MINES BRANCH

DEPARTMENT OF MINES

OTTAWA, CANADA.

IMPRESSIONS OF THE MINERAL INDUSTRY OF BRITISH SOUTH AFRICA

by

W. B. TIMM

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The Third (Triennial) Empire Mining and Metallurgical Congress was held in South Africa, March 24th to May 9th, 1930. Starting at Cape Town, a tour through the Union of South Africa, Southern and Northern Rhodesia, was made by members of the Congress. The principal mining areas were visited such as, the diamond fields of Kimberley and the Premier mine at Cullinan; the gold fields of the Witwatersrand and the eastern Transvaal; the platinum occurrences of the Transvaal in the vicinity of Rustenburg; the coal areas of the Transvaal, Natal and Southern Rhodesia; the asbestos and chrome occurrences of the Transvaal and Southern Rhodesia; the lead-zinc-vanadium mines at Broken Hill, Northern Rhodesia, and the more recently discovered copper fields of Northern Rhodesia.

One is impressed with the extent, magnitude and character of the mineral deposits, in many cases so different from Canadian occurrences, such as, the volcanic pipes in which the diamonds occur; the gold-bearing reefs of the Witwatersrand and eastern Transvaal and the platinum-

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bearing Merensky reef of the Bushveld igneous complex, these extending for miles, dipping for the most part at comparatively flat angles and underlying great areas; the methods employed in the mining of the ore from the flat-lying and narrow reefs; the high grade nature of the chrome and manganese beds, the many occurrences of asbestos-bearing rocks containing a high percentage of crude or long fibre; the great minable widths of the extensive coal measures and the extent and magnitude of the copper-bearing synclinal reefs of Northern Rhodesia. One receives a lasting impression of these outstanding features of the mineral industry and especially the dependency of the industry on the native for the successful operation of the mines.

The salient features of the mineral industry of British South Africa obtained on the Congress Tour and the brief visit to the principal mining areas may be summarized as follows:

1. The mineral industry is the chief industry of the Union of South Africa, of Southern Rhodesia, and will shortly attain the same status in Northern Rhodesia.

2. The reserves of diamonds in developed mines are sufficient to maintain production for a century and there are many pipes which have not been developed. The output is dependent on the world's market and the value of production on keeping control of that market.

3. The reserves of gold ore are sufficient to maintain production at approximately the present rate for the next ten to twenty years. There should still be as much gold taken from the reefs of the Rand as already produced.

4. There are immense reserves of platinum in the norite of the Bushveld Igneous Complex. The production will be limited to what can be disposed of profitably. The margin of profit seems to be around $35.00 to $40.00 an ounce.

5. There are very great reserves of iron and coal in the Union and very large quantities of chrome and manganese. The raw materials are all present for the building up of an iron and steel industry.

6. There are important deposits of non-metallics, such as asbestos, mica, fluorspar, corundum, barytes, phosphate, gypsum, magnesite, dolomite, limestone, salt, soda, nitrates, building stone, silica sands, clays and talc.

7. Although as yet gold is the chief item in the mineral production of Southern Rhodesia there are large reserves of chrome and asbestos which have lately enabled this country to attain a commanding position for both these minerals in the world's markets. The coal reserves of the Northwestern portion of the Colony are extensive.

8. There are enormous reserves of copper ore in Northern Rhodesia, which will have an important bearing on the control of the world copper situation in the next decade.

9. There are deposits of tin, lead, zinc, nickel, cobalt, molybdenum, tungsten and vanadium in the Union and the Rhodesias, in quantities sufficient for their requirements and industrial expansion.

10. The industry owes a great deal to its native population, which makes it possible to mine the narrow reefs and to operate to great depths and in tropical climates.

As a mineral country British South Africa is indeed in an enviable position.

Historical: Many of the mines of British South Africa were worked by the ancients hundreds and perhaps thousands of years ago. Evidence of the ancient workings are to be found at the copper, tin and iron deposits in the Union; at practically all the gold mines in Southern Rhodesia and at the lead and copper deposits in Northern Rhodesia. In fact, Southern Rhodesia seems to have been the centre of mining operations of an ancient civilization. Ruins of ancient fortifications are to be found in many localities, the most notable at Zimbabwe. Relics of crude furnaces, melted and hammered gold and copper have been found at and in their vicinity. The ancient mine workings followed down on rich ore until water was encountered. Many of the mines have been rediscovered from the old workings which are supposed to be the King Solomon's Mines of biblical history.

What is now known as the Union of South Africa, commenced as an agricultural country. In the Rhodesias mining proceeded or was contemporary with agriculture. With the discovery of diamonds at Kimberley in 1870, followed by the discovery of the Witwatersrand Goldfields in 1884, a period of transition took place. The development

of the diamond and gold fields along with the extensive coal areas of south eastern Transvaal and northwestern Natal brought in a new era, in which mining gradually became the chief industry as it remains today. The effect of the rapid mineral development on the form and character of the existing white population was revolutionary. The country became more prosperous and the white population increased more rapidly than could ever have occurred with the slow growth of its agricultural industry. It created the modern industrial community and built up road and rail transportation systems. The effect of the great war, when the country had to rely on its own resources, was to start an industrial era, when for the first time, the conversion of available raw products into manufactured products was undertaken on a small but important economic scale.

Famed as the greatest producer of gold and diamonds, the Union of South Africa has far more important industrial assets in her base metal ores and non-metallics. She has vast resources of high grade iron and manganese ores; extensive coal areas; the large deposits of limestone, dolomite, magnesite and fluorspar - the raw materials essential for an iron and steel industry. Within her boundaries and that of the Rhodesias, the ores of chrome, nickel, tungsten, molybdenum and vanadium occur in quantities sufficient for her own requirements which with the above resources constitute the raw products for an alloy steel industry. Likewise there occur in important quantities the ores of copper, lead, zinc, tin, antimony and cobalt, which are necessary for a metal and alloy industry. On the above reserves, are based the subsidiary industries which make for industrial expansion and progress. While hydro-electric power is lacking the extensive coal measures are a source of comparatively cheap power. She is situated advantageously as a manufacturing and distributing centre not only for the greater portion of Africa, but to South America, East Indian, and Australasian markets.

Mineral Production of the Union: The total value of the mineral production of the Union to date has been over $7,000,000,000. The value of the annual production for 1929 was close to $350,000,000. of which gold accounts for 66 per cent; diamonds 25 per cent; coal and its by-products 6 per cent. Copper, asbestos, tin and platinum were next in order given. From these figures it will be seen that gold and diamonds are 91 per cent of the total production and with coal 97 per cent. The base metal production, on which industrial expansion relies for its raw materials, is still in its infancy.

