DISCOVERY AND DEVELOPMENT OF THE DAMANG GOLD DEPOSIT, GHANA, WEST AFRICA

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INTRODUCTION AND GEOLOGICAL SETTING

The renaissance in the gold mining industry in the Ashanti Gold Belt of southwestern Ghana continues. The Ashanti Belt is small, measuring only 250 km long by about 50 km wide, but it is very rich and is still very under-explored (Figure 1). On a recent ranking of gold endowment, based on the total size of a country and its cumulative gold production over 140 years, Ghana was ranked third in the world. Ghana currently ranks 11th in the list of world gold producers. Production in 1996 was 1.6 million ounces, and is expected to rise to 1.9 million ounces and 2.7 million ounces in 1997 and 1998, respectively.

In Ghana, the expansion of existing mines and the re-vitalisation of old, formerly State-controlled, mines is going hand in hand with the development of entirely new deposits. Well known examples are: the Obuasi (Ashanti Goldfields) lode-quartz vein mine in early Proterozoic Birimian metamorphic rocks producing some 860 000 ounces annually from combined underground/open pit operations; the adjacent Teberebie and Iduapriem mines (which use heap leach and CIL techniques), which are expected to produce a combined total approaching 500 000 ounces in 1997 from Tarkwaian meta-conglomerate; and Gold Fields' Tarkwa mine, which is preparing to develop new open pit conglomerate resources of some 13 million ounces in addition to the existing old underground operations.

Annual production from the Tarkwa District for 1998 is forecast to be around 900 000 ounces (more than that from Obuasi), and to exceed 1.1 million ounces by 2000. This production is all from mines in early Proterozoic Tarkwaian rocks, largely from metamorphically modified placer gold deposits which are like but much younger than those in the world's largest gold producing region in the Witwatersrand Basin of South Africa. As for the new gold deposits, such as the free-milling Damang hydrothermal quartz vein stockwork, Ranger Minerals has defined a "pittable" resource of more than 3 million ounces in this deposit alone (Figure 1), at a finding cost of some US$7 per ounce.

The Ashanti Gold Belt is in the southeastern part of the Man-Leo Shield, which is comprised of Archaean and early Proterozoic rocks once part of a combined craton spanning western Africa and northeastern South America. The belt is one of many north-northeast-striking belts of early Proterozoic metamorphic rocks in Ghana dominantly comprised of volcanic Birimian rocks overlain by synclinorial Tarkwaian clastic fluviatile rocks, which are intruded by granitoids and dolerites. Both Tarkwaian and Birimian rocks have been progressively deformed, culminating in overturning and over-thrusting on both edges of the belt. The Tarkwa district is on the eastern edge of the belt, where the extensive palaeoplacer gold deposits (referred to above) occur. The local stratigraphy and distribution of gold mineralisation is summarised in Table 1. Birimian lode gold deposits are not developed to any important extent in the Tarkwa district, and are geochemically very distinct from the mineralisation in the Tarkwaian rocks — whether hydrothermal or placer in origin.

THE DAMANG DEPOSIT

Damang (Figure 1) is a newly recognised style of quartz vein stockwork deposit found in 1990 in Tarkwaian rocks traced 20 km along strike from the old Abosso underground conglomerate mine (Figure 1). Gold recovery from the Abosso mine was 2.5 million ounces of gold in its 60-year production history. The Damang deposit was first described by Marston et al. (1993) in the context of its relationship to the palaeoplacer gold mineralisation at the Abosso Mine.

It took five years of painstaking exploration and three years of continuous drilling to achieve a total resource estimate (at a 1 g/t Au cut-off) of 30.5 million tonnes at 3.1 g/t Au (3.03 million ounces of gold) [using data to September 1996]. Using a lower cut-off of 0.6 g/t Au the estimate becomes 42.3 million tonnes averaging 2.5 g/t Au for 3.33 million ounces of contained gold. It should be noted that no resource block is generated more than 25 m from a drill hole. Most of the resource blocks in these estimates are

