BIRTHDAY GOLD PROSPECT, GAWLER CRATON, SOUTH AUSTRALIA

M.J. Lintern

CRC LEME, c/- CSIRO Exploration and Mining, P.O. Box 1130, Bentley, WA 6102

LOCATION

The Birthday Gold Prospect is in the northern Gawler Craton, 720 km NW of Adelaide and 120 km NW of Tarcoola (Figure 1), at 29°55’08’S, 133°55’08’E; Coober Pedy 1:250 000 sheet (SH53-6).

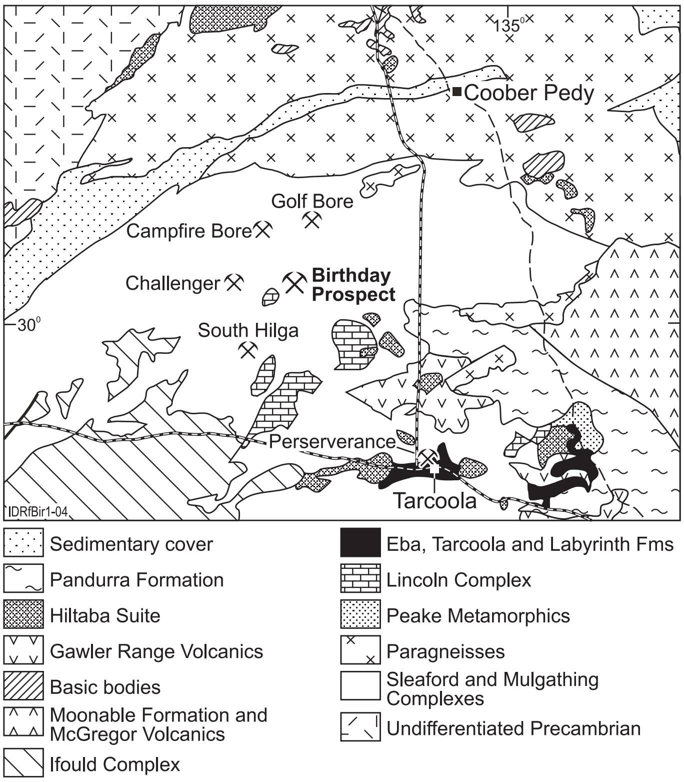

Figure 1 Regional geology of the Birthday and other Au prospects and deposits (after Daly et al., 1998).

DISCOVERY HISTORY

Gold mineralization at the Birthday prospect was located by Minotaur Gold NL in 1996 by drilling to blade refusal after regional calcrete sampling had identified a broad Au anomaly (Figure 2). Subsequent infill sampling located a coherent Au-in-calcrete anomaly peaking at 68 ppb. Early, shallow (0-60 m) rotary air blast (RAB) drilling outlined a series of parallel bands of Au mineralization located at about 30 m depth within saprolite; one-metre samples returned maxima of 1.2, 0.5, 0.7 and 1.1 g/t Au from each respective band. Deeper RC drilling intersected altered contact zones with associated quartz, feldspar, carbonate and sulphide, and widespread low-grade Au mineralization in fresh bedrock (Anon, 1996). Active exploration here was subsequently suspended as the company pursued other regional Au-in-calcrete targets in the area.

PHYSICAL FEATURES AND ENVIRONMENT

The Birthday Prospect occupies an area of low topographic relief. Immediately to the N and W of the study transect (termed the “regolith line”), a low, arcuate rise of variably silicified basement outcrop is partly covered by Quaternary dunes. South and E of this rise is a broad area of alluvial plain and areas of minor sand cover. A low-angle erosional escarpment has developed on the S and E sides to this rise. The upper flanks of the escarpment are clad with silcrete gibber and blocks. There is an ephemeral drainage to the S and E of the rise with some minor clay pans (Lintern *et al.,* 2000). Vegetation consists of chenopod shrubland and open woodlands of mulga and sheoak, with a chenopod understorey. The shrubland consists of members of the Family Chenopodiaceae, principally pearl bluebush *(Maireana sedifolia)*, bladder saltbush *(Atriplex vesicaria)* and limestone copperbarr (*Scleroleana obliquicuspis)*. The climate is arid with annual rainfall of about 150 mm, falling mostly in winter. Average temperatures are 19-35ºC in January and 5-19ºC in July.

