Geology and Mining operations at Palabora Mining Company Limited, Phalaborwa, N-E Transvaal

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SYNOPSIS

A description is given of the general geology, structure and minerals of economic significance of the Loolekop copper orebody at Phalaborwa. The open pit mining method is described with details of drilling, blasting, loading, hauling and primary crushing operations. A brief description is given of mine planning and its relationship to the control of the mining operation.

INTRODUCTION

The Loolekop coppeı orebody is being mined by the Palabora Mining Company Limited by open pit methods. The orebody is situated four km. south of the town Phalaborwa in the north-eastern Transvaal, Republic of South Africa; at latitude 23°57′S and longitude 31°9′E. The distance by road from Johannesburg to Phalaborwa is 550 km. The nearest harbour is Lourenco Marques, some 340 km. by rail, situated on the east coast of Southern Africa.

Recent archeological work seems to indicate that ancients recovered copper from the Loolekop orebody over one thousand years ago. Before modern mining started many shallow workings were discovered in the orebody, indicating the areas where the ancients mined oxide ore which they smelted in small primitive clay smelters in the vicinity of the orebody.

A prospector, Carl Mauch, was the first European to record the copper occurrence at Loolekop, while reconnaissance mapping of a portion of the Transvaal and Rhodesia during the period 1868-71. However, the first mining carried out by Europeans in the vicinity of Loolekop was for phosphates in 1930[3], and vermiculite in 1936[1]. The latter mineral was discovered by Mr. C. H. Cleveland, one of the pioneer prospectors of this area, who noted that large books of "rotten mica" had exfoliated during a grass fire. The late Dr. Hans Merensky played an active part in the prospecting for phosphates and vermiculite during and following the second world war.

Events leading to prospecting for copper in recent years date back to 1952 when members of the Geological Unit of the Atomic Energy Board discovered the presence of uranothorianite in the carbonatite from Loolekop. During the period 1953 to 1956 the Mineral Development Section of the Department of Mines, and the Geological Unit of the Atomic Energy Board, conducted a prospecting programme which included some underground development and surface diamond drilling. This prospecting established that the concentration of radio-active minerals, as such, was of no economic significance, but that the presence of copper minerals could render the deposit of value.

Palabora Mining Company Limited was incorporated on the 22nd August, 1956, for the purpose of acquiring certain options and prospecting rights in the Loolekop area.

During the period 1957 to 1962 this company carried out an extensive drilling programme. One hundred and eleven BX size surface inclined boreholes were drilled, totalling nearly 41 400 m. The drilling probed the deposit to a depth of 1 000 m. and demonstrated the pipelike form and remarkable vertical continuity of rock type, sulphide mineralization, grade, and distribution of the copper, magnetite and apatite. The drilling programme confirmed the existence of over 300 million t. of ore amenable to opencast extraction, from a pit with dimensions of 1 500 m. by 900 m. on surface, and a final depth of 370 m. at a finished pit slope of 45° (Fig. 2).

In October 1960 shaft sinking started, and during the period June, 1961 to March, 1962 a total of 1 610 m. of development was done on the 122 m. level. The rock from this development was bulk sampled and used to run a 100 t. per day pilot plant.

The results obtained from these investigations formed a reliable basis for the planning of full-scale mining, milling, concentrating and smelting operations on a csale hitherto unknown in South Africa.

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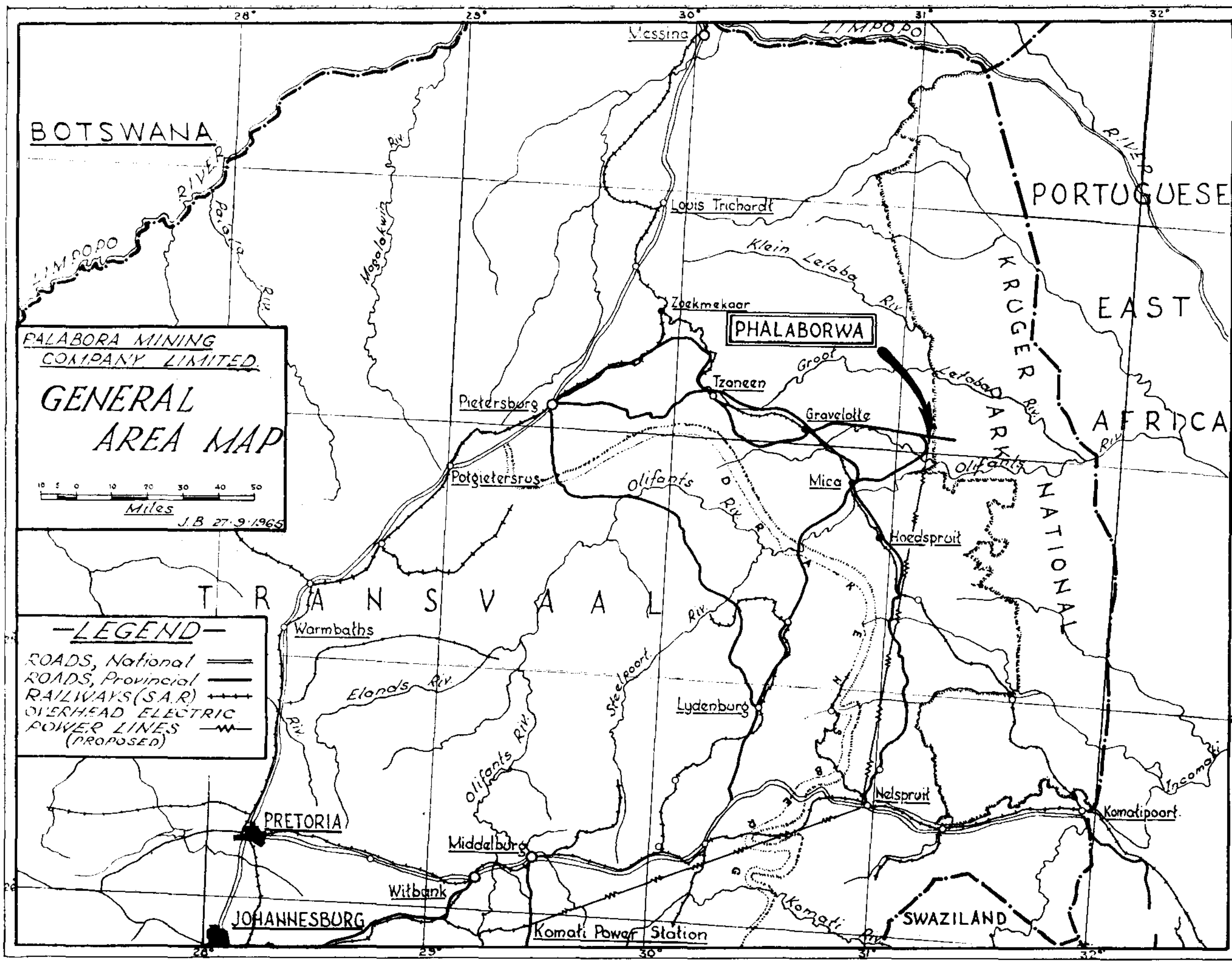

Fig. 1

SECTION: 1 GEOLOGY

General

The Phalaborwa area is underlain by Archaean granite which contains remnants of highly altered sedimentary, basic, and schistose rock of the Basement Complex. Some twenty km. west of the copper deposit is a younger porphyritic granite intrusion known as the Palabora Granite massif. It occupies an elliptical area of roughly 30 km. in an east-west direction and 15 km. north-south.

