KANOWNA BELLE GOLD DEPOSIT, WESTERN AUSTRALIA

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LOCATION

The Kanowna Belle deposit is located 18 km NE of Kalgoorlie at 30°37'S, 121°35'E; Kalgoorlie 1:250 000 map sheet.

DISCOVERY HISTORY

Gold was discovered at Kanowna in 1893 but activity declined rapidly after 1914. Production was initially from quartz reefs along the White Feather structure and later from deep leads and cemented alluvials (Beckett *et al.*, 1998). Although there was sporadic exploration from the late 1970s, Canyon Resources Pty Ltd (later Delta Gold) recognized the potential for open-pit, deep-lead and bedrock mining at Kanowna and acquired tenements in 1982-83. They joined forces with North Mining as the Golden Valley Joint Venture to exploit the nearby supergene QED Deposit and systematically explored the Kanowna Belle area with RAB drilling. In mid 1987, drilling intersected 2 m at 11 g/t Au and 4 m at 3 g/t Au at 52 m and 28 m depths respectively. Soil geochemistry defined a 350 m diameter anomaly of >60 ppb with a peak of 150 ppb Au in the <80 mesh (<180 µm) soil, against a background of 10-20 ppb (Thomson and Peachey, 1993). Further RAB drilling confirmed significant Au mineralization and, in September 1991, an indicated and inferred resource of 11.2 Mt at 5.2 g/t Au was outlined (Beckett *et al.,* 1998).

PHYSICAL FEATURES AND ENVIRONMENT

The deposit is located on a depositional plain (Figure 1) surrounded by low hills and rises. The ridges and hills are generally restricted to the S, SE and central region of the area and give way to gently sloping plains to the N. Several 10-30 km long, shallow incised drainage systems lead into playas to the N of Kanowna Belle. Breakaways generally occur in the headwaters of these drainages or on isolated, low, topographic rises on the boundaries of sandplains. The Kanowna Belle deposit is located within a major northward-flowing drainage basin surrounded by low hills of bedrock and saprolite. The climate is semi-arid, has an irregular average annual rainfall of 250 mm, a January temperature range of 18-34ºC and a July range of 4-16ºC. Vegetation is open *Eucalyptus* woodland with a dense shrub understorey of mulga (*Acacia aneura*) interspersed with open tracts of bluebush (*Kochia*) and saltbush (*Atriplex*).

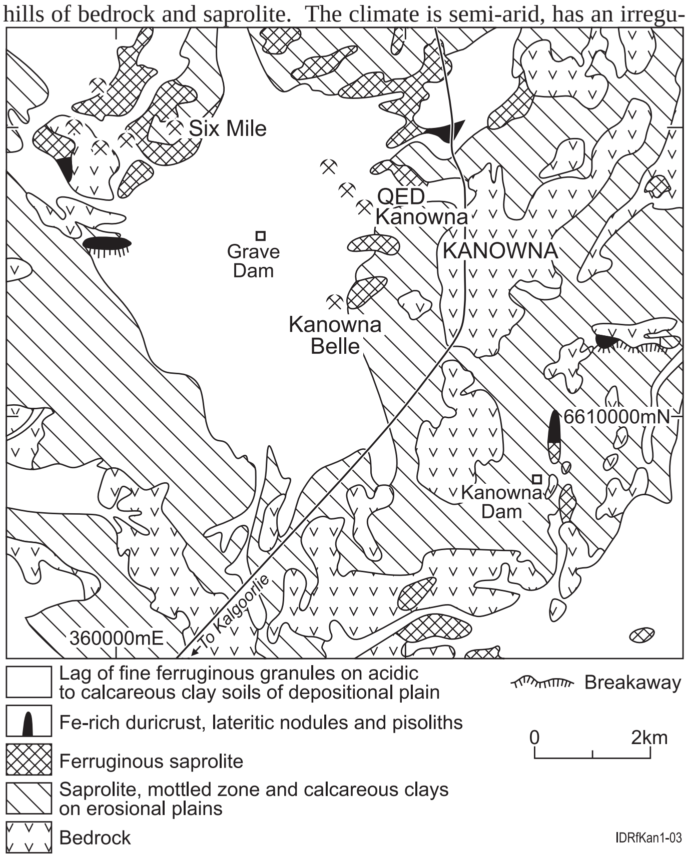

Figure 1. Simplified regolith map for the Kanowna Belle area.