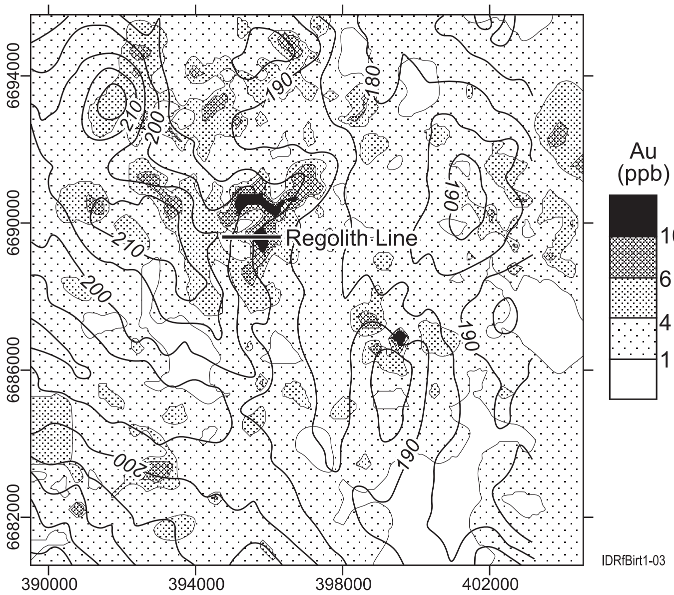

Figure 2. Regional map of Au in calcrete draped on topography (RL in metres), showing the location of the Regolith Line.

GEOLOGICAL SETTING

The Birthday Prospect lies within the Mulgathing Complex of the northern Gawler Craton (Figure 1). A significant proportion of the northern Gawler Craton retains Archaean to earliest Proterozoic radiometric ages, although the region has been affected by extensive and prolonged tectonism (Daly *et al.,* 1998). Archaean metasediments of the Mulgathing Complex (Daly, 1985) were derived, at least in part, from a pre-existing continental basement, and included BIF, chert, carbonate, calcsilicate, quartzite and aluminous metasediments. Eruption of komatiite and tholeiite flows and emplacement of pyroxenite and peridotite sills are thought to have been contemporaneous with sedimentation. Together with abundant other mafic rocks intersected in the sub-surface, these rocks are thought to represent regional attenuation of the Archaean crust and may indicate the presence of oceanic crust during sedimentation. Peak regional granulite-facies metamorphism during the Sleafordian Orogeny (9 Kb at 860℃) and associated extensive syntectonic granite, tonalite and norite have been dated at about 2450 Ma by Rb-Sr whole rock and U-Pb zircon methods (Fanning, 1997).

The local geology includes Archaean quartz-feldspar-garnet gneiss, mafic gneiss and ultramafic rocks with significant sulphide contents (from company reports summarised by Daly *et al.,* 1998). Archaean basement outcrops near the drilled mineralization. It is limited to a small area (100 m square) and consists of banded iron formation (BIF), cross-cut by a stockwork of white to grey hydrothermal quartz veins, many of which are zoned. Some of these veins (100-500 mm wide) stand above the otherwise flat surface by up to 600 mm. Five km N, a larger, partly dune-covered outcrop of silcrete-capped BIF forms part of an arcuate ridge. Strongly weathered basement outcrop (saprolite and silicified saprolite) occurs near, on the escarpment or in stream gullies leading away from it. Mafic-ultramafic dykes intrude the crystalline basement at the Birthday Prospect (Lintern *et al.,* 2000).

