# PAJINGO EPITHERMAL GOLD DEPOSITS, NE QUEENSLAND

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## LOCATION

The Pajingo Au deposits are approximately 53 km SSE of Charters Towers, at 20º32'S, 146º27'E; Charters Towers 1:250 000 SF55-02 sheet (Figure 1).

## DISCOVERY HISTORY

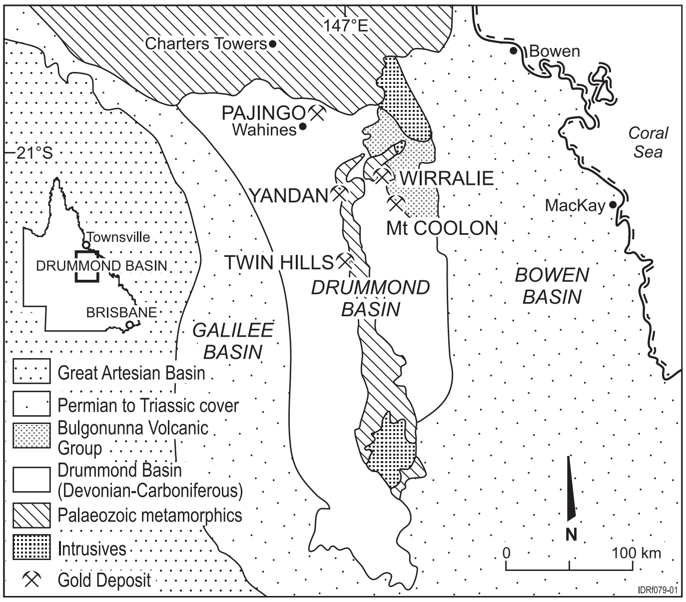


Figure 1. Location map of the Pajingo Au deposits and other Au producers in the Drummond Basin of NE Queensland.

The initial discovery was in 1983, by Duval Mining (subsequently Battle Mountain (Australia) Inc.) in a previously unexplored area and discoveries at Pajingo have continued intermittently over 15 years. Reconnaissance revealed mineralized epithermal quartz veins (Porter, 1990). Follow-up prospecting and outcrop sampling located the *Scott lode,* near the Janet Ranges, in 1984. Regional stream sediment sampling showed a coherent Au anomaly over 60 km$^2$ (Harrison, 1991), but did not highlight individual veins. No new reserves were found despite mapping, prospecting, resistivity, aeromagnetics, remote sensing, stream sediment geochemistry and shallow drilling of numerous outcropping and shallowly covered veins. Open pit and minor underground mining produced 366 500 oz Au and 1 022 601 oz Ag.

Detailed aeromagnetic and gradient array resistivity surveys defined the magnetite-depleted, silicified host structures, beneath shallow Tertiary and younger cover, on strike from known veins. The *Cindy* vein, beneath 5-15 m of Tertiary sediments, was found in 1991 by drilling targets defined by these surveys. Open cut and underground mining produced 46 468 oz Au and 25 066 oz Ag (Richards et al., 1998).

At *Vera* and *Nancy*, outcrop rock chip geochemistry and early shallow drilling were disappointing. A sub-economic resource (about 5,000 oz) was outlined near surface at Vera in the 1980s and there were a few, discontinuous, high-grade intercepts in the upper part of Vera North in 1994 and 1995. In December 1995, after evaluation of quartz textures, aeromagnetics and a new detailed resistivity survey, deep drilling discovered the mostly blind, NW-trending Nancy and Vera North deposits (Figure 2). The top of the economic mineralization is 100-200 m below surface.

*Vera South* (Figures 2 and 3) was discovered beneath >34 m of Tertiary sediments at the end of 1997. Drilling along strike from known deposits gave some economic intercepts. Re-interpretation following a detailed resistivity survey and follow-up drilling discovered the main ore shoots at depth (Butler et al., 1999). *Jandam* was discovered SE along strike at the end of 1998 and drilled out as an inferred resource in 2000. The mineral inventory (resources, reserves and mined at June 30, 2001) of the Vera-Nancy ore-bodies and new deposits on strike at Vera South, Jandam and Anne was 6 592 000 tonnes at 13.5 g/t Au and 14 g/t Ag for 2 856 500 oz Au.

