MURRIN MURRIN NICKEL LATERITE DEPOSIT, WA

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LOCATION

The Murrin Murrin Ni laterite deposit is situated approximately 60 km E of Leonora within the NE Yilgarn Craton of Western Australia at 28°50'S and 121°54'E; Laverton 1:250 000 (SH/51-2) map sheet.

DISCOVERY HISTORY

The area was first targeted for gold prospecting and mining began in the 1890's. Production of Cu followed from 1899 to 1908 from the Anaconda, Rio Tinto and Nangeroo mines, after discovery of small Cu-Zn sulphide deposits (Gower, 1976). Exploration for Ni sulphide deposits was initiated some 60 years later, which although unsuccessful, indicated the smectite-hosted Ni deposits of the area (Monti and Fazakerley, 1996). Anaconda Nickel NL commenced development of Ni laterite deposits for Ni and Co production in 1993.

PHYSICAL ENVIRONMENT

Climate and vegetation

The climate is semi-arid, with generally hot, dry summers and cool, wet winters. The mean annual rainfall for both Leonora and Laverton is 222 mm, the mean maximum temperature for January is 37.1° C and 18.2° C for July (Pringle *et al.,* 1994).

Vegetation is mainly open woodland dominated by acacia (*e.g*., *Acacia aneura* – mulga) and *Eremophila* spp., (*e.g.,* poverty bush), with low shrublands and Wanderrie grasses common (Pringle *et al.,* 1994). Various eucalypts (*e.g*., *Eucalyptus camaldulensis* - river red gum) are restricted to the main drainages. Isolated populations of the rare *Hemigenia exilis* occur S of the Minara Homestead (MM south), restricted mainly to duricrust ridges, hills and creek beds.

Geomorphology

The Murrin Murrin Ni laterite deposits occur within a gently undulating terrain of generally low relief. Weathered ultramafic rocks provide the few high points in the landscape, consisting of sub-parallel, elongated ridges, mesas and buttes, and minor breakaways, capped by ferruginous duricrust. To the N, granitic rocks have significant breakaways with extensive plateaux and backslopes (Figure 1).

Extensive alluvial and colluvial deposits blanket large areas to the NW, SW and ESE of the Ni deposits, producing subdued relief. These alluvial sediments form part of an extensive NW oriented, sub-parallel palaeodrainage system (Figure 1), bounded by the Carey and Raeside lake systems to the NE and SW respectively (Pringle *et al.,* 1994). The Murrin-Murrin deposits straddle the drainage divide between these lake systems.

GEOLOGICAL SETTING

The Murrin Murrin deposits are formed from serpentinized peridotite (komatiitic olivine cumulate) within the Archaean Norseman-Wiluna greenstone belt (Monti and Fazakerley, 1996). These Ni deposits occur low in the stratigraphy with feldspathic, clastic and volcaniclastic sediments, mafic volcanics and intrusives in the upper parts (Monti and Fazakerley, 1996).

A regional, N plunging anticlinorium to the E of the ultramafics and an equivalent synclinorium to the W, constrain the Murrin Murrin ultramafic rocks to a NNE striking sequence. The sequence is further constrained by regional NNE striking, westerly dipping faults (Figure 2), which are offshoots of the NW striking Keith-Kilkenny fault to the SW (Monti and Fazakerley, 1996). Intrusion by granite, granodiorite and adamellite has added tightly folded synclinal structures (Kilkenny syncline) with plunge reversals (Figure 2) to the deformation of the greenstone belts. This deformation has resulted in two areas of outcropping serpentinized peridotite, Murrin Murrin North (MM2) and Murrin Murrin South (MM3; Figure 2). Two representative areas within