Diamonds: The rapid advance of the mining industry of South Africa commenced with the discovery of the world famous diamond fields at Kimberley in 1870. Since that time diamonds having a value of approximately $1,500,000,000. have been produced. The annual production is between four and five million carats. The production is from the volcanic kimberlite pipes in the vicinity of the Orange River and its tributaries and from alluvial ground from the erosion of the upper portions of the pipes. Of some 150 pipes so far discovered, 25 have been mined and the bulk of the production comes from seven. The diamond content of the kimberlite, even in the richest pipes is small, ranging from six carats to thirty-five carats to the ton equivalent to from one in four million to one in seven million. Kimberley blue ground contains approximately one grain of diamond per ton or one part in fourteen million. As a general rule the diamond content diminishes with depth.

The pipes are generally ovoid in cross-section, larger near the surface, and vary in size from over a half-mile across the greatest diameter as at the Premier mine, Cullinan, near Pretoria, to less than 100 feet across. In vertical section they are for the most part steep-sided vertical funnels, worked to a depth of 3,520 feet at the Kimberley pipe. Mining is begun on all pipes by the open-cast method and the removal of the pay-ground to the surface by overhead bucket haulage and by mechanical truck haulage through an incline is very similar to the mining of asbestos rock in Quebec. When depths are reached beyond which this system can be employed, underground mining is resorted to. The underground system of mining involves the sinking of two main vertical shafts in the country rock at a distance of about 1000 feet from the pipe. One of these shafts is used for hoisting, the other for ventilation and emergency. From the hoisting shaft main haulage levels are driven to the pipe at intervals of 600 feet. On these main haulage levels the pipe is developed by a rectangular system of main cross-drives. The ground between is developed by prospect shafts, one usually in the pipe and one in the country rock adjacent to it. From these shafts working levels are developed 40 feet to 60 feet apart in the blue ground by a rectangular system of drives which eventually cuts the ground on each working level into pillars 20 feet by 20 feet. Ore passes connect with the main level below. The method of mining is one of caving and retreating toward the section of the mine nearest the main haulage shaft.

The process of extraction is to reduce the blue ground to a size small enough to ensure separation of the diamond. In some cases the blue ground is spread

out and allowed to weather and disintegrate before concentration. The stages of concentration are as follows:

1. Reduction in gyratory crushers and rolls to $1\frac{1}{4}$ inch size.

2. Concentration in rotary washing pans, the tailings from the coarse pans being reduced to $\frac{1}{2}$ inch size for concentration in fine pans. This concentration results in the rejection as tailings of 98 per cent of the feed.

3. The concentrate representing about 2 per cent of the original feed and ranging in size from $1\frac{1}{4}$ inches to sand is carefully graded into definite sizes and each size is fed to its own pulsator jig.

4. The jig concentrate from each jig is passed over its own grease table, the diamonds adhering to the grease on the upper six inches of the table. At intervals a table is stopped and the grease containing the diamonds scraped off. The grease is melted away from the diamonds in boiling water and the diamonds collected, dried and graded by experts.

The cost of mining and treatment is about 75 cents per ton by the open cast methods at large scale operations such as the Premier mine and up to $1.50 per ton by underground methods in the Kimberley field.

Gold: Of the world's gold production the Union produces 53 per cent of the total, an annual production of over $200,000,000. Practically the whole of this comes from the famous Witwatersrand goldfields, commonly spoken of as the "Rand". Osmiridium to the value of $400,000 annually is recovered as a by-product and about 1,000,000 ounces of silver, having an approximate value of $500,000 is recovered from the gold bullion produced. The annual Rand tonnage of ore hoisted is over 36,000,000 tons; of ore treated over 30,000,000 tons and the recoverable value per ton is about $6.60. The average working costs are about $4.65 per ton, leaving an operating profit of $1.95. To date the Rand has produced gold to the value of over $5,000,000,000. No other gold field has had a like history. The payable field covers a length of almost 70 miles, and a depth of 7500 feet vertical has been reached. Of the production 75 per cent is now coming from the flat-lying reefs of the eastern section, where depths are not so great and greater widths of reef are mined. This area holds greater promise of maintaining production for some years. To what depth mining will be carried depends on the assay value of the gold-bearing

reefs over minable widths; the efficiency of new engineering devices and the nature of and future financial burdens imposed on the mines by the State.

The ore comes from thin sheets of conglomerate, which although they vary in their gold content are so remarkably persistent that it has been possible to lay out the mine development for handling very large tonnages. There are 25 mines crushing more than 600,000 tons annually, five do more than 1,200,000 tons and two over 2,400,000. These large operations have made for large scale investigations into improvements in mining methods and with the free exchange of technical information, the results of such investigations are quickly applied to operation on the Rand as a whole. The co-operation which exists, especially in the pooling of information, among the large number of technically trained men engaged in every phase of mining activities, is responsible to no small extent for the deep mining operations so successfully carried out on these narrow reefs.

The chief difficulties encountered in the mining of the Rand ores are the great rock pressures at depth, the high temperatures at the working faces, and the humidity of the atmosphere which is necessary to control excessive dusting. In most of the mines timber is the chief support, used either green or impregnated with zinc sulphate as a preservative. It is used as single props but generally in the form of cribs filled with waste rock. In the east Rand the timber cribs are being replaced by concrete discs with a timber capping. Waste rock is used for filling and in the flat lying reefs sand filling is being adopted. The sands from the old tailing piles are being delivered underground through bore holes put down for that purpose.

The rock temperature at a depth of 7000 feet is approximately 96.7° F. The rise in temperature is about 1° F. for 219 feet of vertical depth. At 8000 feet it would be 101.2° F. and at 9000 feet, 105.8° F. The ventilating air is delivered at about 10 degrees below the rock temperatures and the temperature at the working faces is about 5 degrees below the rock temperatures. At 7000 feet the maximum temperature reached in the stopes is approximately 91.7° F. The ventilating air is saturated with moisture as the free use of water is compulsory for allaying the phthisis producing dust from mining operations. The necessary high humidity with the high temperatures existing is the chief difficulty to deeper mining operations.

The metallurgy of the Rand ores is comparatively simple in comparison with some Canadian ores. It is not

necessary to carry grinding so far and there are no refractory minerals of importance to contend with. The common method of treatment is coarse crushing in jaw and gyratory crushers followed by heavy stamps. Fine grinding is done in tube mills, coarse ore of a suitable size above five inches being used as the grinding media. Amalgamation and blanket concentration are employed in some mills to recover osmiridium. Sand and slime leaching with cyanide solution is generally practiced. The only mill operating an all slime process is at West Springs in the Far East Rand but any new milling plants will probably be of this type.

With the exception of three mines, electrical power for the Rand is supplied by the Victoria Falls and Transvaal Power Company from five generating stations including the one at Witbank owned by the Electricity Supply Commission. The total capacity of these stations is about 425,000 h.p. This power is developed from steam produced by the use of slack coal from the coal mines. The company also sell compressed air from 13 compressors, all of the centrifugal type, 8 steam-driven and 5 electrically. The total capacity when compressing to 112 lbs. per sq. inch is 416,500 cu. ft. of free air per minute. The net cost of energy to the mining groups is about 0.8 cents per unit, or KWH, for electricity and 2.25 cents per thousand cubic feet of free air delivered at an average guage pressure of about 105 lbs. per sq. in.

