YARAWINDAH BROOK PGE-Ni-Cu DEPOSIT, NEW NORCIA, WESTERN AUSTRALIA

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LOCATION

Yarawindah Brook is approximately 130 km NNE of Perth and 15 km SSE of New Norcia, at 31°05'40"S, 116°15'33"E (Figure 1); Perth 1:250 000 map sheet (SH50-14).

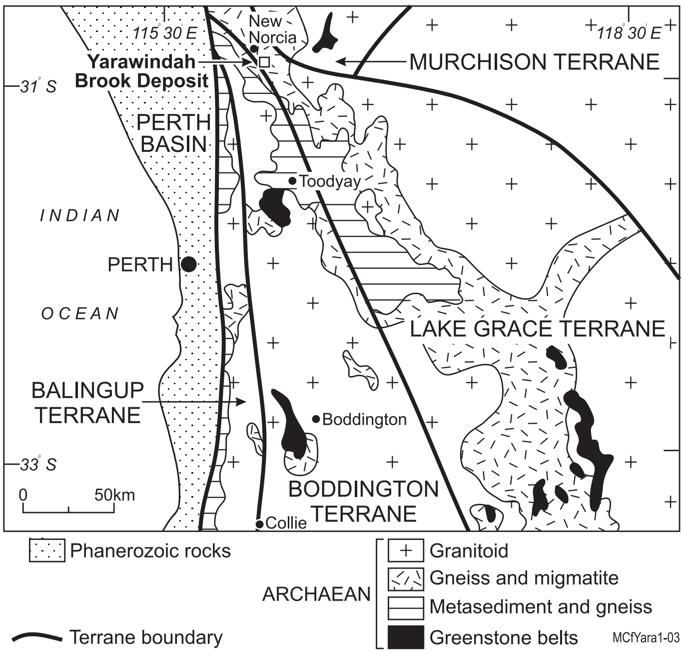

Figure 1. Regional setting of the Yarawindah Brook mafic-ultramafic complex after Wilde et al (1996).

DISCOVERY HISTORY

In 1975, Otter Exploration NL completed reconnaissance sampling of ferruginous materials above aeromagnetic anomalies, identified from BMR aeromagnetic data (Figure 2) in the New Norcia area. The survey discovered anomalous Cu and Ni in gossanous material developed on mafic-ultramafic rocks near Yarawindah Brook (G. Blackburn, personal communication, 2001). Between 1977 and 1982, a joint venture between Otter Exploration NL and Shell Exploration drilled geophysical targets for structurally-controlled Ni-Cu mineralization, but failed to locate an economic deposit. The PGE potential of the main mafic-ultramafic body was noted by Harrison (1984), who re-examined selected parts of the Shell-Otter drill cores.

In 1986, Audax Resources NL obtained an exploration licence over the prospect and, in 1988, formed a joint venture with Reynolds Australia Metals Ltd to explore the PGE potential of the mafic-ultramafic rock sequence and any supergene enrichment. Exploration included re-examining and assaying old drill cores for Pt, Pd and Au, followed by auger, RAB and vacuum drilling to test near-surface mineralization. This work was hampered by local silicification and ferruginization, and RC drilling was used to test the weathered and bedrock zones along several profiles. The drilling outlined four Pd-Pt mineralized zones in laterite and saprolite (Figure 3) above wide zones of sub-economic mineralization in the bedrock. A resource of 2.9 Mt at 0.79 g/t combined Pt and Pd was outlined, using a 0.5 g/t cut-off (or 0.5 Mt at a 1.0 g/t cut-off). Diamond drilling to 200 m tested the bedrock potential beneath the most promising saprolite-hosted Pt-Pd mineralization and confirmed the RC results, showing widespread low-grade mineralization. Reynolds withdrew from the joint venture in 1990 and, subsequently, Audax relinquished the tenement.

In the 1990s, several companies reviewed the PGE potential of the Yarawindah Brook Prospect (Lawrance, 1994; Wright, 1994) without significant exploration. Palladium Resources Pty Ltd re-evaluated the prospect, in 2000, for saprolite and laterite-hosted mineralization in view of a new PGE extraction technique, and investigated the potential for structurally controlled, hydrothermally introduced PGE. In retrospect, this deposit could have been found by regional laterite sampling.