MINERALIZATION

Parallel bands of Au mineralisation occur at about 30 m within saprolite. Anomalous Au appears to be associated with ultramafic lenses and their contacts (faulted or folded) with surrounding gneisses. The two major zones of mineralisation were labelled Zone 1 and Zone 2 for the purposes of this study (Figure 3).

REGOLITH

Sampling and regolith stratigraphic mapping along an approximately

1.5 km transect across the prospect (Lintern *et al.*, 2000) gave a regolith stratigraphy of: -

i) A variably weathered clay-rich pedolith or plasmic zone to a quartz-rich arenose zone 5-10 m thick with mottling or staining to pale-yellow, minor orange and brown.

ii) A saprolith of pale-grey, pale-yellow or off-white saprolite 20-30 m thick, overlying <1 to about 8 m of greyish-brown saprock, grading to fresh rock. Mottling and staining is variable with reds and red-browns typical of saprock, grading to a reddish lower saprolite and yellow and orange upper saprolite;

iii) Fresh felsic, mafic and ultramafic bedrocks.

The irregular upper surface of the silicified pedolith and saprolite is partly exposed at the far W end of the study area. In the centre and E it is buried by a variety of thin (<2 m) alluvial and aeolian sediments. This surface is variably silicified, locally forming a pedogenic silcrete, and is overlain by calcrete-impregnated silcrete and/or massive calcrete. Minerals in the upper regolith include quartz, calcite, gypsum, hematite,

