Early Diagenesis of Silica in the Arctic Ocean Sediments Inferred by Porewater Stable Silicon Isotopes

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The major sink of silicon in the ocean is by burial in marine sediments, half of which takes place in nearshore and continental shelf sediments. The quantification of this sink still remains a major challenge due to multiple simultaneous reactions of silicon during early diagenesis. We used two sediment cores from the Arctic continental shelf taken during the Swedish-Russian SWERUS-C3 expedition on icebreaker Oden in the summer 2014 to investigate early diagenetic silicon reactions by combining major and trace element analyses of porewaters with stable silicon isotope analysis.

In both cores there was a characteristic sharp increase by several hundred µmoles in dissolved Si (DSi) over the first centimeters of sediment below which DSi gradually decreased again. The increase in porewater DSi was associated with a pronounced increase in the δ^{30}Si from 2.1 to 4.4 ‰ in the uppermost 10 cm and a subsequent decrease back to the bottom water δ^{30}Si value. Porewater dissolved iron concentrations followed the same trend of an initial increase and subsequent decrease. Measurements of bacterial sulfate reduction rates indicated that there was no significant removal of iron by iron sulfide formation, so that the observed decrease in dissolved iron was likely due to secondary precipitation of Fe-rich clay minerals.

The data suggest that the elevated DSi concentrations and steep Si isotope gradients were caused by simultaneous dissolution of biogenic Si and authigenic clay mineral formation. The latter was suggested to fractionate Si isotopes by -2 ‰[1], which is consistent with our observations. Authigenic clay mineral formation appeared to be limited by the availability of reactive iron below the surface so that dissolution of biogenic silica controlled porewater δ^{30}Si values at depth. We have employed a Si reactive-transport model to assess the rate of clay mineral formation and other interacting geochemical processes. Our results suggest that authigenic clay mineral formation plays an important role in controlling marine silicon burial and Si isotope fluxes between sediments and the overlaying water.

[1]Ehlert et al. 2016. Geochimica et Cosmochimica Acta, 191, 102-117