

Artificial nickel-cobalt laterite from enhanced weathering of ultramafic mine tailings: Critical metal enrichment, speciation and extraction

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Metals including Ni and Co are critical to the modern clean energy transition. Mining of these metals from ultramafic source rocks, however, generates a massive amount of mine tailings (e.g. up to 1 Gt yr⁻¹), posing significant challenges to waste disposal and management. Enhanced weathering has been applied to sequester atmospheric CO₂ via mineral carbonation, for which ultramafic mine tailings that are rich in CO₂-reactive elements Mg and Ca can be utilized as the feedstocks. Meanwhile, these tailings may contain an appreciable amount of Ni and Co, so enhanced weathering can be tailored to both mineralize CO₂ and recover critical metals.^[1]

Here we demonstrate a proof of concept that enhanced weathering of ultramafic mine tailings produces an Fe (oxyhydr)oxide rich residue (i.e. artificial laterite) that can serve as a non-traditional resource for Ni and Co. Specifically, one-month laboratory column leaching of serpentine- and olivine-rich tailings using 0.8 M H₂SO₄ has produced an artificial laterite at near-neutral pH conditions. The total Ni and Co contents in such artificial laterite are up to 1.7 and 0.05 wt%, respectively, which are 5 – 7 times enriched relative to the raw tailings and close to their cut-off grades of natural laterite ores. Synchrotron-based powder diffraction (PD) and X-ray absorption spectroscopy (XAS, Fe K-edge) results show that the artificial laterite is dominated by poorly crystalline ferrihydrite and schwertmannite. Nickel K-edge XAS data further suggest that Ni in the artificial laterite is largely associated with ferrihydrite. Suspending the artificial laterite in aqueous Fe(II) solutions at circumneutral pH and ambient temperature, which can induce the recrystallization and/or transformation of iron (oxyhydr)oxides, results in a rapid release of both Ni and Co to solution within 1 d of reaction. Followed by the extraction with 0.1 M HCl, the total percent recovery of Ni and Co from the artificial laterite is up to ~79% and ~83%, respectively, with a partial dissolution of mineral Fe(III). Overall, our work indicates that enhanced weathering of mine tailings may produce Ni and Co resources in a carbon neutral way.