KANOWNA BELLE GOLD DEPOSIT – EXPLORATION HISTORY AND GEOLOGY

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ABSTRACT

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Gold was first discovered in the Kanowna area, approximately 20 kilometres north of Kalgoorlie in Western Australia, in 1893. Gold mining in the area peaked in 1898 with the production of 152,000 ounces from vein-hosted and alluvial sources. From 1911, production became sporadic and declined rapidly before ceasing in 1946.

Interest in Kanowna surged again in 1979 as the gold price rose, resulting in increased exploration activity and, in 1986, the recommencement of mining at Kanowna. Total gold production from the Kanowna area is approximately one million ounces.
Exploration for additional mineralisation in the Kanowna area focused on extending, or finding repetitions of known vein deposits and deep leads. Minor success was achieved on both fronts leading to the open pit mine on the old Ballarat and Last Chance vein systems (Delta Gold 67.5%, Pancontinental Mining 32.5%). This was followed by the commencement, after the amalgamation of leases to form the Golden Valley Joint Venture (Delta Gold 50%, Peko Gold 50%), of mining the sticky, clay-rich deep leads for heap-leach treatment at the QED operation.
Using proven mineralisation concepts for the area, the GVJV employed the established techniques of soil geochemistry and RAB drilling to explore for vein and deep lead deposits.

One other concept did exist in the minds of the joint venturers' geologists (in particular, Dr David Gellatly); this paradigm was that the Kanowna area, because of its past production and areal extent of gold occurrences, had the potential to host a major deposit.
The Kanowna Belle discovery evolved as a conceptual model beginning as an occurrence of steeply dipping and narrow gold-bearing veins of limited extent – the interpretation placed on RAB results obtained in 1987 and 1988. A large area (400 metres by 300 metres) of anomalous gold-in-soil values, defined in 1989 in the area of the RAB drilling, was inconsistent with the concept.

Follow-up RAB drilling and the discovery RC drill hole in December 1989 led to an alternative concept – that of a flat-lying but otherwise apparently structureless, supergene body which did not fit either a vein or deep lead concept.
Interpretation of deeper and more widespread (vertical) drilling results throughout 1990 demonstrated an elongation of the deposit to the southwest and suggested a southern dip

direction. (It was the drilling of deeper holes GDD117, GDC118 and GDC119 late in 1990 that revealed the potential size of Kanowna Belle with intercepts of 50 – 80 metres of 2 – 5g/t Au).
Greater use of diamond-core drilling assisted greatly in defining the geometry of the deposit allowing advances and further refinement of the concept. One major advance was the recognition, by Project Geologist Terry Peachey, of a strike-slip planar shear zone, the Fitzroy Fault, and the parallelism of the main mineralised lenses to this fault. Deeper diamond drilling, using the Fitzroy Fault as a plane of reference, provided additional data on lithology, structure, alteration and mineralisation. This included the extent and nature of the brecciation, veining and the variability of the fragmental rock compositions.
Tangential concepts were proposed, based on the new information, ranging from conglomerate-hosted models to milled breccia and diatreme-related modes of genesis.

(An observational aside: in one of the later, deep, angled diamond holes collared 250 metres out in the hanging wall, intersected a rounded quartz cobble, in a conglomerate which contained a 1cm thick gold vein……)

Kanowna Belle is now described as a series of stacked lenses or shoots, striking northeast and dipping moderately (~60 degrees) to the southeast, closely related to the Fitzroy Fault.
The deposit is hosted within Archaean felsic fragmentals and conglomerates intruded by felsic porphyries and is characterised by extensive sericite-carbonate-pyrite alteration with variable silicic and sodic alteration. The deposit contains (1992), in Measured and Indicated Resources of 11.2 million tonnes at grades of 5.23g/t gold (cut to 50g/t gold) or 5.81g/t gold (uncut), approximately two million ounces of gold.

