Black Mountain Mineral Development Company (Pty) Limited in focus*

A diamond-drilling programme conducted from 1971 to 1973 by the Phelps Dodge Corporation revealed three complex sulphide ore-bodies in the highly folded Namaqualand mobile belt on the farm Aggeneys, some 65 km west of the small town of Pofadder on the road to Springbok in the north-western Cape. Of these, the Broken Hill occurrence is the most promising. An adit was driven into this ore-body in 1974 to procure bulk samples for metallurgical testing, and it is this one ore-body that is being mined today. The Black Mountain deposit, from which the mine derives its name, and the Big Syncline area over an extensive strike length, are rather larger, but have lower ore grades and have not yet been explored fully.

Financing

The feasibility of open-pit mining was examined, but in 1976 a detailed study for an underground operation was undertaken, and later that year Phelps Dodge Corporation decided to seek a partner. In October 1977 an agreement was reached in which Gold Fields of South Africa Limited and its associates acquired 51 per cent of the equity in the Black Mountain company for R15 million, which matched the R15 million already spent by Phelps Dodge Corporation. The Gold Fields Group provided an interest-bearing deferred loan of R35 million, and arranged loans from banks and other institutions for a further R111 million. Medium-term contracts for the sale of most of the projected output were negotiated as a pre-condition to the advance of the bank loans.

Geology

A succession of schists, quartzites, and calcitic rocks that form the ore-bearing Bushmanland sequence conformably overly the basal gneisses of the Namaqualand metamorphic complex. Five episodes of deformation have been detected in the Aggeneys area, the chief structural features being isoclinal and easterly plunging folds, which were refolded in a series of open easterly plunging anticlines and synclines.

There is an upper and lower massive ore-body comprising massive sulphides and mineralized schist, with abundant galena and pyrrhotite and lesser amounts of sphalerite, chalcopyrite, and pyrite. The estimated ore reserves are 38 million tons of which 0,45 per cent is copper, 6,35 per cent lead, 2,87 per cent zinc, and 87 g/t silver.

Development

Access to the ore-bodies is by means of an 1800 m 11° spiral decline, with access levels at 35 m intervals for heavy equipment, and a 438 m by 5,5 m concrete-lined circular vertical shaft for the hoisting of men, material, and ore. The shaft will also downcast 375 m^3 per second of ventilating air, with a series of raise-bore holes to surface for the return airways.

Mining Methods

Where the ore dips at more than 50°, blasthole stoping methods will be employed. Primary stopes will generally be 28 m wide with pillar stopes at the safe minimum width, dictated primarily by the relevant stope width and the depth below surface. Rings of blast holes up to 165 mm in diameter are blasted in strike retreat into a transverse slot. Drawpoint loading is accomplished with large load–haul–dump machines. Primary stopes will be filled with a cemented hydraulic mixture of dune sand and classified mill tailings. Pillar stopes will be filled with uncemented material, either hydraulically or as a dry fill delivered to the stope through backfill raises from surface. The flatter-dipping ore-bodies will be mined by various mechanized cut-and-fill methods, permitting almost 100 per cent extraction in the higher-grade areas.

Metallurgical Testwork

During the early stages of the project, selected drill cores from boreholes were combined to prepare various samples for metallurgical testing. Laboratory flotation tests were first carried out in a Canadian laboratory, and were later duplicated at the National Institute for Metallurgy (NIM). The initial tests indicated that the ore could be treated successfully by a bulk copper–lead float, and subsequent separation of the copper and the lead, followed by zinc flotation.

Extensive bulk flotation tests on samples from boreholes and on bulk samples followed. Pilot-plant results proved disappointing and erratic. Subsequent mineralogical studies indicated that the bulk samples, which had been obtained essentially from the higher levels of the ore-body, contained higher proportions of a second-generation pyrite that proved much more reactive than any of the previous samples tested.

The underground ore was sampled by fan-drilling, and composite samples of drill core were tested in batch laboratory flotation tests in Canada. As a result, the process of floating each valuable mineral consecutively or sequentially was developed. The results of these tests were subsequently confirmed at NIM.

In a separate investigation, the mineralogy of the bulk sample was compared with that of the drill-core samples to ensure that no major differences existed.

Continuous pilot-plant testing on a bulk sample, obtained from a cross-cut into the ore-body, followed. Good metallurgical results were obtained, which were consistent with those obtained from the laboratory flotation tests, and complete flow-sheets could conse-

*By the staff of Gold Fields of South Africa, Johannesburg

quently be prepared to form the basis for the design of the commercial plant.

A 60 t/d pilot plant was erected on the mine site, and was used for 12 months before the main concentrator was completed for the training of staff and the optimization of plant parameters.

Concentrator

The flow of materials through the plant is shown in the accompanying diagram.

