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Enhanced CO_2 sequestration within gold mine tailings for carbon-neutral mining

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In addition to reducing carbon dioxide (CO_2) emissions from the mining industry, large-scale carbon dioxide removal (CDR) technologies have the potential to enable carbon-neutral mining and stabilize tailings [1]. While previous research has highlighted the efficacy of ultramafic wastes from nickel and diamond mines for mineral carbonation, few studies have assessed the use of gold mine tailings [2]. The effects of CO_2 injection on cement paste backfill (CPB), a mixture of a cement binder, tailings and water used to fill mined-out voids, are also poorly understood [3]. This study will use tailings from two gold mines to accelerate and monitor CO_2 removal in laboratory-scale sequestration experiments, as a basis for employing mine-scale CO_2 sequestration strategies in tailings impoundments. Additionally, the optimal conditions for maximizing mechanical strength and CO_2 uptake in CPB will be determined. Batch leaching experiments will assess the CO_2 sequestration potential of tailings by reacting with deionized water equilibrated with pure CO_2 gas for 2 days. The reactivity of these samples will be estimated by tracking changes in total inorganic carbon (TIC). Based on these results, enhanced CO_2 sequestration experiments will be conducted, in which aliquots of tailings will be wetted and exposed to varying CO_2 concentrations for 2 weeks. Quantitative mineralogy will be determined by Rietveld refinement of powder X-ray diffraction (XRD) data. Additionally, CPB will be exposed to varying CO_2 concentrations during preparation to assess the influence of reaction time and CO_2 concentration on mineralization. After curing, TIC and XRD analyses will be performed to quantify CO_2 sequestered. The influence of varying CPB composition ratios, CO_2 concentrations and exposure times on the unconfined compressive strength of the carbonated products will be assessed. These findings will aid the development of sustainable mining practices and mine waste remediation, while simultaneously providing strategies for mine-scale deployment of CDR technologies for long-term CO_2 sequestration.

[1] Power et al. (2014), *Minerals* 4, 399–436.

[2] Stubbs et al. (2022), *International Journal of Greenhouse Gas Control* 113, 103554.

[3] Hussain et al. (2025), *Journal of Cleaner Production* 518, 145950.