GOURDIS AND EMPIRE LATERITIC GOLD DEPOSITS, WESTERN AUSTRALIA

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INTRODUCTION

Several "laterite"-hosted Au deposits, including both the Gourdis and Empire deposits, occur in the northern Yandal belt of Western Australia (Figure 1). Ferruginous materials, including pisolitic and nodular duricrust, loose pisoliths and nodules (ferruginous gravels) and colluvium and alluvium comprise the principal ore at the Gourdis and Empire laterite deposits. These represent surficial Au deposits, beneath which there is currently no known economic mineralisation. The following summary is based on work done as part of the Yandal belt project, the results of which were presented at the Yandal greenstone belt symposium (Paine *et al*., 2000).

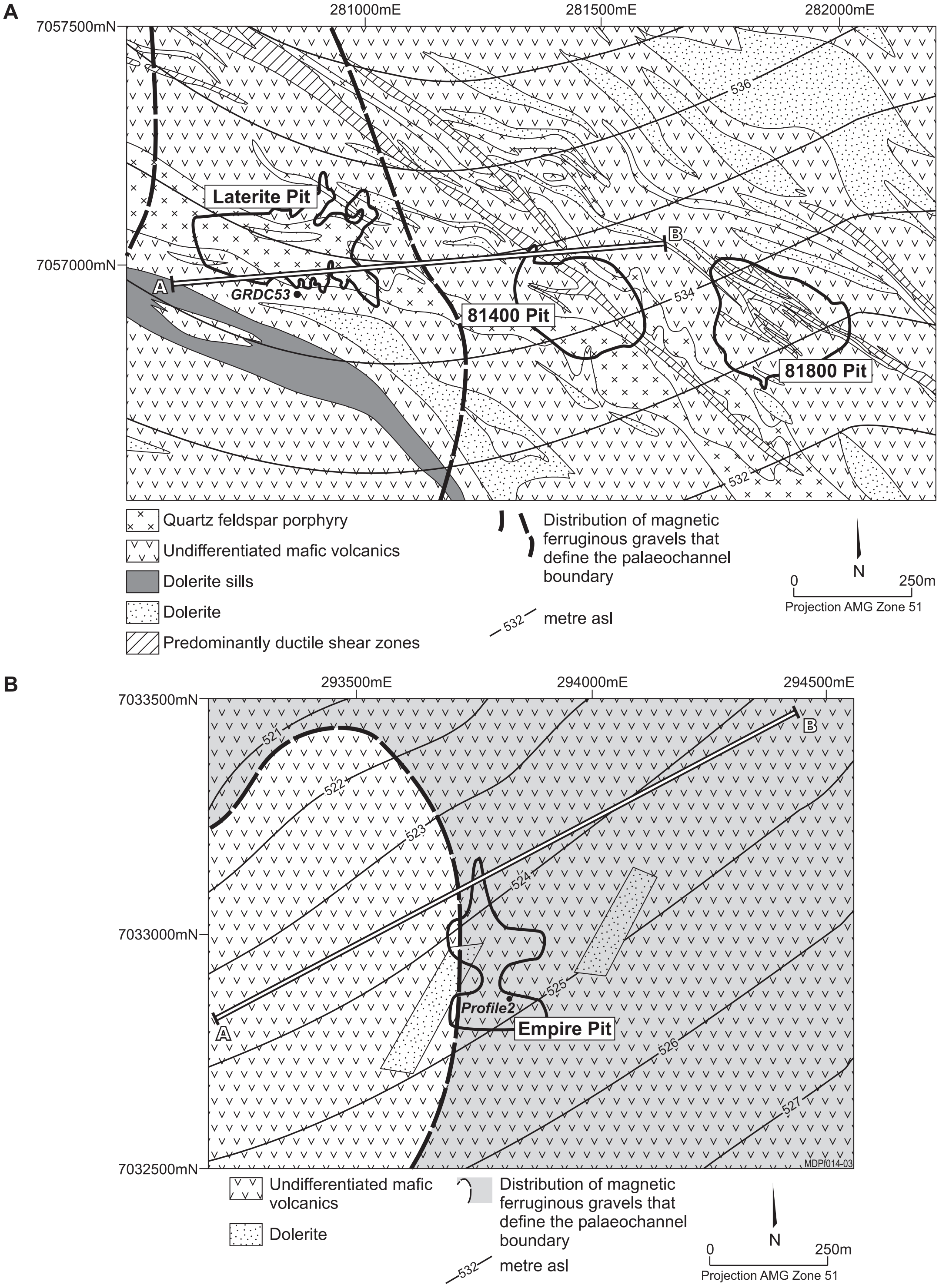

Figure 1. Geology and topography of the Gourdis (A) and Empire (B) laterite-hosted gold deposits in the Yandal greenstone belt. (Geology, pit outlines and elevation data supllied by Newmont Mining Corporation, palaeochannel outline for the Empire deposit modified from Anand *et al.,* 1999).

PHYSICAL SETTING

Geology

Several rock types are common in the Gourdis area, including quartz feldspar porphyry dykes, komatiite, tholeiite and high Mg basalt (undifferentiated mafic volcanics) and dolerite dykes and sills (Figure 1). The area is characterised by a shear system striking 300° to 330° and dipping 40° to 50° to the southwest. Smaller shears also occur and typically occupy the boundary between different geological units, especially between the quartz feldspar porphyry and the basalts. The Gourdis laterite deposit overlies various mafic units and quartz feldspar porphyry dykes. Gold mineralisation at the Gourdis Laterite Pit is mostly concentrated in the ferruginous gravels overlying mafic rocks in the vicinity of the mafic/quartz feldspar porphyry contacts. These range in thickness from 8 m in