New mine developments

The Navachab Gold Mine

by R.L. ATTRIDGE*

Namibia's newest mining enterprise, the Navachab Gold Mine, was officially opened by President Sam Nujomo during June 1990. The mine is a joint venture between Erongo Mining & Exploration Company Limited, Metall Mining Corporation of Canada, and Rand Mines Windhoek (Pty) Ltd. Erongo has a 70 per cent interest in the mine, while Metall Mining and Rand Mines hold 20 per cent and 10 per cent respectively. Anglo American Corporation and its associates hold two-thirds of Erongo shares and CDM (Pty) Ltd one-third. The Mine is managed by Erongo Mining & Exploration Company.

The property is located some 10 km southwest of the town of Karibib and 170 km west-northwest of the Namibian capital of Windhoek (Fig. 1), the name of the Mine being taken from the farm on which the gold deposits were discovered. Navachab is an opencast operation and was brought into production in December 1989 at a cost of around R84 million—R5,2 million under budget. The plant is designed to treat 840 kt annually at an average gold grade of 2,6 g/t. This will produce 1900 kg of gold per year, which at today's prices will earn Namibia more than R60 million in foreign exchange. The

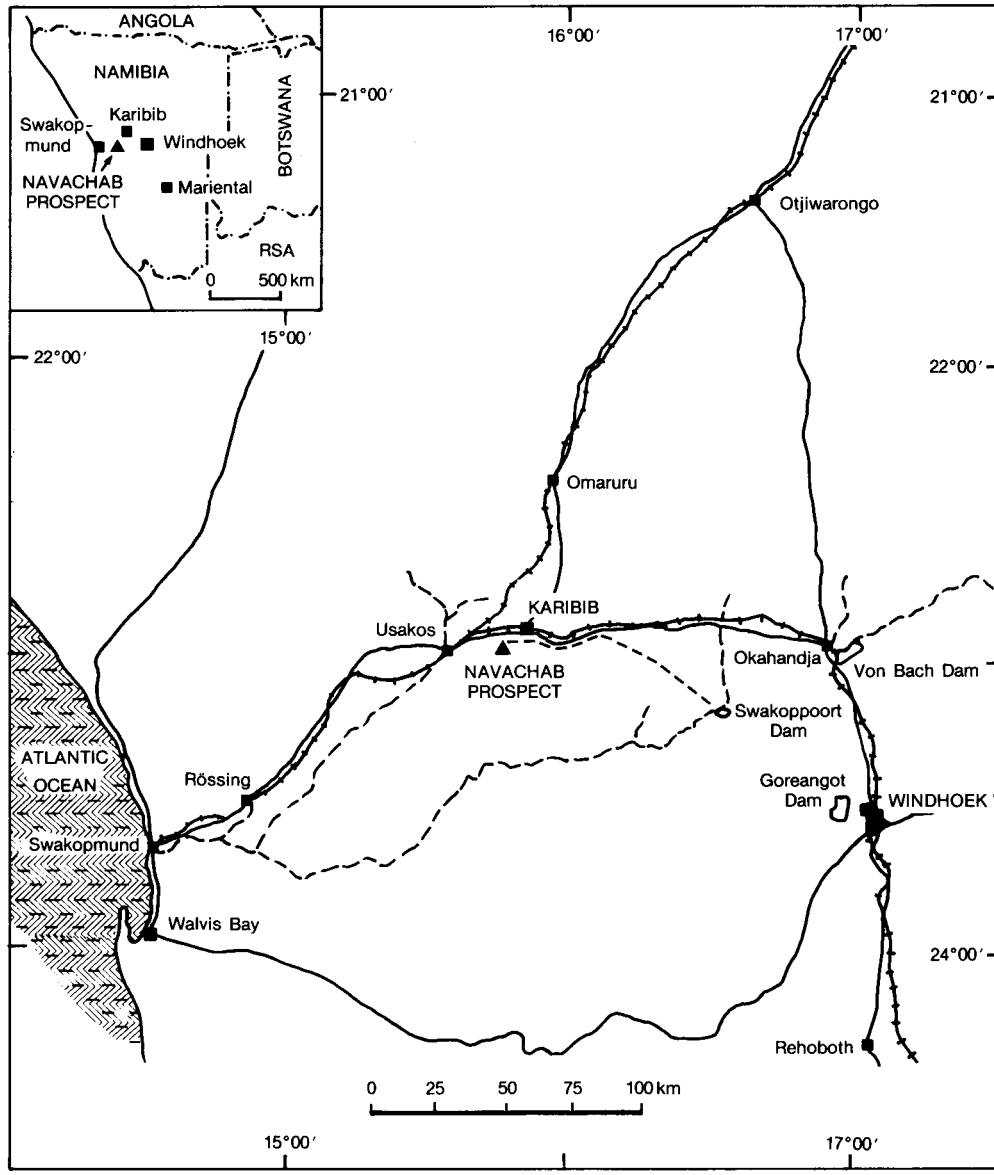

Fig. 1—Map showing the location of the Navachab Mine

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mine currently provides employment for about 300 people, most of whom are from the surrounding areas.

Infrastructure

The mine is well located, being 6 km from the main Okahandja–Swakopmund tarred road. Karibib is on the main railway line, and power is drawn from the nearby Swawek 260 kV power line, which forms part of the Escom–Swawek–Ruacana grids.

In view of the scarcity of water in the area, a guaranteed supply of water was essential to the project. To obtain this, an 85 km pipeline (600 mm) was constructed by the Namibian Department of Water Affairs at a cost of R27,5 million. The buried concrete pipeline runs from the Swakoppoort Dam, south of Okahandja, to the Mine. The Mine, which currently consumes around 3500 m^3 of water a day, contributes to the capital cost of the pipeline by way of a monthly tariff, which, when added to the unit cost of the water, forms a major cost item.