PRESENTATION TO GSA CONFERENCE, Ballarat 1992

Preamble

This paper provides an historical account and description of exploration and the evolution of a variety of ore deposit concepts or models at Kanowna Belle, an Archaean gold deposit near Kalgoorlie, Western Australia which contains 15 million tonnes of ore at an average grade of 5.3g/t gold.**[3.8 million tonnes of ore were added between lodging the abstract above and the presentation of this paper]** Containing over 2.5 million ounces of gold it is arguably one of the best discoveries in Australia in the last 50 years and one that came at a time when the industry needed an injection of confidence and enthusiasm.

Location & Regional History

Kanowna Belle lies hidden beneath a sand and thin sheetwash-covered plain dotted with salmon gums and bluebush about 18 kilometres north of Kalgoorlie. The old townsite of Kanowna and its surrounding vein, 'cement' and deep lead workings lie some two kilometres to the east and northeast of Kanowna Belle.
Gold was first discovered at Kanowna in 1893 about a year after Bayley and Ford discovered the Coolgardie Field and not long after Paddy Hannan located the gold-bearing alluvials that led to the discovery of the Golden Mile at Kalgoorlie-Boulder, also in 1893. Gold production from Kanowna peaked in 1898 with just over 150,000 ounces produced from vein, 'cement'

and deep lead sources. Production was sporadic between 1911 and 1946 when production, to all intents and purposes, ceased.
Total production from the whole field, mostly from within a few kilometres of Kanowna, was approximately one million ounces – a significant field in the old days and certainly worth a serious look ten years ago.

Delta & Geopeko – the 1980's

On the Delta Gold side, that serious look was initiated by David Gellatly, a Delta director, who brought a package of Kanowna tenements into the fledgling company in 1982. North Broken Hill Peko geologists were also prospecting the area independently and had acquired tenements north and west of Kanowna.
The tenement covering Kanowna Belle was originally acquired by Delta in mid-1982. Geopeko, North Broken Hill Peko's exploration arm, farmed into that block in 1983, creating the 'initial joint venture' in which Geopeko was operator. In December 1987 an amalgamation of the patchwork quilt of tenements held by Delta and Geopeko was created by the formation of the Golden Valley Joint Venture (GVJV). This is a 50:50 joint venture in which Delta Gold is responsible for exploration and North Broken Hill Peko for development and mining. The GVJV has, to mid-1992, produced about 70,000 ounces of gold from the QED deep lead operation. It was the deep lead potential that led to the GVJV amalgamation. The reef deposits of White Feather and Shamrock and the Ballarat-Last Chance vein systems in adjacent tenements were excluded from the GVJV and are held 100% by Delta.
Let's summarise and set the Kanowna scene in the late-1980's. The GVJV had defined and commenced mining the Kanowna deep leads. Delta Gold, in joint venture with Pancontinental, was mining gold from Ballarat-Last Chance. Delta was continuing to explore on the GVJV ground and its 100% -held ground for deep leads and reefs using a combination of geological mapping, soil and rock geochemistry and RAB drilling with follow-up RC drilling where anomalous results were obtained. What models were available to assist in designing exploration programmes?
Most exploration geologists create models or concepts, based on the local data available to them, weaving this into the framework of their previous experience and observations.

Leaps, Paradigms & Models

An intuitive leap is required to create a paradigm for which no evidence exists. Kanowna Belle, which is topographically recessive, lies off the trend of the famous Boulder-Lefroy Corridor, strikes northeast and occurs in an area of felsic volcanics, would appear to defy conventional wisdom.
Given the criteria I have just listed, most geologists would not have predicted Kanowna Belle. That is, they would not have created the hypothesis; nor did I or Delta's other geologists – we did however remain confident, given the history and size of the Kanowna gold field, that a major deposit of, say, better than 500,000 ounces could be found. The most likely model was that of a reef gold deposit such as White Feather.
But why be constrained by models? "Where she be, there she be". Almost by default the Cornish approach was adopted for the covered area exploration.