the centre of the pit over the lithological contacts to 1.5 m along the edges of the pit. Over 80% of the gold occurs in the +6.3 mm fraction (Lach and Petrovic, written communication, Wiluna Mines, 1997) whereas the matrix is almost barren (Farrelly and Gillespie, written communication, Wiluna Mines, 1993). Gold has been observed in some of the broken pisolitic material (Craven and Johnson, written communication, Wiluna Mines, 1990).

The primary rock types at the Empire deposit (Figure 1) include basalt, ultramafic rocks, dolerite and mafic schist. A north-trending, basalt-hosted mineralised black shale is situated approximately 100 m west of the deposit. Ferruginous gravels largely host gold mineralisation at the Empire deposit. These gravels have a shallow easterly dip and thin to the west. Gold occurs in the entire ferruginous gravels horizon along the western flanks of the deposit, whereas on the eastern flank of the deposit, it is typically confined to stacked lenses that pinch out to the east (Gifford, written communication, Eon Metals, 1991). The mottled saprolite is also variably mineralised along with random quartz veins.

Geomorphology

The Gourdis laterite deposit is situated on a plain that slopes 1–2° to the south at an elevation of around 535 m asl (Figure 1). The area around the deposit is generally of low relief, being a complex of gentle hills and plains. Drainage is mainly to the south and southwest with the main ephemeral creek situated between the Gourdis deposit and Vause deposit to the south. The Empire deposit is situated on a gently northwest dipping broad flood plain that ranges in elevation from 520 m to 530 m asl (Figure 1). Regionally the area is characterised by occasional breakaways that merge with plains incised by small valleys. Common to both the Gourdis and the Empire deposits are adjacent palaeochannels, which are not represented by the current topography (Figure 1).