Also intrusive into the Archaean granite is the Palabora Alkali Complex, the basic phase of which is an elongate pipelike intrusion with a north-south axis of 8 km. and measuring 3 km. in an east-west direction. The alkali phase consists of numerous pluglike intrusions of syenite into the Archaean granite.

The major pipe filling of the basic phase is a pyroxenite consisting of a pale green diopside with varying amounts of phlogopite and/or biotite and apatite. Surrounding the pyroxenite is a rim of felspathic pyroxenite which is separated from the enveloping Archaean granite by an irregular fenite zone.

Within this major pipe two subsidiary pipes are recognizable; a serpentine-phlogopite-pegmatoid to the north, and the copper-bearing deposit known as the Loolekop orebody which is situated near the centre of the major pipe.

Geology of the Loolekop orebody

Lombaard et al[2] were able to distinguish between the following rock types comprising the Loolekop orebody:

(i) Phoscorite, which is a local name for a coarse grained to pegmatoid rock, consisting essentially of partially serpentinized olivine, magnetite and apatite. The relative proportions of these main constituents vary greatly. Bands of almost pure olivine with widths of up to 15 m. are common. Frequently a rude vertical banding effect is apparent, caused by the alignment of magnetite crystals. The accessory minerals are mica and baddeleyite (natural zirconia). Varying amounts of calcite are present.

(ii) Banded carbonatite, which is a medium-grained to coarse-grained rock, consisting of calcite, magnetite and dolomite, with subordinate amounts of olivine,

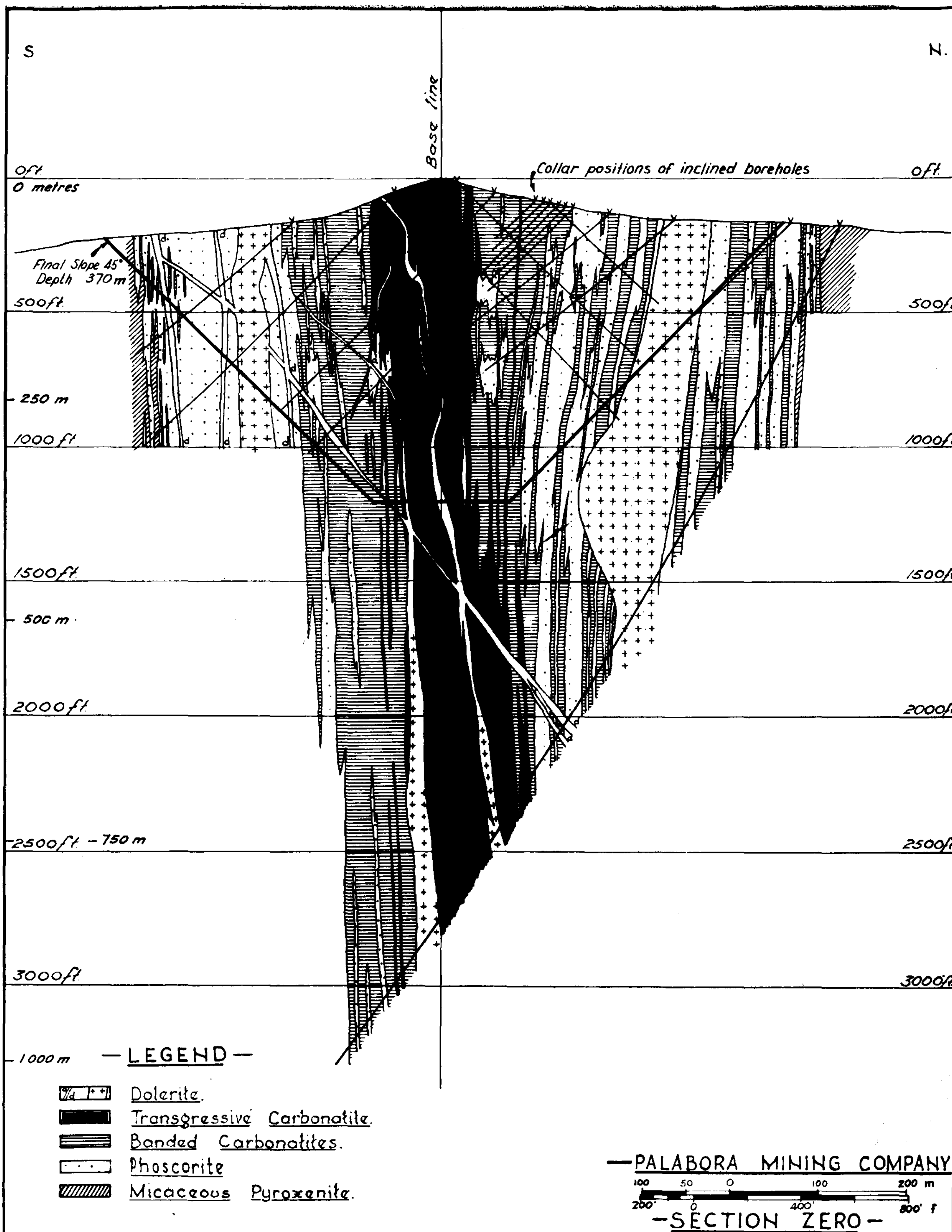
S
N.
Base line
Collar positions of inclined boreholes
0ft
0 metres
0ft
Final Slope 45°
Depth 370 m
500ft
500ft
250 m
1000 ft
1000ft
1500ft
1500ft
500 m
2000ft
2000ft
2500ft – 750 m
2500ft
3000ft
3000ft
1000 m
— LEGEND —
Dolerite.
Transgressive Carbonatite.
Banded Carbonatites.
Phoscorite
Micaceous Pyroxenite.
— PALABORA MINING COMPANY
100 50 0 100 200 m
200' 0 400' 800' f
— SECTION ZERO —

Fig. 2

apatite and chondrodite. The colour is a light-grey to dark-grey. The sub-parallel arrangement of lenses and bands of magnetite exhibits a rough banding effect. It is possible to recognize two distinct generations of banded carbonatite.