Platinum: The production of platinum in 1928 was 17,800 ozs. valued at $1,200,000. This production was from the Bushveld igneous complex, which occupies an eliptical area of 280 miles by 150 miles in central Transvaal. The outside rim of the complex consists of norites and allied basic rocks and the central portion of granites, granophyres, felsites, basalts and tufts. The norite is up to 2½ miles in thickness, the horizontal width being five to twelve miles. It dips from 5° to 50° towards the central position of the complex.

The norite sheet is composed of layers, which lie one over the other and vary in their composition. Platinum occurs in the norite associated with chromite in the Merensky reef; with magnetic nickel-iron sulphides; in dunite deposits and pipes and in many other ways. The dunite pipe occurrences are not so promising. A number of these have been worked but the grade of the ore has diminished with depth and some have been closed down. This accounts for the decline in platinum production for 1929 as compared to 1928. The chief source at the present is from the Merensky reef, payable portions of which have been explored for many miles. The total amount of platinum

metals actually present in the Merensky horizon is very large, enough to supply the world's need for an indefinite period. Much of the reef is too low grade to be economic. Great sections, contain, however, an average of 0.2 to 0.25 ozs. per ton, which is very close to the margin under present market conditions. Unless high-grade ore is discovered the future of the platinum industry in South Africa depends largely on price control above $35. an ounce.

The reef is about 5 feet wide but the payable portion is only from 12 inches to 18 inches of the footwall, including a narrow band of chromite, lying close to the footwall, with which the platinum arsenides and sulp-arsenides are associated. The ore at present being mined is from the upper or oxidized portion of the reef, and averages about 0.4 oz. per ton. The method of mining the narrow widths of commercial ore is ingenious and novel. The reef is opened up by a series of winzes spaced 300 feet apart and sunk so that half the height is in the footwall. Drifts four feet wide at fifteen feet intervals are driven from the winzes along the strike and are the haulage ways for the broken ore. Pillars six feet wide are left supporting the winzes. The reswing method of stoping is used whereby the enriched 12 inches to 18 inches of the footwall portion of the reef is first excavated and the footwall swept clean after which a portion of the hanging is brought down to make the fill for the support of the roof. Pneumatic picks are used for stoping operations.

For the recovery of the platinum minerals gravity concentration and flotation methods are used. For gravity concentration on tables very close classification is necessary. The slimes are concentrated on blanket tables. The primary concentrate is collected, classified and redressed on sand and slime tables. On the oxidized ore about 50 per cent recovery is made. By further concentration by flotation methods the recovery can be increased to 60 per cent. On the unoxidized ore of the lower portions of the reef recoveries of 80 per cent to 85 per cent can be obtained.

Chrome: High-grade chrome ore at the rate of 60,000 tons per year, having a value of $450,000 is being produced from a lower chrome band to that of the platinum in the norite of the Bushveld igneous complex. The largest and richest deposits are in the Lydenburg district but there are also important deposits in the Rustenburg district. The chromite seams which can be traced for miles range from one inch to fourteen feet in thickness. The ore which is shipped through the Port of Lorenzo Marques, is of lower grade than the Rhodesian chrome and higher in iron oxide. It has an average composition of

43 per cent chromic oxide and 28.5 per cent iron oxide. The principal mines are operated by the Chrome Corporation, (South Africa) Limited.

Besides platinum and chrome, occurrences of nickel-copper sulphides are known and being explored in the norite of the Bushveld igneous complex. This large mass of norite holds promise of enclosing extensive deposits of economic minerals.

Both lead and zinc ores have been mined in the Transvaal but no production is recorded for 1929.

Tin: The important economic occurrences of cassiterite in the Union are associated with the rocks of the central portion of the Bushveld igneous complex such as the granites, granophyres, felsites and quartzites. The chief deposits are adjacent to the main line of the South African Railways from Pretoria to Pietersburg and occur as follows:

1. In pipe deposits of altered red granite at the Zaaiplaats and Groenfontein mines.

2. In pipe and replacement deposits of altered coarse red granite or granophyre at the Mutue Fides and Stavoren mines.

3. In lode deposits in the sedimentary quartzites at the Rooiberg and Leeuwpoort mines.

In the first two types of deposits, the cassiterite is coarsely crystalline and comparatively free from impurities so that exceptionally high grade concentrate from 70 per cent to 75 per cent metallic tin can be produced from the ore which averages 1.25 to 3 per cent tin. In the quartzite deposits where the average grade is from 1 to 1.5 per cent tin, the cassiterite is more finely crystalline, and is associated with considerable pyrite, chalcopyrite, magnetite and hematite, making concentration more difficult. The recovery is not over 65 per cent, the grade being 65 per cent metallic tin.

Crushing is done in jaw crushers and California stamp batteries or Huntington mills. The pulp is carefully sized and classified and the cassiterite concentrated in jigs, on tables and Fruvanners. The concentrates are calcined to remove sulphur and re-dressed in jigs, on tables, and in buddles. At the Leeuwport concentrator treating the more difficult quartzite ore, flotation is used to remove pyrite and chalcopyrite and the cassiterite concentrates are roasted to convert pyrite to magnetic oxide and the iron oxides removed by magnetic

concentration. The annual production for the last five years has been about 2000 tons of concentrates of an average grade of 67 per cent metallic tin having a value of about $1,500,000. The value of the total production to date is approximately $35,000,000.

Molybdenite is associated with the rocks of the central portion of the Bushveld igneous complex but no production is recorded.

Copper: Occurrences of copper in the Union are confined to two localities, namely, Namaqualand -- the northwest corner of Cape Province -- and at Messina in Northern Transvaal. It was the first metal which drew the attention of the Europeans after the Dutch had established themselves at the Cape. The first production from Namaqualand was in 1852, which was apparently the first metal mining done by the Europeans in South Africa. The total recorded production from the Namaqualand field, where a dozen mines contributed to the copper output (of which the most important was those of O'okiep and Nababeep belonging to the Cape Copper Company, and Tweefontein, owned by the Namaqua Copper Company) had a value of about $100,000,000. Both companies maintained smelters, in which the ore was reduced to a 50 per cent matte. The matte was shipped over a railway line to Port Nolloth and thence to England for refining. Interest is again being taken in the possibilities of this field.

At Messina, in Northern Transvaal, the copper lenses occur in a brecciated band from 500 feet to 1000 feet in width extending for some fifteen miles in the ancient gneiss and granitic rocks. The copper minerals are chalcopyrite, chalcocite and bornite. The Messina (Transvaal) Development Company, Limited, operates the mines, a 1000-ton concentrator, a smelter and refinery, and ship copper ingots containing 99.8 to 99.9 per cent copper to European markets chiefly through the Port of Lorenzo Marques. The ore as mined contains about 3 per cent copper. By sorting the grade is raised to 3.8 per cent. It is concentrated on jigs and tables and by flotation to over 40 per cent copper. The concentrates are smelted in a reverberatory furnace to a 65 per cent copper matte, which is converted in a stationary converter to blister copper, and refined into ingots of high purity. The output of the mines to date has been over 2,400,000 tons of ore, or 75,000 tons of copper. The value of the total recorded production of copper in the Union is about $135,000,000, the annual production for the last number of years being about $3,000,000.