## PHYSICAL FEATURES AND ENVIRONMENT

The centre of the area has steep hills of outcropping intermediate volcanics of the Janet Ranges rising 180 m above the surrounding plain. The hills are densely covered with eucalypts, acacia and other shrubs. Woodlands of lancewood cover mesas and thrive in the iron-rich, gravelly soil. Areas between the hills are more sparsely vegetated, and consist of open savanna woodland used for grazing.

The climate is tropical, semi-arid. Almost all rainfall (average 660 mm) is in summer when 65% humidity is common. The maximum summer temperature averages 34ºC and the average minimum winter temperature is 10ºC with 35% humidity. Average annual evaporation (2200 mm) exceeds rainfall (Bureau of Meteorology, 1988).

## GEOLOGICAL SETTING

The mid-Carboniferous Pajingo epithermal Au deposits are hosted by a package of intermediate (late-Devonian to Carboniferous), high level intrusives, lavas and various volcaniclastic rocks. These are located in the northern portion of the Drummond Basin and are bounded to the N by the Ordovician to Devonian Lolworth-Ravenswood Block. Quartz veins also occur in the underlying quartz-mica sandstone and in the overlying locally-derived sediments and flow-banded rhyolites that overlie the andesite-dacite package to the S. Mixed provenance, post-mineralization Carboniferous sediments with epithermal vein fragments obscure the prospective stratigraphy to the S (Fellows, 2000). In the vicinity of the Au deposits, the Palaeozoic basement is mostly overlain by the early Eocene Southern Cross Formation sediments and by various talus, colluvial and alluvial deposits.

## REGOLITH

The Palaeozoic rocks are weathered to saprock and saprolite on the high ground, but are more deeply weathered and largely covered by Southern Cross Formation and younger sediments on the lower ground (Figure 4). The weathering front is at about 95 m near the Scott lode and Vera deposits. About 80% of the region is depositional, nearly 20% is erosional and less than 1% is lateritic residuum (Bolster, 1993). The Southern Cross Formation was deposited on an incised palaeotopographic surface. There was initial fluvial excavation of topographic lows (in part controlled by zones of more intense clay alteration related to mineralization and shear zones) followed by syn-tectonic deposition in minor extensional basins (Schafer, 1999). The thickness of the sediment reaches 80 m but varies over short distances.

At Scott lode and Vera South (Schafer, 1999), the sediments are clay rich and contain fluviatile quartz, chert, ferruginous nodules and bedrock clasts from a deeply weathered regolith. Cobbles of epithermal quartz have been carried up to 1 km from source. The sediments are now weathered and mottled. At Scott lode, the basement and the lode are exposed. The edge of a palaeochannel, filled with weathered Southern Cross sediments, cuts into the SW side of the pit, exposing an imbricate rudite of detrital red-brown mottles, resting on mottled basement saprolite. This is overlain by alternating mottled grits and gravely rocks, now weathered to clays, with a thick wedge of mega-mottled red-brown clays with rhizomorphic structures and further mottled gravely sediments. The clasts consist mainly of weathered volcanic rocks with minor quartz, set in a clay matrix.

 