History

The Navachab gold deposit was discovered in 1984 by Anglo American geologists. Although the grant area had previously been prospected by two major mining houses, both had failed to recognize the gold potential of the area. Anglo American Prospecting Services (Namibia) Ltd was, in fact, looking specifically for carbonate-hosted gold in the area when the discovery was made. The discovery resulted from a geochemical-exploration programme.

Exploration drilling of the deposit started in 1985 and was followed in 1986 by an appraisal study. The decision to proceed with a full feasibility study was taken about six months later, by which stage 14 721 m of diamond drilling (164 holes) and 2930 m of reverse circulation (56 holes) had been completed.

One of the main terms of reference of the feasibility study was to examine the economic viability of establishing a 'small' opencast operation along the lines of those currently operating in Australia. In order to achieve this, the capital and manning levels were rigidly contained. The infrastructural items were limited to absolute essentials, but no compromise was made regarding the technical aspects of the plant. Although the concept was simple in itself, this raised very specific problems for a large mining house such as Anglo American Corporation, which is geared for mega mining operations.

In October 1987 a decision was made to proceed with the project. Construction work started in 1988, and the first bar of gold was poured just 21 months later, in December 1989.

Geology

The gold orebody occurs at the base of the lower carbonate sedimentary unit of the Damara Super Group, locally known as the Karibib marbles. Two styles of mineralization can be recognized (Fig. 2).

(a) Skarn-related gold mineralization within a zone of marble and calc silicate (MC zone). This zone hosts the bulk of the gold mineralization and forms the main orebody at Navachab. The mineralization within this zone is stratabound but not stratiform. The gold is associated with pyrite and predominantly with pyrrhotite within calc silicate lenses in the grey-banded marble unit. The orebody dips at 70 degrees, and will eventually be mined by opencast methods to a depth of 160 m.

