Permeability change from CO_2 injection: Experimental considerations

ANDREW J. LUHMANN[1*], BENJAMIN M. TUTOLO[1], XIANG-ZHAO KONG[1], KANG DING[1], MARTIN O. SAAR[1], WILLIAM E. SEYFRIED, JR.[1]

[1]University of Minnesota, Department of Earth Sciences, Minneapolis, USA, luhm0031@umn.edu (*presenting author)

Abstract

Geologic carbon sequestration experiments were conducted using a hydrothermal flow system. The flow system design enables a continuous record of permeability and periodic fluid chemistry sampling during experiments at elevated temperatures and pressures. Initial experiments were conducted with deionized water saturated with CO_2 at room temperature and arkose sediment from the Eau Claire Formation. Outlet pore pressure was 11MPa and confinement pressure was 20MPa throughout the experiments, and temperature of the core was incrementally increased from room temperature to 150ºC. Some temperature step increases were followed by relatively quick changes in permeability, such that measured permeability decreased by 3-4 orders of magnitude during a given experiment. Scanning electron microscopy (SEM) revealed clay mineral formation on potassium feldspar grains (Fig. 1). While some geochemical changes did occur, the relative role of different potential permeability-reducing mechanisms is not constrained by these initial experiments. Potential mechanisms include geochemical changes as well as physical redistribution of grains and CO_2 exsolution. Ongoing experiments are being conducted to isolate the roles of these different mechanisms. Experiments with pure St. Peter quartz sand and fluid supersaturated with CO_2 isolate the effect of CO_2 exsolution, and experiments with solid arkose cores and fluid undersaturated with CO_2 constrain geochemical controls on permeability changes.

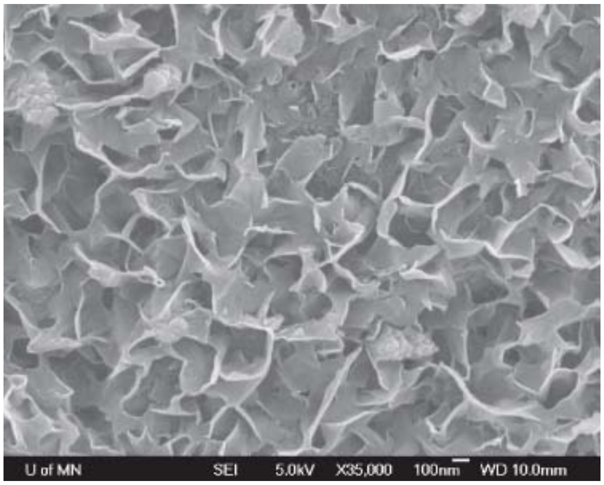

Figure 1: Clay precipitation on K-feldspar grain surface post-experiment.

Chemical speciation of sediment phosphorus and iron suggesting burial of iron-bound phosphorus in the northern Baltic Sea

KAARINA LUKKARI[1*], SANNA KUJANSUU[2] , AND HANNA KAASALAINEN[3]

[1]Marine Research Centre/Finnish Environment Institute, Helsinki, Finland, kaarina.lukkari@ymparisto.fi *
[2]University of Helsinki, Finland, sanna.kujansuu@helsinki.fi
[3]University of Iceland, Reykjavik, Iceland, hannakaa@hi.is

Introduction

Biogeochemistry of phosphorus (P) is of special interest in the eutrophied Baltic Sea. Large areas of the sea-floor, especially in the central basin and in the Gulf of Finland, suffer from hypoxia, which affects P cycling and its burial [1]. Formation of authigenic carbonate fluorapatite, which is an important sink for reactive P in many marine sediments [2], is not significant in the Baltic. Instead, P is buried mostly as organic P [3]. However, in some estuary sediments, P is buried also in iron (Fe) bound form [4].

The Gulf of Bothnia is separated from the main basin by a sill and it has better oxygen conditions than the Baltic Proper. The Gulf receives high riverine input of organic and inorganic material. In order to assess whether part of P may become buried in the Fe-bound form in this Fe-rich basin, we collected samples at two oxic sites in the Gulf of Bothnia and, for comparison, from one anoxic site in the northern Baltic Proper. We made sequential extractions to assess the different forms of sediment P and Fe [5,6] and analysed nutrients and metals from the pore waters and the solid phases.

Results and Conclusions

P and Fe species in the two oxic sediments in the Gulf of Bothnia differed from those in the anoxic sediment in the Baltic Proper. At the anoxic site, sediment P was dominated by organic and detrital apatite-P and it was poor in P bound to hydrated oxides of Fe. This suggests that this redox-dependent form of P was lost during anoxia. Accordingly, reducible Fe oxides were relatively low, and Fe-speciation suggested that Fe was associated with sulphide, carbonate, and silicate phases. This was in agreement with the low dissolved Fe concentrations and the presence of hydrogen sulphide in the pore water. At certain sediment depths in the oxic Gulf of Bothnia, Fe-bound P formed more than 50% of total P concentration. Fe-speciation showed high concentrations of easily reducible and reducible Fe oxides at these same sample depths. Pore water data indicated reduction of Fe oxides and consequent release of dissolved Fe to the pore water below the 5 cm depth at both sites. However, relatively high concentrations of Fe-bound P was found down to 15-20 cm depth suggesting that part of it can be buried. Presence of benthic fauna may partly explain this finding.

[1] Conley et al. (2009) *Environ. Sci. Technol.* **43**, 3412-3420. [2] Ruttenberg (2003) *Treat. Geochem.* **8**, 585-643. [3] Mort et al. (2010) *Geochim. Cosmochim. Acta* **74**, 1350-1362. [4] Hyacinthe & Van Cappellen (2004) *Mar. Chem.* 91, 227-251. [5] Jensen & Thamdrup (1993) *Hydrobiologia* **253**, 47-59. [6] Poulton & Canfield (2005) *Chem. Geol.* **214**, 209-221.