# NICKEL LATERITES

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Nickel laterites are regolith materials, derived from ultramafic rocks, that contain economically exploitable reserves of nickel (and, commonly, cobalt). They are found where the ultramafic rocks outcrop over a wide area and the regolith is well preserved. The deposits are developed on olivine-bearing ultramafic rocks, mainly dunite and olivine-pyroxene peridotite, and their serpentinized equivalents. The nickel is derived principally from forsteritic olivine (>$Fo_{75}$), which commonly contains 0.16-0.40% Ni.

The nickel concentrations generally occur in one or more horizons or units within the profile and the ores can be classified according to their mineralogy (Brand *et al*, 1998):

> *Oxide:* dominated by iron oxyhydroxides, principally goethite, forming the mid- to upper saprolite and extending to the pedolith. Nickel is hosted mainly in goethite, by substitution for iron and/or by adsorption. Manganese oxides (*e.g.*, asbolan, lithiophorite) are commonly abundant and are enriched in both cobalt and nickel. Deposits developed over dunites (adcumulates) may contain abundant secondary silica. Mean grades are about 1.0-1.6% Ni; examples include Cawse, Ravensthorpe, Goongarrie.
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> *Clay silicate:* dominated by Ni-rich smectites such as nontronite and saponite, commonly in the mid to upper saprolite and pedolith. Nickel in these minerals is fixed between structural layers or substitutes for ferric iron in the octahedral layer, with concentrations up to 4%. Mean grades are generally 1.0-1.5% Ni. The deposits form from peridotites (mesocumulates and orthocumulates) and are exemplified by Murrin Murrin and Bulong.
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> *Hydrous Mg silicate:* dominated by hydrous Mg-Ni silicates in the lower saprolite. The silicates are mainly nickeloan varieties of serpentine, talc, chlorite and sepiolite, many of which are poorly defined and are known informally as "garnierite". Globally, these ores have the highest grades (mean 1.8-2.5% Ni), and are typically found in areas of high relief. In Western Australia, they are represented only by low grade altered serpentines (e.g., at Ravensthorpe). Similar minerals also occur in saprolite at the Mt. Keith MKD5 deposit, but this does not constitute a nickel laterite resource.

The deposits formed under the humid climates prevailing in the Cretaceous to mid-Tertiary, but have been modified under later arid conditions by the precipitation of secondary silica, especially over dunites, and magnesite in saprolite.

Enrichment of nickel occurs in the regolith on all originally olivine-bearing ultramafic rocks, although the amount varies according to the mineralogy of the protolith and its metamorphic history. The high grade, hydrous-silicate deposits in high relief areas of the humid tropics are typically developed on ophiolitic olivine-orthopyroxene peridotites (harzburgites). Conversely, talc-carbonate rocks never give rise to economic concentrations of nickel in the regolith, although contents are elevated compared to the primary abundance and to other lithologies.

In addition to bedrock lithology, the formation of nickel laterite, including the type and grade, is controlled by geological structure, tectonism, climatic and weathering histories, regolith-landform setting and topography (Table 1). These influence the intensity of weathering, the drainage status of the regolith at different stages of its development, and the degree of preservation of the profile.

TABLE 1: Summary of controls on nickel laterite formation

| | Hydrous Mg silicate | Clay silicate | Oxide |
|---|---|---|---|
| Climate | Humid savanna – rainforest | Humid savanna; possibly formed or modified in semi-arid climates | Savanna; modified in semi-arid climates |
| Relief | Moderate | Moderate to low | Moderate to low |
| Drainage | Free | Impeded | Free or impeded |
| Tectonism | Promoted by uplift | Inhibited by uplift. | Promoted by uplift |
| Primary structure | Promoted by increased weathering and Ni enrichment along open fractures | Enrichment on some fractures. Possibly promoted where faults impede drainage. | Promoted by increased weathering and Ni enrichment along open fractures |
| Primary lithology (only olivine-rich ultramafic rocks). | Peridotite>dunite. | Peridotite>>dunite | Dunite and peridotite. Component of all deposits. |

Knowledge of the characteristics of nickel laterites is essential for effective exploration for nickel sulphides in deeply weathered terrain. Higher concentrations of nickel may be developed in the regolith over barren adcumulates than over similar rocks containing disseminated or matrix mineralization. Secondary enrichment is commonly focussed along fractures and shears, and the geochemical data alone may simulate the distributions associated with weathered sulphide mineralization and associated wall-rock. Discrimination can be made by use of abundances and ratios of pathfinder elements, such as copper and the platinum group elements, but the solutions are not unique and wholly reliable diagnostic criteria have yet to be found.

**Reference**

Brand, N.W., Butt, C.R.M and Elias, M. 1998. Nickel laterites: classification and features: AGSO Journal of Australian Geology and Geophysics, 17: 81-88.