REGOLITH CHARACTERISATION

Gourdis

Both weathered basement rocks and sediments are encountered at the Gourdis Laterite Pit. Saprock or saprolite, developed from either basalt or quartz feldspar porphyry, form the base of most *in situ* weathering profiles. Where developed over basalt, the saprolite merges upwards into brown to green plastic clays that become progressively paler as they grade into the overlying mottled zone. Ferruginous mottles within this zone are more abundant towards the top of this unit where they form a collapsed mottled zone grading upwards to a nodular duricrust (Figure 2). Ferruginous mottles are poorly developed in saprolite and clay zones developed from the quartz feldspar porphyry, which typically retains its primary porphyritic fabric to within meters of the surface. Pallid clays with β-quartz crystals overlie white to yellow saprolite and saprock developed on the quartz feldspar porphyry. The contacts between the basalt and the porphyry are easily distinguishable to within 1 to 5 meters of the surface. The overlying sediments, which range in thickness from 1 to 7 m (Figure 2), are characterised by a basal approximately 30 cm thick bed of highly magnetic, well-indurated ferruginous nodules. These in turn are overlain by approximately 4 m of poorly bedded ferruginous gravels that in hole GRDC 53 (Figure 2) appear to fine down the hole. Hardpanised pisolitic–nodular duricrust occurs at the top of the sequence.

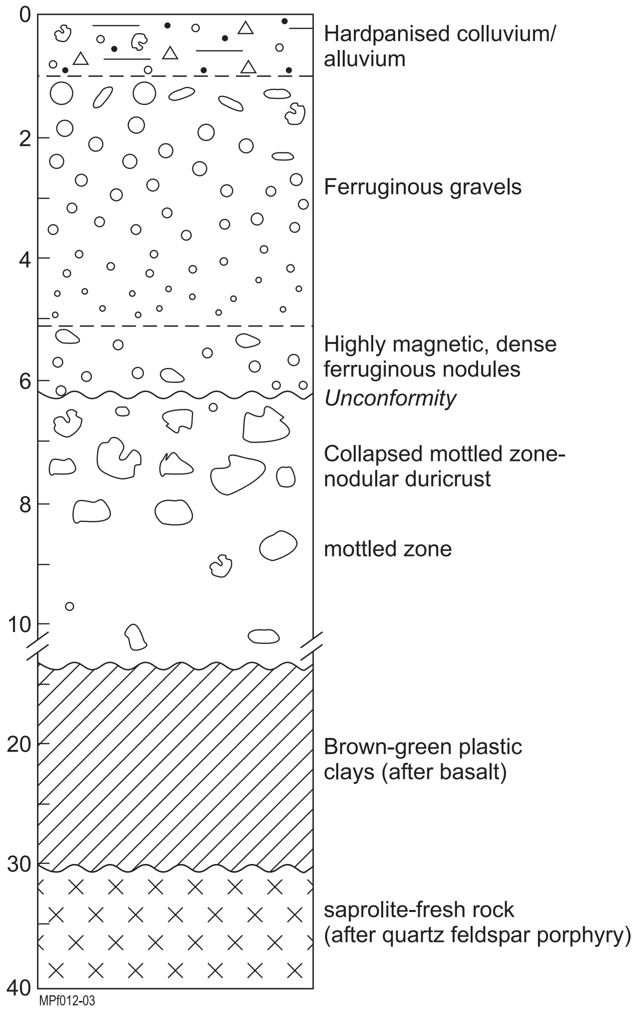

Figure 2. Regolith profile from hole GRDC 53 on the southern flank of the Gourdis Laterite Pit.

Empire

The spatial distribution of regolith materials in the Empire deposit varies in association with the palaeotopography and, like the Gourdis deposit, includes both weathered basement rocks and sediments. Profile 2, the base of which is exposed in the floor of the southeastern portion of the Empire Laterite Pit (Figure 1), comprises mottled saprolite developed on dominantly basaltic lithologies (Figure 3). In places, the mottled saprolite includes large angular goethitic pods and quartz veins hosted by goethite-rich iron segregations. The mottled saprolite is overlain by irregular, yellow-red–brown, subangular, 2 to 20 mm lithic and non-lithic nodules and pisoliths set in a weakly cemented ferruginous matrix. These ferruginous gravels are typically 1.5 to 4 m thick increasing locally to around 10 m. Nodules and pisoliths with yellow-brown cutans are common in the lower portions of this unit whilst in the upper parts of the unit nodules become subrounded and generally lack cutans. The overlying gravelly colluvium, which is typically up to 1 m thick, comprises subangular, reddish-brown, 1 to 10 mm nodules in a quartz-rich matrix. Some nodules are magnetic and some retain a lithic fabric. A gradational boundary occurs between this unit and the overlying hardpanised colluvium/alluvium, which ranges in thickness from 1–2 m. A 1 m thick gravelly soil comprising pisoliths and nodules in a silty brown matrix forms the top of the sequence. This is variably overlain by a lag (or surface accumulation of material) derived from exposed iron segregations occurs to the west of the pit and is characterised by 3 mm to 30 mm black, subangular nodules which are dominated by goethite. Pseudomorphs after sulphides also occur in this material.