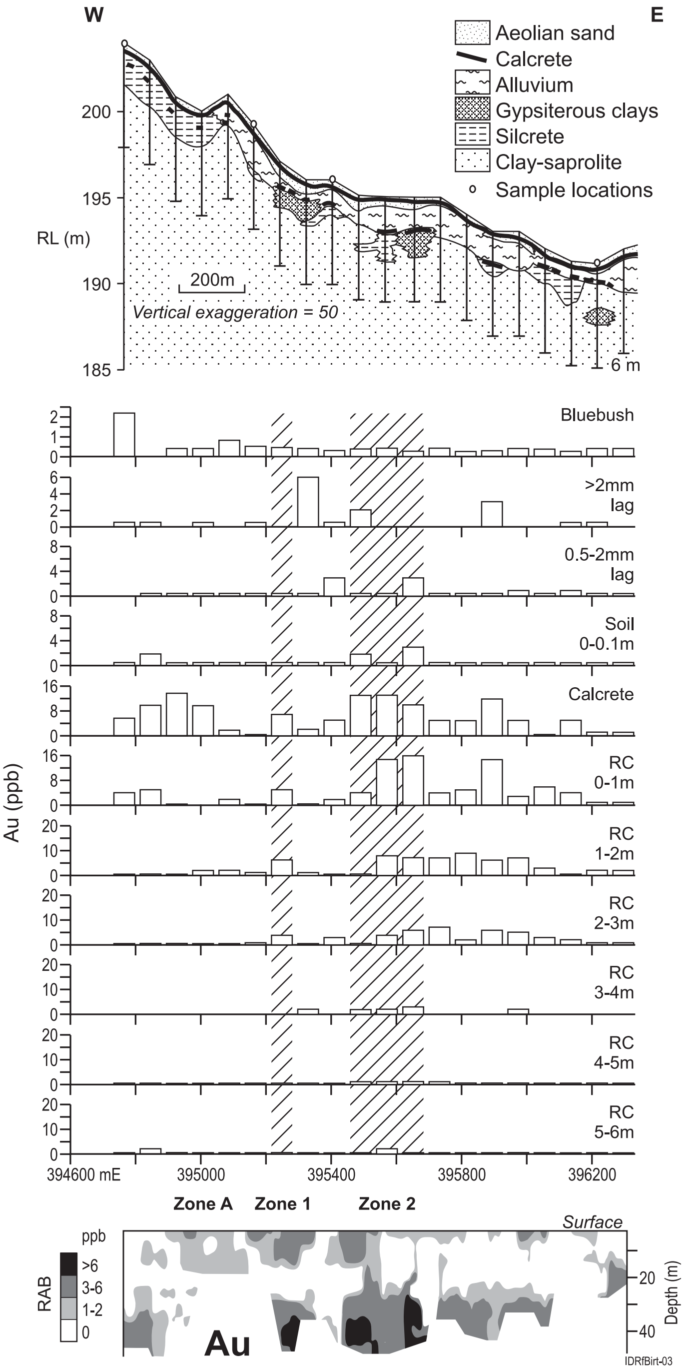

Figure 3. Upper part: regolith stratigraphy of the Regolith Line. Central part: distribution of Au in various sample media (bluebush, lag, soil, calcrete and RC drilled samples from various levels. Lower part: distribution of Au in RAB drilled samples.

mica, K-feldspar, Na-feldspar, goethite, chlorite-smectite and celestite. Quartz either dominates or is co-dominant with calcite in the upper regolith. Kaolinite is the major clay, although there is some smectite. Gypsum appears to be particularly abundant over Zone 2 mineralization. The lower regolith, including the mineralized zones, is dominated by quartz and kaolinite with less mica and goethite. Minor alunite occurs above Zone 2 mineralization and appears to be related to gypsum higher in the regolith and possibly sulphides in the fresh rock. Despite intense weathering, suggested by typical secondary minerals, pale clays and saprolite in the top 30-40 m, primary minerals, such as feldspars, mica and chlorite, throughout the upper regolith indicate incomplete weathering.

REGOLITH EXPRESSION

Drill cuttings, soil (0-10 cm), lag (various size fractions), calcrete and vegetation (bluebush) were sampled at about 80 m intervals. All were analysed for Ag, As, Au, Ba, Bi, Ca, Cd, Ce, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ho, In, K, La, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pr, Rb, S, Sb, Se, Sm, Sr, Tb, Te, Th, Tl, Tm, Ti, U, V, W, Y, Yb, Zn and selected samples were also mineralogically analysed by XRD. Upper regolith samples were subjected to sequential partial extractions of Au using water, iodide and cyanide.

The geochemical results for Au reveal three principal zones of interest (Figure 3: Zones 1, 2, and A) that are discussed below. Zone A is a Au-in-calcrete anomaly in the western part of the regolith line. Zones 1 and 2 are weak mineralizations in the lower regolith of the regolith line:

Zone 1, at 395245mE, has a maximum of 290 ppb Au (from drilling) and is overlain by 35 m of barren saprolite;

Zone 2, in two 170 m spaced drill holes centred on 395655mE, attains a maximum of 580 ppb Au at 35 m depth beneath barren saprolite.

The two zones (1 and 2) are connected at about 30 m depth by a weakly mineralized horizon of supergene Au extending at least 400 m in an E-W direction that reaches a concentration of about 20 ppb. Mineralization does not outcrop in either zone. Of the elements associated with mineralization (Au, Ba, Cd, Ga, Mo, Nb, Pb, U, V, W and REE), only Au is common to both zones. A few elements are anomalous in the lower regolith above mineralization (e.g., Au, Ba, Cd, Mo, Pb, S and REE). Fewer still continue to be anomalous into the upper regolith (Au, S and some REE), with only Au persisting to the surface. It appears that only Au and, perhaps, S can be used confidently as indicators throughout the regolith.