Iron: There are large deposits of iron ore in the Union. Estimates of the probable ore reserves are

as follows:

High grade of over 60 per cent iron and from 1 to 5 per cent silica	120,000,000 tons
Medium grade between 40 and 60 per cent iron and from 5 to 25 per cent silica	6,000,000,000 tons
Titaniferrous ore containing 40 to 50 per cent iron and from 10 to 20 per cent titanic oxide	2,000,000,000 tons

The deposits of high grade ore, similar to the Lake Superior type, are situated in the Rustenburg area of the Transvaal, 120 miles from Pretoria, where the Union Government have decided to establish an iron and steel industry. The ore is high grade hematite of great purity and of Bessemer grade. Replacement deposits of high grade hematite occur in the brecciated banded ironstones in the Postmasburg area, west of Kimberley.

The extensive sedimentary deposits of medium grade ore, occur in the Pretoria series, outcropping near Pretoria and in the Karoo system in northern Natal. In the Pretoria series a bed of oolitic ironstone from 5 feet to 27 feet can be traced for hundreds of miles. This remarkable bed is a magnetic quartzite deposit containing on the average 48 per cent iron and 20 per cent silica. A narrow persistent bed of clayband ironstone of an average thickness of twenty inches is situated 160 feet to 180 feet above the magnetic quartzite and consists of magnetite-chamosite-siderite-oolite containing over 50 per cent iron and less than 8 per cent silica.

In the Karoo system of northern Natal, in the districts of Dundee and Newcastle, a deposit of stratified iron ore occurs underlying the coal measures, the horizon being 150 feet to 250 feet below the main coal seams. The principal outlier is the Prestwick deposit which supplies at present the ore for the one primary iron producer, the Union Steel Corporation at Newcastle. Small outliers of the Dundee-Newcastle deposit are valuable fluxing material for the high siliceous ores on account of the high proportion of lime and carbonaceous matter. These outliers of dolomitic ironstone contain 25 per cent iron, 32 per cent lime and 2.5 per cent insoluble.

The titaniferous deposits which are probably the greatest deposits of their kind in the world, are of igneous origin, and are confined mainly to the Bushveld

igneous complex. They contain small amounts of vanadium. While they are of no great importance at present on account of the smelting difficulties, once a satisfactory solution is obtained they represent an enormous iron ore reserve.

The Union Steel Corporation at Newcastle, Natal, has one small stack producing foundry iron and basic pig iron for their steel works at Vereeniging, Transvaal. There are three other secondary producers established in the vicinity of the Rand goldfields using mainly scrap steel. The total production of the four secondary producers of iron and steel products is 45,000 tons of rolling mill products and castings a year.

Manganese: One of the most interesting discoveries in recent years in the Union has been the manganese deposits near Postmasburg, in the Gamagara hills about one hundred miles west-north-west of Kimberley. The deposits are extensive, outcropping along the crest of the hills for a distance of 40 miles. Where they have been exposed the ore occurs as a layer or sheet from 5 feet to 20 feet in thickness and contains a manganese content of from 45 to 60 per cent, with an average of about 50 per cent. It is not only high in manganese content but low in deleterious elements, such as phosphorous, sulphur and silica. Owing to its hardness it is able to stand shipment without the production of much fines. The deposits are probably the largest in the world and are controlled to a large extent by the Manganese Corporation (1929) Limited. The railway has been extended west from Kimberley to facilitate the transport of the ore to the world's markets. A large crushing and sorting plant has been built to reduce the ore to 5-inch size for ease of handling and sort out waste to ensure consistent quality and a loading plant is being erected at Durban with a storage capacity of 50,000 tons. It is further proposed to build smelting works at Colenso for the manufacture of ferro-manganese and other ferro-alloys, where the Electricity Supply Commission have one of their larger power stations. Provision is made for the mining of over 2000 tons of ore daily so that the Union is very likely to become an important producer of manganese.

Coal: The coal resources of the Union are enormous. The southern Transvaal, the Orange Free State and northern Natal are underlain by extensive coal measures. The chief deposits are in the Ecca series of the Karoo system. The proven tonnage is about 9,000,000,000. The Natal seams are from 4 to 5 feet thick and the Transvaal seams up to 25 feet. There are some 70 operating collieries in the Union, 31 in the Transvaal, 32 in Natal, 5 in Cape Province and 2 in the

Orange Free State. The annual production is about 13,500,000 tons having a value of $18,000,000 or $1.35 per ton. The total value of the production to date is approximately $400,000,000. Besides supplying her own requirements, a considerable tonnage is exported through the port of Durban, from 24 collieries, mostly in northern Natal.

The Transvaal coal is classified as bituminous, principally non-coking, has a calorific value of about 13 and is of the following composition: ash - 12 to 18 per cent; volatile matter - 25 to 28 per cent; fixed carbon - 55 to 60 per cent; and sulphur - less than 1 per cent. Blended with Natal coal in the proportion of one to one, a good metallurgical coke can be made from Transvaal coal.

The Natal coal is classified as semi-bituminous, has a calorific value of 14.25 and of the following composition: ash - 8 to 10 per cent; volatile matter - 18 to 20 per cent; fixed carbon - 70 per cent, and sulphur - 1 to 1.5 per cent. Good metallurgical coke can be produced from many of the seams. The production of coke from dross coal after washing from six collieries in Natal is 138,000 tons of the following average analysis: Fixed carbon - 86.25 per cent; ash - 11.35 to 12.25 per cent; sulphur - 0.75 to 1 per cent. The one by-product coking plant at Waschbank, Natal which supplies the metallurgical coke for the Union Steel Corporation at Newcastle produces tar, creosote, napthalene, benzol, and ammonium sulphate. As in most countries where there are extensive coal resources, too many mines are operating for the available markets, consequently the coal industry is having a most difficult time in maintaining itself.

Asbestos: In recent years South Africa has come forward as a producer of asbestos. Five varieties occur in the Union, namely, chrysotile, crocidolite, amosite, tremolite and asbestic. Only the first three are of importance. In 1928, the production was 12,162 tons of chrysotile having a value of $1,046,400; 5,143 tons of crocidolite having a value of $565,200 and 6,749 tons of amosite having a value of $336,200, making a total production of 24,054 tons with a value of $1,945,800.

The principal occurrences of the chrysotile variety are in eastern Transvaal, Swaziland, and Natal where there are extensive areas underlain by serpentinized basic rocks, similar to those in which the chrysotile of the New Amianthus Kalkkloof and Havelock mines is found. The principal occurrences of crocidolite or 'Cape blue' asbestos are in Griqualand West near Prieska on the Orange River, Cape Province; and of the amosite or 'Cape white' asbestos in the Lydenburg district of the Transvaal where

the amosite veins lie in banded ironstone of the Pretoria series.