Looking – the preliminary steps

Why did it take so long for Kanowna Belle to be discovered? The deposit remained hidden from the old-timers simply because there was no outcrop or pannable or dry-blowable gold at surface. The lack of outcrop and lack of old workings also dissuaded the modern explorers and remember, conventional wisdom dictated that the discovery potential was low. For this reason the exploration was directed, in the first instance by Geopeko, and, after the GVJV commenced, by Delta, to the extension and definition of the deep leads.

Scout RAB drilling, in 1987 by Geopeko, over the initial joint venture area (pre-GVJV) intersected strongly anomalous gold (2m at 11g/t from 52 metres depth, and 4m at 3g/t from 28 metres depth) close to Kanowna Belle. Using reef and deep lead models these intercepts were followed up but low order results were returned. The tendency was to drill to RAB-refusal; a perfectly valid approach used throughout the goldfields but not, with hindsight, appropriate for Kanowna Belle.

We were to discover that whilst Kanowna Belle has a well-developed gold-bearing supergene blanket, above that lies highly weathered, leached and gold-depleted saprolitic bedrock. Those early RAB holes, set out on a 200 x 500 metre grid spacing, intersected some outlying zones to the east of the deposit. The follow-up drilling tested too far east and not deeply enough in the western holes to intersect Kanowna Belle. The interpretation of the results, by those involved, was that the mineralisation was contained in minor, narrow bedrock veins – the bare bones of the first concept had been created.

In early 1988, Delta, in its role as GVJV exploration manager, undertook a soil sampling programme, using bulk-leach techniques, over the general area in which Geopeko had intersected anomalous gold in its RAB drilling. A peak of 180 ppb Au was returned against a background of 10 ppb Au.

Follow-up RAB drilling (12 holes) in November 1988 yielded similar results to those obtained by Geopeko, with no apparent pattern and matching the accepted conceptual model of narrow, vein-hosted mineralisation. The focus continued to be the discovery of more deep lead mineralisation elsewhere in the GVJV area.

In January 1989, a 500 x 500 metre offset-grid bulk soil sampling programme was conducted over the southern GVJV area, yielding a single point anomaly, above Kanowna Belle, of 110 ppb Au.

This anomaly was followed up by a more detailed (80 x 40m) minus-80 mesh soil programme over a larger area than the bulk leach programme, extending sampling to the north and east.

Creeping towards Discovery

In August and September 1989 a programme of 24 RAB holes was completed to test the peak zone of the defined anomaly, all within the 40 ppb Au contour and to test the peak value of 150 ppb Au. This RAB programme returned a best result of 8 metres of 4.5g/t Au.

The coherent nature of the gold-in-soil anomaly and the RAB drilling results provided the encouragement to drill the first two RC holes in December 1989.

With hindsight one can see that each phase of work better defined the anomalous zone but the intense leaching in the saprolite and the shallow base of RAB drilling (to the base of saprolite), in the early stages, yielded equivocal results. Another feature, also obvious with hindsight but distracting at the time, was the displacement, to the north, of the gold-in-soil anomaly peak relative to the primary mineralisation. If one imagines projecting the ore body, at an angle of 60 degrees, to surface, the peak soil results lie at that point. A deep hole drilled vertically from that point will intersect barren footwall rocks. The location of the soil anomaly peak only made sense when the geometry of the main deposit became apparent.