GEOLOGICAL SETTING

The Kanowna Belle deposit lies in a belt of NNW trending metamorphosed ultramafic, mafic, sedimentary and felsic volcanic and intrusive rocks of the Norseman-Wiluna Greenstone Belt in the Archaean Yilgarn Craton. The deposit is hosted by a package of NE trending, S dipping, predominantly intermediate to felsic, tuffaceous mass-flow units and breccias. Mineralization in the Kanowna Belle sequence is associated with the Fitzroy Shear Zone, which separates the mainly polymictic conglomerates of the footwall from the felsic angular rudites with minor pebble beds, boulder beds and mafic flows of the hangingwall (Thomson and Peachy, 1993).

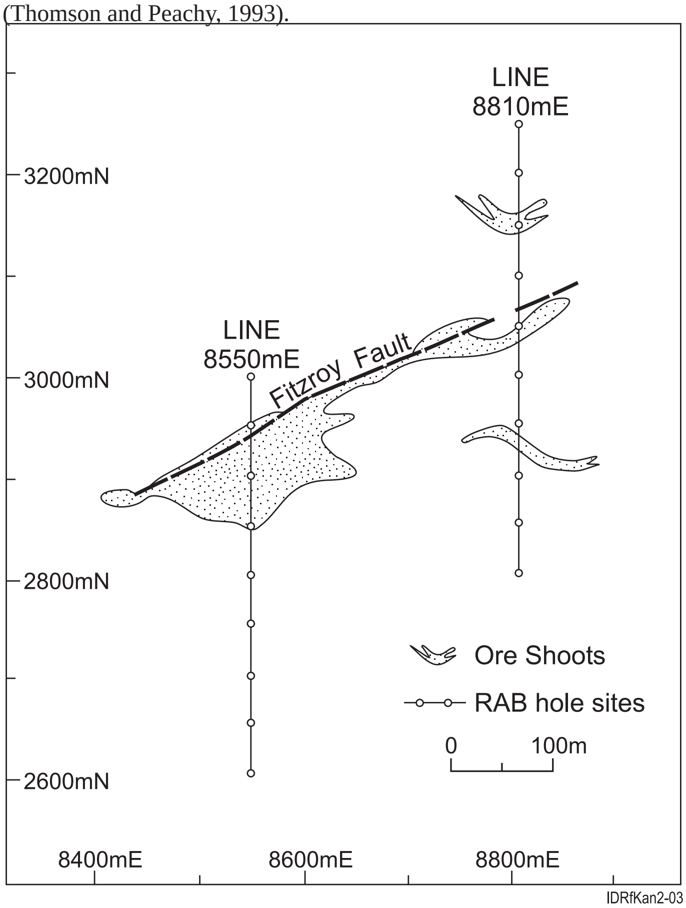

Figure 2. Location of RAB sampling traverses with respect to mineralization. Ore shoots and fault projected onto plane at 300 m rl (50 m below surface).

REGOLITH

Saprolite is 20-50 m thick. Above the rudites and feldspar porphyry, it has been completely silicified to form a silcrete 1-8 m thick. However, primary quartz crystals and bedrock fabrics are sufficiently preserved by relict quartz and pseudomorphs of primary silicates to allow the parent rocks to be identified. Mottled saprolite, 3-6 m thick, forms the top of the residual profile and is thicker on ultramafic rocks than on felsic porphyry.