(b) Separating the MC zone from the overlying dolomitic marble zone is a well-developed hornfels marker horizon. Above this the upper dolomitic marble zone (DM zone) hosts a vein-stockwork style of orebody of limited tonnage. Here the gold mineralization occurs in quartz–calcite veins, which run at very high grades individually. However, the irregular frequency of the veins results in a low recoverable grade owing to dilution. Because of the extreme complexity of the deposit, the ore reserves were estimated by

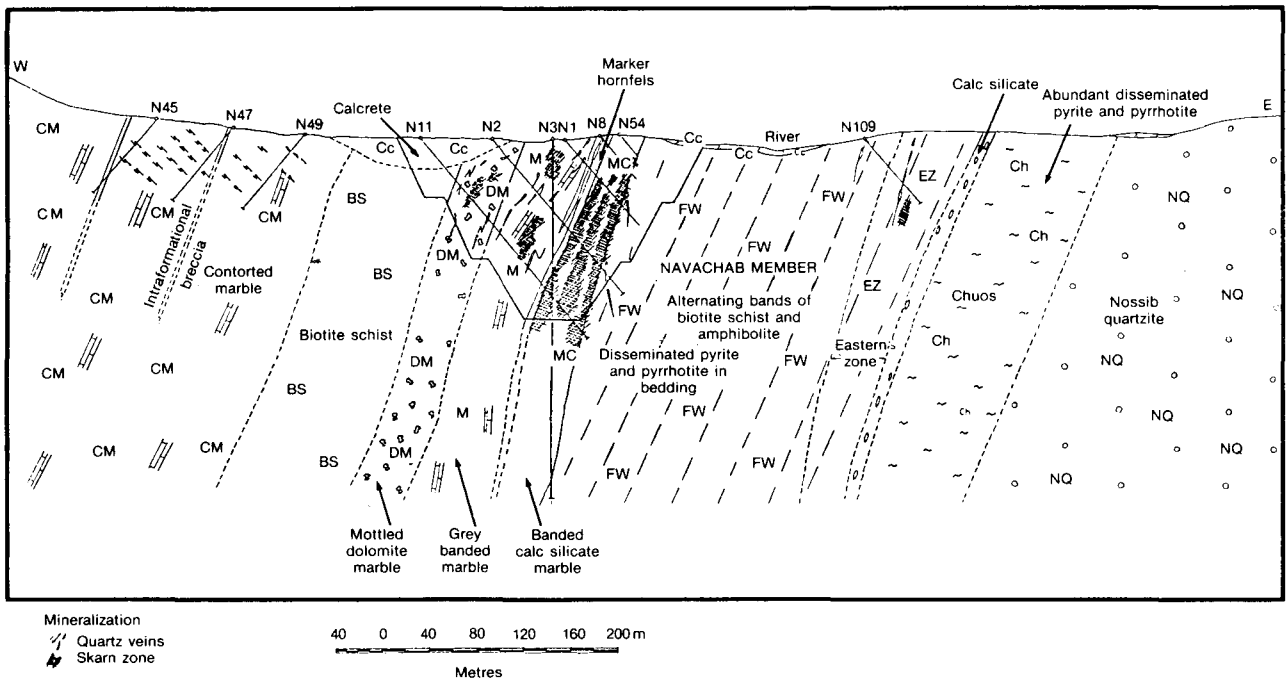

Fig. 2—A geological section at the Navachab Mine as interpreted from borehole sections and surface mapping

geostatistical methods.

Mineralogy

Detailed mineralogical work has been completed only on diamond-drill cores from the MC unit. It has been reported that the gold is associated with distinct cross-cutting veins, as well as with bodies that conform to the layering in the country rock. Both types consist mainly of clinopyroxene, garnet, quartz, and sulphides.

