The role of bioturbation in enhanced silicate weathering in coastal sediments: A long-term mesocosm study

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Mitigating climate change is one of society's most urgent challenges. At the 2015 Paris climate summit, 196 countries signed an agreement to limit global temperature rise to below 2°C compared to pre-industrial levels. Current policies primarily focus on traditional mitigation techniques, i.e. reducing greenhouse gas emissions. However, to reach the Paris targets, we need to actively remove CO_2 from the atmosphere. A promising CO_2 removal technology is enhanced silicate weathering (ESW) in coastal systems. The technology is based on natural silicate mineral weathering, a process that releases alkalinity and thereby increases the seawater's capacity to dissolve atmospheric CO_2. It has been proposed that the silicate weathering process can be sped up by introducing the minerals in coastal sediments where exposure to waves, currents and bioturbation can stimulate the weathering. Although model and laboratory studies suggest that ESW is feasible, research on the process in natural conditions is lacking. As such, the efficiencies of ESW and the resulting CO_2 sequestration in marine environments are largely uncertain. Furthermore, introducing silicate minerals in sediments could have negative effects on local ecosystems, with the potential release of trace metals from the silicate minerals being of particular concern. Hence, a thorough assessment of ESW in natural conditions is critically needed before the technique can be implemented in coastal areas.

To this end, we are conducting the first and longest-running mesocosm incubation experiment to study ESW in natural conditions. In the mesocosms, we quantify the release of alkalinity and other weathering products from natural sediments treated with the silicate mineral olivine. The deep-burrowing lugworm *Arenicola marina* has been introduced to some mesocosms to investigate the effect of bioturbation on olivine weathering and the impact of olivine on biota. Our results show that both olivine weathering and bioturbation increase the sedimentary alkalinity release and CO_2 sequestration, with a tendency for an enhanced effect in treatments with both olivine and bioturbation. No accumulation of trace metals in the lugworms has been detected. However, the introduction of olivine initially impacts the distribution of lugworms, resulting in a decrease in adults and an increase in juveniles. In conclusion, our results show that ESW works in natural sediment, but we have to consider how the technique is applied to protect bioturbating organisms.

Keywords
Coastal Enhanced Silicate Weathering; CO2 Removal; Bioturbation; Climate Change