Table 1. Early Proterozoic stratigraphy of the Tarkwa District, Ghana

Formation and Age	Thickness	Lithology	Gold mineralisation
Tarkwaian Group ca 2.0 billion years			
Huni Sandstone	1300 m	Fine-grained feldspathic quartzite and phyllite, local pebbly wacke at base	Major hydrothermal quartz vein stockwork at Damang
Tarkwa Phyllite	120 m to 140 m	Chloritoid–chlorite–magnetite–carbonate phyllite	Major hydrothermal quartz vein stockwork at Damang
Banket Series	150 m to 600 m	Quartzite, feldspathic quartzite, grit and quartz pebble conglomerate ("banket")	Major hydrothermal quartz vein stockwork at Damang; regionally extensive modified palaeoplacer deposits in banket reef horizons
Kawere Group	250 m to 700 m	Wacke, grit, phyllite, polymictic conglomerate	Hydrothermal quartz vein stockwork at Rex prospect
~~ angular unconformity ~~~~~~~~~~~~~~~~~~~~~~~~~			
Birimian Supergroup ca 2.1 billion years		Metasediments (partly volcanic-derived) and metavolcanic rocks, local manganiferous cherts	No significant deposits known in Tarkwa district *(elsewhere there are numerous arsenical lode gold vein and disseminated deposits, as at Obuasi, and rare disseminated granitoid related deposits as at Ayanfuri)*

Source: Junner et al. (1942)

within 200 m of the surface, and the deposit is still open at depth.

When commissioned in late 1997 at an annualised rate of some 280 000 ounces, Damang will be the first producer of hydrothermal gold from the Tarkwaian. It is planned to become the third largest gold mine in Ghana by the end of 1998.

Ranger Minerals NL: the Sponsor

Abosso Goldfields Limited is the Ghanaian-registered local operating company that is 90% owned by Ranger Minerals NL (Ranger) and 10% owned by the Government of Ghana. Ranger is just 13 years old as a company and has only been listed on the Australian Stock Exchange for 4 years. Following the market listing of its Australian exploration interests via offshoot Orion Resources NL in 1987, Ranger focussed on finding old gold tailings dumps of economic interest: this was seen as a lower risk strategy for an unlisted company than conventional gold exploration.The growth of the company before listing did indeed depend on the successful exploitation of a tailings resource at Cobar in New South Wales in 1987-1988, but further growth needed two injections of private capital in 1990. The sale of Ranger's 21.6% equity in the Salsigne gold mine in France to Orion in 1992 came about as the company (still unlisted) was faced with a substantial funding requirement for re-developing the mine.

Through the issue of 20 million shares to raise A$20 million on listing in October 1993, Ranger had sufficient cash to begin drilling the Damang deposit on behalf of Abosso Goldfields. Otherwise the company may have been forced into a joint venture to fund further exploration and development of the project. Most major companies rejected the prospect as having insufficient potential, well in advance of Ranger's intention to float. There have been four major capital injections since listing: progressive sale of the company's shareholding in Orion (total of A$42 million) in early 1994 and late 1995; placement of 2.5 million shares to raise A$10.85 million in March 1996; and placement of 7.8 million shares to raise A$29.2 million in October 1996. Total issued shares are 63.32 million, with 25 cents par value.

Progressive increase in the gold resource base at Damang and the concomitant rise in planned throughput of ore from 1.5 million tonnes per year to 3.0 million tonnes per year have contributed to the sharp rise in the company's market capitalisation (A$60 million on listing to about A$275 million in June 1997). The company's share register remains tight with strong management interests at around 30%.

THE ABOSSO PROJECT'S HISTORY

Note: Traditional units have been used for gold production or reserves, etc. 1 ounce (oz) (Troy) = 31.103477 gm.

The Abosso–Damang tenements include the northwards strike extension of the geology which contains the same gold-bearing Tarkwaian “banket” conglomerates currently being exploited by the Iduapriem (Ashanti Goldfields), Teberebie (Pioneer Goldfields), and Tarkwa (Gold Fields Ghana) mines (Figure 1).

