

Microbial acceleration of carbon mineralization in mine waste



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Carbonate minerals offer a stable, long term method of carbon storage, and can be generated through a range of active and passive processes. This study examines an active biogeochemical process of storing carbon in magnesium carbonate minerals in ultramafic mine tailings. Magnesium released from mine waste rock through leaching can react with atmospheric carbon dioxide (CO_2) to produce carbonate minerals including magnesite [MgCO_3] and hydromagnesite [$\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$]. These reactions occur slowly in abiotic conditions, but have the potential for enhanced carbon storage rates if accelerated by phototrophic microorganisms. A naturally occurring microbial community dominated by cyanobacteria was used in a model ‘wetland’ to

characterize the aqueous geochemical environment in which biogenic magnesium carbonate formation occurs. The microbes induce the alkaline ($\text{pH} > 9.2$) water chemistry conditions required to generate mineral supersaturation, and provide extracellular structures which act as nucleation sites for mineral precipitation. Dissolved oxygen, pH, dissolved inorganic carbon, and major ion concentrations were monitored in the wetland. Carbonate formation was identified using X-ray diffraction. Scanning electron microscopy and energy dispersive spectroscopy were used to characterize the micron-scale microbe-mineral relationships taking place in the system (Figure A and B). Mineralization occurred as both coatings on cells and as individual crystals. The aqueous geochemistry data was used to quantify the rate of carbon storage that could be achieved at a field-scale carbonation plant at a mine site. If this process can be optimized, it has potential as a strategy for mining operations to reduce their net carbon emissions.

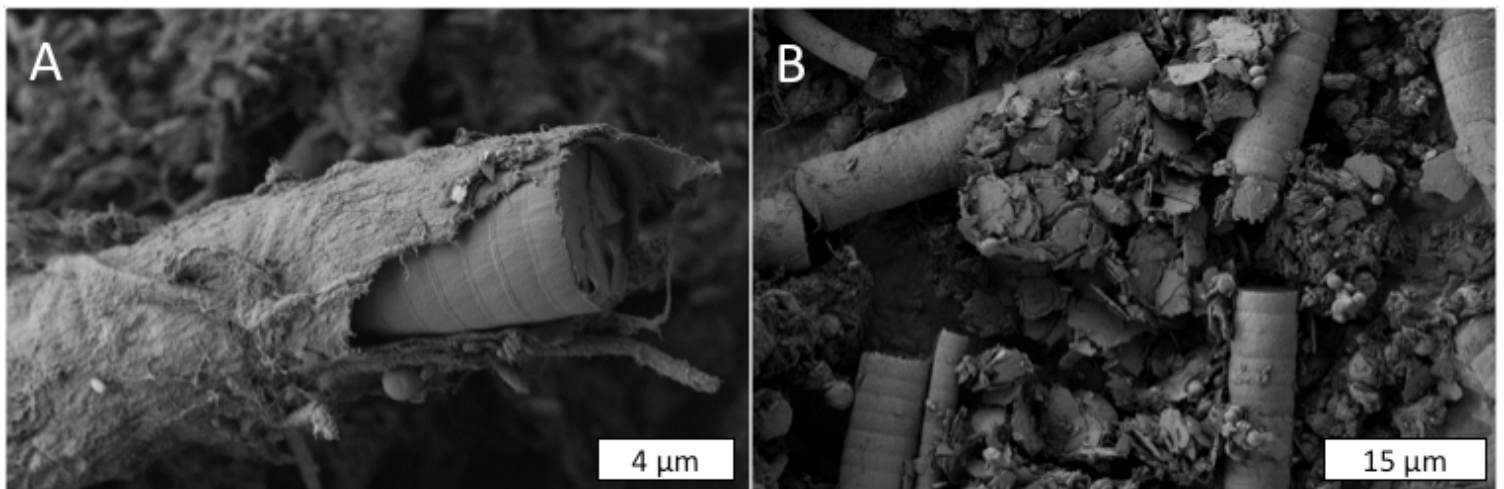


Figure: A) A cyanobacteria filament encrusted in fine grained magnesium carbonate. B) Cyanobacteria filaments surrounded by platy hydromagnesite crystals.