I shall not go into a blow-by-blow description of the early drilling at Kanowna Belle in 1990 but we (Terry Peachey, Guy Lewington and I) convinced ourselves, by using the results from a combination of shallow (80 metre) RC drilling and a fixation on the narrow reef model, that

the near-horizontal zone of mineralisation we were defining was a chemically created supergene enriched deposit sourced from a multitude of narrow vertical veins. About half right!
High grade intersections near the base of oxidation (at around 40 metres) of 19 metres at 17g/t Au and 12 metres at 34g/t Au were easily accommodated by that model as the intersections apparently had limited strike extent. Troy Shoot, as it is now called, fitted the existing model. As you will see it is limited in strike extent but contains about 250,000 tonnes at 10g/t Au, some of which is contained in narrow, near vertical bedrock veins.
By mid-1990 a supergene resource of one million tonnes at 3.5g/t Au was defined using a 1g/t Au lower cut-off. An arbitrary upper cut of 20g/t Au was selected. This resource was, despite the proximity to surface (30 – 50 metres) economically marginal with a high stripping ratio. Additional mineralisation was clearly required to improve viability. This resource was also open in most directions but with diminishing intersections on the margins. The margins of the deposit needed extension and increased rig capacity was required to test for deeper mineralisation. The model was still of a horizontal supergene body with minor bedrock veins.

The Clincher!

The first indication of the true potential of Kanowna Belle came during deeper drilling, to close out the deposit, on section lines to the west. In particular, three holes, GDD 117, GDC 118 and GDC 119, returned intercepts of several tens of metres of mineralisation containing average grades of between 2.3 and 5.2g/t Au. The high grade sections of Troy Shoot were tested further yielding additional intersections of 61 metres at 26g/t Au and 25 metres at 78g/t Au including primary pyrite-related mineralisation. All drilling at this stage was still vertical. All the deeper holes now intersected substantial pyrite-associated mineralisation and provided the evidence to change the existing concept.
Clearly the potential now lay down-dip and within the primary zone below and along strike from GDD 117.
Additional drilling was carried out and a revised resource estimate calculated in December 1990 delivered 2.9 million tonnes at an average grade of 4.0g/t Au, about 370,000 ounces.

Geology

I have avoided mentioning, until now, the geology of this deposit, and in particular the lithologies, to allow you to share the uncertainty and experience the early difficulties in resolving the detail. The geological aspect of the evolution of the Kanowna Belle model improved enormously with the more extensive use of diamond drilling from mid-1990. Until this time, only the gross lithologies had been identified, with felsic porphyries and mass-flow sediments containing clasts of felsic and mafic rocks logged in drill cuttings of fresh rock. The relationship between pyrite, sericite and carbonate alteration and gold had also been recognised by the Project Geologist, Terry Peachey.
It is probably appropriate at this point to locate Kanowna Belle in its geological context.

The deposit lies within the Boorara Domain of the Archaean Kalgoorlie Terrane as proposed by the W. A. Geological Survey. The geology of the area consists of a sequence of mafic and ultramafic lavas with felsic volcanics, sediments and conglomerates of the Gindalbie Formation – correlatable with, to those of you familiar with Golden Mile – Kambalda stratigraphy, the Black Flag Beds.
Kanowna Belle is hosted by coarse felsic fragmental mass-flow sediments, interbedded with

ultramafic clast-bearing polymict conglomerates and felsic fragmentals, all intruded by quartz and feldspar-phyric porphyries.

The Evolving Concept & the Fitzroy Fault

Returning to the evolution of the Kanowna Belle concept, the single most important factor was the recognition, again by Terry Peachey after three angled core holes, of the Fitzroy Fault. It strikes northeast and dips at 60 degrees to the southeast and, once recognised, provided the framework on which the geometry of the Kanowna Belle shoots could be constructed.

The Fitzroy Fault is clearly the dominant controlling factor in the location of the Kanowna Belle deposit. The fault is planar with few flexures and these are of low amplitude.

The fault is typically represented in core as a 10 to 20 centimetre gouge-clay zone or ultra-mylonite. Movement on the fault has created fine ‘crackle brecciation’ textures in the hanging wall felsic porphyries and fragmentals and more ductile shearing in mafic-rich, matrix-dominated fragmentals and chloritic fragmentals in the footwall to the fault.