Ranger was first introduced to the area in 1989 by Sikaman Gold Resources, then busy developing the Bogosu gold deposit with Billiton. With its background, Ranger was naturally attracted to the opportunity to evaluate the tailings at the old Abosso mine, which had closed in 1956 (for non-technical reasons) having produced 2 510 000 ounces of gold from 7.59 million tonnes of ore over a 64-year period. In the last 15 years of the Abosso mine’s life annual ore production averaged 275 000 tonnes at about 8 g/t recovered from two banket ore horizons, each averaging 1 metre in thickness as mined. After drilling almost 600 holes into the tailings and carrying out extensive metallurgical tests, it was concluded that the 4.9 million tonnes identified as averaging 0.87 g/t Au recoverable gold (after a regrind) did not form the basis for a stand-alone project.

During 1990 Ranger then proceeded to examine the remnant high-grade banket ore around the old mine, and the strike extension of this banket northwards into areas never mined on a commercial scale. At the time of closure proved and probable reserves of 2.94 million tonnes of ore averaging 8.33 g/t Au (at 5.4 g/t Au cut-off) were blocked out to vertical depths of as much as 840 m, but almost none of this material was either near the surface or was accessible because the mine remained flooded. Thin, high grade and un-mined banket occurs adjacent to the northern Abosso mine workings in the Bippo Bin-Chida area (Figure 2), where it is exposed in numerous old exploratory adits and drives for a further distance of 12 km north. Commercially attractive gold grades (5 g/t to 15 g/t) are present over widths of 0.5 m to 2.0 m. An underground resource potential of 1.7 million tonnes at 8.3 g/t Au (0.45 million ounces) has been inferred for Bippo Bin-Chida to a depth of 700 m.

Thick low grade banket mineralisation was found still further north in the Tomento and Lima areas (Figure 2). Careful work identified this low grade banket as part of an anticlinal structure, subsequently called the “Damang Anticline”.

Extensive sheeted stockwork sets of gold-bearing quartz–pyrite veins were also found in fractures produced by the tight folding in the core of the anticline near the settlement of Damang. Being in metamorphosed Tarkwaian banket conglomerate, sandstones, other sedimentary rocks and dolerite, this clearly hydrothermal gold system represented a new type of gold deposit for the Tarkwaian. Those deposits are in contrast to the palaeoplacer-style gold deposits which had been mined elsewhere in these rocks over the past 100 years. The tonnage potential of the hydrothermal system quickly became apparent from the initial geological appraisal, which included mapping and sampling of widespread old alluvial workings, several adits and numerous prospecting pits. This discovery (by Paul Woolrich) was to become known as the Damang Gold Deposit, now developed as the Damang Gold Mine.

Exploration and Development of the Damang Gold Deposit

After recognition of the Damang hydrothermal gold deposit more than 1300 vertical sampling pits, four trenches and one adit were excavated in the surface zone of the deposit over the following two years. That sampling showed it to be at least 3 km long and 200 m wide in outcrop. Using a 1 g/t Au cut-off a lateritic resource of 2.5 million tonnes at 2.05 g/t Au was estimated in 1993 for the top 4.5 m of the deposit. The first RC drillhole was put into the deposit in late June 1993, and the 53 drill holes completed when Ranger’s prospectus was issued in September 1993 demonstrated good depth continuity for the mineralisation — as shallow east-dipping lenses. The first stage drilling of a total of 109 RC holes was targeted in five areas of outcropping mineralised laterite and oxidised stockwork, as defined by the systematic pit sampling program. It became apparent later that many of the early drill holes were sited in the lower grade southern section of the deposit.

With adequate funding it was then possible to press ahead and begin to drill out the whole deposit on a regular basis, eventually evolving from 80 m by 80 m to 20 m by 20 m grid spacings. However, this proved to be no easy or quick task due to a shortage of suitable drilling rigs in Ghana, the sheer size of the outcrop of the deposit, and the complexity of the sheeted stockwork gold veins which penetrated many different rock types and structures (Figures 3 and 4). Drilling was initially focussed in the three outcropping (hilly) areas (Figures 5 and 6) of the deposit which resulted in the design of three separate pits, but subsequent drilling below intervening swamps demonstrated a continuous gold system. Hence the three-pit design was changed to one pit 3 km long (Figures 5 and 6).