At the New Amianthus mine, which is controlled by the firm of Turner Brothers, Asbestos, Limited, the fibre-bearing serpentine has an average width of 7 feet and extends along the strike for 2000 feet. About 100 tons of rock are being mined daily, containing about 17 per cent of which 5 per cent is long fibre, or No. 1 crude. The separation of the fibre from the rock is very similar to Canadian practice.

Other Non-metallics: The richest and most extensive corundum fields in the world are in northern Transvaal. Important deposits of barite occur in Cape Province. The Union has become an important producer of fluorspar. Mica of excellent quality occurs in the Pietersburg district of Transvaal, small tonnages being produced. Large deposits of rock phosphate, gypsum, magnesite, dolomite, and limestone also occur. The salt pans are worked for their salt and soda contents. Nitrates occur but there is no production. Building stone such as granite, syenite, norite, dolerite, diabase, limestone, dolomite, marble, sandstone and slate occur in abundance. Silica sands, suitable for ordinary glass-ware, and moulding sands, clays for ordinary brick and tile purposes; kaolin for pottery; fireclays for refractory bricks; and talc for various uses, including engineer's chalk, heat and electric insulators, filler for paper and rubber, toilet powder, etc., are all produced within the Union.

Southern Rhodesia: The history of the mineral industry of Southern Rhodesia may be divided into five periods, namely:

The working of the gold, copper and iron mines by the ancients may be described as the first period. The supposition is that Southern Rhodesia was the Ophir of the Bible. Estimates by competent mining engineers of the amount of gold extracted by the ancients vary but an average estimate is $300,000,000.

The working by the natives of alluvial gold and primitive quartz mining, as found by the Portuguese and existing up to 1890, may be taken as the second period. The extent to which the country had been prospected and the mines worked by some unidentified race is evident from the fact that the majority of the mines, which have been worked since 1890, have been located on old workings.

The third or first European period, from 1890 to 1904, was a period of company promotion. The mining laws provided for mines to be worked only by companies, the British South Africa Company to receive 30 per cent of the scrip as proprietors of the mining rights. The extravagant hopes of the promoters that unlimited wealth was to be found in the re-discovered land of Phier was not realized.

The fourth or second European period from 1904 to about 1923, was the period of the small worker. The British South Africa Company permitted individuals and small syndicates rather than large companies to work the gold mines for profit with small stamp batteries. In 1904 there were twenty small workers. At the end of 1923 over 400 small mines were being worked in this manner.

The fifth or third European period, from 1923 to the present, was one of company consolidation of a number of gold mines, and company operation of the coal measures, the chrome, asbestos and mica deposits and was the commencement of a new era of mining development in Southern Rhodesia.

Mineral Production: The value of the average annual mineral production of Southern Rhodesia for the last fifteen years has been about $24,000,000. While the gold production has been declining slightly, the decrease has been made up by the increased production of other minerals, of recent years, asbestos and chrome. The value of the total recorded production to date is little short of $500,000,000. Gold has accounted for over $350,000,000. It is still the chief item in the mineral production, asbestos is second, amounting to 50 per cent of the gold production, being almost $6,000,000 in 1929. Chrome is third; coal, fourth; mica, fifth; and copper, sixth. Then comes silver, tungsten, iron, tin, diamonds, arsenic, barytes and corundum, in order of production.

Gold: There are nine gold mines producing over 10,000 ounces annually, representing 73.5 per cent of the total gold production. There are many smaller mines producing less than 10,000 ounces, mostly worked by individuals with small capital. The gold occurs in a variety of lode formations, associated with iron pyrites and galena, or with arsenopyrite and stibnite, or copper pyrites, in schistose rocks which are older than the great granite masses intrusive in the schists and which are widely distributed over the country. The usual milling practice is crushing with gravity stamps, amalgamation, in certain cases regrinding in pans or tube mills, concentration on tables and blankets, and cyanide treatment of the tailings and slimes.

Asbestos: The growth of the asbestos and chrome industry has been phenomenal. In terms of the world's output of asbestos, Rhodesia is second (Canada being first). She is already the largest producer of crude fibre. In a few years she will be the leading producer in all classes of fibre combined. Large areas, which a few years ago were considered unpayable are being taken up and developed and likely to become valuable properties. The 1929 production was almost 43,000 tons of fibre, having a value close to $6,000,000. The chief producing areas are in the Bulawayo mining district, including such properties as Shabani, and Nil Desperadum in the Belingwe area, and the Pangana mine in the Filabusi area; in the Victoria mining district, including such mines as the Gath and King in the Mashaba area; and in the Lomagundi district. The asbestos is all of the chrysotile variety and occurs in intrusions of dunite, altered to serpentine and talc-schist, and in the great Dyke of norite. The chief producing mines are controlled by the firm of Turner Brothers Asbestos, Limited.

Two methods of mining are employed, namely, quarrying, in which the broken rock is first cobbed for crude fibre, and then delivered through an ore pass to a level below and is trammed or hauled to the mill through adits or up inclined shafts. The second method is shrinkage stoping, by which hand picking and cobbing of the crude fibre has to be done at the mill. The milling methods for the recovery of the fibre from the asbestos-bearing rock and the preparation of the crude and other grades for shipment are very similar to the Canadian practice.

Chrome: Southern Rhodesia is the world's largest producer of chrome ore and is likely to remain so for many years to come. In 1929 the production was close to 300,000 tons, no less than 65 per cent of the total world's output, having a value of $3,350,000. Her chrome ore is in demand, being high grade, easily reaching the standard requirement of 48 per cent Cr_2O_3.

The chief occurrences at present are at Selukwe, Mashaba and a number of points along the great Dyke. The Selukwe deposits are the most important, producing over half of the annual output, although the higher chrome content of the numerous occurrences along the great Dyke is bringing these into prominence.

At Selukwe the chrome occurs in large irregular lenses in talc schist and serpentine, derived from the alteration of the dunite intrusions. The chrome lenses are quarried but recently underground methods have been

introduced. The ore for the most part is hard and lumpy, averages around 50 per cent Cr_2O_3 and is shipped as mined. In one quarry where the ore is richer, it is more friable and becomes mixed with dirt. It is put through a Hardinge mill, and passed over shaking tables from which a very high grade product is obtained.

The Great Dyke deposits are narrow seams of chromite in the norite up to thirty inches in thickness, the average being seven and one-half inches. The seams dip inward from the margins of the Dyke at angles from 10° to 45°. The chromite seams are soft and crumbly but are of higher grade than the Selukwe chrome, containing 50 to 52 per cent Cr_2O_3. The seams are worked from the surface by the open-cast stoping to a depth of ten feet when underground resuing methods have to be resorted to from inclines. Depths of 150 feet have been reached and this method of underground mining has proven that the narrow chromite seams can be profitably worked even under existing transportation difficulties. The southern Rhodesia chrome ore is shipped to world markets through the port of Beira in Portuguese East Africa.