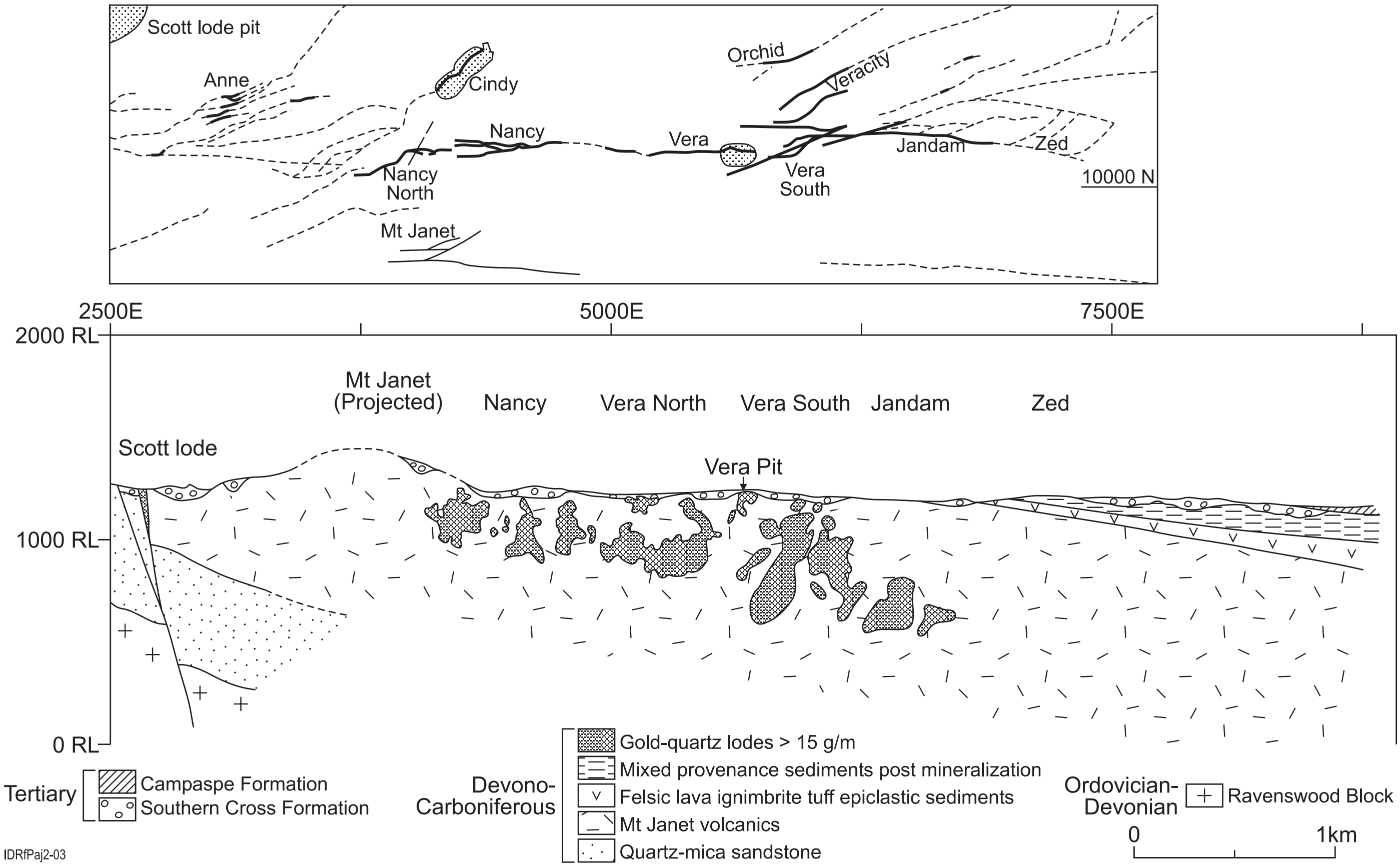


Figure 2. The Pajingo Au Deposits in plan and section in relation to the cover sequences and the hosting fracture systems.