Most mineralisation occurs in the core and on the eastern limb of the Damang Anticline, a long attenuated structure, probably bounded on both sides by strike faults. Flat-lying to gently east-dipping lenticular quartz veins with pyrite–pyrrhotite selvedges make up ladder-like sets of east-dipping zones of mineralised rock. The zones are commonly best developed between less well-mineralised sills of (meta)dolerite (Figure 4). Steeply east-dipping metamorphosed sandstone (now quartzite) and conglomerate are the principal host rocks, but in the hanging wall a laminated iron-rich, staurolite–tourmaline metasediment and succeeding finer grained metamorphosed sandstones are also mineralised.

Disseminated sulphides permeate the host rocks in better veined areas.

Some of the thickest and best intersections occur in the quartz conglomerate ("banket") lenses where these are thickened in palaeochannels or in fold closures. The banket is regionally anomalous in gold (metamorphically modified, of palaeoplacer origin), and significantly this rock type does have a slightly higher mean gold content in the Damang deposit as a whole. This suggests that gold of hydrothermal origin has been added to earlier placer gold.

Even with over 1200 resource drillholes (totalling some 136 000 m) now completed in the deposit there are still areas where the mineralisation is open along and across strike, despite some drill sections being over 300 m wide across the deposit (Figures 4 and 5). A significant observation is that there is also no sign of any diminution in widths and grades of gold mineralisation with depth. Some examples are: 69.3 m @ 3.01 g/t Au; 65.0 m @ 2.19 g/t Au; 51.0 m @ 2.72 g/t Au; 44.0 m @ 3.93 g/t Au; 43.8 m @ 4.03 g/t Au; 32.5 m @ 4.13 g/t Au; and 32.0 m @ 3.86 g/t Au.

The Resource Long Section (Figure 6) illustrates the diluted estimate published in October 1996 for gold resources at Damang totalling 3.03 million ounces, with 22.9 million tonnes at 3.1 g/t Au (2.3million ounces) in the measured and indicated categories, and was arrived at by consultant Mining & Resource Technology (MRT) using drilling results (1178 drill holes for 134 000 m, of which 40% is for core samples) available to September 1996. These resources were defined by drilling at various spacings to vertical depths of as much as 200 m, and successive drilling has shown a progressive conversion of inferred resources, below and between drill sections, into measured and indicated resources and thence reserves. A mineable reserve of 19.55 million tonnes at 3.2 g/t Au (1 g/t Au cut-off) was announced in April 1997, equivalent to 1.90 million ounces of gold at 94.8% mill recovery. The overall waste to ore ratio at this cut-off is 6.1.

The deepest scout drilling now reaches to depths approaching 300 m, and a large number of intersections fall directly below the base of the current pit design (Figure 6). Given adequate drilling it is expected that these intersections will be upgraded to be included in future reserves. Trial-grade control drilling conducted on a small part of the deposit has also shown that close-spaced drilling finds significantly more ore lenses than more open-spaced resource drilling, so it is likely that the current resources and reserves are conservative.

With a gold resource equivalent to some 16 000 ounces per vertical metre of the deposit drilled to date, this clearly places Damang in the big league of open pit gold deposits (Figure 7). The northern part of the deposit is inadequately drilled down to 150 vertical metres, but there is a strong expectation that the deeper section of the pit design can be extended northwards with a corresponding rise in the ounces per vertical metre. The potential is clearly there for a pittable resource of more than 4 million ounces to be defined to a relatively modest open pit depth of some 250 m, with manageable strip ratios. A deeper pit still remains a strong possibility.

Even with three separate pits in an earlier design the consultants considered that the deposit was easily capable of supplying ore to a conventional CIL mill at the rate of 3 million tonnes per year, which translates to an output of more than 280 000 ounces of gold per year. Consequently, the company is developing a mine and process plant which reflects the total likely resource base of this major gold deposit rather than that portion which has been defined to date.

The metallurgy of the Damang deposit resembles that of other gold deposits in Tarkwaian rocks in that the ore is free milling and requires only a conventional CIL or CIP process plant to achieve high recoveries, indicated to average almost 95% for a minimum 1 g/t Au feed. There are no deleterious or toxic base metals (such as copper and arsenic) present in the Damang ores. Being very siliceous the rocks are abrasive and hard and therefore need appropriately designed crushing and milling circuits.

