SEG 2023 Conference: Resourcing the Green Transition

Microbial Impacts on the Circular Economy via Metal Mobility and Carbon Sequestration

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Climate change, caused by greenhouse gas emissions, has led to an increasing demand for companies to 1) reduce their carbon footprint and 2) explore green energy technologies. Microorganisms can accelerate the nucleation and growth of secondary carbonates, a process that can sequester carbon dioxide from the atmosphere. This can be particularly useful in mafic and ultra-mafic materials, such as kimberlite residue, produced as a by-product of diamond mining. This transition to green energy is different from traditional methods of energy generation and as a result requires very different ingredients—known today as critical metals. These metals are more difficult to mine and are failing to meet an ever-growing demand. Microorganisms can play a significant role in the extraction of critical metals from low-grade ore and tailing materials that are not amenable to conventional processing methods. Bioleaching, which uses microbes to extract metals by producing sulfuric acid, is increasingly being used for metal extraction.

To track the effectiveness of these microbial interventions, various analytical tools such as X-ray fluorescence mapping (XFM), mineral liberation analysis (MLA), and high-resolution SEM have been used in conjunction with geochemical analysis to track metal mobility and secondary carbon precipitation across time. Bioleaching columns of both the Princess Creek and Mt. Garnet Tailings have shown the accelerated release of Pb, Ni, Cu, and Li relative to abiotic controls, while pilot study experiments with mined kimberlite material from the Venetia diamond mine reveal that bio amendments accelerate the increase in precipitation of secondary carbonate materials—to a CO_2e offset of around 20% per year when scaled.

Overall, the application of biotechnology in the mining life cycle can contribute to the green transition by aiding in the extraction of critical minerals, remediation of mining waste, and carbon sequestration via bio-mineralisation.