The mottled saprolite is overlain by 2-5 m of transported silty red clays (kaolinite-quartz), acidic in the lower part, but with some minor carbonates in the top 0.3 m. Above this are 0.2-1.0 m of pale orange, sandy clay soils, rich in calcite, kaolinite and quartz (Figure 3). Both calcareous and non-calcareous soils contain abundant hard, black, vitre-

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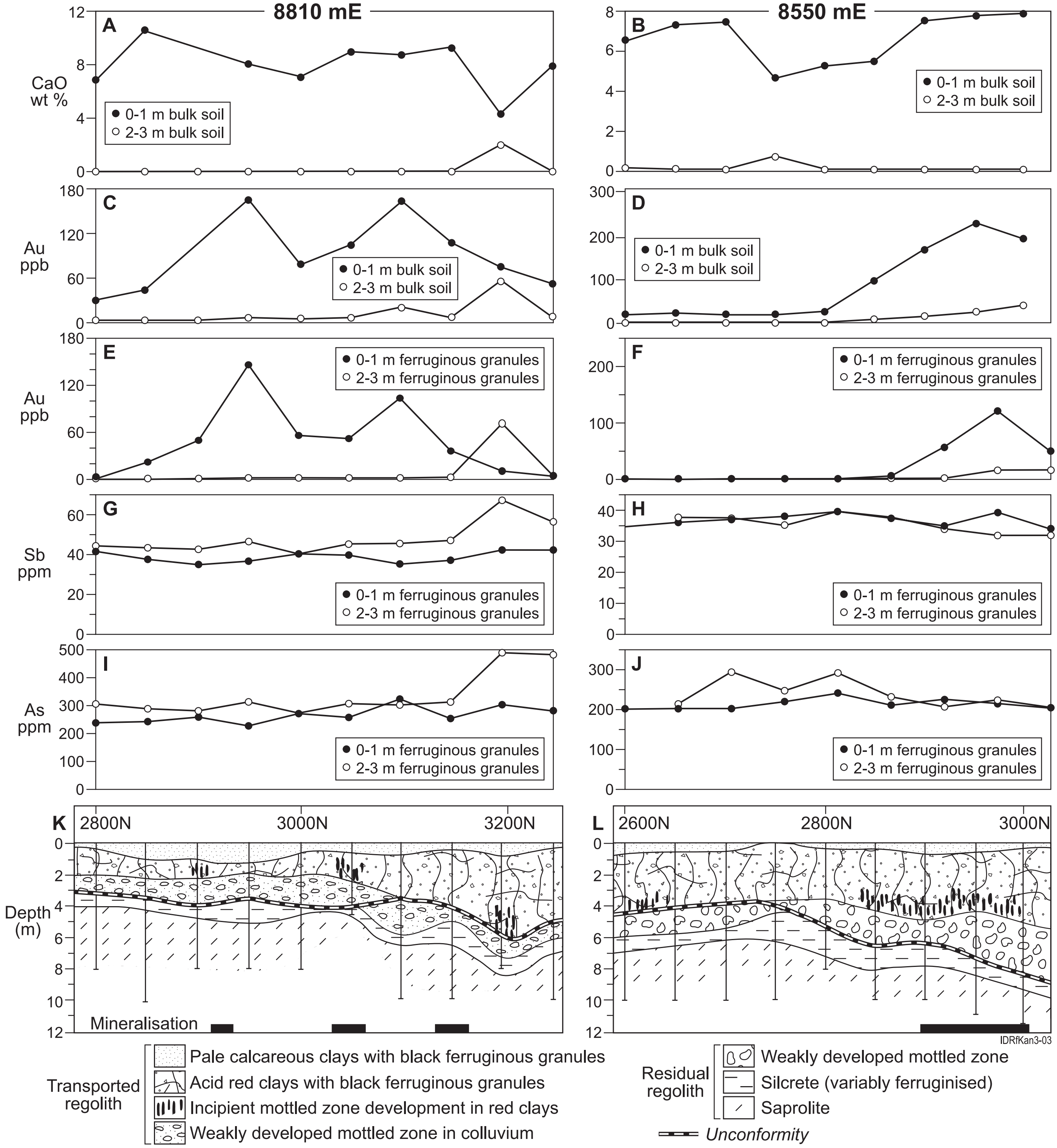

