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Mineralogical controls on artificial laterite formation and nickel mobilization during acid leaching of ultramafic rocks

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Nickel (Ni) laterites are secondary alteration products formed through prolonged weathering of ultramafic rocks and constitute the largest surficial Ni resource. They represent a promising feedstock for integrated CO_2 mineralization and Ni recovery. The primary mineralogy of ultramafic ores and tailings may exert a strong control on laterite development, governing its role as a Ni sink and regulating Ni mobility and phase partitioning. However, existing studies focus largely on serpentine-rich tailings, leaving the influence of primary ore and tailings mineralogy on laterite development poorly constrained. This study investigates the formation of artificial laterite [1] during acid leaching of three mineralogically distinct Ni-bearing ultramafic materials: one dominated by serpentine, another comprising a mixed assemblage of serpentine, talc, chlorite, and amphibole, and a third dominated by amphibole. Laboratory leaching experiments monitored pH evolution, Mg–Fe–Ni release, and the precipitation of secondary Fe (oxyhydr)oxide phases (i.e., artificial laterite) in 50-mL syringe columns over 29 days. Reactive transport simulations combined variably saturated flow with PHREEQC-based geochemical reactions to evaluate mechanistic controls on artificial laterite development. Results show that mineralogy exerts a primary control on dissolution behavior, pH buffering, and Fe availability for artificial laterite formation. Serpentine-rich and mixed materials exhibited limited Ni mobilization and substantial solid-phase retention (≥85% of the initial inventory), coincident with Fe oxyhydroxide precipitation. In contrast, amphibole-rich material mobilized up to ~50% of Ni under persistently low pH conditions that suppressed laterite precipitation. Collectively, these results demonstrate that ore and tailings mineralogy controls laterite formation and Ni partitioning, with important implications for predicting Ni mobility and enhancing CO_2 mineralization in ultramafic mining waste.

Reference

[1] Wang et al., (2025) ES&T,