(iii) Transgressive carbonatite, which has the same mineral composition as the banded carbonatite. The texture varies from coarse to fine sugary. The banded orientation of magnetite, characteristic of the banded carbonatite, is poorly developed or absent.

(iv) A number of Karroo dolerite dykes, trending north-east, cut the rocks of the Palabora Complex. The maximum width is 75 m. Even where these dykes cut across the carbonatites, no alteration of the wall rocks is visible.

Structure of the orebody

The structure of the Loolekop orebody is that of an annular vertical pipe. In plan (Fig. 3) the pipe is elliptical in shape with the long axis lying in an east-west direction. The dimensions of the pipe are 1 200 m. along the long axis, and 670 m. north-south. Carbonatite is the predominant rock of the central part of the pipe, grading outwards into a concentric zone in which phoscorite predominates, the latter in turn giving place to micaceous pyroxenite which forms the wall rock. The contact between the phoscorite and surrounding pyroxenite is not sharp, but is a zone made up of discontinuous bands of varying thickness of these two rock types.

Lombaard et al[2] expressed the opinion that the rocks of the Loolekop orebody were formed in a pipelike conduit, and that the concentric pattern of the phoscorite and the banded carbonatite was the result of the emplacement of these rocks parallel to the walls of such a pipe.

Subsequently, this pipe was intruded by a later generation of carbonatite, having a transgressive relationship to the earlier structures. Pre-existing fracture systems controlled to a very large extent the emplacement of the transgressive carbonatite. It is thought that these fractures were not due to regional tectonic features, but were probably the result of differential structural conditions within the pipe locus.

The transgressive carbonatite forms a well-defined geological unit, some 100 m. wide near the centre of the pipe, but fingers out at both ends into a dykelike protrusions. It also occurs in the eastern part of the pipe as a number of fairly large crescentic bodies which conform to the ring-like structure of the pipe. In addition to the major occurrences of transgressive carbonatite, it constitutes a multitude of discontinuous steeply dipping veinlets, ranging in width from a fraction of a centimetre to a metre, cutting the banded carbonatite, phoscorite, and occasionally extending into the pyroxenite.

Minerals of economic significance

Economically, the most important mineralization that occurred was the introduction of copper sulphides along minute fractures within the phoscorite and the carbonatites. The highest concentration of copper sulphides is found in the transgressive carbonatite. Lombaard et al[2] advanced the theory that the latter carbonatite, which was aligned along a structurally unstable locus, was repeatedly fractured, thus affording abundant access for invading copper-bearing solutions. However, copper sulphides within the phoscorite frequently occur independently of fractures in the form of small patches of massive ore. These seem to have formed by replacement of constituent minerals of phoscorite.

The primary copper sulphides, in descending order of importance, are chalcopyrite, bornite, cubanite, valleriite and chalcocite.

Chalcopyrite occurs in irregular, thin, discontinuous veinlets and in coarse grains. Intergrowths of bornite-chalcopyrite are common. The carbonatites are the most important host rocks for the chalcopyrite.

Bornite is most frequently found occurring in coarse blebs, and is more commonly associated with phoscorite.

Cubanite generally occurs in coarse intergrowth with chalcopyrite.

Valleriite is a dull, bronze-coloured, platy, mineral with a copper content of about twenty-three per cent. It is soft and easily soils the fingers. It is the last of the copper sulphide minerals to have formed, and partially replaced the other sulphides as well as magnetite, carbonatite and silicate gangue.

Chalcocite, apart from occurring in bleb-like form, is frequently found associated with bornite in graphic intergrowth.

Next in economic importance is magnetite which form about twenty-five per cent by weight of the whole orebody. The magnetite occurs in grains and blebs, in irregular lenses and bands of widely variable width, from a few centimetres to a metre. The magnetite was presumably introduced at the same time as the other rock-forming minerals of the carbonatites and phoscorite.

Titanium is present in solid solution in the magnetite and also in the form of titanium minerals, e.g. ilmenite, ulvöspinel högbomite. The magnetite which is associated with the transgressive carbonatite, has an average titania-content of less than 0,5 per cent, whereas the titania-content of magnetite in phoscorite frequently exceeds six per cent.

The economic phosphate mineral apatite, which contains a low percentage of fluorine, is present in the carbonatites in small quantities, resulting in an average of less than three per cent phosphorus pentoxide. In the phoscorite the overall average phosphorus pentoxide exceeds seven per cent. The apatite occurs as coarse anhedral grains and irregular veins, lenses and blebs in the phoscorite and carbonatite.

The important ancillary heavy minerals which are present in minute quantities are baddeleyite and uranothorianite. The baddeleyite, which occurs in small black slender prismatic crystals, is mostly confined to the phoscorite. Uranothorianite is more often associated with the carbonatites.

