MAGGIE HAYS NICKEL MINERALIZATION, LAKE JOHNSTON DISTRICT, WESTERN AUSTRALIA

W. Clayton[1], C. Stott[1] and R.H. Mazzucchelli[2]

[1]*Lionore Australia Pty Ltd., P.O. Box 906, West Perth, WA 6872*

[2]*Searchtech Pty Ltd P.O. Box 189 Kalamunda, Western Australia 6076*

LOCATION

The Maggie Hays Ni sulphide deposit is located at 120º30'E 32º15'S, approximately 500 km E of Perth: Lake Johnston 1:250 000 map sheet (SI51-01) (Figure 1).

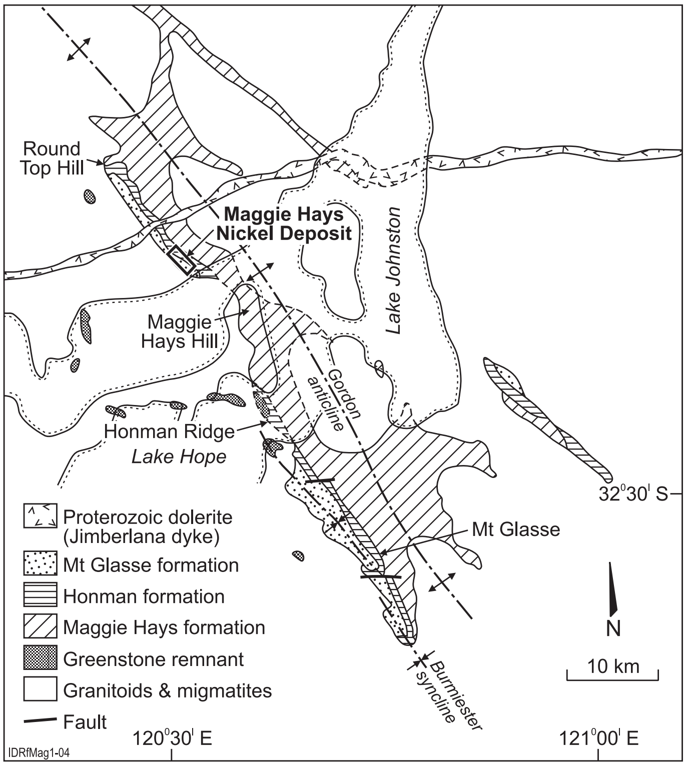

Figure 1. Location and regional geology after Gower and Bunting (1976) and Buck et al., (1998).

DISCOVERY HISTORY

Nickel sulphide mineralization was first reported at Maggie Hays in 1971, when the Union Miniere - Laporte Mining joint venture intersected 6.1 m at 0.98% Ni and 420 ppm Cu in drill hole LJ3. The target for LJ3 was a coincident 2000 ppm Ni and 180 ppm Cu anomaly defined by <0.2 mm soil samples, collected on a 60 m by 30 m grid. Five gossanous rock chip samples from the same area returned 1050–1200 ppm Cu and 1200-5000 ppm Ni (Eshuys *et al.*, 1972). This mineralization occurs at the contact between ultramafic and felsic volcanic rocks, but is shallow and is now known as the Maggie Hays South deposit.

The Maggie Hays deposit, located some 400 m to the N, was first intersected in drilling by Amoco Minerals Australia Incorporated in 1981, but the main deposit was delineated by LionOre only in 1993, after some 22 years of exploration by different groups. That the deposit is blind, the top occurring at depths of 100-180 m below surface, and the complex geometry of the mineralized contact, account for the protracted exploration history (Buck *et al,* 1998).