Coal: The northern and southern portions of Southern Rhodesia, the basins of the Zambezi and Limpopo rivers, are underlain by extensive coal measures. In the Wankie collieries there are large reserves of high grade bituminous coal, suitable for coking purposes. Lack of railway facilities make it impossible to operate the Limpopo coalfields.

The Wankie collieries supply coal to the railways as far south as Mafeking and as far north as the Belgian Congo. The coke and coal is used in the mining fields of northern Rhodesia and the Belgian Congo. The production will rapidly increase as the large copper deposits are brought into production. The Wankie collieries are equipped for a production of 10,000 tons of coal per day. Last year the production was 1,143,000 tons having a value of $2,550,000. At the No. 1. colliery the thickness of the seam being mined varies from 6 to 15 feet, all workable, while at No. 2. colliery, the average thickness is 30 feet, 20 feet of the footwall portion being mined. The general method of working is by the pillar and stall system. In No. 1 colliery about 56 per cent of the coal is extracted and in No. 2 about 37 per cent. Screening plants are maintained at both collieries for the grading of the coal and washing plants for the elimination of impurities from the fines. Coke is manufactured in 180 retort ovens of the Coppee pattern and a battery of 49 Beehive ovens are held for emergency. The company also operate a brick plant for the manufacture of

machine-made red bricks for general purposes and a fire-brick plant from which the famous Wankie firebricks are manufactured for their coke ovens, the smelting plants in Northern Rhodesia and the Belgian Congo and for other purposes. The fireclay is from a bed 80 feet thick lying above the coal measures at the base of the upper shales and outcrops about five miles from Wankie.

The company owns 400 square miles of the coal measures of which 30 square miles have been definitely proven by boreholes. Taking the average minable width as 12 feet which is much below the thickness proven by the boreholes, the proven reserves are 300,000,000 tons. The coal seams are contained in a bed of shale about 80 feet thick and vary in number and thickness. The main or lowest seam, which is the one being mined, varies from a minimum of 6.5 feet to 38 feet in thickness. The feature of this seam is its high quality and calorific value.

The average analysis of the Wankie coal is as follows:

Fixed moisture	0.76 per cent
Volatiles	23.77 " "
Fixed Carbon	65.70 " "
Ash	9.77 " "
Evaporative power	13.89 lbs.
Calorific value	7,459 calories or 13,426 B.T.A.

Other Minerals: Mica in payable quantities and of excellent grade is mined in two areas in Southern Rhodesia, the Miami area in the northern part and the Rusambo area in the northeastern part. The value of the production for last year was $400,000, for about 200 tons. Copper occurs in several localities. Silver is produced from the gold bullion and tungsten is also a by-product of the gold mines. Iron of good quality occurs in many parts of the country, the only production in recent years being as a flux for the copper smelters. Tin is worked on a small scale. Diamonds and other precious stones are found in the alluvial deposits near Gwelo. Arsenic is produced as a by-product of the arsenical gold mines and is mainly used as a constituent of cattle dips. Barite is produced in the Gwelo district. There are large deposits of corundum, the difficulty being in marketing this mineral. Nickel and platinum occur in the Great Norite dyke, which is a unique body of igneous rock over 330 miles in length and a maximum width of 6 miles which traverses the country in a north-north-easterly direction. It is one of the chief occurrences of the chrome ore. The asbestos and other chrome occurrences are reasonably close to its margins.

Northern Rhodesia; Mineral Production: The value of the mineral production of the Crown Colony of Northern Rhodesia up to the present is about $30,000,000. The chief production has been lead from the Rhodesian Broken Hill Mines; copper from the Bwana M'Kubwa and Kansanshi mines; zinc and vanadium from the Rhodesian Broken Hill Mines; and gold and silver from a number of small gold mines. There have been produced also small amounts of mica, manganese, iron and bismuth.

The value of the lead production has been over $15,000,000; copper, $7,500,000; zinc, $3,500,000; vanadium, $1,000,000; gold, $500,000; silver, $250,000; with mica, manganese, iron and bismuth contributing to the balance.

Lead, Zinc, Vanadium: The lead, zinc, vanadium deposits at Broken Hill were discovered in 1902. Mining and smelting operations were commenced in 1906 on the arrival of the railway but were shortly afterwards suspended. During the Great War the lead smelter was built. The mines are operated by the Rhodesian Broken Hill Development Company, Limited, and have been the chief source of the mineral production. The deposits are replacements in dolomite and are conspicuous, being exposed as kopjes or small hills in the otherwise flat lying country. Some six of these kopjes have been worked. No. 1, the largest, was the specimen mine of the world. When the upper portions were being removed, large open fissures and caves, lined with beautiful crystals of pyromorphite and cerussite were disclosed. Good specimens of descloigite and vanadinite were common and the rare zinc phosphate minerals, tarbuttite, hopetite and parahopeite could be obtained. It was in one of these pre-historic caves that the skull of 'Homo rhodesiensis' was found along with numerous animal remains.

The ore occurs as a central core of massive sulphides of zincblende and galena around which is an oxidized shell consisting of zinc silicates, iron oxides, quartz, zinc and lead carbonates and vanadium minerals. The first operations were the mining of the rich sulphide ores from the central portion of the ore bodies, by open-cast methods, leaving the oxidized ore in place. It is only within the last three years that the treatment of the oxidized zinc silicate ores has been possible by the erection of a specially designed electrolytic zinc plant with a capacity of about fifty tons a day and a new hydro-electric power plant at Mulungushi Falls about 35 miles distant where 12,500 h.p. is developed. The lead smelters which produced over 115,000 tons of pig lead have been closed down, the efforts of the Company for the

present being directed to the recovery of zinc and vanadium from the oxidized ores. The ore reserves are stated to be about 1,000,000 tons averaging 30 per cent zinc, 8 per cent lead and 0.9 per cent vanadium oxide.

Copper: The presence of copper in the Belgian Congo and Northern Rhodesia was known to the early Portuguese traders. In 1899 the Kansanshi copper mine, about 230 miles northwest of Bwana M'Kubwa and about 150 miles northwest of N'Changa, was located by George Grey, who also explored the Katanga and located the large deposits now operated by Union Miniere du Haut Katanga. To him belongs much of the credit for the pioneer mineral exploration in this portion of Africa. The Kansanshi mine is at present being developed by the Rhodesia-Katanga Company, Limited. Here the copper ore occurs in lode formations cutting through the schist beds, and carries values in gold and silver. The schist beds in the mine area are pyritic and in places contain sufficient copper to form important ore bodies. Between 1908 and 1914 the mine produced 3,250 tons of copper, from high grade ore averaging 18 per cent copper, which was smelted in a small blast furnace using charcoal for fuel.