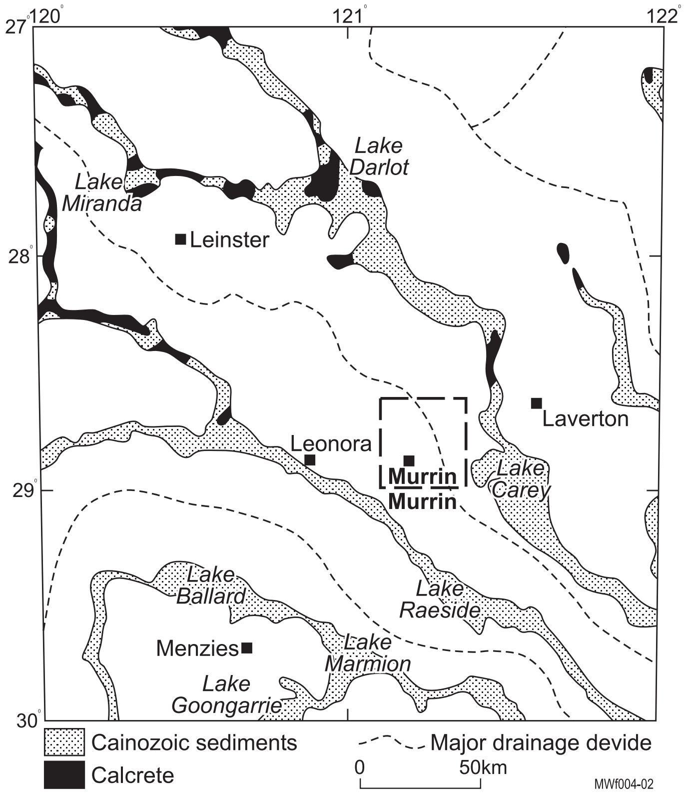

Figure 1. Palaeodrainage system of the Leonora-Laverton Area. The most active drainages are shaded.

the MM2 and MM3 deposits were selected to highlight differences in the regolith and its evolution between Murrin Murrin North and Murrin Murrin South.

REGOLITH

Nickel laterites

Lateritic weathering of serpentinized peridotites at Murrin Murrin has produced a profile that may be broadly divided into three units: (i) saprolite at the base of weathering, overlain by (ii) a smectite zone, capped by (iii) a ferruginous zone (Camuti and Riel, 1996; Monti and Fazakerley, 1996). Calcrete, interleaved with thin, ferruginous hardcap, is developed in some places at the top.

A three-dimensional model of the laterite profile developed at MM2 is shown in Figure 3. Profile development at MM2 is influenced locally by faulting and shearing (Figure 3), whereas that at MM3 is not structurally controlled. The saprolite at both MM2 and MM3 consists mainly of Mg-rich clays (saponite, Mg-chlorite) and cryptocrystalline silica. Magnesium-rich clays have pseudomorphously replaced serpentinized olivine, retaining the cumulate fabric of the original peridotite. Serpentine forms rims around altered cumulate grains (Camuti and Riel, 1996). Secondary silica occurs mainly in sub-horizontal veins, and colloform blocks of magnesite, reaching 1 m across, occur in the lower saprolite.

Further weathering of serpentinized peridotite has produced a zone of Fe-rich nontronite-like smectite with chlorite, saponite and Fe oxides (goethite and hematite). In the smectite zone at MM3, 'nontronite' comprises 30-50% of the normative mineralogy[1], with about half as much chlorite. In comparison, at MM2, chlorite is typically twice as abundant as 'nontronite', accounting for 10-20% of the normative mineralogy in the smectite zone.

The ferruginous zone at both sites consists dominantly of kaolinite (30-50%) and Fe oxides (goethite and hematite). Kaolinite replaces chlorite as the main Al-bearing phase in the intensely weathered upper

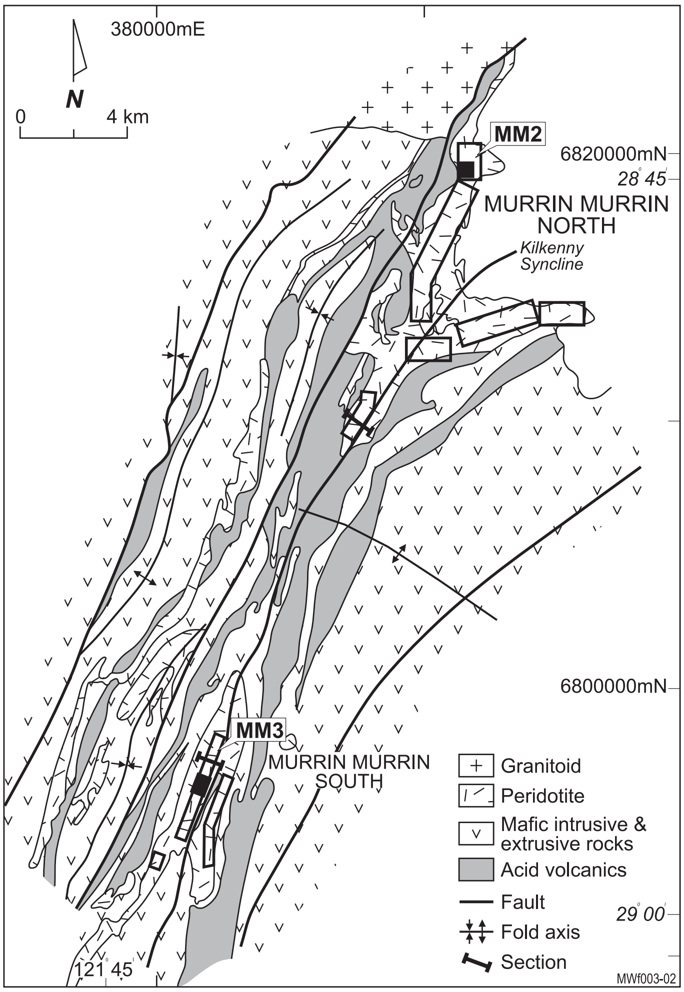

Figure 2. Generalised geological and structural setting of the Murrin Murrin Ni-deposits (modified from Monti and Fazakerley, 1996). Two areas, marked with a black square, were selected within the MM2 and MM3 deposits for detailed study.