PHYSICAL ENVIRONMENT

The climate is semi-arid with irregular annual rainfall averaging about 300 mm. The region is characterised by widespread sand-plains, probably derived from weathered Tertiary sedimentary cover. The Maggie Hays Ni mineralization occurs within an erosional window centred on the playa system dominated by Lakes Johnston and Hope (Figure 1). The mafic lithologies form low, rounded hills between 350 and 450 m ASL, although a substantial part of the prospective belt lies within the playa, and is concealed by alluvial and windblown deposits. Eucalypt woodland vegetation is well developed, grading to saltbush plains with local sand dunes on the margins of the playas.

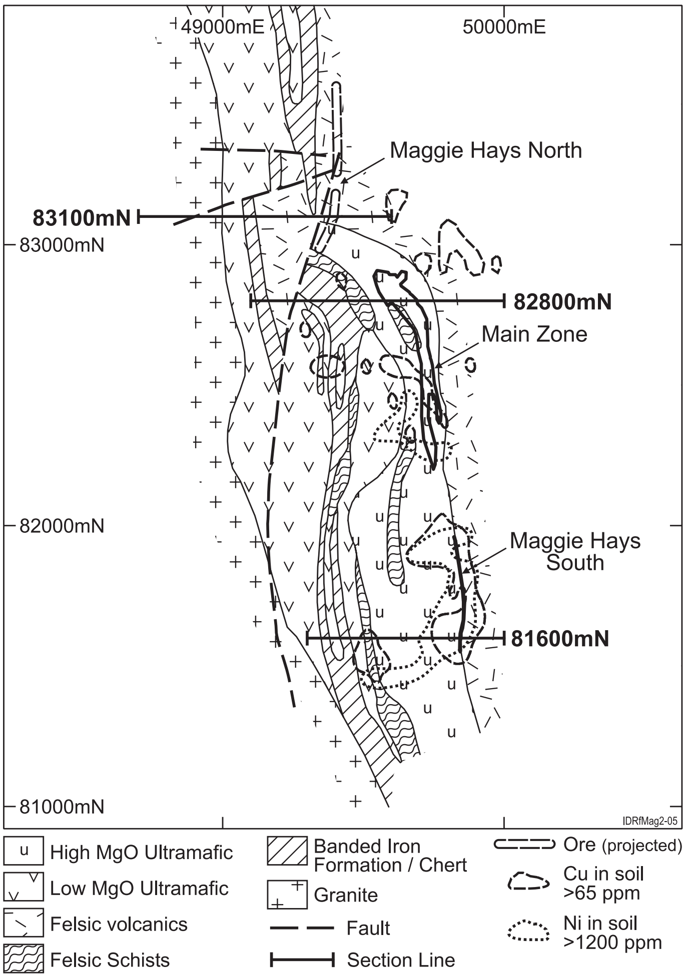

Figure 2. Bedrock geology with locations of cross-sections and soil geochemistry.

GEOLOGICAL SETTING

The Maggie Hays deposit is located in the Lake Johnston Greenstone Belt, which forms part of the Southern Cross Province in the Archaean Yilgarn Craton. Regional mapping in 1971 (Gower and Bunting, 1976) sub-divided the greenstones into the Maggie Hays, Honman and Mt Glasse Formations, each containing an ultramafic unit. The Maggie Hays deposit lies within the Honman Formation and is hosted by the Central Ultramafic Unit (CUU). Regional metamorphism to the almandine amphibolite facies has recrystallized the mafic and ultramafic rocks.

Near the deposit, the rocks strike NW and dip from 60º E in the N, to 80º W in the S (Figure 1). The sequence consists of a footwall of porphyritic, felsic to intermediate volcanic rocks, a thick olivine mesocumulate to adcumulate ultramafic flow unit (CUU), a strongly sheared, interlayered series of felsic volcanic and banded iron formation (BIF) and thin, differentiated komatiite flows of the Western ultramafic unit (WUU). Spinifex textures are common in the WUU and indicate that the sequence faces W and is partly overturned (Buck *et al.*, 1998). The footwall porphyritic felsic volcanic rocks have an age (SHRIMP U-Pb) of 2921$\pm$4 Ma (Wang *et al.*, 1996). A major thrust, dipping at 50-60º to the E, truncates the ultramafic sequence at depth and to the N. Mineralization extends along the fault zone, N of the structural termination of the CUU, to form the Maggie Hays North shoot.