PHYSICAL FEATURES AND ENVIRONMENT

The mafic-ultramafic rocks are poorly exposed and located in a gently undulating terrain of moderate relief. Parts of the mafic sequence and the eastern metasediments form a prominent ridge, covered with tall eucalypts and shrubs; lower surrounding areas are largely agricultural. The area has a Mediterranean climate with an annual rainfall, mainly during winter, of about 530 mm, and with minimum and maximum temperatures ranging from 8-17ºC in July and 17-33ºC in January.

GEOLOGICAL SETTING

The mineralization is hosted by a mafic-ultramafic raft (4.0 x 0.75 km) within the Archaean Jimperding Metamorphic Belt (Wilde, 1980), that is part of the Lake Grace Terrane (Wilde *et al.,* 1996) of the SW Yilgarn Craton (Figure 1). Locally, the Archaean basement comprises quartz-feldspar-biotite gneiss, quartz-mica schist and coarse-grained metaquartzite. The mafic-ultramafic body strikes NNW and appears to dip 20-30°E. The eastern contact is conformably overlain and partly intercalated with coarsely recrystallized metaquartzites and minor metapsammites that laterally extend over at least 4-5 km and resemble those exposed near Toodyay. The W contact is less well exposed, but limited drilling suggests that it is strata-parallel to and overlies the metasediments. The mineralized sequence comprises, from E to W, an upper mafic zone (mainly tremolite-serpentinite, after olivine gabbro-norite), an ultramafic zone (mainly tremolitic serpentinite, after harzburgite) and a lower mafic zone (tremolitic serpentinite and plagioclase-bearing amphibolite, after gabbro-norite).

Deformation of the Yarawindah complex is consistent with medium to high-grade (high amphibolite facies) metamorphism. The critical

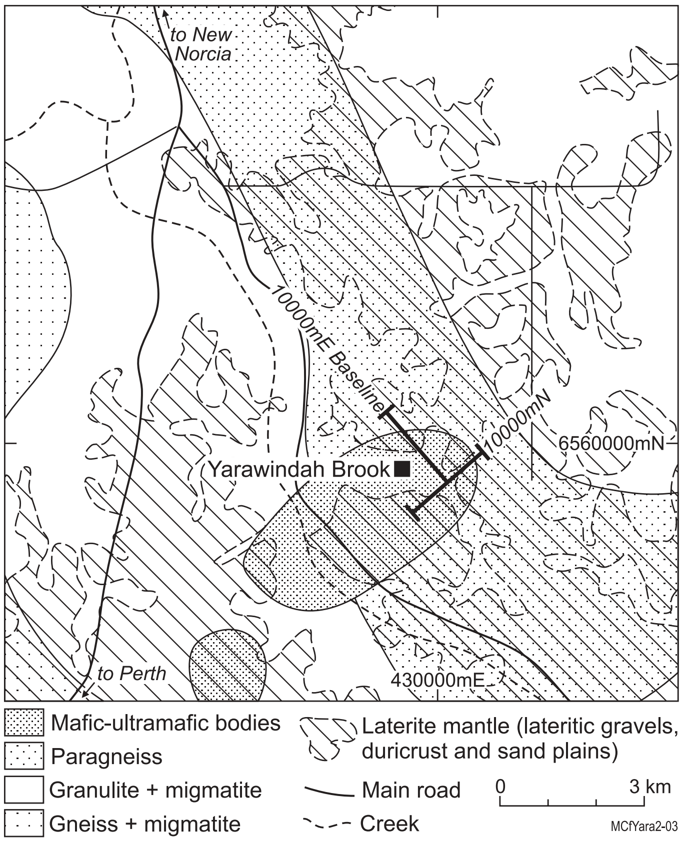

Figure 2. Local geological setting of the Yarawindah Brook deposit and superimposed laterite mantle (after Wilde and Low, 1978). Mafic-ultramafic bodies inferred from BMR aeromagnetic data.