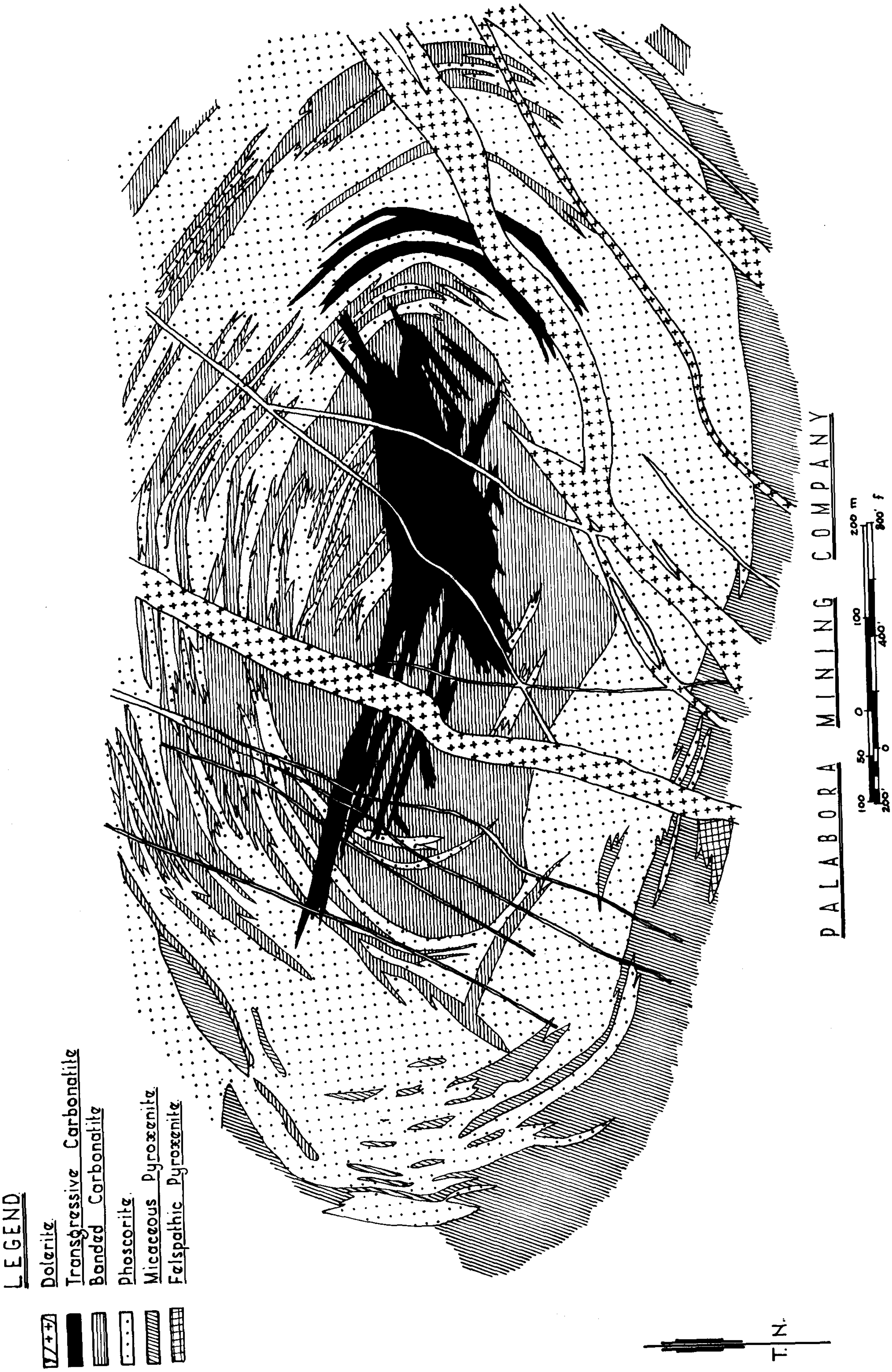
LEGEND
Dolerite
Transgressive Carbonatite
Banded Carbonatite
Phoscorite
Micaceous Pyroxenite
Felspathic Pyroxenite
PALABORA MINING COMPANY
200 m
100
50
0
100
800 f
400
0
200
N

Fig. 3

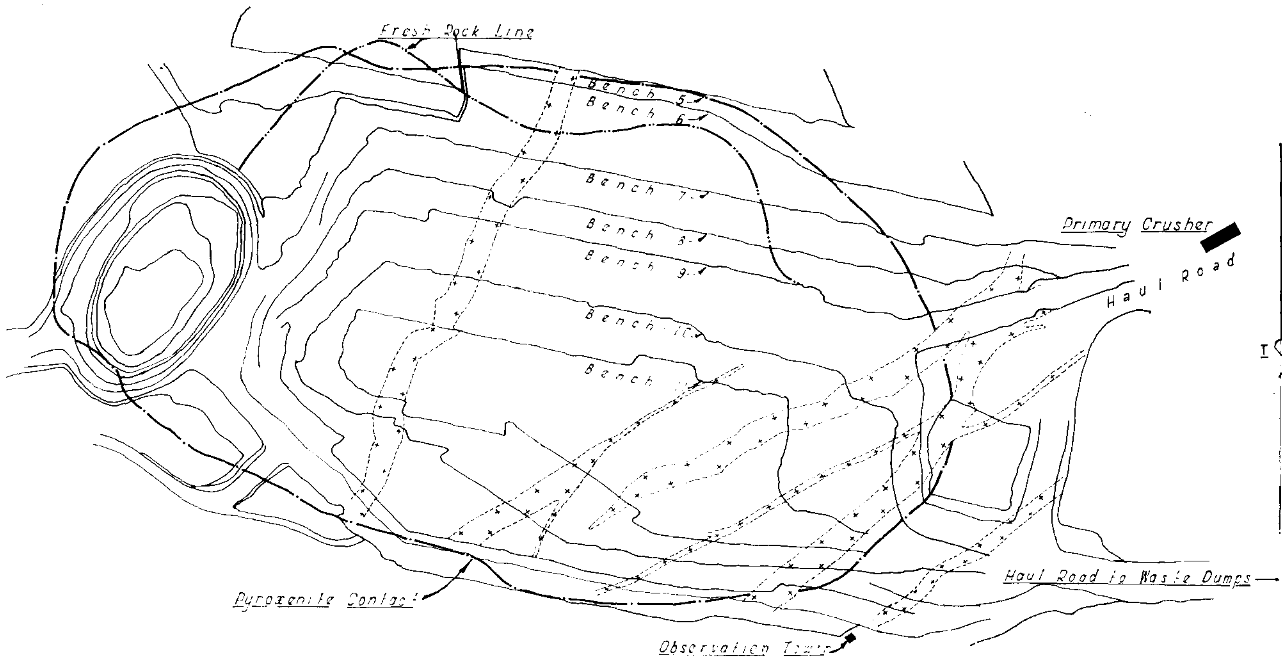

Fig. 4—Shows a general plan of the open pit workings.

SECTION 2: MINING

General description

On the basis of present planning, the Palabora open pit operation will result in a pit measuring 1 500 m. by 1 100 m. on surface, and 430 m. in depth. Finished slope will be 45°. Approximately 460 million t. of copper will have been dug from this enormous excavation, giving an overall waste-to-ore ratio of 0,93:1.

The need to blend material from several loading faces (to avoid large grade fluctuations) and to segregate ore types (according to the titanium concentration in magnetite) precludes the use of very large loading units. Nearly all ore and internal waste is loaded by 3,4 and 4,6 m^3 shovels, whilst the one 9,2 m^3 machine is devoted primarily to overburden removal.

The pit benches run on east west axes with the main entrance ramp on the south east side of the pit. From this ramp haul roads lead to the primary crushers and the main discard dumps.

Haul roads are designed with a maximum adverse grade of 8 per cent, and at the start of each new bench a ramp is mined down in the form of a box cut on this grade.

At present, ore is delivered to the crushers at the approximate rate of 62 000 t. per day, six days a week, to feed the mill at a rate of approximately 53 000 t. per day, milling seven days a week. Five ore benches are in operation to maintain this production.

Ore is segregated into two principal types: copper ore, associated with low titanium magnetite, and copper ore associated with high titanium magnetite. The loading is scheduled so that each of the two primary crushers receives only one ore type. Low titanium-bearing magnetite ore is then kept separate throughout the crushing and milling operation, and finally upgraded for sale.