The bulk of the gold is contained in the calc silicates, occurring in fractures in the latter, accompanied by very fine quartz. Rare coarse gold is contained in a quartz-rich or calcite–biotite gangue. Native gold accounts for more than 85 per cent of the total gold, most of the remainder occurring as maldonite (AuBi). The bulk liberation size of the gold is 5 to 10 μm. Sulphides, mainly pyrrhotite with accessory pyrite and minor chalcopyrite and sphalerite, are locally abundant, and even massive over core widths of 30 to 50 cm. The sulphides do not host the gold mineralization, although they are often in close proximity.

Other metals and minerals are associated with the mineralization:

- Silver, which is present with the gold in a ratio of about 1:10
- Chalcopyrite in small amounts
- The characteristic shiny, grey gold–bismuth mineral (maldonite), which is widespread generally with quartz but in much smaller amounts
- Scheelite, which is present as a trace mineral.

The combined orebodies are estimated to contain 9,5 Mt of ore, with an average gold grade of 2,6 g/t at a cut-off grade of 1,2 g/t, and a further 1,5 Mt of marginal ore with an average gold grade of 0,98 g/t at a cut-off grade of 0,6 g/t. It will take approximately 13 years to mine and process these known reserves.

The lower-grade ore is currently being stockpiled, and will be processed at the end of year 9, when the actual mining operation has ceased. At that stage, the lower-grade ores that have been stockpiled will become economic since they will have to bear only a treatment cost.

The life of the mine could be increased depending on the outcome of current exploration aimed at finding extensions to the known ore reserves. There is also a possibility that the present pit could be deepened. The known orebody extends below the pit as planned at present. Current exploration drilling could prove that the economic bottom of the pit lies beyond a depth of 160 m.

Mining

The mining operation is carried out under contract by Karibib Mining & Construction Company (Pty) Ltd, which is a member company of the LTA Group, who are currently mining a total of 500 kt per month. The management, planning, geology, grade control, and survey remain the responsibility of the Navachab Mine itself.

This mining contract is somewhat unusual in the South African context in that the total mining function, including drilling, blasting, loading, and haulage of ore and waste, is the responsibility of the mining contractor. The concept of a mining contractor, common in other parts of the world, was adopted because of the unfavourable impact on the viability of the project of the additional front-end capital needed for inhouse mining.

Although the operating costs are marginally higher for the use of a mining contractor, this route was adopted because there are significant advantages, such as the flexibility of equipment and the availability of trained site personnel, which are major considerations when operating in a remote locality such as Karibib.

The mining equipment currently being used consists of

2 Liebherr 9844,3 m^3 backactors
9 Caterpillar 769 35 t haul trucks
2 Water carts
2 Operating-face spraying-water bowsers
2 Bulldozers (D6 and D7)
1 Grader
4 Ingersoll Rand 500 hydraulic drill rigs, which are used for the drilling of blastholes.

All the blastholes drilled in the ore zones are sampled for grade-control purposes.

The benches are 5 m high, the ore zones being mined by backactor in 2,5 m lifts. It has been found that this configuration permits the best grade control to be maintained and results in the backactor being used at optimum efficiency.

Pit Design

Data Mine, in conjunction with an Apollo Domain Series 3000 computer and two IBM PCs, is used for mine planning and grade control. Surveying is carried out by two surveyors using only a Surpac Data Logger and Brooker software linked to a Wild station.

The current pit design was selected from a comparison of the net present value of the operating profit calculated for a number of alternative pit designs. (In all, some 12 pit configurations were examined.) The optimum cut-off grade and pit depth occur at the point of maximum profit. The current cut-off grade is of the order of 1,2 g/t.

The current pit design (160 m deep and 800 m long) will provide access from both ends of the pit owing to the relatively steep slope (53 degrees overall on the hanging wall and 56 degrees on the footwall, with inter-ramp angles of 64 degrees). Spillage berms will be established about one-third and two-thirds of the way down.

The pit ramps have been designed at a gradient of 10 per cent, and are 15 m wide. It is possible that the slope of the footwall may have to be flattened in the near future owing to the presence of incompetent zones of gossan, which had not been intersected in the drill core but have been exposed during mining, and also to strongly developed and unfavourably oriented jointing.