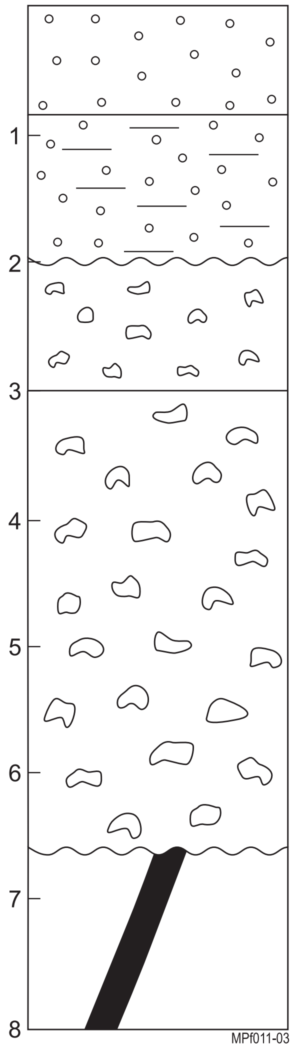

Figure 3. Regolith profile from Profile 2, exposed in the southeastern portion of the Empire Laterite Pit.

REGOLITH STRATIGRAPHY

Gourdis

An east–west cross section for the Gourdis area shows considerable variation in the shape and depth of various regolith boundaries (Figure 4). The top of fresh rock (TOFR), which represents the weathering front, ranges in depth from 55 to 100 m and appears to deepen in the vicinity of the quartz feldspar porphyry and the major shear zone. The top of saprock (TOSA) ranges in depth from 25 to 80 m and appears to rise over the main quartz feldspar porphyry unit but shows little variation over the other lithologies. The base of complete oxidation (BOCO) ranges in depth from 20 to 60 m. As with TOSA, BOCO rises over the quartz feldspar porphyry but decreases markedly over the major shear zone. The base of transported cover (BOA) about the Gourdis Laterite Pit increases in depth towards the west and southwest of the deposit (Figure 4) as it approaches a north-northeasterly trending palaeochannel. Maghemite-rich gravels coincident with dendritic aeromagnetic patterns define the flanks of the channel (Figure 1). Clays occur in the central portion of the palaeochannel.

Empire

A northeast–southwest cross section plotted over the Empire Laterite Pit shows considerable variation in the nature and depth of various regolith boundaries (Figure 5). The top of saprock (TOSA) ranges in depth from 25 to 70 m about the Empire area. It appears to deepen significantly beneath deepest BOA, which is coincident with an extensive palaeochannel system. The base of complete oxidation (BOCO) ranges in depth from 10 to 65 m over the Empire prospect with considerable undulation. The base of transported overburden (BOA) ranges in thickness from 0 to 25 m and increases in depth to the east as it approaches a north-trending palaeochannel. Maghemite-rich gravels that are coincident with dendritic aeromagnetic patterns, as reported by Anand *et al.* (1999), define the flanks of the channel. The ferruginous gravels interfinger with palaeochannel clays on the eastern flank of the deposit and the clays deepen and thicken towards the central portion of the channel. The ferruginous gravels exposed in the pit appear to be thicker and BOA appears to be deeper in east-west elongated lobes at the northern and southern ends of the pit (Figure 1).