The minerals are recovered as sulphide concentrates by crushing, grinding, flotation, thickening, and filtration. A tailings dam, drying facilities for the lead concentrate, and facilities for the storage and transportation of the products have been provided. Primary crushing to minus 150 mm is done underground. Fine crushing is carried out on surface in closed circuit, the major equipment in this facility consisting of a secondary cone crusher and two tertiary cone crushers in closed circuit with two vibrating screens.

The grinding equipment consists of a rod mill operating in open circuit, followed by a closed-circuit ball mill. After the ore has been ground, the copper, lead, and zinc minerals are separated in that order by sequential flotation in Outokumpu flotation machines. Dewatering of concentrates takes place in three cable-torque thickeners, followed by separate filtering facilities for each concentrate. The copper flotation tailings are also thickened ahead of the lead flotation. The lead concentrates are dried in a rotary dryer fired by coal tar. The addition of reagents is complex, nine reagents being added in forty different places in the flotation circuit. Most of the reagents have to be added in stages.

The flotation process is difficult, and requires very careful metallurgical control. The lead-to-copper ratio in the feed to the plant is extremely high, and varies with upper limits of over 40:1. On average, the run-of-mine grade anticipated for the first few years will be somewhat higher than the estimated total ore-reserve grade.

The ore also has the following additional characteristics.

- The ore contains pyrite, pyrrhotite, and marcasite, which makes its treatment more complex.
- In sections of the ore-body, pyrrhotite has been oxidized to pyrite II, and marcasite and oxides of chalcopyrite to bornite, chalcocite, digenite, covellite, and copper oxides.
- Marmatite occurs in place of sphalerite.
- The chalcopyrite is finely disseminated with the gangue and requires very fine grinding.
- The marmatitic sphalerite is finely disseminated with the gangue and also requires fine grinding.
- The lead mineral requires a coarser grind and tends to slime during grinding, which decreases the recovery, particularly in the case of lead and silver, and affects all the concentrate grades adversely. Grinding therefore has to take place in three stages and in three separate circuits.
- The ore is not uniform but consists of massive and magnetic ores, one contained in the other, which, for practical reasons, have to be blasted concurrently. This makes the attainment of a uniform feed to the plant extremely difficult.
- The milling unit has been designed for an ore hardness that is based on the two ore types in the proportions of 1,5 to 1. The maintenance of this proportion from minute to minute in the mine is not possible, and overgrinding with sliming, or undergrinding with chatting, could result.

A very up-to-date process-control instrumentation, which cost over R1 million, has been incorporated in the design. This includes three computerized systems supplied by Outokumpu Oy, of Finland.

Services

Because of the relative remoteness of the mine and the nature of the climate, great thought was given to the planning and provision of amenities for the comfort of employees. The mine township consists of 309 houses, and the mine also employs some 570 migrant workers from the Transkei. Shops, schools, a church, and a wide variety of sporting facilities have been erected by the mine.

An Escom sub-station fed by their high voltage line to Springbok has been erected on the mine property. A 56 km pipeline, installed by the Pelladrift Water Board, daily brings some 12 Ml of clarified and treated water from the Orange River for mining and domestic purposes.