The feasibility study completed in 1996 was focussed on a 3 million tonnes per year plant and mine. The CIL plant has been constructed by Minproc Engineers and consists of a gyratory crusher, a primary high-lift SAG mill in closed circuit with a secondary ball mill, gravity concentration, a six-stage CIL leach–adsorption circuit, and an Anglo desorption plant. The total new capital needed from 1 January 1996 to establish a project of this size to first gold pour in the last quarter of 1997 is estimated at US$115 million. This capital includes infrastructure work for the life of the mine (expected to be more than 10 years), such as the diversion of drainage, a 6.6 km deviation of a railway line, and the establishment of a new townsite for Damang. Based on using 15 cubic metres excavators and 85-tonne trucks operated by contract miner African Mining Services and a 3-metre bench height, the cash operating cost over the currently defined mine life (for >1 g/t Au feed) of 7 years is estimated to be the equivalent of about US$200 per ounce. It is evident that an economically robust project has been defined at Damang. Debt finance totalling US$80 million has been provided by Bankers Trust Australia, Barclays Bank, Dresdner Australia, NM Rothschild & Sons, Rothschild Australia, and the Commonwealth Development Corporation.

The Damang gold deposit (total resource, including potential resources, exceeding 4 million ounces) may be joined by other auxiliary sources of gold ore as the Abosso–Damang tenements are further explored. The presence of the further resources and potential resources is summarised below (cf. Figure 2), and indicates that an additional 1.0 miilion to 1.5 million ounces of low cost recoverable gold mineralisation is in prospect.

Note: Traditional units have been used for gold production or reserves, etc. 1 ounce (oz) (Troy) = 31.103477 gm.

- Abosso Mine tailings (surface) 137 000 ounces recoverable
- Bippo Bin-Chida high grade banket (u/ground to 700 m) 500 000 ounces potential
- Lima low grade banket (open pit) 500 000 ounces potential (of which 250 000oz is indicated and inferred)
- Rex stockwork (open pit) 500 000 ounces potential inferred from trenching and scout drilling

The proximity of the Abosso Mine and the Bippo Bin-Chida areas means that success in finding economically viable mineralisation at Bippo Bin-Chida could justify a separate processing plant for banket ore and old mine tailings. Rex and Lima ore could be trucked to Damang, or heap leached on site.

CONCLUSIONS

As elsewhere in the world, many low-grade bulk mineable gold deposits have been overlooked in the past in Ghana because of unattractive gold contents and their unfamiliar geological appearance to traditional prospectors and miners. Accordingly, more world class discoveries associated with major structures are expected to appear, given appropriate expertise and the expenditure of sufficient funds. Remote sensing and airborne geophysical surveys will provide the means to target important areas for follow-up ground work.

Quartz vein stockwork gold deposits in the Tarkwaian rocks of southwestern Ghana are an attractive target for exploration and development. Such deposits offer large tonnage low grade “clean” deposits that are amenable to large throughput bulk mining techniques, and being metallurgically simple do not have any important problems associated with processing and achieving high gold recoveries.

Significant effort, technical skills and finance are needed to achieve adequate definition of such deposits as they tend to be large and are geologically complex in detail. However, an extended mine life is possible, and higher grade sections may even offer the prospect of development using trackless underground equipment (eg, as at Mount Charlotte, Kalgoorlie).

Ghana is competitive with many other developing countries by providing a fiscal system that is generally favourable to foreign investors in mining, but particularly those that set their sights on a large project. This helps offset the high capital costs that may be incurred by allowing the rapid write-off of capital and debt in the early years of the project, before substantial tax is payable. Corporate tax is currently levied at 35%, but the Government retains a 10% free carried interest in all mining companies in the country. There is also a royalty and an additional profits tax related to the internal rate of return of the company. Ghana is anglophone and has a common law system.

There is a well-established modern mining industry in Ghana with development historically being financed by bilateral and commercial lenders such as the International Finance Corporation (IFC), German Investment and Development Company (DEG), Netherlands Development and Finance Company (FMO), Barclays, and Rothschilds. Ranger has successfully involved some new lenders to mining finance in Ghana. The country’s infrastructure is relatively well-advanced. The provision of cheap electricity compared with countries such as Australia is a particular advantage, even though costs are due to rise as the existing hydro-electric system is supplemented by thermal generating stations.

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