LOCATION

The Boddington Au deposit (Figure 1) is in the Darling Range, approximately 100 km SSE of Perth, at 32º44’S, 116º22’E; Pinjarra 1:250 000 map sheet (SI50-02).

DISCOVERY HISTORY

In 1979, a geochemical prospecting program (stream sediments, soil and rock) by the Geological Survey of Western Australia discovered anomalous Au (max 1.6 ppm), As, Cu, Pb, Mo and Zn in an area 5 km long by 500 m wide in the Saddleback Greenstone Belt (Davy, 1979). In 1980, Reynolds Mines Pty Ltd commenced Au exploration of this area, which had previously been explored for bauxite, by sampling laterite. Promising areas were followed up by reassaying bauxite drill samples and led to the discovery of the Boddington Au deposit.

PHYSICAL FEATURES AND ENVIRONMENT

The deposit is situated towards the eastern edge of the Darling Plateau, beneath a deeply weathered, undulating landscape (Figure 2) varying from 250 to 400 m asl. Local relief is about 50 m, with shallow valley floors adjacent to smooth, broadly convex crests. Inselbergs, such as Mt Wells, project above the plateau to >500 m. The climate is Mediterranean with an average annual rainfall of 800 mm; mean temperature ranges are 14-32ºC (January) and 4-15ºC (July). The dominant vegetation is eucalyptus forest.

GEOLOGICAL SETTING

The Boddington deposit lies within the N part of the Archaean Saddleback greenstone belt, a steeply-dipping and extensively faulted sequence of greenschist to lower amphibolite metamorphosed sedimentary, felsic, and mafic volcanic and pyroclastic rocks, which have been extensively faulted. The deposit is adjacent to a NW-trending lineament that, at mine-scale, forms a shear zone along the western margin

REGOLITH

The regolith consists of saprock, saprolite, ferruginous saprolite, a bauxite zone, ferruginous duricrust and loose nodules and pisoliths. The saprolite is clay-rich, 25-70 m thick, and ranges from white to multi-coloured and ferruginous. The gibbsitic bauxite zone, about 4 m thick, contains fragments of saprolite, incipient nodules and is mottled in places. Ferruginous duricrust forms an almost continuous blanket over large areas. Its thickness, facies and origin vary with topographic position. It is better developed and/or better preserved on mid slopes than on crests or lower slopes. The mid-slopes are typically dominated by 1-2 m of fragmental duricrust overlain by 0.5-1.0 m of pisolithic duricrust. Fragmental duricrust has subangular to angular, dark brown to red, hematite-rich fragments, that range from a few mm to more than 30 mm, in a matrix of gibbsite and goethite. Pseudomorphs after primary minerals are common. The transition from fragmental to pisolithic duricrust is sharp in some places and gradational in others. The pisolithic duricrust is darker and more Fe-rich than the fragmental duricrust. It contains red to black, simple or compound, generally transported pisoliths that are either hematite or maghemite-rich (Anand, 1994), cemented by goethite and gibbsite. Fragmental duricrust is generally related to the underlying lithologies, whereas the pisolithic duricrust has suffered limited colluvial transport that is still continuing. The loose hematite- and maghemite-rich gravels are shallow (0.2-0.5 m) on crests and upper slopes and increase in thickness (2-4 m) down slope. The nodular and pisolithic surface lag on this gravelly material is dark red-brown to black, highly magnetic, and dominated by hematite, maghemite and poorly crystalline alumina.

MINERALIZATION

The primary Au mineralization is hosted in intermediate to felsic volcanic rocks. It is a low-sulphide system with intense silification, potassic and calc-silicate alteration, and a Au-Cu-Mo-(Bi) association (Symmons et al., 1988). In the regolith, Au is concentrated in the lower part of the bauxite zone, the middle of the clay saprolite and the
base of the saprolite. Mineable lateritic reserves of 60 Mt at 1.6 g/t occur over 4.5 km² (Symons et al., 1990).

REGOLITH EXPRESSION

A stream sediment orientation survey in 1983, prior to mining, showed maximum concentrations of Au (>1 ppm) and As (80-350 ppm) in all size fractions (Table 1) occurring directly over mineralization, decreasing progressively down drainage (Beeeson, 1995). The greatest dispersion of Au was in the <75 μm fraction, with anomalous concentrations (0.06 ppm Au) extending 8 km down drainage. Visible Au in panned concentrates, bulk cyanide leach Au and As (>10 ppm) concentrations (0.06 ppm Au) extending 8 km down drainage. The greatest concentrations of Au (>1 ppm) and As (80-350 ppm) in a stream sediment orientation survey in 1983, prior to mining, showed several path anomaly at >40 ppb Au, but much larger anomalies are shown by the deposit itself. A pre-mining survey using lateritic pisoliths and (Figure 3).

