

## **Synchrotron micro-spectroscopic examination of Indonesian nickel laterites**

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### **ABSTRACT**

Nickel is typically distributed across several fine-grained minerals in nickel laterites, formed by intense tropical weathering of ultramafic rocks. Indonesia accounts for approximately 16% of the world's lateritic nickel reserves, which play an increasing role in global nickel production. However, relatively few geochemical studies of Indonesian laterites have been undertaken and quantification of Ni speciation is unclear. In this study the Ni geochemistry of an Indonesian laterite composed of limonite and saprolite has been examined using synchrotron microprobe analysis (microprobe X-ray fluorescence microscopy,  $\mu$ -XFM; microprobe X-ray diffraction,  $\mu$ -XRD; microprobe X-ray absorption spectroscopy;  $\mu$ -XAS) and bulk XAS. This approach provides semi-quantitative species specific information not readily obtainable using traditional laboratory methods that are hampered by the fine-grained heterogeneous nature of laterites. In the limonite 16  $\pm$  4% of the Ni was found to be substituted for Al in lithiophorite with 26  $\pm$  7% being associated with lizardite (a serpentine) substituted for Mg. A minor proportion of the Ni is adsorbed onto the Mn layers of phyllomanganate (e.g., lithiophorite). However the majority of the Ni, 58  $\pm$  15% is substituted for Fe in goethite. The majority of the Ni (85  $\pm$  21%) within the saprolite is found to be associated with lizardite, the predominant mineral. A few relatively large Ni asbolane grains are also observed, which account for 14  $\pm$  3% of the Ni with the remaining 1  $\pm$  0.3% of the Ni replacing Fe within goethite.

**Keywords:** Indonesian nickel laterite, limonite, saprolite, X-ray absorption spectroscopy, synchrotron microprobe,  $\mu$ -XRD,  $\mu$ -XFM