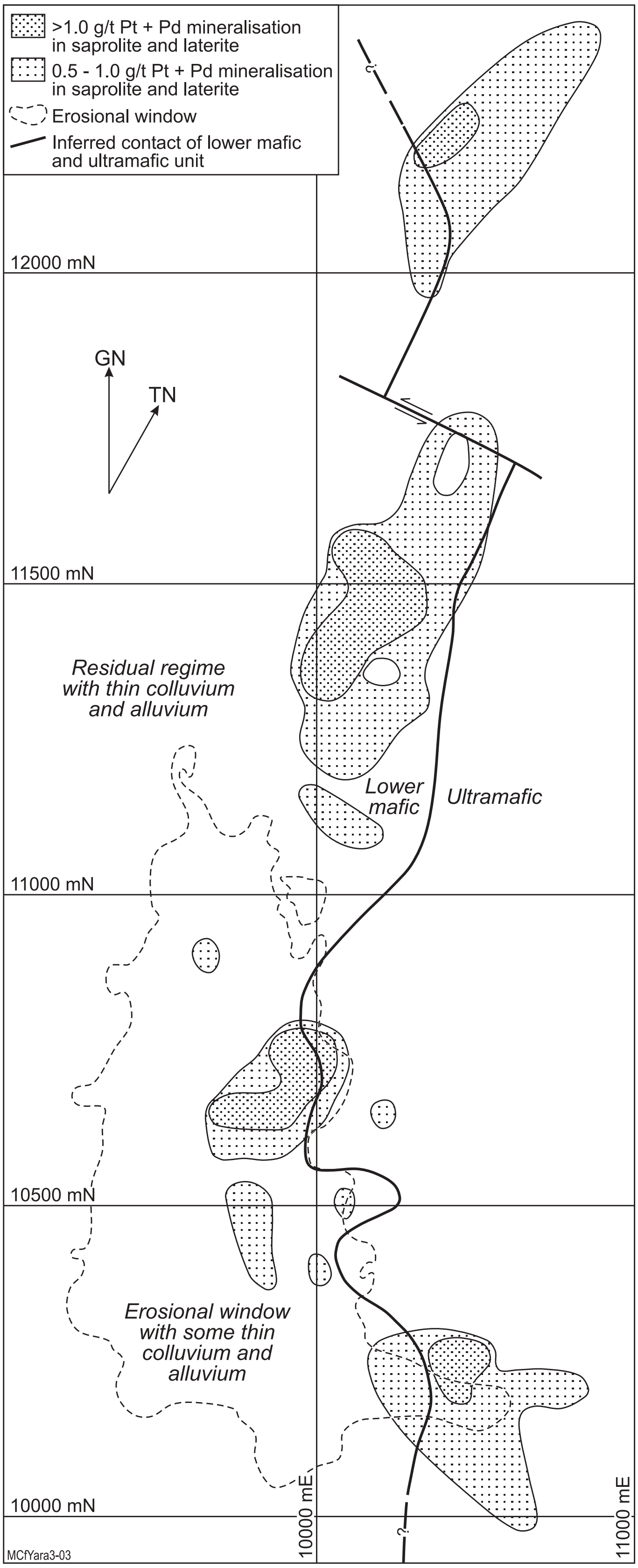

Figure 3. Pt+Pd anomalies and major regolith units in the prospect area.

assemblage at Yarawindah is almandine (+pyrope), plagioclase (An_{50}) and hornblende.

REGOLITH

Weathering, in the prospect area, penetrates to 30-50 m and outcrop is scarce, with the exception of doleritic dykes that form boulders in the southern part. The dominant feature is an approximately NNW trending ridge, following the 10 000mN baseline approximately, that is formed by a shallow E dipping metaquartzite and massive lateritic duricrust formed on mafic-ultramafic rock at the top of the ridge. In the S part of the prospect, WSW of the ridge, the residual regolith has been eroded to the saprolite and buried by shallow colluvium, formed partly of transported lateritic gravel and lithic fragments. Transported quartz-rich lateritic scree also covers slopes on the E side of the prospect. Elsewhere, the weathering profile is largely intact along ridges and scarps, where remnants of residual pisolitic to nodular lateritic duricrust occur. Colluvium and alluvium cover the partly eroded residual profile in morphologically lower parts in the N part of the prospect.