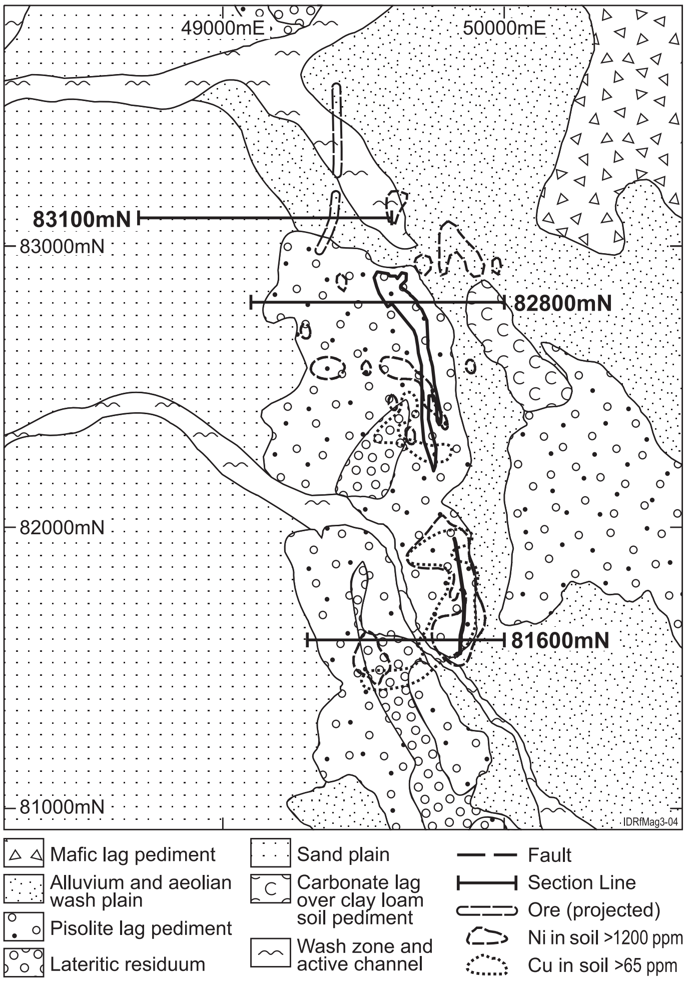

Figure 3. Regolith geology with locations of cross-sections and soil geochemistry.

REGOLITH

Bedrock exposure is negligible (Figure 3). A low ridge of lateritic residuum follows the trend of the BIF unit, surrounded by a pediment of lateritic lag. This grades into depositional regimes to the E, N and W. The Maggie Hays South area is the best exposed, with thin lateritic soils. Transported overburden thickens to the N, the main zone mineralization being concealed by some 5 m of colluvium, which increases to 20 m over the Maggie Hays North deposit. The regolith and the degree of exposure of the mineralization to weathering largely determine the geochemical response.

MINERALIZATION

The Maggie Hays deposit has an indicated and inferred resource of 11.8 Mt at 1.47% Ni as of March 1998. The mineralization occurs over a total strike of 1400 m, extends to a vertical depth of 400 m and can be divided into three significant zones:

The *Main Zone*, which consists of ultramafic-hosted massive and disseminated sulphides adjacent to the eastern, basal ultramafic contact. The Main Zone has a strike of about 800 m. The massive sulphide forms a sub-vertical to steeply E-dipping tabular body with a strike of 400 m. It attains a maximum thickness of 7 m and is generally overlain by a zone of disseminated sulphides up to 40 m thick. The massive and disseminated sulphides of the main zone do not occur above the base of oxidation. The massive sulphide averages 3.79% Ni and is dominated by pyrrhotite, with pyrrhotite/pentlandite ratios as high as 12:1. The disseminated sulphides average 1.20% Ni and comprise a pyrrhotite-pentlandite-pyrite-chalcopyrite assemblage, with a pyrrhotite/pentlandite ratio of 4:1. Supergene alteration of pentlandite and pyrrhotite to violarite and pyrite occur locally to vertical depths of 400 m. However, there is no near-surface supergene zone developed, as the bulk of the mineralization occurs below the watertable (Buck *et al.*, 1998).