REGOLITH EVOLUTION

The evolution of regolith materials at both the Gourdis and Empire Laterite Pits includes two main processes:

Dominantly *in situ* weathering of basement rocks has produced

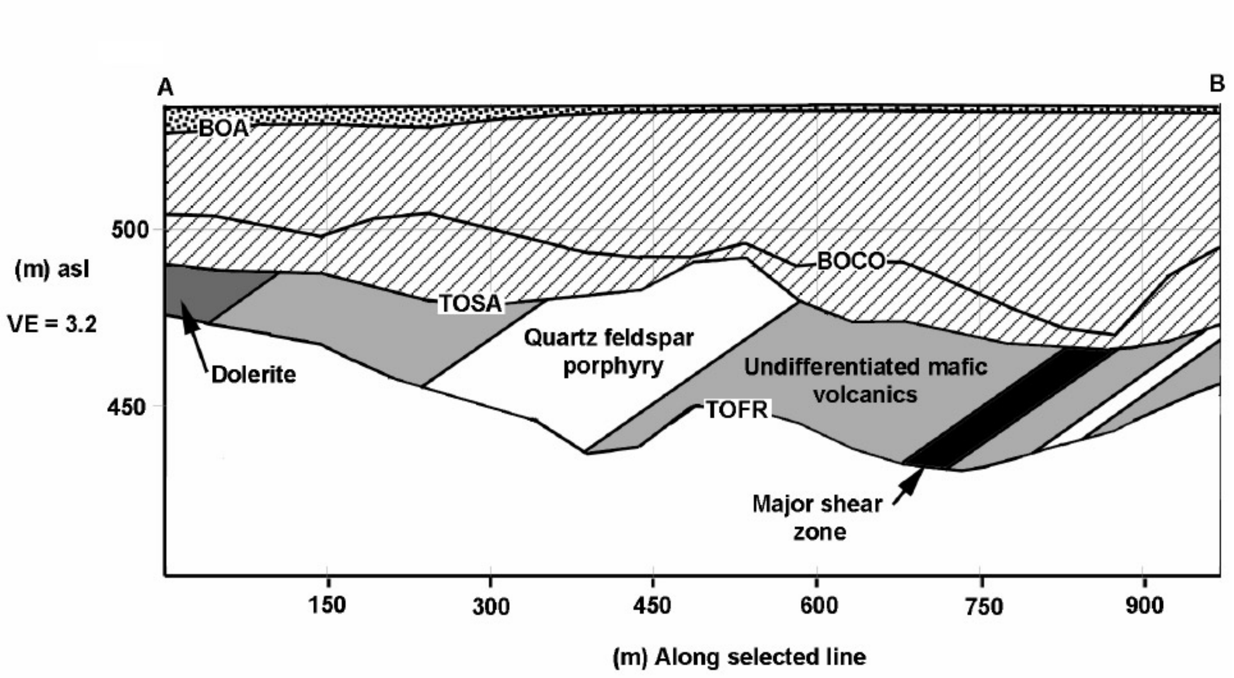

Figure 4. Cross section for Gourdis Laterite Pit. See Figure 1 for location. Geology provided by Great Central Mines Ltd. (BOA = base of transported overburden, TOSA = top of saprolite, BOCO = base of complete oxidation; TOFR = top of fresh rock)