The Bwana M'Kubwa mine was located by W. C. Collier in 1902. About the same time he located what is now known as the Roan Antelope mine. When the Bwana M'Kubwa mine was discovered, the richest portion of the deposit was pitted with ancient excavations. The mine was worked intermittently until 1922 when it was taken over by the present company, The Bwana M'Kubwa Copper Mining Company, Limited. In the open pit, which is about 2000 feet long, there are two distinct ore-bodies, the footwall ore body of 50 - 100 feet in thickness and the hanging wall ore-body of 25 - 50 feet wide. The chief copper minerals are malachite and chrysocolla. The oxidization goes to water level which is about 270 feet from the surface and the present plan is to continue the open cut to this depth, using steamshovels. The ore contains an average of 3 to 4 per cent copper and the treatment plant is designed for 1000 tons per day.

The process of extraction of the copper values is by leaching with ammonia. Briefly the ore is crushed in gyratory and disc crushers and rolls, and classified into sands and slimes. The copper is extracted from the sands by downward percolation in leaching tanks and from the slimes in Merrill presses by forcing strong ammonia solution through the charge, a wash being used to displace the strong solution in each case. The rich leach solution is evaporated, copper is precipitated as

copper oxide and the distillate of ammonia and carbon dioxide is condensed and returned to the leaching plant circuit. The copper oxide is dried, mixed with tar, charged to a reverberatory furnace, smelted, and later refined, the copper ingots averaging 99.9 per cent copper.

= It is on the discovery, exploration and development of the very extensive copper deposits, mainly in the M'Kana Concession, bordering the mineral province of Katanga of the Belgian Congo, that world-wide interest has been focussed for the last few years. These deposits are of great length and are persistent as to width and grade of ore. For the most part they are huge synclinal deposits in the sediments, extending for miles in the direction of the axis of the syncline. In many cases both limbs of the syncline contain commercial ore. Unlike the oxidized deposits of the Belgian Congo and Bwana M'Kubwa, where the large ore bodies of copper carbonate and silicate ores stand out prominently as kopjes above the surrounding country, there is little evidence of rich mineralization to be found on the surface, as the country is level, and covered with a soil blanket with but few outcrops. The dambos or lack of vegetation on the outcrops led to the discovery of several of the deposits. However, it was only by working out the geology in detail, and thus supplementing the data obtained from the outcrops, that locations for drilling exploration were determined and the deposits proved up to their present dimensions. Some five of these deposits are in course of development: Roan Antelope and its westerly extensions known as Muliashi and Baluba; N'Kana; Chambezi; Mufulira and N'Changa with its westerly extension into the Rhodesian Border Concessions. Other smaller properties are also being explored. The area in which these deposits occur constitutes the most important individual copper district in the world.

The chief characteristics of the ore beds as determined from the cores of very extensive drilling operations are the uniformity of the mineralization, their fairly regular widths, and their extension for great horizontal distances. At the Roan Antelope mine both limbs are commercial ore of a 3.3 per cent copper grade, of an average width of from 20 to 30 feet and extending from the nose of the syncline for 16,000 feet on the south limb and 12,000 feet on the north limb. A further 22,000 feet of the south limb has been drilled, a number of widely spaced holes showing similar continuity of ore values and widths. The extension of the north limb known as the Baluba deposit is of a similar grade and thickness for about 5,000 feet. At N'Kana, three ore bodies in the same bed have been explored on

the eastern limb of the N'Kana syncline, the largest or middle deposit called the North ore body is about 8,000 feet long with a width of about 30 feet, has been drilled to a depth of 2500 feet and averages 4.3 per cent copper. The south ore body is about 6500 feet long and about 20 feet wide and averages 2.8 per cent copper. Two miles north of the North ore body the Mindola ore body has a proved length of 12,000 feet, an average width of 14 feet, and assays 3.7 per cent copper. The Chambezi deposit has been drilled for 1000 feet in depth, is known to extend for 5,000 feet and averages 3 per cent copper. At the Mufulira Mine, the west limb of the Mufulira syncline has been explored for 6,000 feet and to a depth of 1,500 feet and the ore bed traced for a further length of 6,000 feet to the northwest. The deposit is somewhat different from the others, in that, at its south-easterly end there are three distinct ore beds, separated by 25 feet and 45 feet of barren rock. The beds have a total width of about 70 feet and merge towards the northwest, forming a single ore body of even greater width. The ore averages about 4.7 per cent copper. At the N'Changa mine, three ore bodies have been explored. The ore on the north limb called the River Lode is known to be 70 feet wide for 1,000 feet in length. The two on the south limb are called the Dambo and the New Discovery lodes. The Dambo lode is known to have a width of 50 feet for 2500 feet, and the New Discovery to have a width of 85 feet for over 7000 feet. The deposits have been drilled to a depth of 900 feet, and the ore averages above 4 per cent copper. The New Discovery lode extends into the ground of the Rhodesian Congo Border Concessions, where it has been traced for a length of over 7000 feet with an average width of about 100 feet, and contains from 5 to 8 per cent copper. A new discovery has also been made at Chingola, two miles to the southwest. Drilling and other exploratory work is proceeding, adding to the known lengths of these extensive ore beds.

The actual ore blocked out by underground development is small, compared to the estimated tonnage calculated from drilling results. Some of the latest estimates place this calculated tonnage at approximately a half billion tons of four per cent copper ore, an enormous reserve of copper, sufficient to meet the world's requirements at the present rate of consumption for 10 years. It is to be expected that these figures of estimated tonnage will be exceeded, but the amount of copper which will be produced is a matter of individual opinion, and will depend on financial arrangements for developing the mines and bringing them into production, the price at which copper can be produced, and the world's capacity to consume copper.

Generally speaking complete exidation has penetrated to the ground water level from zero to 200 feet. Below this the amount of oxidization varies from as little as at the Roan Antelope, N'Kana and Mufulira, to almost complete oxidization as at N'Changa. The depth to which it occurs varies not only at the different mines but in the same ore body. The oxidized minerals are malachite, azurite, chrysocolla, cuprite and tenorite.

The sulphide ore minerals are chalcocite, bornite, chalcopyrite, covellite, linnaeite, and occasionally a little pyrite. Rarely, some native copper is found. The minerals occur as minute specks uniformly disseminated through the ore bed rock of silicified sandstones and shales. The average grain size is about 0.5 m.m., but many grains are discernable only under the microscope. Because of the presence of the cobalt mineral, linnaeite or carrollite, the sulphide ores carry 0.02 to o.46 per cent cobalt. This mineral is closely associated with the chalcopyrite. It is claimed that the amount of chalcopyrite increases with depth. The specific gravity of the ore is 2.8, very little higher than the barren rock.

All mining operations will be under ground. The Roan Antelope Mine is the closest to production. The eastern section, consisting of the nose of the syncline and both limbs for about 4000 feet, will be first mined. Several levels have been opened up from four incline shafts, two on each limb, and the main hoisting shaft has been put down in the footwall of the south limb. The concentrator is designed to treat 5000 tons of ore daily, provision being made for increased tonnage later. The ore hoisted in 10-ton skips will be crushed in gyratory and Symons cone crushers, ground in two stages by ball mills provided with ample bowl classifier capacity, and concentrated by flotation. The concentrates will be thickened, filtered, partially dried and smelted without preliminary roasting in a standard reverberatory furnace and the matte converted into blister copper. Pilot mill test conducted on 3.5 per cent copper ore from development showed a concentration ratio of 15.5 to 1, a recovery well over 90 per cent in a concentrate averaging from 50 to 65 per cent copper. Very fine grinding is necessary, the ore having to be reduced to practically all through 200 mesh to liberate the mineral sulphides.