Fig. 5—An aerial photograph of the Palabora Open Pit.

MANNING STRUCTURE AND ORGANISATIONAL CONTROL

Reference to Fig. 6 shows the overall manning structure. In June 1970 a total of 497 persons were employed in the open pit, broken down as follows:

	Operations	*Maintenance*	*Crushers*	*Total*
Salaried	18	16	—	34
Day Rate	50	67	3	120
Bantu	247	87	9	343

Productivity for June 1970 was 259,6 t. per manshift; this included shifts worked by the Mine Engineering Department, chargeable to the open pit.

On each shift there is one foreman, each with one shovel and one truck shift boss; in addition, there is one construction shift boss on day shift only. A drilling and

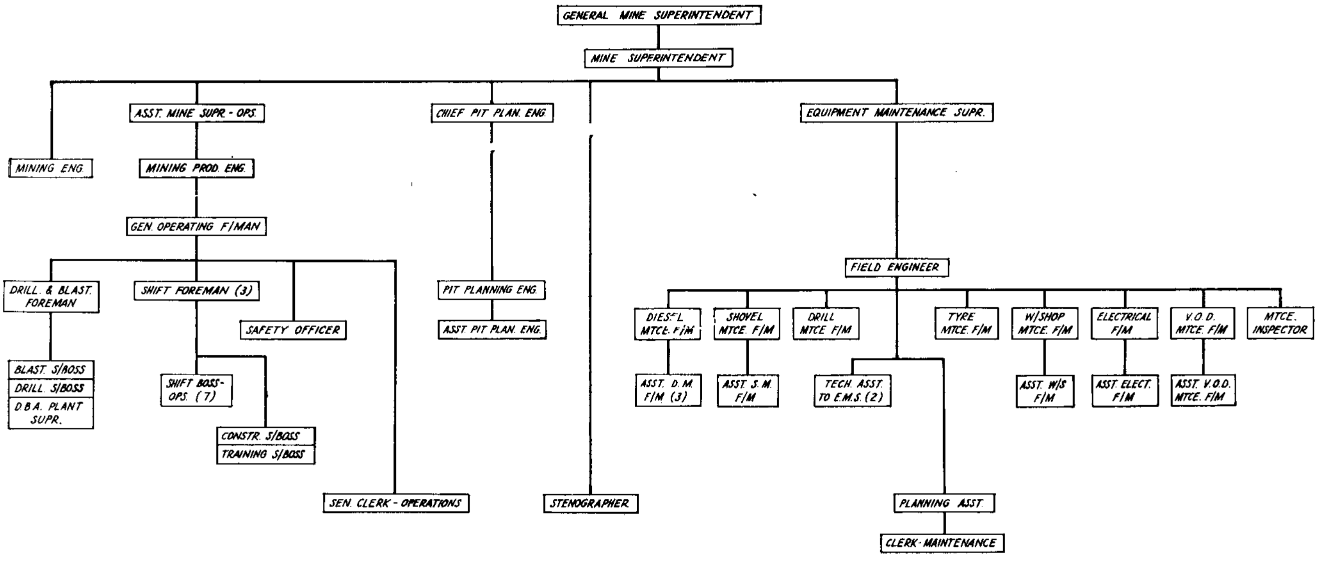

Fig. 6—Mining Department Manning Structure.

blasting foreman works on day shift, with one blasting and one drilling shift boss. On afternoon and night shift a lead hand driller is in charge of drilling operations.

Afternoon and night shifts are of 8 hours duration, whilst the day shift is 7 hours 40 minutes to allow 20 minutes for blasting. Change of shift takes place "on the job" except at the end of day shift. Shift foremen receive loading and other instructions in a Shift Log Book; continuity between shifts is maintained in this way.

Instruction and training of drivers and machine operators takes place on day shift under an instruction shift boss assisted by one Bantu instructor.

There is an open pit safety officer, assisted by one Bantu safety instructor. The five-point Quebec Safety System is practised in addition to a Safety Award Scheme.

Communication is by two-way radio between all pit vehicles, and there is a centrally situated observation tower that is manned on each shift by one of the operating officials. The observation tower is also in contact with the shovels on a separate radio frequency. This allows the operating official to control haul truck movements, verify and report breakdowns and to order any necessary shovel moves.

An open pit fire engine, mounted on a $1\frac{1}{2}$ t. L.D.V., is kept at all times at the Observation Tower. In the event of a fire, it is immediately taken to the spot by the official on duty. All pit personnel are trained in its use.

Mine Engineering Services, i.e. geology, survey, sampling and long-range planning, are provided as required.

Drilling

Blast holes are laid out by surveyors, subject to modification by the Drilling and Blasting Foremen. Various patterns are used depending upon the rock formation to be drilled. In general, three row shots are laid out along the east-west axis of the pit, i.e. parallel to the bench axis. Holes are sub-drilled to a depth of 2,13 m. below the 12,2 m. benches. The soft weathered rock and fresh dolerite dykes are usually drilled vertically, whilst in the hard orebody they are drilled at 15°
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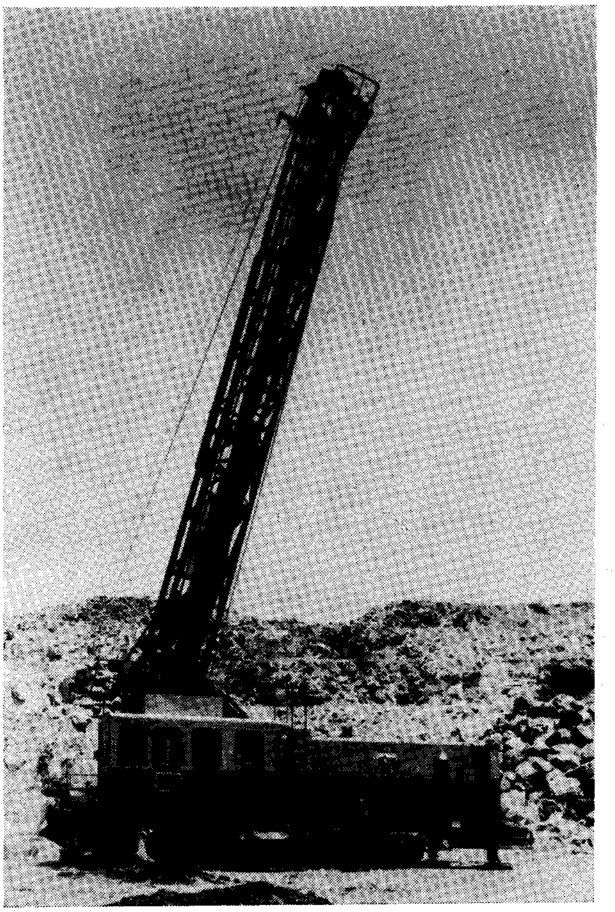


Fig. 7—Bucyrus-Erie 60-R Rotary Drill.

