EGU2020-19690
https://doi.org/10.5194/egusphere-egu2020-19690
EGU General Assembly 2020

Microbial control on Anthropocene carbonates in slag drainage waters

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Over the last decennia, alkaline leachates from the weathering of legacy steel slag disposal sites have affected the surrounding soils and drainage streams. The hyperalkaline and hypersaline conditions around these sites are comparable to extreme paleo environments such as alkaline lakes in rift volcanic settings. Investigating the carbonate deposits forming in these man-made systems provides a unique opportunity to link the ongoing physical and microbial processes to their resultant carbonate morphologies.

Here we present data from 3 sites across Dene Burn, a slag drainage stream in Consett, County Durham, UK. After 100 years, iron and steel production ceased in 1980, leaving over 20 million tons of slag in the form of several large mounds. Analysis showed Dene Burn to be typical of slag drainage waters with an elevated pH (>9) and saturated with different secondary phase minerals-particularly calcite. However, the physical distribution of carbonates is more comparable with estimated local kinetic precipitation rate than it is to thermodynamic saturation, indicating that the fundamental control on carbonate formation arises from crystal surface processes. A microbial community comprising predominantly Proteobacteria (Alpha-, Gamma-, Beta- and Deltaproteobacteria), Cyanobacteria, Bacillariophyta (diatoms) and Bacteroidetes (Flavobacterium) was identified at the 3 sites. The microbial communities and an abundance of extracellular polymeric substances (EPS) were shown in close association with the mineral phases detected at the sites. The presence and composition of these biofilms appears to control local carbonate mineralisation rates and carbonate morphologies.

Drainage streams from steel slag provide a unique opportunity to study carbonate mineral formation under extreme environmental conditions. Furthermore, maximising carbonate formation at such sites could be utilised as a remediation and carbonate sequestration technique.