Figure 3. Geochemistry of bulk soil samples (A-D), ferruginous granules (E-J) and regolith stratigraphy (K-L) of the two sampling traverses 8810mE and 8550mE. Black bars indicate the mineralization at 35-45 m depth.

ous, ferruginous granules (hematite-maghemite) up to 6 mm in diameter. Their petrography suggests a largely detrital origin but some have formed *in situ* in the red clays. Silica (10-22%), Fe_2O_3 (68-78%) and Al_2O_3 (5-8%), together form most (95%) of these granules. The soil is mantled by a polymictic lag of abundant black, ferruginous granules, with some detrital vein quartz and lithic fragments (Dell, 1992; Anand *et al.*, 1993).

MINERALIZATION

The main Kanowna Belle orebody, the Lowes Shoot, is tabular, mostly porphyry-hosted, strikes for 350-500 m and is 5-50 m thick. It remains open below a vertical depth of 800 m (Thompson and Peachy, 1993) and is spatially closely related to the Fitzroy Fault (Figure 2), generally lying above it in the upper parts of the deposit and below it at depth. In primary mineralization, Au is associated with pyrite, minor arsenopyrite, chalcopyrite and sphalerite. Gold is strongly depleted in the upper regolith and concentrated below the base of complete oxidation. Supergene Au mineralization (>100 ppb) is significant, with a well-developed horizon 1-4 m thick and up to 200 m wide at the base of the saprolite (35-45 m below surface). Smaller (<20 m wide) pods of supergene mineralization (<100 ppb) occur close to the surface (5 m).

REGOLITH EXPRESSION

The mineralization is indicated by a multi-element geochemical halo within both the calcareous soils and ferruginous granules (Figure 3, Table 1). Gold is concentrated in calcareous soil (mean 90 ppb), ranging from 17 to 230 ppb and commonly exceeding 60 ppb in the top metre. Peak Au concentrations conform well to the position of major ore shoots below. In contrast, Au contents of mostly acidic, red clays are much lower (Mean 11 ppb), with higher values occurring where carbonate is present.

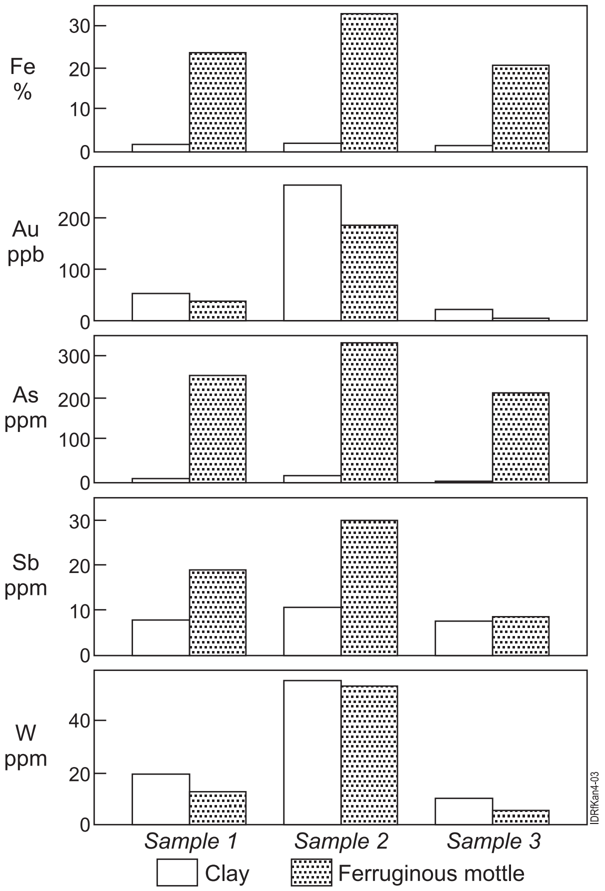

Figure 4. Distribution of Fe, Au, As and W in clay and ferruginous components of samples separated from mottled zone, Kanowna Belle deposit.

