

Artificial nickel laterites for carbon dioxide removal and critical metal recovery – what is its techno-economic potential?

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Nickel is primarily mined from laterite or sulphide ore deposits derived from ultramafic rocks. Inevitably, large amounts of waste materials, i.e., mine tailings, are generated during Ni mining and extraction. These tailings are subject to natural weathering over time, which leads to the formation of carbonate minerals via interactions between atmospheric CO₂ and alkaline elements like Mg and Ca – carbon mineralization. As such, enhanced leaching has been proposed, as an engineering analogue to natural weathering, to facilitate the carbon mineralization while recovering residual Ni that remained in the tailings [1]. While this indirect carbon mineralization approach holds significant promise, its complexity necessitates comprehensive economic assessments to evaluate its feasibility and scalability.

This study conducts a prospective techno-economic assessment (pTEA) of integrated carbon dioxide removal (CDR) and metal recovery, combining classical analysis, experience-based learning, and IAM constraints to evaluate feasibility considering resources, energy, operations, and grid emissions. Preliminary findings indicate a substantial CDR potential and significant economic value, with an estimated annual CDR capacity of 200 million tonnes CO₂ and projected net revenues reaching hundreds of billions of dollars by 2050. If deployed immediately, the net CDR efficiency is estimated to range between 7–32 tCO₂ removed per tonne of Ni recovered in regions with low-carbon electricity grids. However, in regions with high-carbon electricity sources, achieving net-zero nickel production remains a challenge. These findings highlight the critical role of energy decarbonization in maximizing the climate mitigation potential of this technology.

The pTEA study will also explore how CDR costs may decrease over time, how revenue from this low-carbon mining waste treatment could grow, and how deployment potential and economic viability may vary across regions and over time. Additionally, it highlights critical factors that will influence future optimization, offering insights into scaling strategies for

the process to target potential revenue from credible carbon removal and critical metal production.

References

[1] S. Wilson and J. L. Hamilton, ‘Fizzy ore processing sequesters CO₂ while supplying critical metals’, *Proc. Natl. Acad. Sci. U.S.A.*, vol. 119, no. 39, p. e2212424119, Sep. 2022, doi: 10.1073/pnas.2212424119.