Production

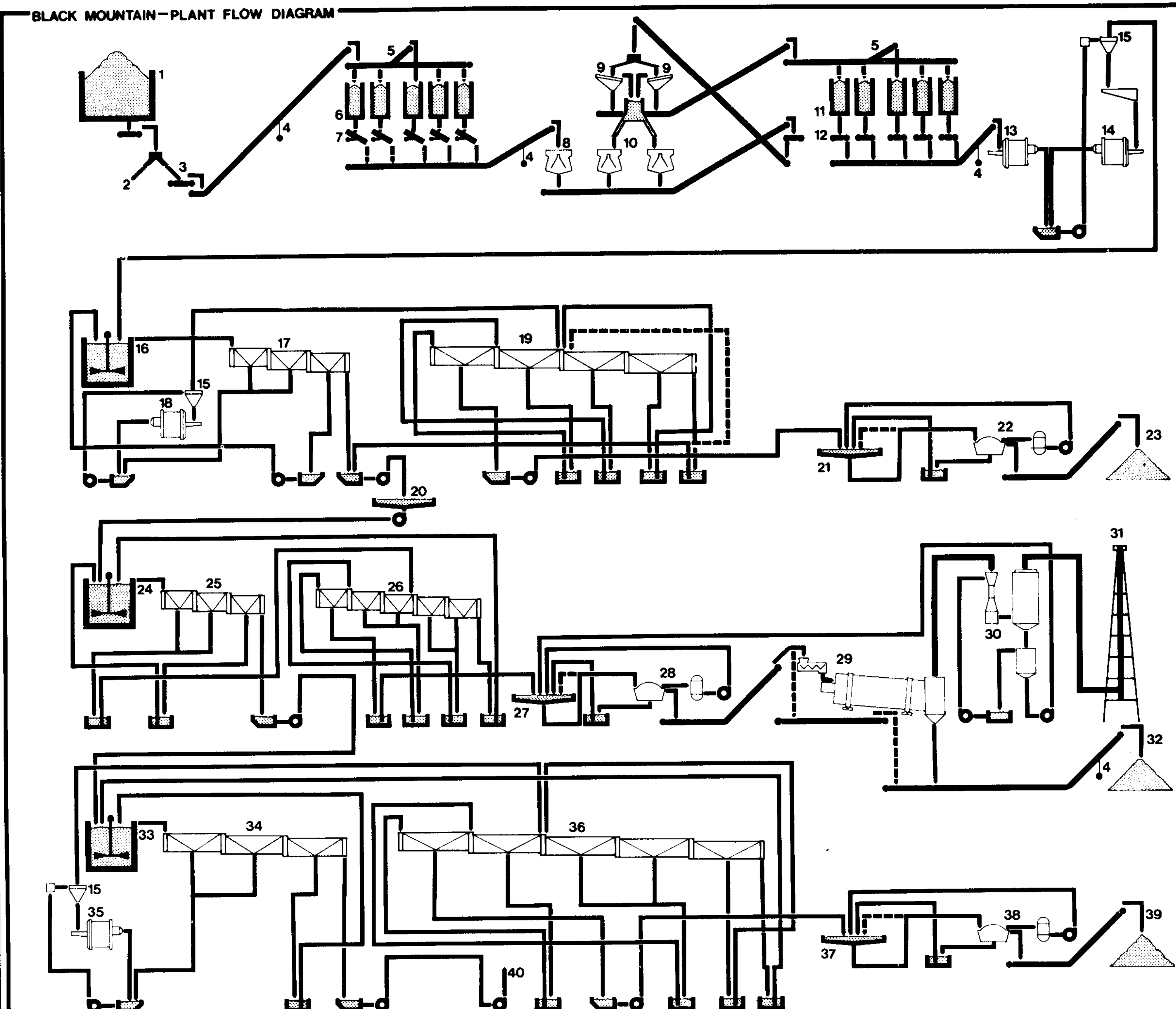
It is planned for the first few years of operation to mine and process at a rate of 1125 kt of ore per annum. From this annual production, it is forecast that about 24 kt of copper concentrates, 132 kt of lead concentrates, and 34 kt of zinc concentrates will be recovered. Silver will be credited as a byproduct in the first two concentrates. The operation will later be expanded to 1800 kt per annum.

The concentrates are transported by 60 t tractor–tridem rigs over a 166 km specially constructed metal-top road of the Cape Provincial Administration to Loop 10 on the Sishen–Saldanha railway line, where the company has erected handling and storage facilities for concentrates and a railway siding. Copper and lead concentrates are shipped to overseas smelters through Saldanha Bay, where storage and port facilities have been provided by the South African Railway Administration. Zinc concentrates are railed to the electrolytic zinc smelter of Zinc Corporation of South Africa Limited, at Springs, in the Transvaal.

In a statement issued in December 1979, when all the elements of the mine and plant had been commissioned, the company announced that the total expenditure on the project, including the interest on loans to that stage, had been R140 million, with a forecast that a total of R170 million would be spent in bringing the mine to the stage of financial self-sufficiency during 1980. This amount compares with the estimated total requirement of R181 million that was forecast in October 1977, when Gold Fields' participation in the venture was announced.

On the basis of the lead, silver, copper, and zinc prices that prevailed in world markets during the last six months of 1979, the net revenue at the mine of a

BLACK MOUNTAIN—PLANT FLOW DIAGRAM



1 Headgear bin
2 Waste
3 Ore
4 Weightometer
5 Tripper
6 Coarse ore bins
7 Vibrating feeders
8 Secondary crusher
9 Vibrating screens
10 Tertiary crushers
11 Fine ore storage
12 Belt feeders
13 Rod mill
14 Ball mill
15 Cyclones

COPPER:

16 Conditioners
17 Rougher and scavenger flotation
18 Regrind ball mill
19 Cleaner flotation
20 Tails thickener
21 Concentrate thickening
22 Concentrate filtration
23 Concentrate storage

LEAD:

24 Conditioners
25 Rougher and scavenger flotation
26 Cleaner flotation
27 Concentrate thickening
28 Concentrate filtration
29 Concentrate drying
30 Dust extraction
31 Stack
32 Concentrate storage

ZINC:

33 Conditioners
34 Rougher and scavenger flotation
35 Regrind ball mill
36 Cleaner flotation
37 Concentrate thickening
38 Concentrate filtration
39 Concentrate storage
40 To tailings dam

full year's production, in terms of the sales contracts that have been arranged, would be approximately R110 million. This compares with an estimate of R50 million at the time of the October 1977 announcement.

