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Artificial nickel laterites for enhanced metal recovery and CO_2 mineralization

SASHA WILSON[1], BAOLIN WANG[1], ARIF HUSSAIN[1], CONNOR C. TURVEY[1], ANNAH MOYO[1], MAKOTO HONDA-MCNEIL[1], JONATHAN SPENCE[1], MAXIMILIAN MANN[2], DAN SU[3], DR. ZHEN WANG, PHD[2], JASWANTH YADDALA[3], ANDREW J FRIERDICH[2], JESSICA HAMILTON[4], LAURA LAMMERS[5], IAN M. POWER[6], PHIL RENFORTH[3] AND NINA ZEYEN[7]

[1]University of Alberta
[2]Monash University
[3]Heriot-Watt University
[4]Australian Synchrotron, ANSTO
[5]Travertine Technologies, Inc
[6]Trent University
[7]University of Geneva

Presenting Author: sawilson@ualberta.ca

Serpentinites and nickel laterites, which are highly weathered serpentinites, are important hosts for the critical metals needed to electrify and decarbonize global energy systems. These magnesium-rich rocks are also amongst the best feedstocks for storage of CO_2 in minerals or as alkalinity. At least six times more nickel and cobalt (a common by-product of nickel mining) are expected to be mined from such rocks by 2040 relative to 2020 production [1]. Approximately half of the nickel in the low-grade serpentinite deposits we are mining and exploring for today is found in easily recoverable sulfide minerals; the remaining half is in serpentine and olivine minerals, which are currently remitted to tailings as unprocessable waste.

Here, we describe a novel acid heap-leaching process that turns unweathered serpentinite ore or tailings into an artificial nickel laterite while producing a magnesium-rich liquor that can be used to convert atmospheric or industrial CO_2 into magnesium carbonate minerals. Column leaching experiments were done using variably serpentinized and carbonate–chloride altered nickel ores and tailings from mines and exploration projects in Canada and Australia. Daily treatments of dilute sulfuric or hydrochloric acid were used to leach magnesium, nickel and cobalt from silicate and sulfide minerals and, where present, brucite [$Mg(OH)_2$]. Our results show that the degree of serpentinization controls the efficiency of metal extraction, the carbonation potential and the physical properties of the porous medium. Leaching of highly serpentinized ore and tailings extracts more magnesium, yields higher pH solutions, and is more easily tuned to produce and recover either aqueous nickel and cobalt or nickel- and cobalt-rich iron-oxyhydroxides. Our results provide guidance on how heap leaching can be adapted to enhance recovery of critical metals while generating a magnesium-rich liquor for CO_2 mineralization.

[1] IEA, “Global energy review 2021”. https://www.iea.org/reports/global-energy-review-2021.