Maggie Hays North, consists of massive and stringer sulphides hosted by felsic volcanic rocks within a major E-dipping, planar fault zone. The North Shoot mineralization strikes for 1000 m and has an average thickness of 2-3 m. Any geochemical expression of the mineralization at surface is blanketed by transported clay and colluvium up to 20 m thick. The Maggie Hays North mineralization has an average grade of 2% Ni.

Maggie Hays South, is a separate deposit located some 400 m S of the Maggie Hays Main Zone. It consists of ultramafic-hosted low grade disseminated sulphides above the eastern contact of the CUU. Mineralization extends to surface with oxidized sulphides exposed in old costeans. The Maggie Hays South mineralization has an average grade of 0.9% Ni.

REGOLITH EXPRESSION

Nickel sulphide mineralization is expressed by a coincident Ni-Cu anomaly in soil (Figure 3). However, this anomaly is related to the sub-economic Maggie Hays South deposit. The main Maggie Hays deposit is blind and has little, if any, geochemical expression at the surface; the Maggie Hays North deposit is concealed by transported overburden and geochemical response at the surface is subtle. Figure 4 shows three geological cross-sections, accompanied by geochemical profiles, which illustrate these variations in geological and regolith setting. A variety of geochemical media, tested in the area, are also compared in Figure 4.

Over the exposed sub-economic Maggie Hays South mineralization on Line 81600mN, there is an anomaly in Ni, Cu, Co, Zn, and in the Ni/Cr ratio, on both eastern and western contact zones (Figure 4A). In general, the response is greatest in the magnetic lag, followed by augered soil and <2 mm soil, although the profiles for all three media are similar. The profiles for Zn in auger soils and Co in all media show peak displacement to the W of the eastern contact mineralization, possibly due to encroachment of transported cover. The reverse is shown by lag, with a secondary peak to the E of the eastern contact mineralization, possibly due to down-slope dispersion. Both magnetic and non-magnetic lag have been tested, and as there is no significant difference in response, only the magnetic lag has been used.

Geochemical response in surface media over the concealed Main Zone (Figure 4B) is severely attenuated in comparison to that shown in Figure 4A. The only element to display clear peaks is Co, although subtle features in the Ni, Cu and Ni/Cr profiles could be related to weak mineralization on the eastern CUU contact, where it is concealed by transported cover. The strongest anomalies for Ni, Co and the Ni/Cr ratio probably reflect exposed ultramafic rocks; the highest Cu response lies over hanging-wall rocks to the W of the Maggie Hays mineralization.

The response for all elements is even less on the Maggie Hays North traverse (Figure 4C) although a broad Ni peak, with narrow coincident response for Ni/Cr, Cu and Zn appear to coincide with the subcrop of the Maggie Hays mineralization, despite some 20 m of transported cover. The Co response is also strong but shows displacement to the W. The absence of ultramafic rocks on this traverse suggests the response for Ni and Co is related to mineralization, although down-slope dispersion cannot be ruled out.

Rigid application of a single anomaly threshold is impractical at Maggie Hays, where the host varies from ultramafic to felsic, and the response is attenuated to varying degrees by transported overburden. The figures given in the following tabulation are based on statistics that exclude samples taken over ultramafic rocks. Mean backgrounds and thresholds over such rocks would be appreciably greater. Concentrations in <0.2 mm soils were 15-60% greater than those in the <2 mm fraction due, primarily, to the lower proportion of barren quartz in the finer fraction.

