LOCATION

The Ora Banda sill is centred about 55 km NNW of Kalgoorlie; this prospect is 1 km S of the Ora Banda town site, at 30°24’00”S, 121°03’30”E; Kalgoorlie map sheet SH 51-9 (Figure 1).

DISCOVERY HISTORY

Much of the sill was explored by Carbine Gold N.L. during 1987-1990 at their Ora Banda and Mt. Carnage prospects, S and W of Ora Banda, respectively (Figure 1). Initial exploration was by soil surveys for Au, Pt and Pd, followed by rotary air-blast (RAB) drilling (Menzies, 1988a, 1988b). Overlapping angle holes (inclination 50-65°) were drilled to a downhole depth of 40 m on selected lines across strike. At Ora Banda, the principal drill section was on line 12500E (Figure 2), which intersects the strike of the inferred pyroxenite-peridotite contact at approximately 40°. This drilling confirmed concentrations of up to 2 ppm PGE in lateritic duricrust developed on pyroxenites, with some localized concentrations deeper in the regolith, but none in economic tonnages. Similar results were obtained by BHP Exploration on adjacent areas of the sill. Carbine Gold N.L. tested possible primary mineralization with two diamond drill holes, oriented approximately normal to the strike, drilled to intersect the pyroxenite-peridotite contact beneath 12500E. The drilling found general PGE enrichment in the pyroxenite, but no economic concentration. Much of this account is derived from detailed study undertaken as part of CSIRO-AMIRA project 252 (Butt et al., 1992).

PHYSICAL ENVIRONMENT

The geomorphology of the Ora Banda site is controlled by the lithology of the sill. To the S, a prominent hill of unweathered norite rises above the duricrust-capped surface on the pyroxenites. There is an eroded zone along the pyroxenite-norite contact; in places, the contact forms a dip slope capped by an erosion scarp (breakaway). There is an undulating, locally dissected, lateritic surface on the pyroxenite, with a gentle slope across the peridotite to broad-floored drainages N of the site. The peridotite thus underlies slightly lower, less dissected ground. The area has a low acacia woodland, with scattered eucalypts; casuarinas are common on exposed duricrusts. The climate is semi-arid, with a mean annual rainfall of 250 mm and mean maximum and minimum temperatures of 35 to 20°C (January) and 17 to 5°C (July).

REGOLITH

Peridotitic and pyroxenitic rocks are generally weathered to 40-60 m depth. In contrast, the norite tends to be unweathered in outcrop. Essentially complete lateritic profiles are extensively preserved over

<table>
<thead>
<tr>
<th>Zone</th>
<th>Thickness (m)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>830</td>
<td>Peridotite, Olivine bronzite orthocumulate.</td>
</tr>
<tr>
<td>2.</td>
<td>165</td>
<td>Orthopyroxenite, massive equigranular bronzite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>orthocumulate, grain size 1-2 mm.</td>
</tr>
<tr>
<td>3.</td>
<td>95</td>
<td>Norite, massive equigranular plagioclase orthopyroxene</td>
</tr>
<tr>
<td></td>
<td></td>
<td>orthocumulate.</td>
</tr>
<tr>
<td>4.</td>
<td>315</td>
<td>Bronzite-bearing gabbro-norite cumulate. Some mm-scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>layering; local lenses of anorthosite.</td>
</tr>
<tr>
<td>5.</td>
<td>540</td>
<td>Pigeonite-bearing gabbro-norite cumulate.</td>
</tr>
<tr>
<td>6.</td>
<td>50-100</td>
<td>Pegmatoid gabbro, granophyre.</td>
</tr>
</tbody>
</table>

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the pyroxenite, which is therefore characterized by tracts of lateritic duricrusts and derived soils. Duricrust is rare or absent over the peridotite, and soils are derived from saprolite. Massive, blocky duricrusts developed locally on the peridotite appear to lie directly on saprolite, and may be partly transported in origin. The top 1 to 4 m of the regolith contain pedogenic carbonate. Much of the lag is residual and shows excellent preservation of primary fabrics (Robertson, 1996). Typical profiles are:

**Pyroxenite**
- Lag: coarse, brown, clay-rich granules, with dull, cellular surface, derived from duricrust.
- 0-2 m: Gravelly, calcareous soils; numerous lateritic nodules and pisoliths.
- 2-7 m: Massive, nodular and pisolithic duricrust, cemented near the surface; friable with depth.
- 7-13 m: Mottled clay zone; nodules and pisoliths in a ferruginous clay-rich matrix.
- 13-16 m: Clay saprolite, commonly ferruginous with some nodules; some green clays.
- >16 m: Saprolite; yellow green, soft and clay-rich near the top, harder with depth.

**Peridotite**
- Lag: dense, dark brown to black, ferruginous granules with a vitreous with depth.
- 0-2 m: Calcereous, clay-rich red earths.
- 2-5 m: Non-calcereous red earths.
- 5-11 m: Clay saprolite; red clays becoming brown and green with depth.
- >11 m: Clay saprolite; brown, khaki and yellow green saprolite; abundant silica in or/magnesite.

