Counteracting anthropogenic CO2 emissions by microbial stimulation of silicate weathering

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On the COP21UN climate change summit, all governments 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 carbonate and silicate dissolution consume atmospheric CO2. The chemical weathering of olivine is influenced by a number of parameters, of which the temperature and pH are the most important. One important 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 may 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 in Rattekaai (The Netherlands) 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, H2S and O2, as well as the evolution of pore water profiles of nutrients (PO43-, NH4+ and dSi), trace metals (e.g. Ni) and alkalinity. Cable bacteria activity was comparable between treatments, while phosphate and ammonium profiles showed no difference between treatments. In contrast, dSi and alkalinity concentrations were higher in the treatments with higher olivine enrichments. These results suggest that olivine dissolution is indeed stimulated in electro-active sediments. Given the widespread distribution of cable bacteria in natural sediments, microbial stimulation of silicate weathering could provide a viable option for ESW.Text

Keywords: Cable bacteria; Net Emission Technologies; Silicate weathering