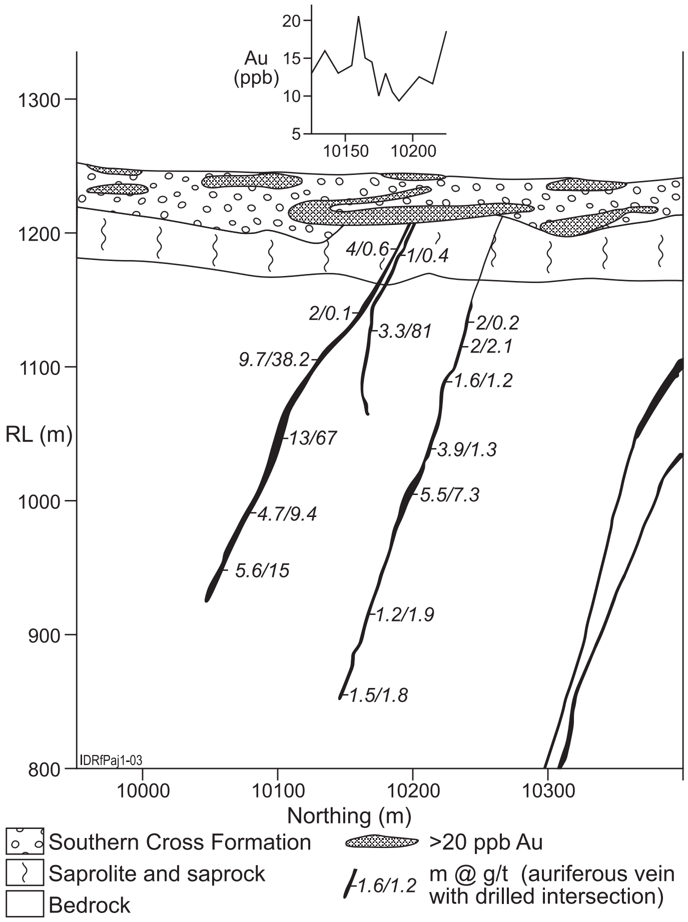


Figure 3. The Vera South Au veins showing drilled intersections, the weathered rocks above and the Tertiary Southern Cross Formation cover with Au anomalies. Graph indicates BLEG data that are more related to the cover than to the underlying vein mineralisation.

Exposure in the Vera Pit and drilling at Vera North show relationships between Tertiary sediments, basement and lode similar to Scott lode, with some surface exposure and abrupt thickening of the Tertiary sediments in the hangingwall. At Vera South, the distribution of the Tertiary sediments appears to be fault-controlled into a NE-trending palaeochannel (Schafer, 1999).

The Cindy lode is obscured by the Southern Cross Formation. Mottled saprolite of the basement volcanics is overlain by a thin basal conglomerate with alternating conglomerate and gritty layers above and a thick, mottled horizon on top. The detritus was derived from a variety of regolith horizons; it includes pisolitic fragments and lithic nodules with thin cutans of yellow-brown clay. Some nodules preserve volcanic rock fabrics, completely pseudomorphed by kaolin.

The Campaspe Formation, comprising moderately indurated medium to coarse-grained immature sands (Henderson and Nind, 1994) underlies lowlands in the Pajingo district, but does not occur in the uplands near the deposits (Figure 4). Alluvium ranges from boulders, through gravels to massive clay deposits up to 4 m thick. These immature materials contain ferruginous pisoliths from pre-existing lateritic profiles, vein quartz and weathered volcanics, in part inherited from the Southern Cross Formation.

## MINERALIZATION

The Pajingo lodes are epithermal, low-sulphidation, Au-mineralized quartz-adularia veins. The Scott lode (Porter, 1990) has a strike of 560 m, a maximum width of 23 m and dips S at 70-80º. It consists of chalcedonic and microcrystalline quartz with goethite and hematite bands and shows textures indicating multiple brecciation of vein and matrix, and resealing with silica. There has been only minor supergene enrichment. The Au-Ag mineralization (mostly electrum) has a basal 50 m thick base-metal zone and is associated with (maxima in ppm) Hg (1.3), As (240), Sb (170), Pb (6700), Cu (2350), Zn (2800), Te (3.4), Tl (20), Bi (6) and F (400).

The Cindy lode strikes for 300 m and dips S at 70-80º. Colloform-crustiform banding is only weakly developed and the lode is mainly moss-textured quartz with various breccias. Deposits along the NW

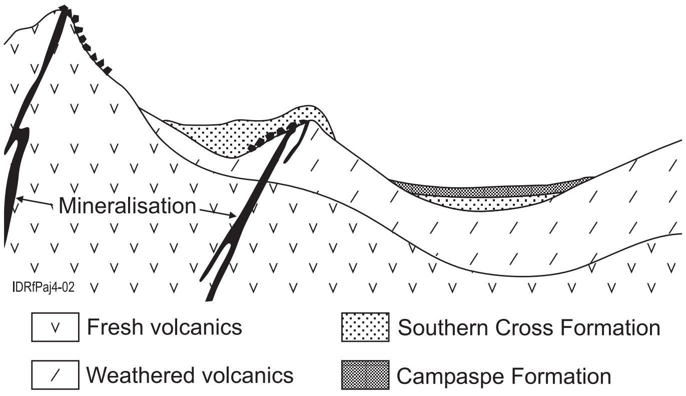


Figure 4. Relatively fresh rock developed on the high ground with deeply weathered rock on the pediment which is partly obscured by Southern Cross and Campaspe formation sediments.