Gold is associated with Ca in drill cuttings in the top 1-2 m. The highest Au concentrations of 16 and 15 ppb are located in adjacent samples above mineralization near the centre of the section (Zone 2); calcrete nodules from the same location contain 13 ppb Au. A broad zone (400 m) of elevated Au (>5 ppb) is located at 0-2 m depth in the central and E part of the regolith line and persists, partly, to greater depths (Zone 2: 2-6 m) but at decreasing concentrations (1-5 ppb). Near-surface calcrete in the W part of the section (Zone A) contains up to 14 ppb Au. Drill cuttings from the same location (0-1 m, 1-2 m, etc.) all contain <5 ppb, so the anomaly does not persist much below surface. In contrast to the Ca of the carbonate, there is little evidence for significant Au associated with Ca in the gypsiferous clays. Across the section of the regolith line, there appears to be a barren zone with low Au concentrations (<2 ppb) extending from near the surface to about 30 m. At about 30 m, Au is broadly distributed across several hundred metres, including mineralised Zones 1 and 2, with concentrations from about 4 to 20 ppb. This suggests a weak supergene zone, possibly related to an earlier water table or redox front. High Au concentrations deeper in the regolith are probably related to primary mineralization. Mean concentrations in RAB drill cuttings from 0-10 m show a maximum over Zone 1 mineralization but not over Zone 2. This contrasts with the 0-6 m samples, collected from the adjacent drill hole, and suggests an inhomogeneous Au distribution.

Of most significance are the anomalous Au concentrations in calcrete over mineralization (Zone 2, maximum of 13 ppb, Figure 3). However, concentrations are also high over Zone A (14 ppb) where no

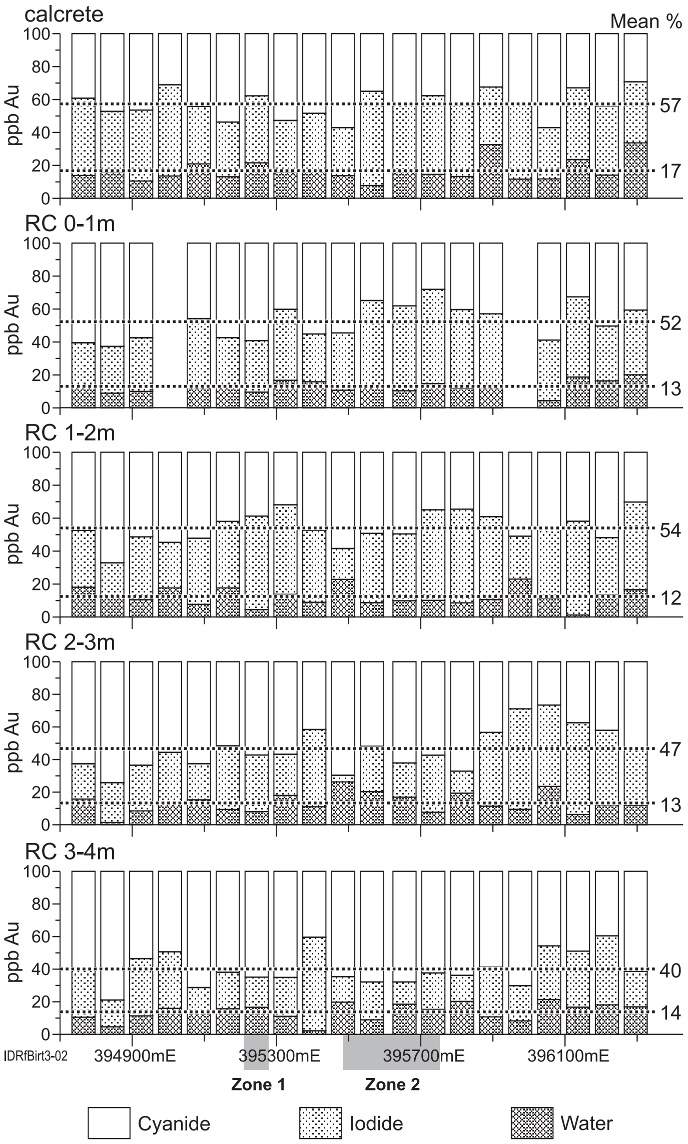

Figure 4. Distribution of Au in calcrete and RC drilled samples from various levels in the profile as determined by sequential partial extractions. Dotted lines across histograms indicate mean concentrations expressed as a percentage of combined extractable Au.

mineralization has been identified. Data normalization of Au with respect to Ca or Ca+Mg is commonly used to offset the possible diluent effect of other components within the sample, e.g., aeolian sand. However, normalizing Au to the alkaline earths neither significantly enhanced the response over mineralization nor removed the apparent spurious anomaly at Zone A.