Deformation generated by the fault extends with apparently diminishing effect for over 100 metres to either side. The Fitzroy Fault is proposed as a fluid pathway for mineralising fluids and generator of depositional sites.

Drilling On…

Drilling continued throughout 1990 - 1991, on an east-west collar spacing of 20 metres between holes on north-south sections 40 metres apart. Obvious continuity between sections of the major mineralised intersections (at this time ranging between 10 and 60 metres true thickness) demonstrated strong parallelism between mineralised shoots and the Fitzroy Fault. Sufficient continuity between lenses and their relationship to the Fitzroy Fault enabled discrete lenses to be recognised. These were named, by Terry Peachey, after some of the Kanowna pioneers from the 1890’s and early 1900’s.

The Mineralised Lenses

I shall now describe the main lenses: Hilder, Coyle, Lowes, Troy and the Hangingwall Shoots with their relative locations and geology to try and provide a coherent picture of Kanowna Belle.

In the north-eastern corner of the deposit and lying in chloritic fragmental rocks approximately 100 metres in the footwall to the Fitzroy Fault lies the small Hilder Shoot. Hilder Shoot has a strike length of about 100 metres, a down-plunge dimension of 120 metres and contains about 160,000 tonnes at just over 3.0g/t Au.

Immediately below the Fitzroy Fault and extending discontinuously along strike for over 600 metres and to 700 metres vertically is the Coyle Shoot. This shoot merges across the Fitzroy Fault to join the larger Lowes Shoot and parallels the eastern edge of western Lowes Shoot with a south-easterly plunge, or rake, in its central section where it remains open at depth.

Lowes Shoot, the footwall of which is defined by the Fitzroy Fault, extends along strike continuously for over 600 metres, strikes to the southwest and makes considerably in its western section where true thicknesses of up to 60 metres are reached. A down-plunge dimension of over 600 metres has been defined and it remains open at depth over a strike extent of about 300 metres.

The mineralisation is hosted within a broad range of rock types of dominantly felsic fragmentals, porphyries and felsite. Lowes and Coyle Shoots contain some 12.5 million tonnes at an average grade of 5.5g/t Au to a depth of 700 metres and remain open at depth over a collective strike length of 500 metres.
Higher in the hangingwall lies a series of stacked lenses, generally diminishing in thickness with distance out from Lowes Shoot, called the Hangingwall Lenses. These are best developed above western Lowes Shoot, extend in a zone up to 100 metres up dip from the Fitzroy Fault over a strike length of about 350 metres and contain about 1 million tonnes at an average grade of 4g/t Au.

Rocks hosting this zone comprise mostly felsic fragmentals and quartz porphyries.
The Hangingwall lens position in the east of the deposit envelope contains the still enigmatic Troy Shoot which appears, uniquely, not to parallel the Fitzroy Fault.
Troy Shoot strikes east-west, plunges east-southeast and is relatively shallow, extending between 40 and 140 metres vertically, with some indications of thin continuation down-plunge, over a strike length of 130 metres.
Troy shoot contains 250,000 tonnes at an average grade of 10.38g/t Au, hosted predominantly by angular felsic fragmentals.

A supergene blanket overlies the primary shoots at or near the base of complete oxidation, usually between 35 and 45 metres depth and contains almost 1 million tonnes at an average grade of 3.73g/t Au. The blanket, as that term implies, is a gently undulating, near horizontal body between 1 and 10 metres thick, draped over the primary lenses and generally extending laterally beyond the projections of the lenses.

Fractal Graphics 3D Mine Models

Alteration

The deposit contains widespread and variable carbonate-sericite, sodic and minor silicic alteration. Pyrite is variably disseminated, occasionally veined, comprises between 1 and 5% of the rock by weight and is generally related to gold mineralisation.
Other sulphide species or tellurides are present in minor amounts of less than 0.1% combined.
Gold mineralisation occurs with disseminated pyrite on and within discrete grains or blebs.
Visible free gold is occasionally seen.
Higher-grade zones frequently exhibit stringer-type quartz-pyrite veins. Generally, the bulk of the +5g/t Au mineralisation is associated with fine networks described as crackle-brecciation with strong sericite-carbonate alteration and variable silicification.