Geochemical data for gossan outcrops are listed. Backgrounds and thresholds are derived from a broad-based gossan-ironstone dataset, comprising about 900 samples. Note that the thresholds listed for Co and Zn are upper concentration limits for Ni sulphide gossans as defined by Bull and Mazzucchelli (1975) and Mazzucchelli, (1979).

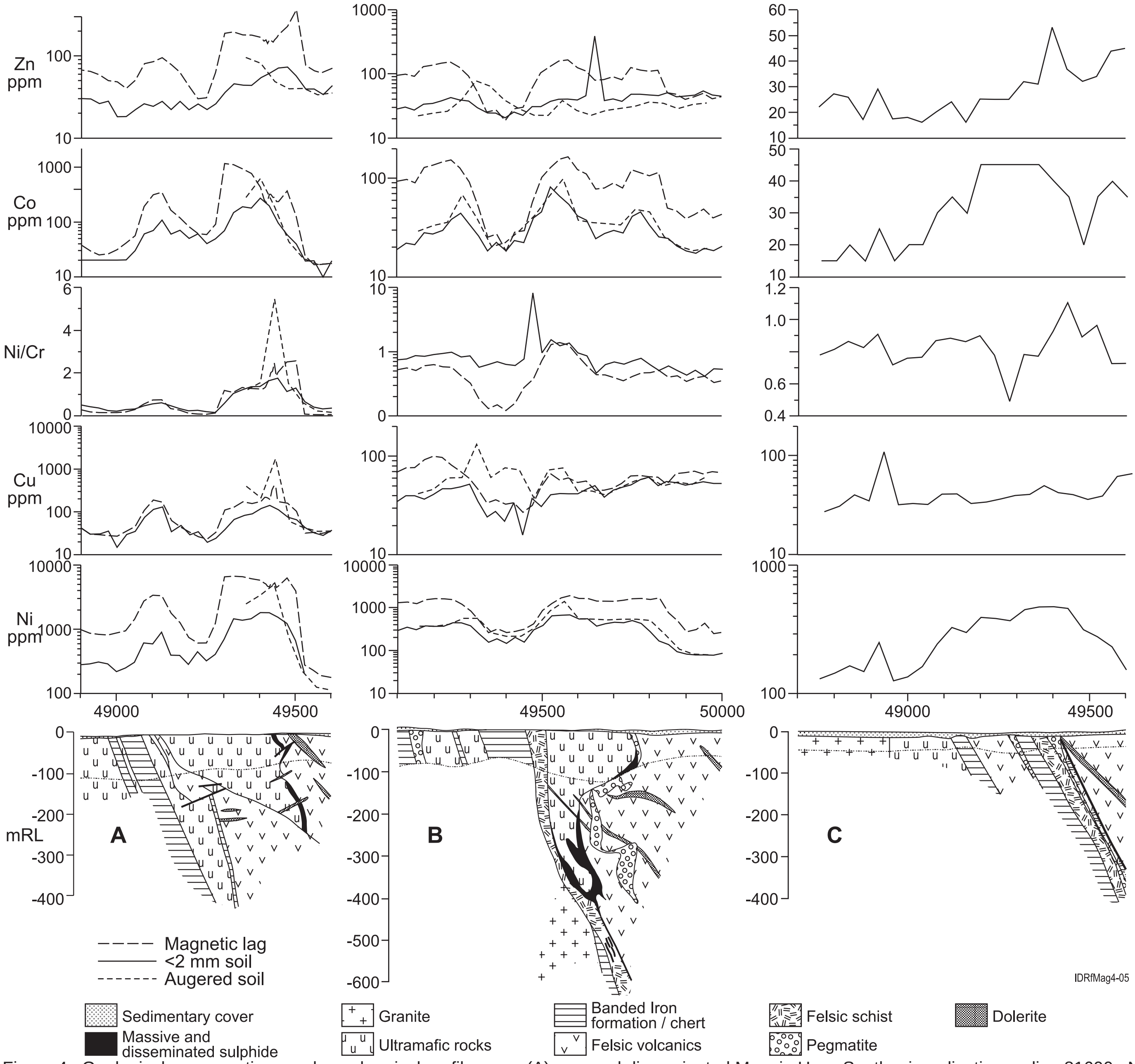

Figure 4. Geological cross-sections and geochemical profiles over (A) exposed disseminated Maggie Hays South mineralization on line 81600mN, (B) over blind Ni sulphide Main Zone mineralization on line 82800mN Main Zone (B) and (C) over concealed Maggie Hays North mineralization on 83100mN.

SAMPLE MEDIA - SUMMARY TABLE

Sample medium	Indicator element	Analytical method[1]	Detection limit (ppm)	Background (ppm)	Threshold (ppm)	Maximum anomaly (ppm)	Dispersion distance (m)
Soil <2mm	Ni	ICP-OES	1	202	500	2240	250
	Cu	ICP-OES	1	31	60	144	180
	Co	ICP-OES	1	22	50	265	250
	Cr	ICP-OES	1	252	500	4850	n/a
	Zn	ICP-OES	1	23	40	139	200
Magnetic Lag	Ni	ICP-OES	1	600	1000	6849	250
	Cu	ICP-OES	1	40	70	427	250
	Co	ICP-OES	1	40	50	1188	300
	Cr	ICP-OES	1	500	1000	10170	n/a
	Zn	ICP-OES	1	50	80	371	300
Auger Soil	Ni	ICP-OES	1	543	1000	5650	?
	Cu	ICP-OES	1	64	100	1850	?
	Co	ICP-OES	1	41	30	634	?
	Cr	ICP-OES	1	674	?1000	7530	?
	Zn	ICP-OES	1	31	80	100	?
Gossan	Co	ICP-OES	1	15	400*	160-320	n/a
	Cr	ICP-OES	1	40	N/A	648-4850	
	Cu	ICP-OES	1	390	200	530-2970	