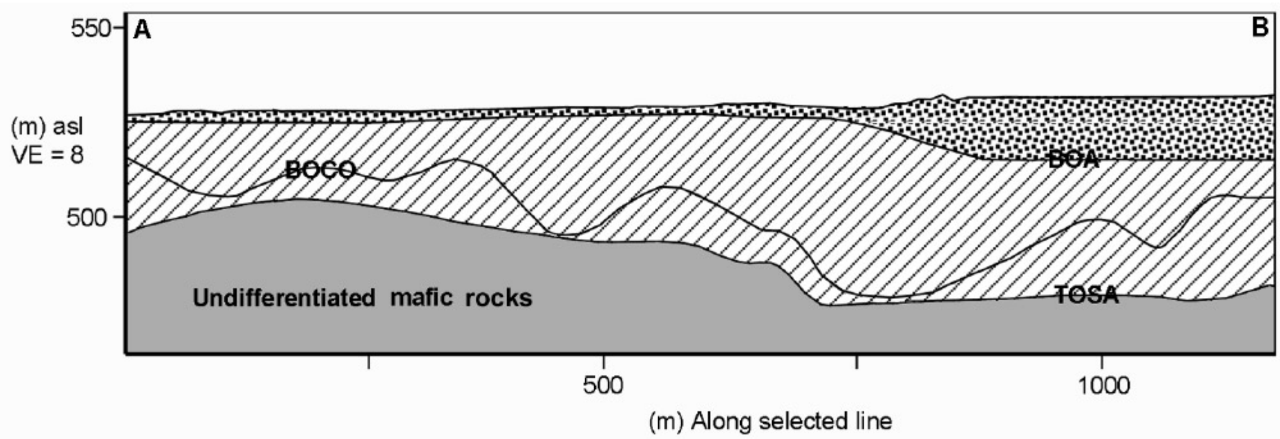

Figure 5. Cross section for Empire Laterite Pit. See Figure 1 for location. Geology modified from Great Central Mines Ltd. (BOA = base of transported overburden, TOSA = top of saprolite, BOCO = base of complete oxidation)

weathering profiles typified from bottom to top by saprock, saprolite, clay and/or mottled clay zones and ferruginous duricrusts. The processes by which these materials form has been discussed at length in numerous contributions to Phillips and Anand (2000) for various basement rock types throughout the Yandal Belt and will not be discussed in detail here.

Gourdis

Weathering of basalts underlying the Gourdis Laterite Pit has produced an *in situ* weathering profile comprising brown–green clays, mottled clays, and a collapsed mottled zone that grades into a nodular duricrust. The resultant weathering profile is similar to that observed in the adjacent 81400 deposit, the significant difference being that the 81400 profile lacks a well developed ferruginous duricrust. The overlying ferruginous gravels in the laterite pit are sedimentary. They are interpreted as being at least in part derived from the adjacent 81400 deposit on the basis of their palaeotopographical position (downslope from the 81400 deposit), coarse grain-size (which is suggestive of a proximal source) and elevated Au concentration (suggesting they formed in a mineralised environment). The downward fining nature of the ferruginous gravels in the laterite pit possibly represent changing depositional energies or, more likely, a change in the nature of the source rocks. Given the general trend of increasing mottle size with depth in weathering profiles developed over basalt it is possible that the finer ferruginous gravels were derived from the upper portions of a eroding profiles nearby, including those in the vicinity of the 81400 deposit. This was followed by deposition of courser ferruginous gravels sourced from lower in the profile.

Empire

Ferruginous gravels at the Empire deposit appear to have evolved via the removal of clays and consequent collapse of the underlying mottled saprolite and/or mottled zone. The more angular nodules with yellow–brown cutans concentrated at the base of the ferruginous gravels are believed to have developed *in situ*. With decreasing depth, the ferruginous gravels become sub-rounded and assume a red colouration, losing any pre-existing yellow-brown cutans. These are interpreted as having undergone local transport. The easterly dip of the palaeoslope and thickening of the gravels towards the eastern extent of the Laterite Pit where they interfinger with palaeochannel clays suggests that these transported ferruginous gravels have been derived from the west. The transported ferruginous gravels appear to be thicker and deeper in east-west elongated lobes at the northern and southern ends of the pit, which are interpreted as east flowing palaeovalleys into the main palaeochannel. The primary source of these Au-bearing gravels is thought to be an eroding mineralised weathering profile located to the west of the deposit. The hardpanised colluvium and alluvium and gravelly soil overlying the ferruginous gravels are likely to have a dual origin, with some contribution from the previously mentioned eroding mineralised weathering profile to the west. Quartz sands infiltrating the upper parts of the profile are interpreted to have been derived from felsic rocks to the east (Foo, 1999).

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