Resources

The last resource estimate, calculated in May 1992, (too late to update your Abstract Volume for this Conference) contained a Measured, Indicated and Inferred Resource of 15.0 million tonnes at an average grade (upper cut-off 50g/t Au, lower cut-off 1g/t and 2g/t Au*) of 5.33g/t Au giving 2.56 million ounces of gold, or 5.86g/t Au (uncut) giving just over 2.8 million ounces of gold.
The Resource Estimate is based on 113 diamond drill holes (largely NQ) and 334 RC holes for a total of just over 64,000 metres. Alistair Cowden has largely supervised the data base construction, liaising with Micromine and Genalysis and ensuring the quality of the Resource data prior to delivery to the GVJV.

*A 1g/t Au lower cut-off was used for the Resource Estimate above 200 metres – the likely base of the proposed open pit. A minimum 2 metre true thickness constraint was applied with internal waste limited to 2 metres true thickness. The Resource was calculated using classical cross-sectional polygons with computer assistance for volume determination and verified by independent, flitch-constrained classical and computer generated block models.

The Resource Estimate below 200 metres was calculated using a 2g/t Au lower cut over 3 metres true thickness with a maximum 3 metres internal waste.

Classical sectional polygons were created, then refined and constrained by 10 metre vertical interval flitch plan interpretations. Data manipulation, compilation and digitising were carried out at Micromine under Alistair Cowden's supervision. Block models were created on Microlynx using 80 metre x 15 metre and 40 metre x 10 metre first and second pass search ellipses depending on data density. Ellipse orientations were varied when appropriate to match sectional, flitch or geological interpretations.

Mining techniques and mine design are the subject of the definitive feasibility study due for completion in the September quarter of 1992. Mike Donoghue's input, by providing the mining engineering viewpoint, into the later stages of the exploration program has been of great benefit.

At this stage it appears likely that open pit mining will proceed to a total depth of about 200 metres. Underground mining will be by open-stope bulk mining. Optimisation studies are still in progress but a mining rate of 1 to 1.5 million tonnes per year is likely.

Metallurgy

Metallurgical test work, supervised on the Delta side by Jerry Perkins, has indicated that the eastern shoots and all oxide mineralisation are generally amenable to conventional CIP processing. A large proportion of Lowes and Coyle Shoots' mineralisation is partially refractory with 60 – 70% recoveries indicated from conventional direct cyanide leach. Roasting, bio-oxidation or pressure-oxidation should, according to bench-scale test results, yield recoveries of 90 – 95%.

It is likely, given the distribution of oxide and eastern shoot mineralisation, and, in particular the near-surface high-grade Troy Shoot, that initial production will come from a 'starter pit' in this area with conventional CIP recovery and a refractory plant to be established two to three years later.

Construction could commence early in the fourth quarter of this year with plant start-up and commissioning around mid-1993.

Conclusion

It has been an exciting few years for the team of people involved from Delta and Geopeko. Future years promise to be equally exciting. Clearly the deposit will continue to grow and our understanding will improve considerably once mining commences in 1993.

The broad concept of a typical Archaean shear-zone related gold deposit, as well described by David Groves and Susan Ho*, now appears to be unassailable. Other controls on mineralisation will be revealed, allowing further refinements and we look forward to discovering those in the years ahead.

I wish to thank Delta Gold N. L. and North Broken Hill Peko Limited for the opportunity to present this paper.

Kanowna Bell Update Delta Gold Annual Report 1990 Exploration and Kanowna Belle

Not the Kalgoorlie Miner

*Reference: Recent Advances in Understanding Precambrian Gold Deposits Editors: SE Ho & DI Groves, 1987, University of Western Australia.