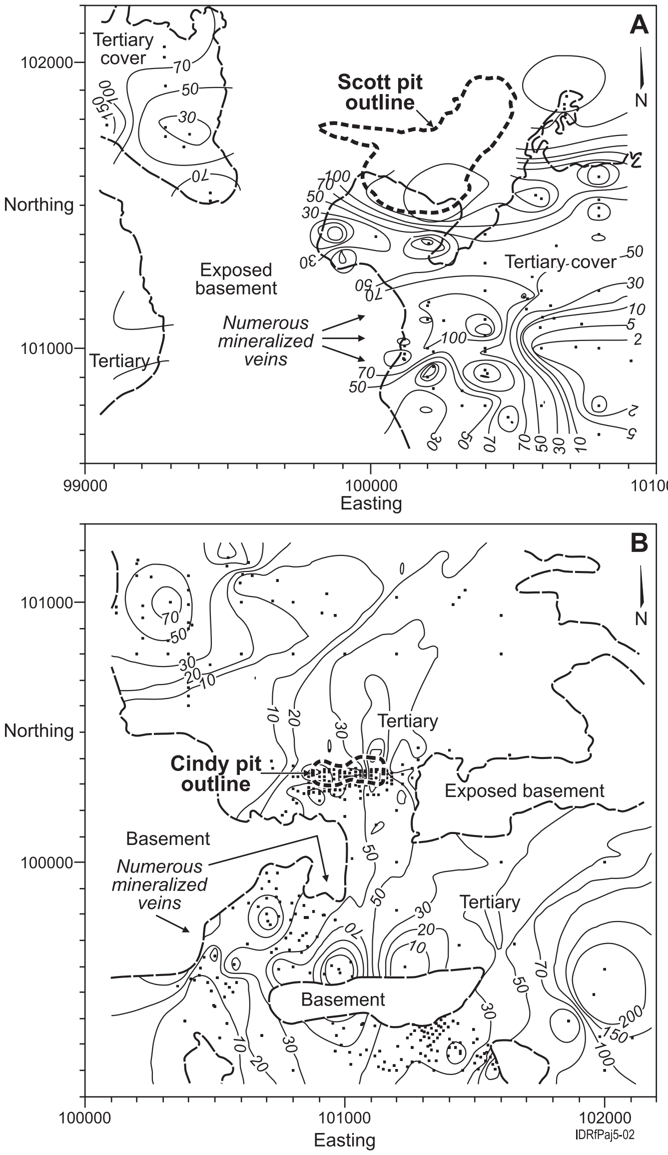


Figure 5. Gold anomalies developed in the Southern Cross Formation by erosion of mineralized veins around the Scott lode (A) and Cindy lode (B). Dots show location of drilling.

trending Vera-Nancy structure have a combined strike of 2.5 km and dip to the SW at 55-90º. The veins are up to 10 m thick but average 2 m. Textures are similar to those at Scott lode and Cindy. There is no evidence for base-metal enrichment at the base of the precious metal zone at Cindy or Vera-Nancy. Gold and Ag are restricted to the quartz veins, and there is no Au dissemination in the altered wall rocks.

Alteration varies in width and intensity between the deposits but consists of an almost regional chlorite-dominated propylitic assemblage. Phyllic alteration (silica-pyrite-sericite) is up to 20 m thick adjacent to the veins, and decreases in intensity and is dominated by illite-smectite clays away from the veins. This is irregularly overprinted by dickite within the veins and kaolinite distally. Carbonates (ankerite, dolomite, calcite and siderite) occur as late stage infill in veins, cross-cutting veinlets, matrix to late breccias and disseminations within the wall-rocks.