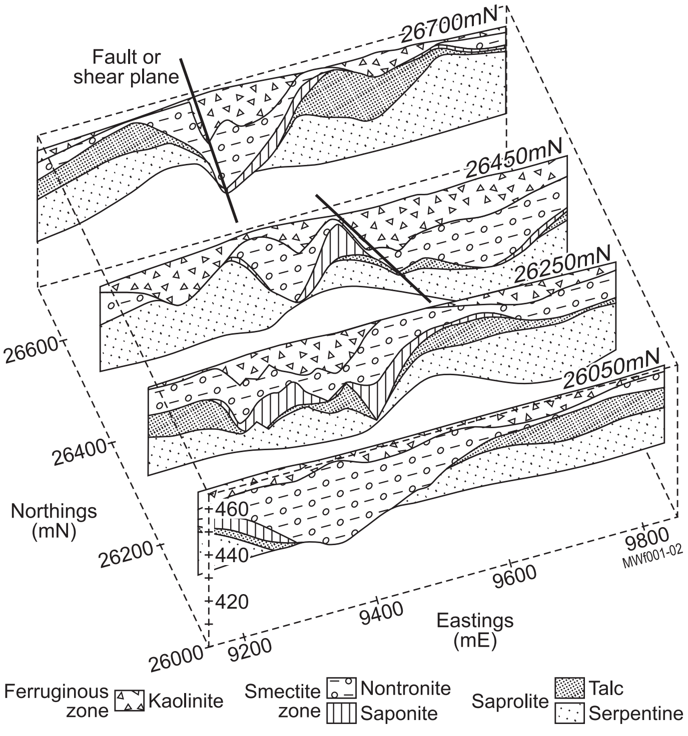

Figure 3. Three-dimensional perspective (200° azimuth, 50° elevation with x5 vertical exaggeration) of the Ni-laterite profile at MM2, taken as vertical slices along four transects. A shear or fault plane is evident to the north of the deposit and has offset or normally displaced the smectite zone.

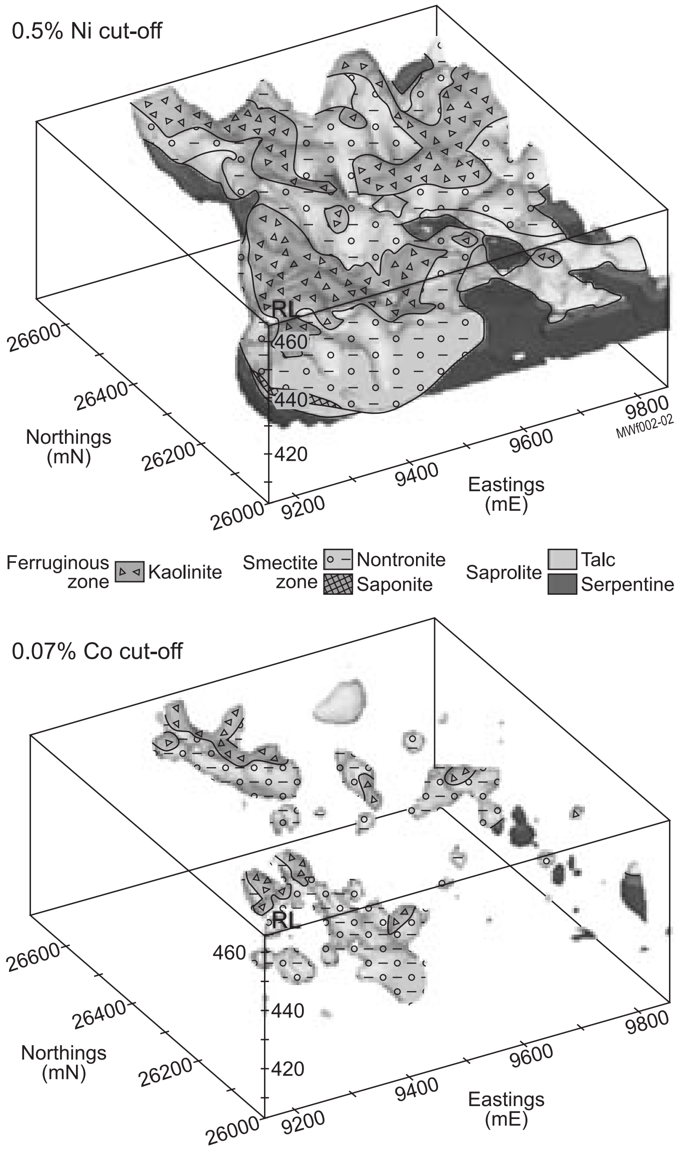

Figure 4. Three-dimensional perspective (200°azimuth, 45° elevation with x5 vertical exaggeration) of block models of the distribution of Ni and Co at cut-off concentrations of 0.5% and 0.07% respectively. Nickel occurs mainly in the smectite zone and upper saprolite, being hosted mainly by smectite and chlorite.

profile. Iron oxides, which generally comprise only 5-10%, of the minerals in the saprolite and lower smectite zones, increase markedly in abundance to 50-70% in the upper part of the smectite zone and ferruginous zones.

