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Acid leaching for carbon sequestration and critical metals recovery: Increasing scales and lessons learned

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Mining increased amounts of critical metals is necessary to transition the global economy to renewable energy and reduce greenhouse gas emissions. However, doing so produces more greenhouse gas emissions and mine tailings represent an additional environmental hazard. Some mine tailings have the capacity to sequester CO_2 and still contain critical metals.

In our previous work we have used dilute acid leaching and sequential precipitation to first recover critical metals and then sequester atmospheric CO_2 from ultramafic mine wastes or ores at the laboratory benchtop scale (<100 g per reactor). But to demonstrate the potential of such technologies they must be tested at industrially relevant larger scales. Here we present the methodology and initial findings of an outdoor leaching and sequential precipitation pilot. During the pilot, 750 kg of ultramafic nickel ore was leached with 180 L of 0.2 M H_2SO_4 daily for 30 days, producing ~4800 L of metal-rich leachate. Leachate pH was tracked and subsamples of the leachate were collected for later analysis. Leachate pH was ~8 at the beginning of the experiment but slowly fell over the course of the experiment, reaching pH 2–3 by day 24 and remaining before plateauing.

Eleven sediment cores were taken from the leached ultramafic residue and ICP-MS analysis was conducted on the leachate subsamples. Daily Mg^{2+} concentrations started at ~6000 mg/L and decreased over time to ~2000 mg/L by the end of the experiment. Ni^{2+} concentrations in the leachate rose from 0 to ~50 mg/L over the course of the first week and then remained between 40 and 60 mg/L for the rest of the experiment.

These leaching results for a 750 kg pilot experiment correspond well with those of previous much smaller (~60 g) laboratory scale experiments using similar leaching conditions, demonstrating that the technology can be increased in scale while providing consistent results with initial tests that can be used for TEA/LCA and geochemical modelling for the larger operation. However, operating a pilot of this scale in a university laboratory environment led to several practical challenges that would need to be overcome in future experiments or any larger pilots.