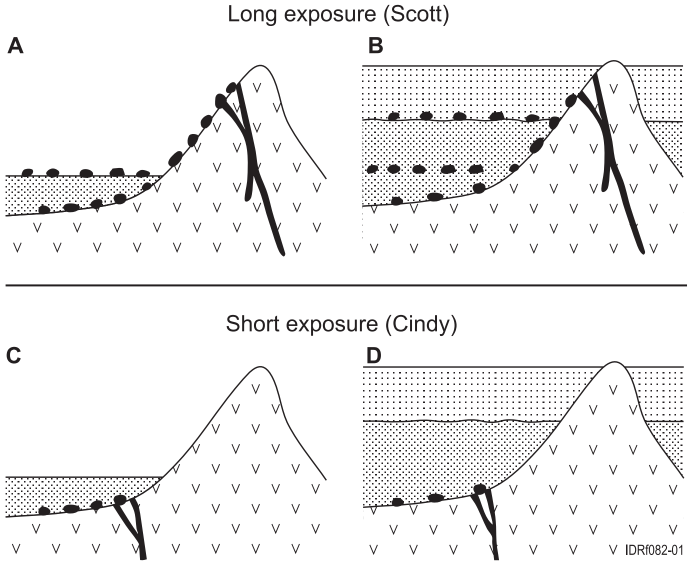


Figure 6. Detrital exploration model for Pajingo. Long exposure (e.g. Scott Lode) produces anomalies at various levels within the cover but short exposure and early burial (e.g. Cindy Lode) leaves only minor anomalies at the base of the cover.

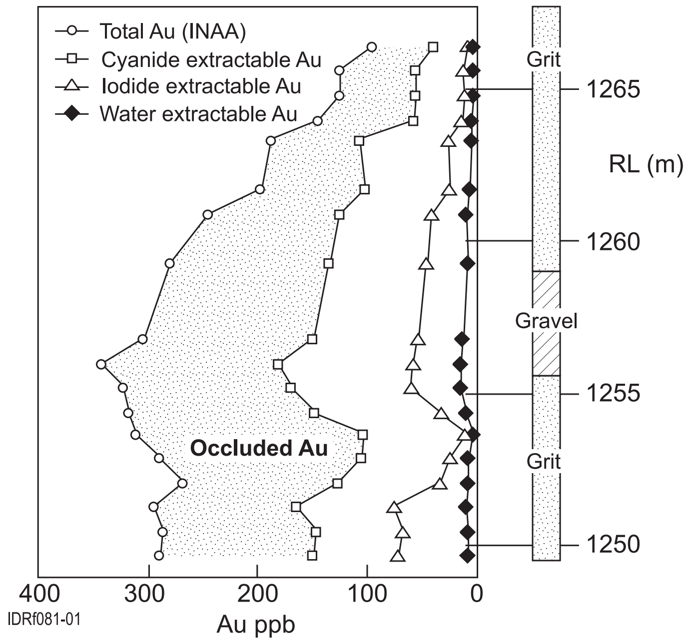


Figure 7. A comparison of water, KI, and KCN extraction of Au with INAA analysis, indicating that a large proportion of the Au in the Southern Cross Formation is occluded from cyanide extraction.

## REGOLITH EXPRESSION

### Dispersion in weathered Palaeozoic basement

There is no lateritic residuum near the deposits, and there seems to be no dispersion of Au into the saprolite near the veins, although this has not been investigated systematically. Supergene processes have affected the ore-bodies to a limited extent, but significant supergene enrichment, depletion and redistribution of Au appear to be lacking.

At Scott lode, kaolinite is the dominant weathered phase, probably due to acid conditions from weathering of pyrite. In areas of high sulphide (generally wall rocks and veins), supergene natroalunite is developed in fractures, veins and vein selvedges with kaolinite, goethite and jarosite (Porter, 1991; Bobis 1992). Gypsum (mainly selenite) has also been noted locally (Bobis, 1992).