Variations in profile mineralogy are related mainly to the underlying lithology. At MM2, the regolith is derived principally from comparatively Al-rich ortho- and meso-cumulates (Hill *et al.,* 1996). This may account for chlorite being the dominant phase within the saprolite and, in particular, the smectite zones, with chlorite generally twice as abundant as either saponite or nontronite. MM3 is developed from an Al-poor adcumulate (Hill *et al.,* 1996) and chlorite is less abundant than either saponite or nontronite in the saprolite and smectite zones, respectively (Wells and Butt, 2000). Locally, weathering of talc-carbonate altered cumulates has left largely talc and silicified magnesite.

Geochronology

Palaeomagnetic dating of grey, ferruginized saprolite from trial pits at MM2 indicates both Tertiary and Mesozoic weathering events (B. Pillans, CRCLEME/ANU, written communication, January 2000).

MINERALIZATION

Nickel-cobalt mineralization is hosted mainly within the smectite and upper saprolite zones, with less in their ferruginized equivalents (Figure 4). In all these zones, Ni is mainly hosted by smectitic clays and chlorite, with less in serpentine and Mn oxides. The smectite is typically referred to as nontronite, but is strictly a Fe-rich dioctahedral smectite, being intermediate between the Fe, Al and Mg smectite end-members, nontronite, beidellite and montmorillonite, respectively (Wells and Butt, 2000).

Cobalt mineralization is principally associated with Mn oxides at or near the contact of the smectite and ferruginous zones in the profile (Figure 4). The Mn oxides are asbolan-like, $(Co,Ni)Mn_2O_4(OH).xH_2O$, with a variable Co:Ni ratio that is typically 1:1 and a Co:Mn ratio of 0.33 (Wells and Butt, 2000).

As of January 2001, the ore reserves for Murrin Murrin were estimated at 304 Mt at 1.0% Ni and 0.064% Co (0.8% Ni cut-off) (Register of Australian Mining 2001/02, 2001). The mine is predicted to operate for at least 30 years.

REGOLITH EXPRESSION

The serpentinized ultramafic bedrock contains about 0.2% Ni hosted by lizardite. The overlying saprolite zone has more Ni (to >5%) mainly associated with Mg-chlorite and other Mg-clays (*e.g.,* saponite). In this zone Ni also occurs in lesser amounts with preserved serpentine generally in the range 0.2->1.0% (Camuti and Riel, 1996). Local concentrations of Ni (0.5-1-2% Ni) occur in magnesite.

Nickel contents of smectite (nontronite-beidellite-montmorillonite) in the smectite zone range 0-3%. Nickel with other clays in this zone ranges from below detection to about 1.5% (Camuti and Riel, 1996). Nickel in the ferruginous zone is mainly hosted by smectitie, in amounts up to 2-4%. In the absence of clay, Ni is also associated with goethite to 2-4% (Camuti and Riel, 1996) and Mn oxides.

Cobalt is largely restricted to Mn oxides at or near the contact of the smectite and ferruginous zones. Cobalt abundances reach 7-8%, with very high Ni contents of 6-8%. These asbolan-type Mn oxide minerals are also enriched in Ba (up to 1-2 % Ba; typically 0.5-1.0%).

DISPERSION MODEL

TBA

REFERENCES

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(Footnotes)

[1] Mineral abundances were calculated as mineral-Norms of 495 pulp samples after phase identification by XRD and reflectance IR analysis. Details are given in Wells and Butt (2000).

SAMPLE MEDIA – SUMMARY TABLE

Sample medium	Indicator elements	Analytical methods	Detection limits (ppm)	Background (ppm)	Grade cut off (ppm)	Max concentratio n (ppm)
Ferruginous zone	Ni Co Mn	XRF XRF XRF	10 10 20	400 40-100 200		8600 5500 29000
Smectite zone	Ni Co Mn	XRF XRF XRF	10 10 20	<2000 100 400	5000 600-700	22400 3000 13000
Saprolite zone	Ni Co	XRF XRF	10 10	1000-1300 <100		16300 1400
Serpentinized ultramafic	Cr Ni	XRF XRF	10 10	1000-2400 <2000		24400 16700