

The Carbfix project: Mineral CO₂ sequestration into basalt

S.R. GISLASON¹, W.S. BROECKER², E.H. OELKERS³,
E. GUNNLAUGSSON⁴, H. SIGURDARDOTTIR⁴,
A. STEFANSSON¹, D. WOLFF-BOENISCH¹, J. MATTER²,
M. STUTE² AND G. AXELSSON⁵

¹Institute of Earth Sciences, University of Iceland, Iceland

²Earth Institute, Columbia University, USA

³CNRS, LMTG, F-31400 Toulouse, France

⁴Reykjavik Energy, Iceland

⁵Icelandic Geosurvey, Iceland

The reduction of industrial CO₂ emissions is considered one of the main challenges of this century. Among commonly proposed CO₂ storage techniques, the injection of anthropogenic CO₂ into deep geological formations is quite promising due their large potential storage capacity and geographic ubiquity. Finding a storage solution that is long lasting, thermodynamically stable and environmentally benign would be ideal. Storage of CO₂, as solid carbonates, in basaltic rocks may provide such a long lasting, stable and environmentally benign solution [1].

In nature, the carbonization of basaltic rocks occurs in a variety of well-documented settings, such as the hydrothermal alteration in geothermal systems and in deep ocean vent systems. The goal of this research project is to optimize industrial methods for storing CO₂ in basaltic rocks through a combined program consisting of, field scale injection of CO₂ charged waters into basaltic rocks, laboratory based experiments, study of natural CO₂ waters as natural analogue and state of the art geochemical modelling. The bulk of the research is to be performed by graduate student and post-doctoral trainees to generate the human capital and expertise to apply the advances made in this project in the future.

At the Hellisheidi Iceland site, the hot gases released from geothermal energy production will be processed to separate the CO₂. It will then be dissolved in water at about 25 bar pressure and 20°C, pumped into the porous basalt at about 550 m depth, at the rate of 3000 tonnes per year in the initial phase of the experiment, starting in May 2009. Model simulations, natural analogues and experimental work suggest that the CO₂ charged waters will react with the basalt and form carbonate minerals such as FeCO₃, FeCO₃ - MgCO₃ solid solutions and CaCO₃. By this method the fixed CO₂ will remain trapped as mineral for millions of years.

[1] Oelkers *et al.* (2008) *Elements* 4, 333-337.

Iron cycling at an ultradiffuse seafloor hydrothermal system at the base of Loihi Seamount: A seafloor expression of the subsurface

B.T. GLAZER¹ AND O. ROUXEL²

¹University of Hawaii, Department of Oceanography, 1000
Pope Rd., Honolulu, HI 96822 (glazer@hawaii.edu)

²Woods Hole Oceanographic Institution, Clark 403, MS#25,
Woods Hole, MA 02543 (orouzel@whoi.edu)

It is well recognized that seafloor hydrothermal systems support unique biological communities capable of using dissolved chemical species, such as Iron (Fe), as well as mineral substrates as sources of metabolic energy. The deep-sea hydrothermal systems found at Loihi Seamount are important examples of environments where biological oxidation of Fe can successfully compete with chemical oxidation, and they provide ideal systems in which to test hypotheses on biotic vs. abiotic origin of iron-oxide formation.

We performed widespread profiling using a combination of voltammetric and temperature sensors to provide real time *in situ* redox characterizations of hydrothermal fluids and geochemical gradients associated with iron-oxidizing microbial mats and flocs at a newly described ultra-diffuse hydrothermal field at the base of Loihi Seamount (~5000m depth, 0.2°C anomalies). Extensive iron-oxidizing microbial mats were shown to occur up to 2m in thickness over several hundred square meters. Bottom water oxygen concentrations were near-saturation, and we observed steep gradients at the mat interface, with little O₂ penetration and Fe²⁺ concentrations of up to 150mM. Our *in situ* electrochemical analyses provided an efficient and valuable means for directed discrete sampling of hydrothermal fluids and microbial flocs, as well as previously unattainable high spatial resolution geochemical profiles through the mats.

Fluids collected from the mat system had distinctly negative Fe-isotope values between -0.3 to -1.5‰. These negative values are best explained by near-complete oxidation of isotopically light Fe(II) source. Negative δ⁵⁶Fe values in the source fluid are likely generated by subsurface precipitation of isotopically heavy Fe-oxides during partial Fe(II) oxidation. These results, together with the significant enrichment in Mn-oxides at the mat surface, are consistent with the higher oxygen level in deep seawater relative to mats at the Loihi summit, and suggest extensive microbial Fe(II) oxidation below the seafloor.