Most ore samples from the oxide zone at Scott lode show no obvious association with Fe oxides. However, in places, Au occurs with patches of hematite and in goethitic fractures. These oxides are thought to have been introduced, rather than derived from sulphides. In some Au-rich hematite patches, the supergene Ag halides cerargyrite, bromargyrite and iodargyrite have been identified. Bonanza Au grades of >2000 g/t occur as late stage infill structures accompanied by either Fe oxides or clay (Porter, 1991).

At Vera, there are some small grains of native Au (very low Ag), in addition to electrum with Au rims. Rare secondary chalcocite, covellite and goethite (after pyrite) were also noted (Carey, 1996).

**Dispersion within the Southern Cross Formation**

*Regional, local and lode-proximal backgrounds*

Distant from known mineralization, the *regional Au background* in the Southern Cross Formation is low *(e.g.,* 5-10 ppb or less at the Wahines Prospect; Figure 1; Campbell, 1996). Within 1 km of the Scott lode and the Cindy deposit, the *local background* reaches about 30 ppb Au (Robertson, 1997). The *lode proximal background* (within the pit) at the Scott pit is very high (>100 ppb) because the lode was only partly covered and local mineralized detritus has been shed continuously from the lode into the palaeodrainage. However, the lode proximal background is substantially less (16 ppb) at Cindy, due to dilution by detritus from up-slope, beyond the mineralization. In general, within the cover sequence, a Au background of >20 ppb may indicate a distal Au source; >35 ppb may indicate a proximal Au source (Robertson, 1997). However, the source may not necessarily be economic as significant dispersion halos have resulted from a large number of small, subeconomic, auriferous veins.

*Localized dispersion*

Mechanical dispersion has produced localized anomalies in Au, W and Mo in the cover sequences (Robertson, 1997). At Scott lode, the highest Au concentration (700 ppb) is within gritty sediments, more than 10 m above the unconformity. Anomalous concentrations of Au (200 ppb), As (80 ppm) and W (6 ppm) lie within gravely sediments near, but not at the base of the channel. At Cindy, Au is locally concentrated (>500 ppb) down slope of the mineralization, where it was cut by a small outflowing palaeodrainage. Again, the anomaly occurs near, but not at the base of the sediments. Thus, dispersion is not necessarily at the base of the cover but may be at any level, requiring analysis of the whole sequence.

Exploration drilling within 1 km of the mines confirmed Au dispersion of 100-300 m (>70 ppb) both from the Scott lode and Cindy deposits and/or from areas of numerous auriferous quartz veins nearby (Figure 5). Gold anomalies occur at several levels in the cover (Figure 3) indicating that local sources remained exposed during sedimentation (Figure 6A and B). Dispersion was probably mechanical. However, partial extraction experiments (Figure 7) indicate that a proportion of the Au is soluble in weak extractants; K-iodide (8-26% of the total Au) and water (up to 4% of the total Au) implying some chemical reworking of Au (Robertson, 1997). A slightly greater proportion of the Au is held in the fine fraction (<100 μm) of the Southern Cross Formation at Scott lode (Campbell, 1996). About half of the Au is occluded from cyanide attack (difference between INAA and KCN extraction; Figure 7).

**Geochemistry of soils on transported regolith**

Subsequent to discovery, orientation soil geochemistry was conducted over Vera South, where the mineralized veins most closely approach the surface. Several partial leach techniques were tested including Mobile Metal Ion (MMI), unbuffered cyanide leach and BLEG. The sample medium was soil developed on the Southern Cross Formation that is known to contain mineralized quartz fragments. Samples were collected at 10 m intervals, decreasing to 5 m over the surface projection of the mineralization, over a total length of 300 m. All techniques produced ‘anomalies’ over the entire line, but the peaks are not coincident with the surface projection of the mineralization. Figure 3 shows the BLEG (static cyanide leach, 2 kg samples) results with respect to the regolith and mineralization. Samples were also collected from a 2 km distant, poorly mineralized vein under about 20 m of cover for comparison. The best anomaly there is about 30% greater than that at Vera South and is located 50 m from the surface projection of the structure. The Au in the soil represents detrital Au in the sediments which has no direct relationship to Au in the underlying veins.

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