The Au distributions shown by ferruginous granules separated from the soils are similar to those shown for the bulk samples. The patterns across the traverse in the calcareous soils (0-1 m) similarly indicates the positions of the main ore shoots, with concentrations ranging from 2 to 150 ppb, whereas granules separated from the acidic red clays at 2-3 m have low Au contents (Mean 7 ppb) – again except where some carbonate is present.

Concentrations of As (200-500 ppm) and Sb (30-60 ppm) in the ferruginous granules are generally 4 and 7 times, respectively, greater than those of the bulk soils. Mean concentrations of As and Sb are similar in granules separated from the calcareous top soil (0-1 m; As 240 ppm, Sb 38 ppm) and acidic red clays (2-3 m; As 290 ppm, Sb 43 ppm). There is little variation in abundance across the traverses but the concentrations are significantly greater than background abundances (As <40 ppm; Sb <1ppm). The As and Sb concentrations thus appear to reflect the presence of mineralization at a prospect scale, but do not indicate individual ore shoots. Cerium is significantly concentrated both in soil (30-55 ppm) and ferruginous granules (17-38 ppm), compared to backgrounds of <10 ppm and <5 ppm, respectively; Ce abundances are positively correlated with Ca.

Comparison of ferruginous (goethite-hematite-kaolinite) and clay-rich (kaolinite and minor quartz) components of mottled saprolite show that Au and W are slightly more abundant in the clay (Figure 4). In contrast, As, Sb, Bi, Cu and Zn are strongly enriched in the ferruginous mottles.

The presence of anomalous Au concentrations in calcareous soil occurring directly above mineralization, despite 2-5 m of sedimentary cover, can be explained by hydromorphic or biological transport, or mechanical mixing, bringing Au to the surface. The Au source may be the underlying mineralization (at 50 m depth) or, more likely, Au enrichment in the silcrete or upper saprolite. The reasons for Au being present in ferruginous granules in the soil at 0-1 m, but absent at 2-3 m are unclear. It is possible that hydromorphically or biologically dispersed Au was precipitated not only onto carbonates but also onto the surfaces of the detrital ferruginous granules. Similar observations have been made at other sites in the Kalgoorlie region (*e.g.*, Mystery Zone, Mt. Percy; this volume).

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TABLE 1 - COMPARISON OF SAMPLE MEDIA

	Bulk Soils										
	0-1 m Calcareous soil N=18					2-3 m Acidic red clay N=19					
	Mean	SD	Minimum	Maximum	Median	Mean	SD	Minimum	Maximum	Median	Background
CaO%	7.4	1.7	4.6	10.8	7.5	0.3	0.5	0.1	2.3	0.1	
Au ppb	90	70	17	232	76	11	15	1	57	5	<20
As ppm	29	10	18	49	26	64	65	21	238	48	<20
Sb ppm	5	2.7	0.7	12	5	9.8	11.1	2	39	6	<1
Ce ppm	40	7	30	55	37	nd	nd	nd	nd	nd	<10
	Ferruginous granules										
			0-1 m	N=19				2-3 m	N=19		
Fe2O3%	72.2	1.6	69.1	75	72.6	72.8	2.9	68.6	78.8	72.1	
Au ppb	38	45	2	147	22	7	16	2	71	2	<5
As ppm	241	34	201	321	238	292	79	201	485	290	<40
Sb ppm	37.9	2.6	34	42	38	42.7	8.7	32	67	42	<1
Ce ppm	29	6	17	38	29	5	5	1	22	4	<5

Background approximately 400 m away from mineralization   nd = Not determined