Thomas M. McCollom in Boulder, Colorado.

What were the key tools or instruments you used to conduct this research?

For the modeling the software codes SUPCRT92 and EQ3/6 were used. The experiment was conducted in a flexible cell hydrothermal apparatus.

Is this research part of a larger project or program?

No

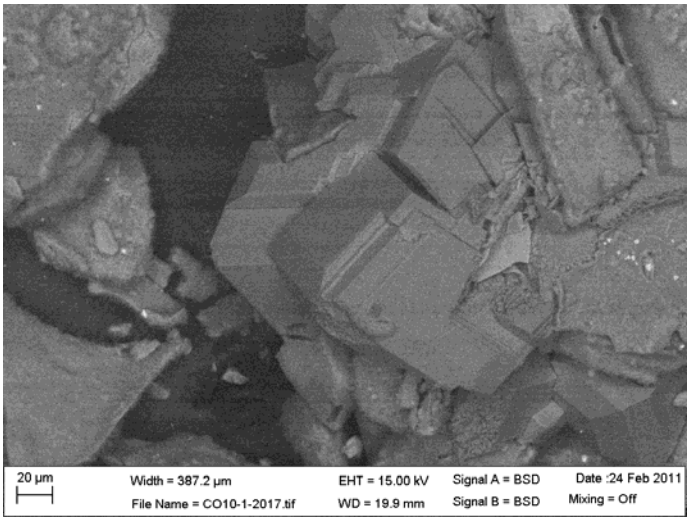
What are your next steps?

Conduct similar experiments at different temperatures and different rock compositions.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

One paper on the modeling results is published in Lithos (http://www.sciencedirect.com/science/article/pii/S0024493711002155). A manuscript on the experimental results has been submitted to EPSL.

Please provide photographs, illustrations, tables/charts, and web links that can help illustrate your research.



This image shows euhedral magnesite, which formed during the experiment at the expense of other magnesium-bearing minerals.