Drill	Hole Diameter cm	m/shift Rock Type Dolerite	Carbonatite	Weathered Ground	Average m/shift Jan.-June 1970 Average	Bit Life m Jan.-June 1970 Average
I-R Quarrymaster	22,9	20	37	91	51,8	1 729
B-E 60-R/45-R	25,0	49	85	210-300	85,0	425

off vertical. At present there are three standard drilling patterns.

7,3 m. spacing by 6,7 m. burden used for carbonatite ore

8,2 m. spacing by 6,6 m. burden used for dolerite dyke

9,1 m. spacing by 7,9 m. burden used for weathered ground.

Blast hole drilling equipment consists of 6 diesel-powered self-propelled, down-the-hole Ingersoll-Rand Quarrymaster machines, one Bucyrus-Erie 60-R electric rotary drill. The former machines drill holes of 22,9 cm diameter, using tungsten carbide button insert bits; the latter machines drill holes of 25 cm diameter using either steel tooth or tungsten carbide button insert tri-cone bits, depending on rock type.

The table above shows average performance of drills and bit performance, although these vary greatly with rock type:

During the first half of 1970, 66 547 m. were drilled with the two rotary drills and 89 349 m. with the Quarrymasters.

Secondary drilling amounts to approximately 9 000 m. per month with two Ingersoll-Rand crawler drills drilling 50 mm. diameter holes, and eight jackhammers drilling 36 mm. diameter holes.

Blasting

Primary blasting in the pit is carried out with aluminised ammonium nitrate slurry and pumptruck emplacement. Solution consisting of ammonium nitrate, sodium nitrate, and water is mixed and stored at 73,3 °C in insulated, heated tanks at the mine. The hot Aqueous ammonium nitrate solution is delivered in 20 t. insulated road tankers from Sasolburg.

Two grades of dry premix are used, named DBA (Dense Blasting Agent) 37 and DBA 31; the former is more powerful than the DBA 31 and is used to obtain a stronger bottom loading of the hole. This premix, previously imported from IRECO Chemicals in the United States, is now prepared on site principally from local ingredients.

The slurry pump truck carries an insulated solution tank and two premix bins. Solution and premix are fed at a predetermined calibrated rate into a mixer, and are then pumped through a 50 mm hose into the blast hole at a rate of from 180 to 225 kg per minute. Approximately 544 kg of slurry is required for a blast hole in sulphide ore.

The blast is initiated by electric detonator connected to cordtex trunk lines going to each hole. Each line of holes is fired utilising millisecond relays. From the trunk lines two cordtex leads are fed down each hole and two 397 g. Pentolite boosters are used to detonate the charge which is tamped with drill hole cuttings.

Blast size averages approximately 100 000 t. although they can range from 50 000 t. to 500 000 t. Shots are normally fired once per working day at 3.50 p.m. during shift change.

For secondary blasting ammon dynamite is used, and secondary shots are usually tied into primary shots with cordtex.

Reference to the table below will show the primary blasting efficiency for the first half of 1970.

A typical primary blast layout is shown in Fig. 8.

Loading

Loading equipment consists of two 3,4 m^3 diesel electric, five 4,6 electric, and one 9,2 m^3 electric shovels, all manufactured by the Harnischfeger Corporation. The 3,4 m^3 shovels being fairly manouverable, are used to gain flexibility on the removal of ore or discard material. Ore production and pit internal discard material removal is carried out by the 4,6 m^3 shovels, whilst the 9,2 m^3. shovel is employed almost exclusively on stripping of overburden.

Loading on both sides of the shovel is normal practice and a bulldozer, rubber-tyred or tracked, is maintained at each shovel to keep the loading area free from spilled rock.

Shovel power is supplied at 3 300 v. from a ring feed around the pit. Feeder cables are tapped into this feeder at suitable points, and then fed to the shovel via a link kiosk with overload protection. Shovels are equipped with automatic lubrication systems and only require pre-shift checks between the two-weekly major services.

t broken	kg Explosives	t broken per kg of Explosive	m Blasted	t broken per m of Hole
18 812 210	4 934 820	3,81	147 767	127,3

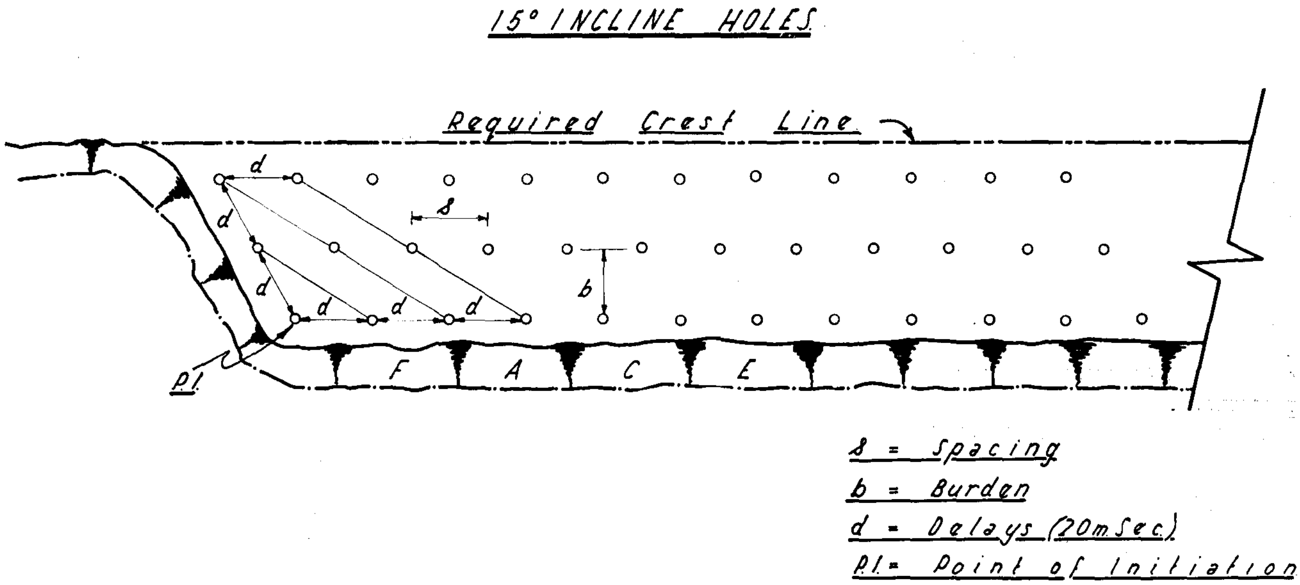


Fig. 8—Typical Blast Layout.