Gold contents in soil are generally below or just above detection (1 ppb, Figure 3). The highest concentration was 3 ppb over Zone 2. Normalising Au to the alkaline earths produced a stronger, single point maximum over mineralization (Zone 2).

The polymictic lag consists of varying proportions of silcrete, calcrete and ferruginous material. The highest Au concentrations for coarse and fine lag were 6 and 3 ppb respectively, although most samples contain <1 ppb (Figure 3). Coarse lag was generally scarce (except at the W end of the regolith line) and samples could not be collected at half of the sites. One fine lag and two coarse lag samples from the E and W ends of the traverse, that were particularly ferruginous, had Au contents below detection, indicating that Fe oxides are not strong trap sites for Au here.

Gold concentrations in bluebush were close to detection (0.3 ppb) in background at the western end of the traverse (except one sample at 2.2 ppb dry weight) that requires further investigation (Figure 3). In Western Australia, concentrations in excess of about 2 ppb are considered anomalous, although there may be locally higher thresholds (unpublished data, Lintern; Lintern *et al.*, 1997). Therefore, most of the Au concentrations at Birthday Prospect are not significant when compared with data from Western Australia.

The sequential partial extractions provide information on the relative solubility of Au in the surficial environment and, by inference, its potential mobility. The data indicate important differences that occur in Au solubilities in the top 6 m of regolith (i) with depth and (ii) between calcrete and drill hole materials (Figure 4). The main features are summarized below:

1) The proportion of cyanide-soluble Au (least soluble) increases with increasing depth from 48% to 60%. This is thought to be due to larger Au particles in the saprolite than in the soil.

2) Calcrete has the highest proportion (57%) of soluble Au (iodide and water soluble). This agrees with other data (summarised by Butt *et al*, 1997) that suggest Au in the carbonate horizon is relatively mobile.

3) The sum of the sequential extraction concentrations (water+iodide+cyanide) generally agrees with the total from aqua-regia digestions. This indicates that the general quality of the soluble Au data is acceptable.

REFERENCES

Anon, 1996. Minotaur Gold NL Quarterly Report, ending 31-12-96. Adelaide, South Australia.

Butt, C.R.M., Gray, D.J., Robertson, I.D.M., Lintern, M.J., Anand, R.R., Britt, A.F., Bristow, A.P.J., Munday, T.J., Phang, C., Smith, R.E. and Wildman, J.E., 1997. Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, Western Australia. CRC LEME 36R/Exploration and Mining Report 333R. 153 pp.

Daly, S.J., 1985. Tarcoola map sheet. Geological Survey of South Australia. Geological Atlas 1:250 000 Series, sheet SH53-10.

Daly, S.J., Fanning, C.M. and Fairclough, M.C., 1998. Tectonic evolution and exploration potential of the Gawler Craton. Journal of Australian Geology and Geophysics, 17: 145-168.

Fanning, C.M., 1997. Geochronological synthesis of Southern Australia. Part II. The Gawler Craton. South Australia Department of Mines and Energy, Open File Envelope 8918 (unpublished).

Lintern, M.J., Butt, C.R.M. and Scott, K.M., 1997. Gold in vegetation and soil - three case studies from the goldfields of southern Western Australia. Journal of Geochemical Exploration 58: 1-14

Lintern, M.J., Sheard, M.J. and Gouthas, G., 2000. Regolith studies related to the Birthday Gold Prospect, Gawler Craton, South Australia. CRC LEME Open File Report 79. 201 pp.