MINERALIZATION

Primary mineralization

The PGEs are associated with interstitial and intercumulus magmatic sulphides, and veins and segregations of mobilized sulphides, commonly hosted by sperrylite ($PtAs_2$), michenerite ((Pd,Pt)BiTe) and rare majakite (PdNiAs) (Cornelius *et al.,* 1987). Concentrations of 0.05-0.2 g/t Pt+Pd occur over widths of up to 70 m, mainly in the ultramafic and the lower mafic zones. Limited diamond drilling indicates the Pt-Pd enrichment to be laterally continuous, but concentrations vary significantly between holes. There are also scattered high-grade pods with 1.0-3.0 g/t Pt+Pd over several metres (see Figure 4) but these appear to lack lateral continuity. Palladium is extremely enriched over Ir, indicating strong secondary fractionation during mobilization and re-deposition of Pd. There is no evidence for Merensky Reef-type PGE mineralization. The total bedrock resource is estimated at 31 000 t at 0.5 g/t Pt+Pd (Cornelius, 1989).

Significant intersections of primary Cu-Ni mineralization include 12 m at 0.9% Cu and 0.3% Ni, 1.5 m at 2.14% Cu and 0.04% Ni, and 1.03 m at 0.36% Cu and 1.22% Ni, as chalcopyrite and pentlandite. Chalcopyrite generally forms veins and segregations whereas pentlandite occurs in less altered ores and as a primary intercumulus sulphide with a maximum tenor of 6% Ni.

Weathered primary mineralization

A resource of 2.9 Mt at 0.79 g/t Pt+Pd (0.5 g/t cut-off) or 0.5 Mt at 1.44 g/t Pt+Pd (1 g/t cut-off) was identified in four bodies of saprolite and ferruginous materials. The highest concentrations are 10.2 g/t Pt, 9.25 g/t Pd and 1.89 g/t Au in a one-metre interval of bleached clay. Discrete platinum group minerals could not be identified in this material. Metallurgical testing of the saprolite-hosted mineralization by Lakefield Oretest Pty Ltd for Palladium Resources Pty Ltd, using Lakefield's Platsol Leaching process, indicates recovery rates of $\geq$95% for Pt, Pd and Au, using H_2SO_4 in a high pressure and high temperature autoclave (D. Sargeant, written comm., 2002).

Gossanous ironstones were described by Shell/Otter and Reynolds Australia Metals along the eastern contact of the mafic-ultramafic body with the metasediments, and on Mg-rich rocks. They contain anomalous Pt, Pd, Cu and Ni concentrations.

REGOLITH EXPRESSION

The discontinuous, up to 70 m wide, primary zones of elevated Pt and Pd concentrations (>150 ppb Pt+Pd) in the bedrock extend into the regolith (Figure 4). RC drilling on sections 10200 mN and 10400 mN shows no apparent depletion of Pt or Pd in the saprolite or clay zone, nor any broad enrichment trend in the lateritic zone. This contrasts with observations of the distribution of Pt and Pd in the regolith on the Ora Banda sill where PGE contents increase steadily towards the surface, with a total enrichment of x 3-5 in the lateritic, ferruginous zone (Gray *et al.,* 1996; Butt *et al.,* this volume).

PGE concentrations are less in loose pisoliths and nodules, probably due to dilution by local colluvial transport. A dispersion halo in loose pisolitic and nodular material, defined by Pt+Pd concentrations >50 ppb in drilling, extends more than 100 m beyond the subcrop of primary mineralization. At lesser concentrations, the dispersion halo extends several hundred metres.