At the N'Kana mine, considerable development has been done on the North ore body. It is planned to open it up through four inclined and two vertical shafts, one of which will be the main hoisting shaft. The Mindola ore body will be opened up by a number of inclined shafts

spaced at convenient intervals along the outcrop. It is planned to equip N'Kana for a daily capacity of 10,000 tons of ore. Crushing will be done in gyratory and cone crushers followed by rolls in circuit with screens. The concentrator and smelting equipment will be similar to the Roan Antelope. A pilot mill has been in operation working out the details of the concentration practice, the concentrates from which will be smelted at the Bwana M'Kubwa plant. It is also planned to use the Bwana M'Kubwa leaching plant for the treatment of the oxidized ore.

At Mufulira, the richest sulphide mine of the copper belt, development is in progress. The pilot mill at the Roan Antelope is being used to work out the details for their concentration plant. It is proposed to equip this mine for 10,000 tons daily capacity. It is reported that the concentrates will be treated at the Roan Antelope smelter.

At the N'Changa mine, a certain amount of development has been done on the North lode, where levels have been run from the shaft at 150 and 300 feet. On the Dambo lode, two inclined shafts have followed the ore down for 600 feet at which depth a level was driven. The ore mostly oxidized and the method of treatment has to be worked out and established. Development is also retarded by the present lack of railway connections.

Roan Antelope, N'Kana and Mufulira have established rail connections with the main line. Progress is such that Roan could be brought into production in 1932 and N'Kana and Mufulira by 1934 or 1935. An annual production of 150,000 tons of copper could be established by 1936 from these three mines and increased to twice this amount in a further few years if world conditions warrant it.

At present, the rail outlet is southward to Bulawayo in Southern Rhodesia and thence to Beira on the East coast or southward to South African ports. The railway under construction from Lobito bay on the West Coast to connect with the main line north of Elizabethville in the Belgian Congo will shortly be completed and give a more direct outlet to Europe and America. Lobito is some 3,000 miles closer to European copper markets than Beira, the rail haulage from the mines being about the same distance.

There are many problems to be solved in bringing the mines into production, none of which are insurmountable, and all are gradually being worked out. The system of mine development and stoping to be employed requires careful study. With the ore beds dipping at various angles to almost vertical no one system will apply to all the mines or to the various sections in the same mine. The drainage water during the rainy season of these

great synclinal basins has to be controlled. Especially is this a problem in the heavy wet ground of the N'Changa mine. The mines with their concentrators and smelters will require a large power supply. Up to the present this is generated from coal from the Wankie Collieries in Southern Rhodesia, about 600 miles distance from the mines. A closer and cheaper source of coal is being investigated as is also the development of a certain amount of hydro-electric power. The labour supply, which has been so successfully solved on the Rand, will no doubt be handled in a similar manner, although climatic conditions are not so good and the source of the native labour supply who take kindly to mining operations is further afield. This latter problem will be met as far as possible by mechanization. Steps are being taken to control the tropical fevers and make living conditions better for both white and black. These are a few of the more important problems which have to be met and which will retard the bringing of the mines to the producing stage.

Belgian Congo: In the adjoining province of Katanga, of the Belgian Congo, the 1929 production of copper was over 150,000 tons. This production was by one Company, the Union Miniere du Haut Kantanga, which controls all the mineral occurrences in this section of the Belgian Congo and is greater than either Chili Copper or Utah copper, formerly the two world's largest producers. This large production was chiefly from huge deposits of oxidized and partly oxidized copper minerals, the average recovery being about 7 per cent copper to the ton of ore treated. Reserves are estimated at more than 70,000,000 tons, sufficient for 30 years at the present rate of production.

Union Miniere du Haut Katanga produces over one-half of the world's requirements of cobalt. Sales in 1929 amounted to 700 metric tons and resources of cobaltic copper ores have increased. She produces almost the entire world's supply of radium, the sales for 1929 amounting to about 60 grams of the radium element. Tin is also mined in appreciable quantities.

Labour Supply for the Mineral Industry: In every mining field of the world, the supply of trained white labour for the development and operation of mines and for the construction and operation of metallurgical works, has not been a serious problem. Men have gone from Europe and America to all parts of the globe to assist in opening up the world's mineral wealth. They came to the diamond fields of Kimberley, to the gold mines of the Witwatersrand and to the other mining districts of the Union and Southern Rhodesia, and carried on mining and metallurgical

operations, just as efficiently and progressively as in Europe and America. And so to the mines of Northern Rhodesia, experienced operators and skilled workmen will be drawn to the great copper fields as they were to the Rhodesian Broken Hill Mines and the mines of the Belgian Congo, where conditions are very similar. The Universities, Colleges and Technical Institutes of the Union of South Africa are turning out professional and trained men who will seek employment in the newer mining fields.

The supply of unskilled labour is a more difficult problem. The existence of the mineral industry in Africa depends very largely on the natives who under the direction of the whites, performs all the unskilled work and to some extent the skilled work. In the Union, native labour for the mines is to a large extent imported from Portuguese East Africa. The natives of the Union and the Rhodesias do not take to mining, preferring agriculture and surface employment or living on their reserves.

In order to assure the mines of the Union of a supply of unskilled labour, it was found necessary to form Native Recruiting Agencies or Labour Associations. These recruit and bring the natives to established depots, distribute them to the mines, look after their health and return them to their kraals after their term of contract has expired. Some such organization will have to be formed for a steady supply of native labour for the copper mines of Northern Rhodesia. In the Union there are about 340,000 natives employed in the mining industry. In the Rand mines alone there are about 210,000. The white force is about 22,000. Assuming that the same proportion will be required to operate the Rhodesian Copper Mines, there will be required for the production of 300,000 tons of copper, a force of 65,000 natives and 6,500 whites.

In the mines of the Union, the average wage of the white employee is $5.00 per shift and for the native fifty to sixty cents per shift. The mines have, therefore the advantage of cheap native labour, although this labour complicates the social problems of the country. One must admit that the low cost of mining is largely due to native employment as a comparison of figures shows that one white man receiving $5.00 per shift in a Canadian mine produces as much ore as five natives receiving a maximum of sixty cents a shift in a Rand Mine. It is also doubtful whether white labour could produce very much more per man shift than the native, working in the hot humid atmosphere that prevails in the deep levels of the Rand. Were it not for this cheap labour, much of the Rand and other reefs would not be profitable. Widths of 18 inches to 2 feet are being mined on the Rand, at Pilgrims Rest and Sabie in the eastern Transvaal, of the Platinum-bearing Merensky reef, of the chrome beds and other similar narrow mineral occurrences. The Rand owes the great depths to which mining operations are carried largely to the native labour, with which it will be possible to go to even greater depths.