The Recovery Process

The carbon-in-pulp (CIP) process of gold recovery is used at Navachab, and 70 kt of ore are being treated each month to produce an average of 160 kg of gold.

To contain capital costs, a single-line CIP plant was designed to treat 750 kt per annum. (This was subsequently increased to 840 kt per annum.) At all stages, consideration was given to the technical risks of such a single-line operation. A single-stage 48 by 52 inch jaw crusher was installed below a 50 t receiving bin, with grizzly bars spaced at 700 mm. The ore is fed to the crusher via a vibrating grizzly feeder, and the oversize material is

broken on a static grizzly by a hydraulic impact breaker.

The crusher arrangement subsequently proved to be too light to handle the blocky marble ore, which has also proved extremely difficult to blast in the pit. Also, marble has a tendency to slab and causes frequent chute blockages. With hindsight, a gyratory crusher and apron feeder would have been a better selection for the crusher, although the cost was higher.

The nominal minus 200 m crushed product is conveyed from the crusher over 1 km to a 3600 t concrete silo, where a Langlaagte chute feeds the material onto a variable-speed belt and into a single-stage autogenous mill of 10 m by 4 m diameter.

The designed milling rate of 92 t/h is currently being exceeded by around 12 per cent, with a consequential increase in monthly production from an initial estimate of 62 kt per month to a current 70 kt per month. This increase in milling rate has allowed some of the lower-grade marginal ores to be fed incrementally through the crusher, resulting in an immediate financial advantage.

In view of the coarse nature of the vein-related gold and the fineness of the disseminated pyrrhotite-hosted gold, plane tables were installed below the mill. The entire mill discharge passes over the tables, where a gold concentrate is produced. This concentrate is then passed over an endless belt, where further upgrading occurs. The endless-belt concentrate is leached in an intensive cyanidation reactor.

The plane-table tailings are pumped to single-stage cyclones, producing a 90 per cent minus 75 μm product. After thickening, this is leached in a series of 7 leaching tanks for 24 hours with mechanical agitation. The gold is then adsorbed onto activated carbon in a series of 7 adsorption tanks.

Gold is eluted from the loaded carbon using the AARL elution system with separate acid-wash and elution columns. Firstly, the carbon is washed with hydrochloric acid in a fibre-glass column, and is then passed to a stainless-steel column for the high-temperature AARL elution (120°C).

The carbon is regenerated in a Wellman rotary kiln and then re-introduced into the circuit.

Following elution, the leach liquor from the intensive cyanidation and the eluate from the carbon elution are combined before passing to three electrowinning cells, where the gold is plated onto steelwool.

The steelwool is calcined and then smelted to produce bullion of plus 900 fineness. The doré bar is sold and refined in Europe.

The Mine has its own assay laboratory, which can perform 5000 gold determinations per month.

General

The Mine has built 84 new houses in the town for all its staff, and has provided the roads, drains, and water and electricity services for these houses.

The value of the residential improvements in Karibib—houses and alterations—directly and indirectly attributable to Navachab is just over R6 million. In addition, several business premises have been altered and extended. The municipal value of the town has almost doubled in the short time since the Mine started.

Although the infrastructure has been kept at a basic level to contain capital costs, the operation is technically sophisticated, requiring a small but highly skilled work force.

The management team have an added responsibility in view of the remote location of the site and the low manning complement currently being used to run the Mine. It is possibly significant to note that the manning levels are about half of those currently associated with similar-size operations in South Africa.

The innovative business decision to open Navachab Gold Mine has certainly spilled over into the local community. By developing the Mine, Anglo American and CDM have committed themselves to making a real and permanent contribution to the well-being of the inhabitants of Namibia. Taxes generated from employees and the businesses they support will contribute significantly to the country and the community as a whole.

Patent searching

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