Shovel performance for the first half of 1970 is shown below:

Shovel	t. per Operating Hour
3,4 m^3	520
4,6 m^3	749
9,2 m^3	2 026

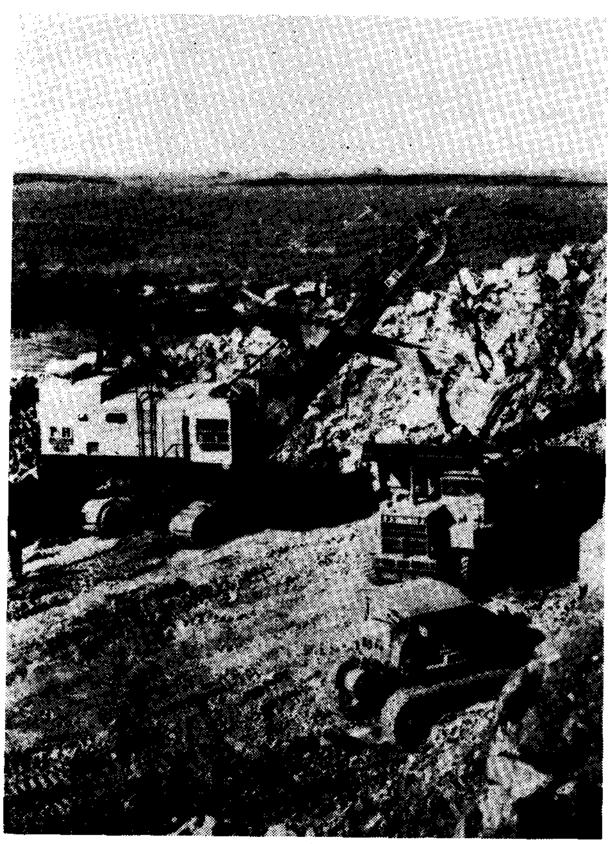


Fig. 9—4,6 m^3. Shovel loading into a 59-t. Haul Truck.

Hauling

The haulage fleet consists of thirty 59 t. KW-Dart trucks and 90 t. M100 Lectrahaul trucks. The average ore haul distance to the primary crushers of 3 048 m. and 5 182 m. on the waste haul. At present approximately 28 trucks per shift are required to satisfy production requirements with the balance either in maintenance or on standby.

Each truck is fuelled and has its oils, water and tyres checked once each shift; this is carried out on a continuous basis throughout the shift, making use of standby trucks where possible.

The truck factor is variable, depending on the material being handled; at present it is approximately 57 t. for the KW-Dart and 92 t. for the M100 Lectrahauls.

General Motors or Cummins 644 hp diesel engines driving through torque converters are used in the KW-Dart trucks, whilst the Lectrahaul trucks are equipped with 973 hp Caterpillar diesels driving a General Electric generator supplying current to motors in the rear wheels.

Truck performance for the first half of 1970 is shown below.

Haul road profiles are designed to give the lowest adverse grade, and in no case does this exceed 8 per cent. Road maintenance assumes great importance, and four graders and four water sprinkler trucks are used to ensure that road surfaces are kept smooth and rock-free. Roads on waste rock or outside the ore limits are top-dressed with weathered dolerite or weathered magnetite.

Truck Type	km per per Shift (loaded)	t per Shift	t-km per Truck Shift
KW-Dart	49,23	1 449	2 811
M100 Lectrahaul	65,76	2 461	6 050

Within the ore limits, reclaimed crushed ore, from the secondary crushers, is used, especially in areas around working shovels. A fifteen-tonne Grid-Iron roller is at present being used on an experimental basis. Results so far have been encouraging. Any protruding rocks that cannot be removed by dozing or grading are drilled and blasted.

Since tyre cost is a major element in the operation, continuous tests are carried out in an attempt to find the most suitable type for the operation. At Palabora, tyre duty is extremely arduous due to the high average haul speeds that cause dangerous heat build-up in the tyres, especially on the longer waste haul. Depending on tyre size, pressures vary from 5,2 to 7,1 bars and are nitrogen-filled to exclude humidity and to promote cooler running temperatures.

Tyre life is variable, according to the haulage duty, and is especially affected by ambient temperature and weather conditions generally. Consumption is in the order of 40 tyres a month.

To ensure equal tyre duty on all trucks, once every 24 hours long-haul waste trucks are changed with the shorter-haul trucks, all tyres are checked for pressure and wear daily, and during stoppages any small rocks embedded in the tyres are removed by the drivers.

Fig. 10—9,2 m³ Shovel loading 90-t. truck.

Primary crushing

Ore from the open pit is delivered to twin Allis-Chalmers 137 cm gyratory crushers set to 17,8 cm. Optimum crusher capacity is 2 400 t. per hour per unit. Crushing takes place on three-shifts, and in June 1970 1,58 million t. of ore were crushed at an average rate of 1 400 t./hr. per crusher. Both crushers are used in order to obtain the required ore split into low titanium and high titanium magnetite-bearing ore. The plant is fully automated and is controlled by the operator from a central observation control room. In order to prevent damage to the apron feeders below each crusher, a low level radio-active isotope is used to control the ore level; this ensures that a cushion of ore is left on the apron feeder at all times and that, if the level falls below the isotope probe, the feeder stops.

Crusher chokes are prevented by means of a high level radioactive isotope; should the ore level rise to this point, a danger light and audible signal is activated in the control room.

Crusher ore is fed to the coarse ore belts discharging on to two 33 000 t. live capacity stockpiles from where it is drawn as required.

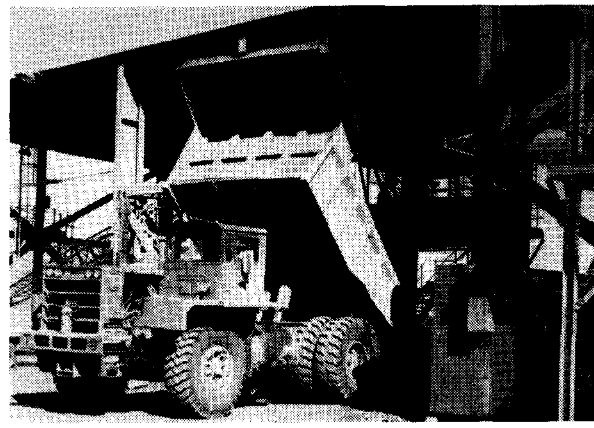


Fig. 11—59-t. Haul Truck tipping at the Primary Crusher.