The Gold Fields team moved onto the site in late 1977, when the access decline had been advanced 625 m. All the essential installations, including the shaft, underground crushers, ore passes, concentrator, housing, and offices, were completed within the succeeding 24 months. Stoping started in September 1979, and trial milling in November 1979. The company has been in production since January 1980, and it is planned to increase the mill throughput to the designed capacity of 94 kt per month during the first half of 1980. The official opening of the mine, by the Chairman of Standard Bank of South Africa Limited, the lead Bank of the consortium that provided the project with more than R100 million in loan finance, took place on 22nd April, 1980.

Obituary*: Theo Meyer (1893-1980)

A strong and determined character, Theodore Carl August Meyer had a very firm approach to people whose opinions or conclusions differed from his own, but this trait was leavened by touches of startlingly original ideas and enthusiasm that certainly produced effective results from his subordinates.

Born in 1893 in Kimberley, where his father was a German missionary, Theo matriculated from Kimberley Boys' High School in 1910. He was first boy in his year, and won the Rhodes Diamond Scholarship together with two lesser bursaries. These awards enabled him to enter the South African School of Mines and Technology in Johannesburg, which was the forerunner of the University of the Witwatersrand. He studied for a degree in mining engineering, and in 1914 became an associate of the South African School of Mines and Technology in this discipline, as well as graduating with a B.Sc. (Mining Engineering) from what was then the University of the Cape of Good Hope. Subsequently, he was awarded a B.Sc. degree by the University of the Witwatersrand once the university had been recognized by London University.

At the end of his time with the School of Mines, he was awarded the Transvaal Chamber of Mines' gold medal and scholarship for post-graduate work. However, he was not able to pursue this work immediately as the First World War had started; until the end of 1915, he was on active military service with the 2nd I.L.H. in German South West Africa. Once that campaign was over, he was sent to Australia to do his post-graduate work at the lead and zinc producer, Broken Hill Proprietary Mines.

A year later, he returned to South Africa, enlisted in the Royal Flying Corps, and towards the end of 1917 was sent to England, where he was commissioned in the Royal Air Force.

It was only in 1919 that he was demobilized, and he immediately joined the Royal School of Mines, where he obtained that body's associateship in metallurgy in 1920. He was then granted another post-graduate scholarship — this time to the U.S.A., where he stayed for more than a year specializing in iron and steel metallurgy with the Tennessee Coal, Iron and Railroad company, a subsidiary of U.S. Steel Corporation.

Towards the end of 1922, Theo Meyer returned to his home country and joined the gold-mining industry as a miner. He worked his way up to mine manager before joining Anglovaal as assistant consulting engineer in 1936.

The next eighteen years were probably the most active of his professional life, for the Group was extending its mining interests from its single gold mine at Rand Leases to the then recently discovered Klerksdorp and Free State goldfields, as well as into the Barberton field. He was well-equipped both with temperament and know-how to cope with the very taxing problems associated with the major new projects launched by the Group. He met these problems head on and overcame them successfully, whether they were new problems associated with geological, mining, and metallurgical operations, or the numerous problems raised on the personnel side through the establishment of new mines in isolated farming areas.

It was during this period of his life that he revealed his great versatility, and the energy and drive that taxed not only his own strength, but that of his workforce to its limits. Not unnaturally, his efforts were recognized for what they were, and he received a number of promotions, culminating in his appointment as Technical Director in 1952 — some two years before he retired.

In his private life he showed great social charm, and, in both this sphere and his business life, he evinced real concern for people in need of help.

Outside his business life, his main hobby was farming both on large farms and at his Aloe Hill home. Age eventually caught up with him, and he was forced to give up those interests in a practical form about four years ago.

He played tennis and, in later life, bowls for the Johannesburg Country Club. He also played football and rugby for Griqualand West, the Royal Air Force, and the Royal School of Mines. He rowed for the latter at Henley; indeed, his various medals and cups are proof of his above-average sporting ability.

He was an active participant in the affairs of the South African Institute of Mining and Metallurgy for many years: he became a Member in 1923, and a Life Member in 1940; he was President in 1941/42; and was made a Life Fellow in 1970.

A man generous to causes, he particularly favoured youth and education, and he is remembered with gratitude and affection by his many friends. He is survived by his wife, Ethel, and son, Anthony.

*Compiled by R. G. Moore and N. M. Holford, Anglo-Transvaal Consolidated Investment Company, Limited, Johannesburg.