Potential of Microbiologically Induced Mineralisation to Increase Geologic CO_2 Storage Security

ANDREW C. MITCHELL[1]*, ADRIENNE J. PHILLIPS[2], ELLEN LAUCHNOR[2], JAMES CONNOLLY[2], LOGAN SCHULTZ[2], ROBIN GERLACH[2] AND ALFRED B CUNNINGHAM[2].

[1]Institute of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, UK, nem@aber.ac.uk (* presenting author)
[2]Center for Biofilm Engineering, Montana State University, Bozeman, USA,

During the operation of Geologic Carbon Capture and Storage (CCS) and the injection of supercritical CO_2 into underground formations, microbe-rock-fluid interactions occur. These interactions may be important for controlling the ultimate fate of the injected CO_2, and may also be manipulated to enhance the storage of the CO_2, via mineral-trapping, solubility trapping, formation trapping, and leakage reduction.

We have demonstrated that engineered microbial biofilms are capable of enhancing formation, mineral, and solubility trapping in carbon sequestration-relevant formation materials. Batch and flow experiments at atmospheric and high pressures (> 74 bar) have shown the ability of microbial biofilms to decrease the permeability of natural and artificial porous media [1], survive the exposure to $scCO_2$ [2], and facilitate the conversion of gaseous and supercritical CO_2 into long-term stable carbonate phases as well as increase the solubility of CO_2 in brines [3].

Ongoing microscopy and modelling studies aim to understand these processes at both the pore- and core-scale in order to facilitate larger scale understanding and potential manipulation for biologically based CCS engineering [4,5]. Successful development of these biologically-based mineralisation concepts could result in microbially enhanced carbon sequestration strategies as well as CO_2 leakage mitigation technologies, which can be applied either before CO_2 injection or as a remedial measure around injection wells.

[1] Mitchell *et al.* (2009) *International Journal of Greenhouse Gas Control* **3**, 90-99.
[2] Mitchell *et al.*(2008) *Journal of Supercritical Fluids* **47**, 318-325.
[3] Mitchell *et al.* (2010) *ES&T* **44**, 5270-5276.
[4] Schultz *et al.* (2011) *Microscopy Today* **19**, 12-15.
[5] Cunningham *et al.*(2011) *Energy Procedia* **4**, 5178-5185.

Isotope fractionation of selenium during sorption to iron oxide and iron sulfide minerals

K MITCHELL[1*], R-M COUTURE[1], T M JOHNSON[2], PRD MASON[3] AND P VAN CAPPELLEN[1]

[1]University of Waterloo, Waterloo, Canada (*presenting author: kristen.mitchell@uwaterloo.ca)
[2]University of Illinois, Urbana, USA
[3]Utrecht University, Utrecht, The Netherlands

Sorption and abiotic reduction are important processes influencing the mobility and cycling of Se in natural environments. Although these processes have received increasing attention in recent years, the associated isotopic fractionations are poorly known [1, 2]. In this study we determined the rates of reaction and isotopic fractionations of Se(IV) and Se(VI) during sorption to iron oxides (2-line ferrihydrite, hematite and goethite) and iron sulfides (FeS and FeS_2) in batch reactor experiments. No change in Se oxidation state was observed when Se(IV) and Se(VI) sorbed to iron oxides. In contrast, XANES spectra showed evidence of reduction on the iron sulfides. Reaction rates were obtained using inverse modeling of dissolved Se concentration time series, following the mixed-reaction modeling approach of [3]. Sorption rates were highest in the Se(IV)-goethite system, while Se(VI) sorbed slowly on 2-line ferrihydrite and not at all on hematite and goethite. Reduction was fastest in the Se(IV)-FeS system and slowest for Se(VI)-FeS_2. Changes in the isotopic composition of aqueous Se were monitored as a function of time. The results revealed the absence of measurable equilibrium isotope fractionation for all systems studied. Kinetic fractionation was observed in the case of Se(IV) sorbing to 2-line ferrihydrite and Se(IV) being reduced by FeS_2. Figure 1 illustrates the $\delta^{82/76}$Se trends of aqueous and solid-bound Se(IV) sorbing to 2-line ferrihydrite. The data follow the standard Rayleigh fractionation model, except for the last two time points, as the system approaches equilibrium.

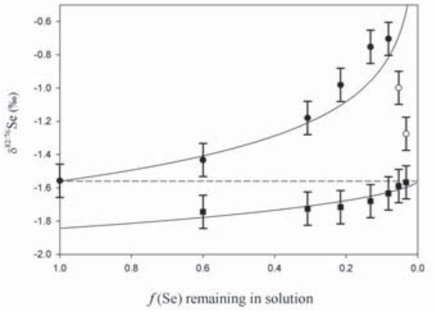

Figure 1: Se(IV) sorption to 2-line ferrihydrite. Circles show measured $\delta^{82/76}$Se of the remaining Se(IV) in solution, squares the calculated $\delta^{82/76}$Se of Se(IV) sorbed to 2-line ferrihydrite. The open symbols correspond to the two last samples collected, whose data were excluded when fitting the data with the Rayleigh fractionation model. Error bars indicate the precision of $\delta^{82/76}$Se measurements.

[1] Johnson (2003) *Geochim. Cosmochim. Acta* **67**, 413-419.
[2] Johnson (1999) *Geochim. Cosmochim. Acta* **63**, 2775-2783.
[3] Zhang (2005) *Environ. Sci. Technol.* **39**, 6101-6108.