Planned maintenance

A Planned Maintenance scheme is operated for all equipment used in the open pit. This is based either on a calendar system or on engine hours run, e.g. shovels have a major service once every 14 days, whilst haul-trucks and other equipment are serviced according to accumulated tacograph hours. Unit mechanical availability for the first half of 1970 was as follows:

Unit	% Availability
Quarrymaster Drills	92,7%
B.E. 60-R Drill	93,7%
B.E. 45-R Drill	89,0%
3,4 cu m Shovels	83,6%
4,6 cu m Shovels	93,7%
9,2 cu m Shovels	90,0%
Haultrucks (not including L-H)	87,8%
Rubber-tyred Dozers	85,1%
Tracked Dozers	81,3%
Graders	81,0%

The preventive maintenance system is in the process of being computerized, to give a yet closer control over equipment performance and repair costs.

Control — mine planning

Over a period of two years the mine short term planning has been developed by the open pit operating staff. In this way many major difficulties and problems have been recognized and solved on paper, before being tackled in the field. The importance of short term planning, i.e. from one week up to six months, cannot be overstressed. The geological formation of the Loolekop orebody is such that it is essential that sound, workable plans are developed prior to mining operations. Planning has to be adapted to suit the following main geological features:

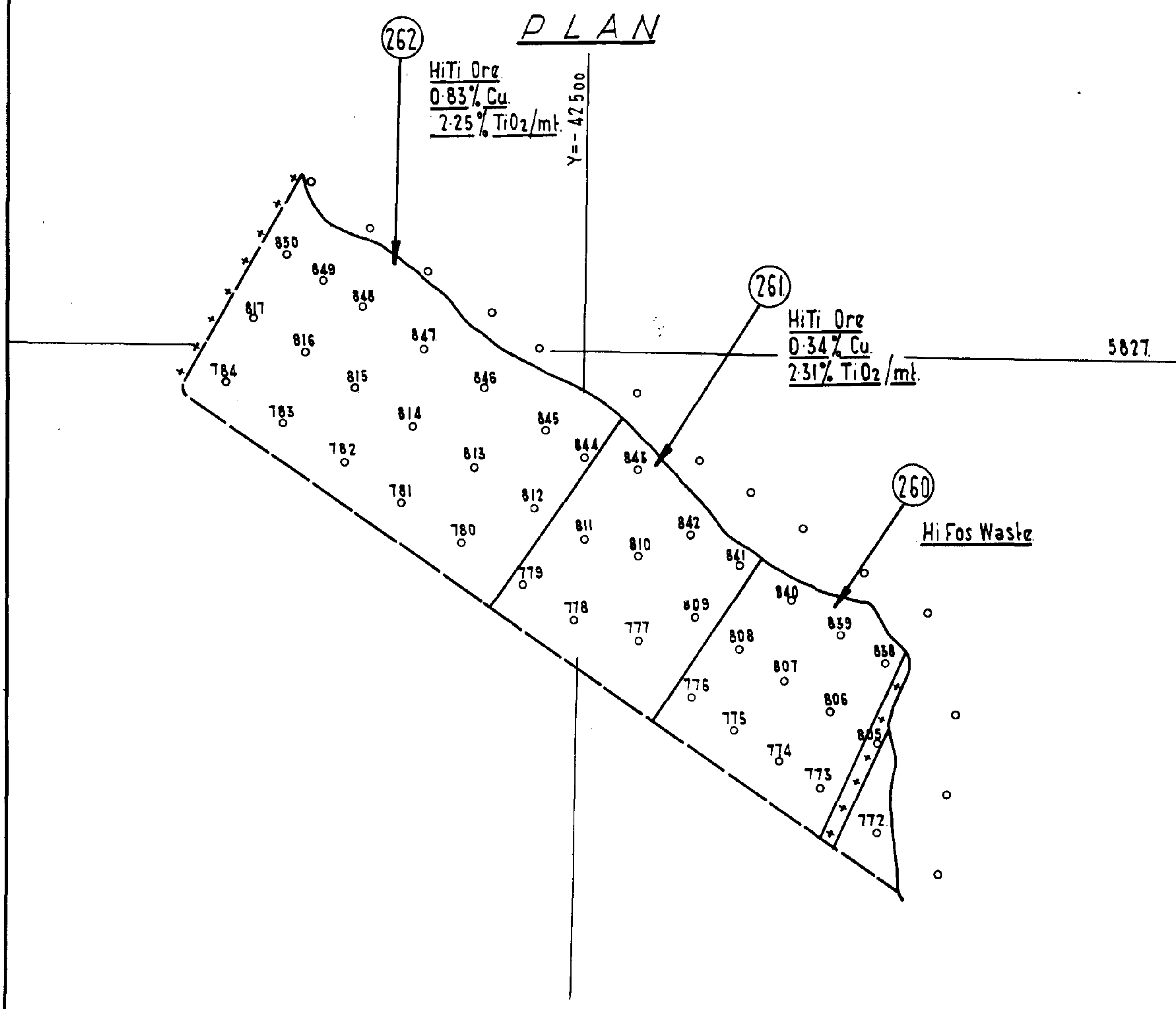
(a) wide grade fluctuations
(b) two separate ore types
(c) an orebody crossed by several barren dolerite dykes.

BLAST SHEET

Broken Rock Classification — Legend

Crusher	Yellow	Lo Ti Ore	Dump 12		
Crusher	Blue	Hi Ti Ore			
Dump 3	Orange	Marginal	STRIPPING AREA		
Dump 2	Red	Oxide	Dump F 7	Pink	Fresh Rock
Dump 4	Purple	Waste (Lo. Fos.)	Dump F 8	Grey	Weathered P2O5 Ore
Dump 5	Brown	Waste (Hi Fos.)	Dump F 9	Blank	Weathered P2O5 Waste
Dump 6	Green	Dolerite	Dump F10	Light Green	Foskor Pyroxenite Ore
Dump 11	Orange Hatch	Low Grade Marginal			

PLAN



Scale 1:500

BLOCK No.	DUMP No.	STOCKPILE CODE	APPROX TONNES 0312Ms-	CHECKED
261	CRUSHER	HiTi Ore	15000	
262	— ıı —	HiTi Ore	33000	
260	5	Hi Fos Waste	16000 (1000 Dol.)	
			65000	

To:- General Mine Superintendent

From:- Mine Engineering Department

Bench No. 10.s. (Series 7)

Blast No. 149. Blast Date 24 6 70.

Legend

——— Limits of Blocks

— — — Approx. Back break line

Date 24 . 6 . 70. Chief Mine Engineer

Fig. 12—Blast Sheet.