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Field and Laboratory Experiments for CO_2 Removal via Alkalinity Generation and Mineral Dissolution of Asbestos Mine Wastes in Newfoundland

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Ultramafic mine tailings represent a promising feedstock for atmospheric carbon dioxide removal (CDR) through mineral dissolution and alkalinity generation. This study uses field and laboratory approaches to evaluate the CO_2 sequestration potential of tailings from a former asbestos mine, Advocate Mine, in Baie Verte, Newfoundland, Canada. Field CDR experiments placed a chamber with circulating air over tailing ponds in three areas labelled AM1, AM2, and AM3; and over a nearby stream labelled AM BG for a background measurement. The tailing ponds' pH ranged from 8.2 to 9.6, which was significantly higher than the stream's pH which ranged from 6.8 to 7.8. Ponds AM2 and AM3 demonstrated active CO_2 sequestration (CO_2 flux of -11.3 ± 0.3 and -4.1 ± 0.5 $\mu mol/m^2 \cdot min$ respectively), while AM1 and AM BG did not. Elevated dissolved Mg, total inorganic carbon (TIC), and alkalinity levels across sites indicated mineral dissolution was likely driving CO_2 capture. The CO_2 sequestration potential of the tailings was assessed through two laboratory methodologies. First, a two-phase flow-through system simulated near-surface water-rock interactions over 400 hours. Second, batch CDR experiments, similar to the field setup, exposed mine wastes to fluid and CO_2-rich air for four hours. Both flow-through and CDR experiments used two types of fluids: neutral DI water (pH ~7) and basic MgOH-rich fluid (pH ~10). In both setups, fluids rapidly buffered to pH 8.5–9.8 due to mine waste dissolution, creating conditions favourable for CO_2 sequestration. Experiments using MgOH-rich fluid and mine tailings (MG+MT) sequestered significantly more CO_2 (25 ± 3 µmole) than those with DI water (DI+MT), 15 ± 2 µmole. Notably, MgOH-only fluid exhibited CO_2 sequestration (32 ± 3 µmole), whereas DI-only fluid showed negligible uptake (0.8 ± 1.5 µmole), underscoring the role of pH in CDR efficiency. These results demonstrate that mine waste interactions effectively buffer fluids to pH conditions conducive to CO_2 sequestration. Experimental and field data show that natural processes at AM2 and AM3 match laboratory-identified drivers of CO_2 sequestration such as mineral dissolution, high pH and alkalinity. This study identifies ultramafic mine waste at Advocate Mine as a viable feedstock for scalable CDR.