Fe oxide species, despite similar Fe contents. Areas very rich in Fe (>70% Fe₂O₃) have a wide range of As (200-1500 ppm). Hematite-maghemite-rich areas are poor in As relative to goethite-rich areas, suggesting that As, originally present in goethite, was probably ejected during dehydration to maghemite (see below) and carried away in solution.

The W anomaly (max 130 ppm) in gravelly lag, in the SE of Pit A and in Pit D, is 500x400 m. The Sn anomaly (max 48 ppm) is similar to W in strike continuity and breadth but less strong. It is relatively more abundant in Pit D. The Sn and W occur mainly as cassiterite and scheelite, respectively. Molybdenum is anomalous both over Pit A and Pit D, reaching a maximum of 130 ppm. Copper and Zn are weak and do not appear to be particularly useful in defining mineralization. Bismuth (max 50 ppm) is unevenly distributed and strongest and most widespread in the SW corner of Pit A.

The non-magnetic fractions of gravelly lag and pisolitic duricrust are enriched in Au, As, Mo, Cu and Bi relative to the magnetic fractions, probably due to their ejection during transformation from goethite to maghemite (Sidhu et al., 1980). The non-magnetic fractions of gravelly lag and pisolitic duricrust are rich in Au, As, Mo, Cu and Bi relative to the magnetic fractions. The non-magnetic lag consists mainly of hematite and goethite, whereas the magnetic lag contains maghemite, which has formed from heating of goethite and hematite during bushfires (Anand and Gilkes, 1987), causing the loss of these elements (Sidhu et al., 1980) during the transformation.

The major components of the bauxite zone, fragmental duricrust, pisolitic duricrust and gravelly lag were separated and analysed (Figure 7). In the bauxite zone, the hematite- gibbsite-rich fragments have

<table>
<thead>
<tr>
<th>Elements</th>
<th>Size fraction (μm)</th>
<th>Threshold anomaly (ppm)</th>
<th>Maximum anomaly (ppm)</th>
<th>Dispersion (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au</td>
<td>400-1700</td>
<td>0.02</td>
<td>&gt;1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>200-400</td>
<td>0.02</td>
<td>&gt;1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>75-200</td>
<td>0.02</td>
<td>&gt;1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>&lt;75</td>
<td>0.02</td>
<td>&gt;1</td>
<td>8</td>
</tr>
<tr>
<td>Au</td>
<td>400-1700</td>
<td>10</td>
<td>350</td>
<td>&gt;12</td>
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<td></td>
<td>200-400</td>
<td>10</td>
<td>80-100</td>
<td>&gt;12</td>
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<td></td>
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<td>&lt;75</td>
<td>10</td>
<td>80-100</td>
<td>&gt;12</td>
</tr>
</tbody>
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In a more detailed survey (Table 2), lag samples (nodules and pisoliths) were collected over a radius of 5-10 m at 100 m intervals close to the mine. Over Pit A (Figure 4) and Pit D, the Au pattern shows small, erratic anomalies (<0.1 ppm) with some higher concentrations (to 1.15 ppm) at the S end of Pit A. Gold is more abundant in the underlying lateritic residuum (mean 0.25 ppm) and the bauxite zone (0.61 ppm; Figure 5). There is a strong relationship between the Au distribution in the bauxite zone and the overlying fragmental duricrust but no direct relationship between the Au distribution in fragmental duricrust and the overlying pisolitic duricrust (Anand, 1994). This suggests precipitation of Au at the bauxite zone and fragmental duricrust with subsequent leaching or modification of the Au distribution during formation of the pisoliths. High rainfall and soil waters rich in organic ligands from the abundant vegetation may have leached Au from the surface pisoliths to precipitate it at the base of the bauxite zone.

Although Au contents in lag and colluvial gravel at or near the surface are relatively low, As, W, Sn, Mo and Bi are strongly anomalous. The As concentrations are high and widespread over Pit A (maximum 350 ppm) but is weaker (maximum 58 ppm) over Pit D. The As anomaly is some 400x300 m over Pit A and shows a more consistent and widespread distribution than Au (Figure 4). High concentrations of As reflect arsenopyrite bedrock mineralization. Electron microprobe data of selected ferruginous pisoliths indicate a moderate association of As with Fe oxides (Figure 6). However, the As abundance varies with the
more Au than the corresponding gibbsite-rich matrix. In the overlying fragmental duricrust, there is no systematic Au distribution between fragments and matrix. In the pisolitic duricrust, the goethite- and gibbsite-rich cutans are the main host of Au. At surface, Au is more abundant in nodules than pisolits and this may reflect the greater abundance of Au in fragmental duricrust. There are small (<5 µm) droplet Au grains in Au-rich material in the bauxite zone. No microscopically visible Au occurs in pisolitic duricrust or gravelly lag, suggesting that the Au is sub-microscopic.

REFERENCES