Chromium, Ni, Cu and Sc concentrations in lateritic gravels show a dispersion halo of approximately 1000-2000 m around the mafic-ultramafic raft, and 3 km spaced sampling of lateritic residuum and gravels on an isometric grid would have located the mafic-ultramafic body. Sampling of lateritic gravels at a spacing of ≤500 m would have

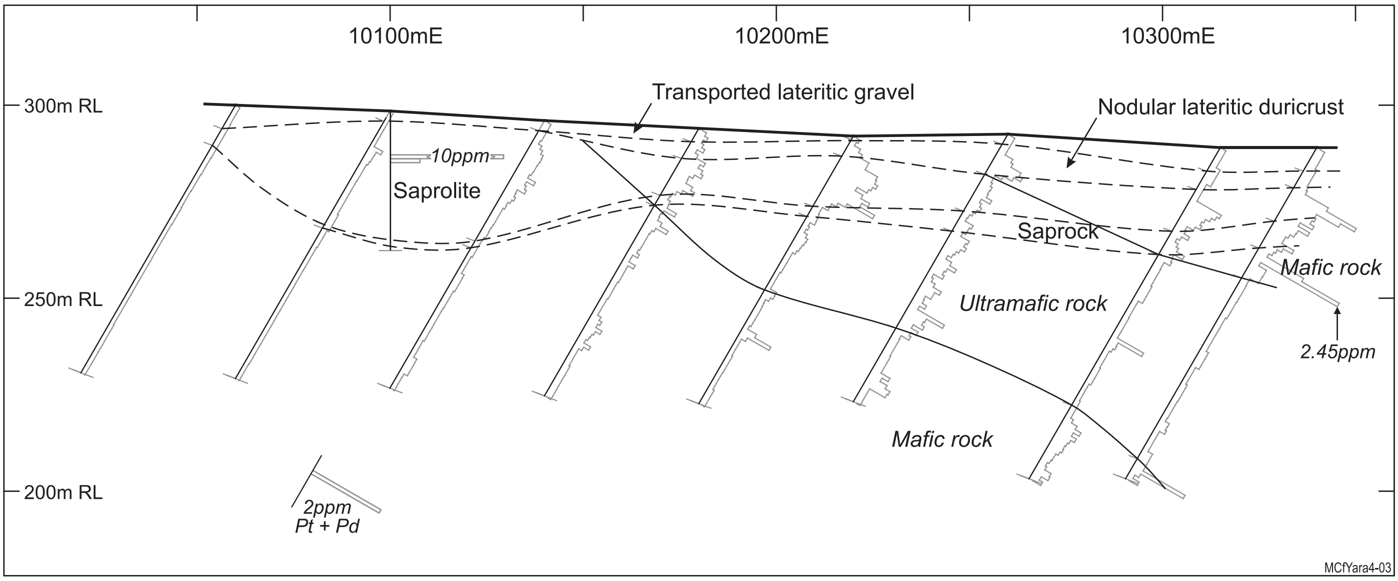

Figure 4. 10200 mN cross section showing Pt+Pd in ppm, and the main regolith and fresh rock units.

recognized the PGE potential.

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SAMPLE MEDIA - SUMMARY TABLE

Sample medium	Indicator elements	Analytical methods	Detection limits (ppm)	Max concentrations (ppm)	Background concentrations (ppm)	Dispersion distance (m)
Lateritic residuum (duricrust and gravel)	Pt	NiS FA followed by ICP-MS	0.001	0.295	≤0.001	200-300
	Pd		0.001	0.940	≤0.001	200-300
	Cu	Fused disc, XRF	10	970	17-32	1000-2000
	Ni	Fused disc, XRF	10	360	26-49	1000-2000
	Cr	INAA	5	12000	400-800	1000-2000
Gossan	Pt	NiS FA followed by ICP-MS	0.02	0.08	NA	NA
	Pd		0.005	0.64		
	Cu	AAS	2	3300		
	Ni	AAS	5	1800		
Saprolite and saprock	Pt	NiS FA followed by ICP-MS	0.001	10	ND	NA
	Pd		0.001	9		
	Cu	AAS	1	2000		
	Ni	AAS	1	700		

ND = Not determined NA = Not applicable

