Extended abstract

Brilliant Marine Research Idea 2018

1. General information

Title of the idea	Counteracting anthropogenic CO_2 emissions by microbial stimulation of silicate weathering
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2. Brilliant Marine Research Idea

Extended abstract

On the COP21UN climate change summit in Paris, all parties have agreed to limit global warming within a 2˚C increase with respect to preindustrial conditions. To achieve this target, large-scale deployment of so-called negative emissions technologies (NETs) - the active capture and removal of CO2 from the atmosphere - will be needed. One of several NET approaches that is gaining increasing attention is Enhanced Silicate Weathering (ESW). ESW makes use of the natural weathering reaction, whereby dissolution of silicate rocks consumes atmospheric CO_2. Olivine has been identified as a promising mineral for ESW. The chemical weathering of olivine is influenced by a number of parameters, of which the temperature and pH are the most important. One recent finding is that pore water conditions in coastal sediments can be far more acidic than previously thought. In so-called electro-active sediments, long filamentous microbes called “cable bacteria” perform long-distance electron transport, a metabolism which induces strong acidification (down to pH ~ 5) of the top few centimeters of the sediment, which greatly stimulates the dissolution of acid-sensitive minerals such as carbonates and iron sulfides, and is also expected to strongly increase the dissolution rate of olivine. Recently, it has been argued that electro-active sediments could be globally common in the coastal zone and therefore, these acidic marine sediments could be a target location for coastal ESW. However, until now, the impact of pH changes induced by cable bacteria on the enhanced weathering of olivine has not been investigated.

Here we present the results of a small-scale laboratory incubation experiment. Natural coastal sediment was collected and enriched with 0, 5, 10 and 20 % of olivine (dry wt percent). We have followed the development and activity of the cable bacteria over 2 months using microsensor profiling of pH, H_2S and O_2. To assess the impact of cable bacteria metabolism on olivine weathering, we followed the evolution of pore water profiles of nutrients (PO_4^{3-}, NH_4^+ and dSi), trace metals (e.g. Ni) and alkalinity. This was complemented by measurements of the benthic fluxes of the same compounds, as well as the evolution of the CO_2 concentration in the water phase over time.

Our results showed that cable bacteria activity was comparable between treatments, while phosphate and ammonium profiles showed no difference between treatments. In contrast, dSi concentrations and fluxes were higher in the treatments with higher olivine enrichments, while pore water alkalinity was also elevated in the treatments with olivine. The release of alkalinity to the overlying water allowed more CO_2 to be dissolved in the water phase. Overall, these results suggest that olivine dissolution is indeed stimulated in electro-active sediments, and that the release of alkalinity does increase the uptake rate of CO_2 by seawater. Given the widespread distribution of cable bacteria in natural sediments, microbial stimulation of silicate weathering could hence provide a viable option for ESW.