### MINERALIZATION

Fresh pyroxenite has a broad zone of sulphide, PGE and associated Cu enrichment (as chalcopyrite), with mean concentrations of 130 ppb Pt (maximum 300 ppb), 80 ppb Pd (maximum 215 ppb) and 215 ppm Cu (maximum 3940 ppm). The distribution is rather uniform, with a possible antipathetic relationship between PGE and Cu contents indicating successive cycles of PGE-enriched sulphides. The base of the pyroxenite appears to correspond to the onset of sulphide saturation and the appearance of cumulate sulphides (Witt and Barnes, 1991). Peridotite has mean concentrations of 40 ppb Pt (maximum 235 ppb), 55 ppb Pd (420 ppb) and 30 ppm Cu (180 ppm). A peak value of 980 ppb Pd was not reproduced on re-analysis.

An apparently continuous PGE-enriched "stratigraphic unit" was intersected in saprolite, close to the top of the peridotite (Table 2). This unit has maxima of 3000 ppb Pt + Pd, 52 ppb Ru, 114 ppb Rh, 6 ppb Os, 20 ppb Ir over intervals of 1 to 3 m in three RAB holes. The high abundances of all PGE suggests that this represents a primary mineralized layer but, due to faulting or lack of continuity, the unit was not intersected by the diamond drilling.

### REGOLITH EXPRESSION

The overall abundances of PGE and Cu in the regolith reflect the primary distribution, i.e., weathered pyroxenite is PGE- and Cu-rich compared to equivalent units in weathered peridotite. Distributions in the regolith are illustrated in Figure 3. High concentrations of PGE at Ora Banda occur particularly in lateritic residuum over the pyroxenites; this contains 300-400 ppb Pt and 110-190 ppb Pd i.e., 2 to 3 times that in fresh rock. At Mt. Carnage, PGE concentrations are greater, mostly 1000-1950 ppb Pd across thicknesses of 2-8 m, representing an enrichment of 4 to 7 times (wt/wt). The data also suggest that some enriched zones transgress regolith horizons; such zones dip gently S, sub-parallel to the presumed dip, and may therefore represent primary layering. There has been some apparent fractionation of Pt and Pd during weathering, with gradual depletion of Pd towards the surface. Thus, over the pyroxenites, the Pt/Pd+Pd ratio increases from a mean of 60-65% in the unweathered rock and saprolite to 70-75% in the lateritic horizons; the ratio increases to 90% in lag. There are no lateritic horizons preserved over the peridotites, but the data suggest that there may be some surface enrichment associated with calcareous soil and saprolite, perhaps equivalent to that known for Au in this region. However, selective leaching analyses have not confirmed such an association and the enrichment may be due to the residual accumulation of ferruginous lag.

The Cu content in the regolith developed on the peridotite is commonly <30 ppm. In comparison, all regolith units on pyroxenites have Cu contents >200 ppm and concentrations increase upwards through the saprock (mean 205 ppm) and saprolite (mean 315 ppm), to maxima of 700-1095 ppm in the saprolitic and mottled clays and the lower (nodular) horizon of the lateritic residuum. These high Cu concentrations form an approximately sub-horizontal zone of enrichment and are attributed to secondary accumulation with Fe oxides. The Cu distribution is accordingly similar to that of Fe, with which it is associated. Higher in the profile, in the upper lateritic horizons, the Cu and Fe contents decline (<600 ppm Cu); this corresponds to concentration of Al(20-28% Al₂O₃), as gibbsite and in aluminium goethite and hematite, during the further evolution of the lateritic duricrust and, ultimately, formation
of the present soil. Copper is probably leached, rather than diluted, during the process of Al accumulation, and may contribute to the Cu enrichment of underlying regolith units. Equivalents of the narrow intervals in fresh pyroxenite having >3000 ppm Cu are not recognized in the regolith.

Ruthenium, Rh, Os, Ir also show upward increases in concentration through the regolith on pyroxenite, although abundances of Os and Ir are very low (Table 3). The highest contents are in the ferruginous horizons (mottled clay zone and lateritic residuum) and are probably due to residual accumulation as immobile elements. The enrichment is of the same order as that of Cu, Cr and Zr.

No separate, PGE-enriched, minerals were identified, despite detailed physical and chemical investigation (Gray et al., 1996). Most PGE are in the <2 µm fraction, mainly in Fe oxides; Pt is hosted by hematite and some Pd by Al-rich goethite. This separation may reflect differences in primary host minerals, with Pt in an easily weathered phase, leading to early release and incorporation in hematite, and Pd in a more stable phase, to be incorporated in later formed minerals such as Al-goethite.

In lag, the Pt and Pd contents clearly reflect those of the parent pyroxenite and peridotite, and the regolith developed from them (Figure 4).

![Figure 4](attachment:figure4.png)

**REFERENCES**


WA Mines Department. 15 pp.