

Role of Detrital Matter in the Benthic Silica Cycle

Suvasis Dixit¹ & Philippe Van Cappellen²

¹ Earth and Atmospheric Sciences, 221 Bobby Dodd Way, Georgia Institute of Technology, GA-30332, USA

² Faculty of Earth Sciences, Utrecht University, 3508TA Utrecht, PO Box 80021

Typical silicic acid pore water profiles show a downward increase in concentration which levels off at a quasi-constant value called the asymptotic concentration. Asymptotic concentrations vary from location to location in the oceans, and range from less than 200 μ M to 900 μ M. At present, there is no consensus on the processes causing variable build-up of pore water silicic acid concentrations. In this paper, we integrate laboratory batch and flow-through reactor experiments with pore water silica profiles and data on sediment composition to determine how processes occurring in the water column and during early diagenesis affect the solubility of biogenic silica and the build-up of silicic acid in pore waters of marine sediments. Specifically, we focus on the effect of detrital matter on the benthic silica cycle.

Materials and Methods

Biosiliceous sediments collected from the Indian sector of the Southern Ocean were used in the experiments (Van Cappellen and Qiu, 1997a). Silica solubilities of surficial (0–5cm) sediments were determined using flow-through reactor experiments. The Al/Si ratio of diatom fragments of the same sediments were measured by electron probe microanalysis. The effect of detrital matter on the build-up of silicic acid was examined by mixing biosiliceous sediments (85wt.% SiO₂) with kaolinite or basalt. The mixtures were suspended in 5ml solution of 0.7M NaCl and pH 8 solution. The suspensions were sampled every three months and analyzed for dissolved silicic acid. A steady state concentration was assumed when the silicic acid concentration did not change ($\pm 2\%$) over a period of three months.

Results and discussion

The spread in the experimentally-measured silica solubilities can be explained, in part, by differences in specific surface area and Al content of biosiliceous fragments. Preferential dissolution in the water column of delicate skeletal structures and frustules with high surface areas leads to a progressive decrease of the specific surface area in the water column, which reduces the solubility of skeletal fragments 10–15% by the time they reach the ocean floor. The solubility of biogenic silica is also decreased due to aluminum uptake during their growth (van Bennekom et al., 1991). The uptake of aluminum is species specific and depends on the concentration of dissolved

aluminum in the surrounding water (van Beusekom and Weber, 1995). After deposition at the sea floor, dissolution of detrital material releases dissolved aluminum to the pore waters. Soluble aluminum may become structurally incorporated into the deposited biosiliceous debris, further decreasing their solubility. Uptake of aluminum by diatom fragments during early diagenesis is evident from the positive correlations between the pore water aluminum levels and the detrital content of the sediments, as well as the Al/Si ratio of the diatom frustules. Compared to Al-free biogenic silica, the solubility of diatom frustules is lowered by as much as 25% when one out of every 70 Si atoms is substituted by an Al(III) ion. The steady state silicic acid concentrations measured in the experiments decrease with increasing detrital to opal ratios of the mixtures. This trend is similar to that observed between asymptotic pore water silicic acid concentrations and detrital to opal ratios in Southern Ocean sediments (Van Cappellen and Qiu, 1997a). Flow-through reactor experiments further show that in lithogenic-rich sediments, precipitation of authigenic aluminosilicates prevents the pore waters from reaching equilibrium with the biogenic silica pool. This is consistent with data from Southern Ocean sediments where, at sites containing more than 30 wt.% lithogenic material, the pore waters remain undersaturated with respect to the experimentally determined in situ silica solubility. The results of this study show that large variations in the asymptotic silicic acid concentration are caused by early diagenetic interactions between opal and detrital material. The release of Al(III) by the dissolution of lithogenic material affects the build-up of silicic acid by reducing both the apparent silica solubility and the dissolution kinetics of biosiliceous materials (Van Cappellen and Qiu, 1997b), and by inducing precipitation of authigenic aluminosilicate minerals.

van Bennekom AJ, Buma, AGJ and Nolting R.F., *Mar. Chem.*, **35**, 423–434, (1991).

van Beusekom JEE and Weber A, *Eur. J. Hydrography*, **5**, 213–220, (1995).

van Cappellen P and Qiu L, *Deep-Sea Res. II*, **44**, 1109–1128, (1997a).

van Cappellen P and Qiu L, *Deep-Sea Res. II*, **44**, 1129–1149, (1997b).