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Comparative study of limonitic and saprolitic laterite ores on the leaching characteristics under atmospheric pressure

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ABSTRACT

Sulfuric acid leaching as a function of acid dosage (200–800 kg H_2SO_4/dmt) and time (1–168 h) was performed on saprolitic laterite ores (SL) and limonitic laterite ores (LL) from different regions to characterize and compare the leaching behavior of saprolitic and limonitic laterite ores at room temperature and atmospheric pressure. The major mineral of SL is antigorite/lizardite, whereas the main minerals of LL are goethite and talc. The metal leaching efficiency of both SL and LL increased with rising acid dosage, and leaching behavior was related to acid consumption. The nickel leaching efficiency and rate constant of SL were higher than that of LL under the same acid dosage condition. XRD analysis on the residue after leaching confirmed that serpentine is easier to leach than goethite and talc due to the mineral structure. Kinetic analyses showed that the leaching of laterite ores employed in the present work was well fitted to the Shrinking Core Model with the rate-determining step of a solid product layer diffusion.

1. Introduction

Recently, demand for high-nickel, which is required for manufacturing battery cathode materials, has been increasing rapidly as the demand for electric vehicles has accelerated under the 2050 NET-ZERO strategy. This is because nickel can increase the energy density of the cathode material to extend the mileage and reduce the proportion of cobalt, which is more expensive, to improve energy efficiency and reduce manufacturing costs. The demand for nickel in battery precursors is expected to surge from 7 % in 2021 to 41 % in 2040 (Statista, 2024a; Statista, 2024b), requiring a stable supply chain to address the surge in demand. The main sources of nickel are sulfide ore and laterite ore, with about 60 % of the world's nickel currently coming from sulfide ores and about 40 % from laterite ores. However, high-grade sulfide ores capable of producing high-grade nickel are becoming increasingly depleted. Major sulfide deposits have already been developed and optimized, and the discovery and development of significant new sulfide regions are slowing down (Norgate and Jahanshahi, 2011; Stanković et al., 2020). In the case of low-grade sulfide ore mining due to the depletion of high-grade sulfide ores, it is difficult to develop further sulfide ores because of the need for deeper drilling and increased mining costs (Mweene et al., 2024; Zhu et al., 2012). As a result, there is a need to process laterite ores, which account for 70 % of the global nickel reserves, as a new source of nickel.

Nickel laterite ores are broadly categorized as limonite and saprolite depending on chemical composition and mineralization. Unlike sulfide ores, nickel is distributed throughout laterite ores (Hosseini Nasab et al., 2020; Mweene et al., 2024; Norgate and Jahanshahi, 2011) and is mainly present in a substituted form for iron and magnesium, which makes it difficult to be beneficiated by physical methods (such as flotation) before processing (Hosseini Nasab et al., 2020; Norgate and Jahanshahi, 2011; Stanković et al., 2020; Zhu et al., 2012). Therefore, the recovery of nickel from laterite ores is conducted directly from ores without further processing such as beneficiation (Mweene et al., 2024), and most commercialized processes currently involve pyrometallurgy and hydrometallurgy. Pyrometallurgy is mainly applied to saprolitic laterite ores with high nickel and magnesium content (Bahfie et al., 2022; Elias et al., 2002; Hosseini Nasab et al., 2020; Pandey et al., 2023; Stanković et al., 2020), and the minimum nickel grade required by the process is 1.7–2.1 % (Dalvi et al., 2004; Stanković et al., 2020). The disadvantages of the pyrometallurgy include high operational expenditures (OPEX), high energy intensity, high carbon footprint, and the fact

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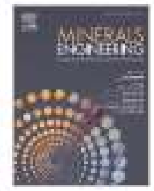

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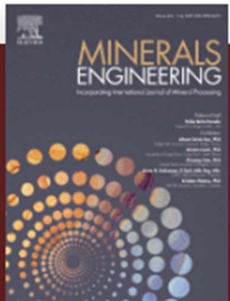
Highlights

- Sulfuric acid leaching was performed at room temperature and atmospheric pressure.
- Leaching mechanisms of different laterite types were studied.
- Serpentine-type mineral is easier to leach than goethite and talc.
- Leaching of laterite ores employed in the present work matched the shrinking core model.



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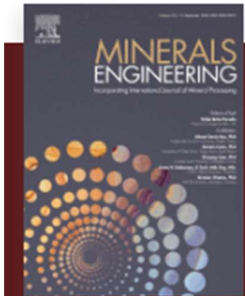

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