	Ni	ICP-OES	1	30	2500	3850-8598	
	Zn	ICP-OES	1	315	200*	64-132	

[1] After mixed acid digest

REFERENCES

Buck, P.S., Vallance, S.A., Perring, C.S., Hill, R.E. and Barnes, S.J., 1998. Maggie Hays nickel deposit, In: D.A. Berkman and D.H. Mackenzie (Editors.) Geology of Australian and Papua New Guinean Mineral Deposits. The Australasian Institute of Mining and Metallurgy, Melbourne, pp 357-364.

Bull, A.J. and Mazzucchelli, R.H., 1975. Application of discriminant analysis to the geochemical evaluation of gossans, In: I.L. Elliott, and W.K. Fletcher (Editors), Geochemical Exploration 1974. Elsevier, Amsterdam pp 219-226.

Eshuys, E., Willett, G. and Smith, R.E., 1972. Final report - Lake Johnston program. Unpublished report. Unimin - Laporte Joint Venture.

Gower, C.F. and Bunting, J.A., 1976. Lake Johnston, Western Australia Sheet SH51-1. Geological Survey of Western Australia 1:250 000 Geological Series Explanatory Notes.

Mazzucchelli, R.H., 1979. Geochemical technology in mineral exploration, In: D.F. Kelsall, and I.T. Woodcock, (Editors) Mineral Resources of Australia. Australian Academy of Technological Sciences, Melbourne, pp 101-120.

Wang, Q., Schiotte, l. and Campbell, I.H., 1996. Geochronological constraints on the age of komatiites and nickel mineralization in the Lake Johnston Greenstone Belt, Yilgarn Craton, Western Australia. Australian Journal of Earth Sciences 43: 381-385.