Anniversary Address by the President

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MINERAL RESOURCES OF SOUTH AFRICA AND THE RHODESIAS AND THEIR IMPORTANCE IN RELATION TO THE MINERAL WEALTH OF THE BRITISH EMPIRE.

In this address I shall endeavour to give an outline of the principal mineral resources of South Africa, including South-West Africa, and Northern and Southern Rhodesia, their present and future importance, particularly in regard to the mineral economy of the British Empire as a whole.

It will be useful to obtain, at the outset, a broad conception of the importance of the mineral resources of these territories and I propose to introduce my subject by statistics of Empire mineral production. For purposes of comparison I shall use production figures for the year 1935, which was a year of relative prosperity—the first since 1929—and for which Empire and World statistics have been compiled by the Imperial Institute as set out in the tabulation overleaf :—

In 1935 the value of the mineral production of South Africa amounted to about 21 per cent. and that of the Rhodesias to about 3 per cent. of that of the Empire ; outside the United Kingdom itself South Africa leads, Canada coming next with 16 per cent.

It may come as a surprise to some of you that the United Kingdom, which relies on imports for most of her mineral requirements, should produce minerals equal in value to those of South Africa, Canada and Australia combined. This is, of course, on account of the immense importance of the English coal industry, which, in 1935, produced coal to the value of £144,542,000 out of the total of £165,807,000, or about twice the value of the gold produced on the Witwatersrand in the same year.

Apart from coal, the United Kingdom is not a major producer of mineral wealth. To better illustrate the importance to the Mother Country of South Africa and other Empire countries as a source of minerals other than coal, I have subtracted the value of the coal

VALUES OF THE BRITISH EMPIRE MINERAL OUTPUTS, 1935.

	Value of output, 1935 £ sterling.	Percentage of total value.	Chief minerals produced. Figures show percentage value of the country's output.
United Kingdom	165,807,000	41·84	Coal, 87 ; building and roadmaking materials, 8 ; iron ore, 1
Union of South Africa ..	84,074,000	21·21	Gold, 91 ; coal, 4 ; diamonds, 3
Canada	63,446,000	16·01	Gold, 37 ; coal, 13 ; nickel ore, 11 ; copper ore, 10 ; lead ore, 3 ; silver, 3 ; zinc ore, 3 ; asbestos, 2
Australia	21,014,000	5·30	Gold, 30; coal, 24; silver-lead and zinc ores, 17; iron ores, 8
India	19,520,000	4·92	Coal, 25 ; petroleum, 24 ; gold, 12 ; silver-lead and zinc ores, 11 ; manganese ore, 5 ; tin ore, 4
Federated Malay States ..	9,400,000	2·37	Tin ore, 95 ; gold, 2 ; coal, 1
Southern Rhodesia ..	6,256,000	1·58	Gold, 81 ; asbestos, 10 ; coal, 5
Northern Rhodesia ..	5,300,000	1·34	Copper ore, 87 ; zinc ore, 5 ; cobalt ore, 4
Gold Coast	3,758,000	0·95	Gold, 68 ; manganese ore, 18 ; diamonds, 14
New Zealand	3,057,000	0·77	Coal, 55 ; gold, 34
Trinidad	2,033,000	0·51	Petroleum, 94
New Guinea	2,000,000	0·50	Gold, 100
Nigeria	1,830,000	0·46	Tin ore, 77 ; gold, 15 ; coal, 5
Unfederated Malay States ..	1,135,000	0·29	Iron ore, 60 ; tin ore, 30
Newfoundland	1,095,000	0·28	Lead-zinc ores, 58 ; iron ore, 37
Sierra Leone	900,000	0·23	Diamonds, 55 ; gold, 24 ; iron ore, 20
North Borneo, Brunei and Sarawak	730,000	0·18	Petroleum, 70 ; gold, 28
Naru and Ocean Islands ..	700,000	0·18	Phosphate rock, 100
South-West Africa ..	683,000	0·17	Diamonds, 80 ; vanadium ore, 9 ; manganese ore, 3
Other Empire countries ..	3,600,000	0·91	Gold, 31 ; petroleum, 7
TOTAL	396,000,000	100·00	

production for the various countries in the foregoing tabulation, and recalculated the proportionate value of their mineral production. The results are as follows :—

VALUES OF BRITISH EMPIRE MINERAL OUTPUTS, 1935.
EXCLUSIVE OF COAL.

	Value of output (£)	Per cent. of total value.
United Kingdom	21,265,000	9·34
Union of South Africa	80,534,000	35·39
Canada	54,922,000	24·13
Australia	15,971,000	7·02
India	14,616,000	6·42
Federated Malay States	9,300,000	4·09
Southern Rhodesia	5,916,000	2·60
Northern Rhodesia	5,300,000	2·33
Gold Coast	3,758,000	1·65
New Zealand	1,376,000	·61
Trinidad	2,033,000	·89
New Guinea	2,000,000	·88
Nigeria	1,740,000	·76
Unfederated Malay States	1,135,000	·50
Newfoundland	1,095,000	·48
Sierra Leone	900,000	·40
North Borneo, Brunei, Sarawak	730,000	·32
Naru and Ocean Islands	700,000	·31
South-West Africa	683,000	·30
Other Empire countries	3,600,000	1·58
	£227,574,000	

In this tabulation South Africa produces about 35 per cent. of the Empire's mineral wealth as against 21 per cent. in the previous case, and the United Kingdom only about 9 per cent. as against almost 42 per cent. This figure of 9 per cent. is made up, for the most part, by building materials and other non-metallic minerals, and the United Kingdom is largely dependent on imports for her requirements of metals.

The principal mineral resources of South Africa and the Rhodesias are gold, copper, diamonds, asbestos, cobalt, chrome ore, manganese ore, platinum group metals and vanadium. Coal and iron must be viewed in a different light from that in which other minerals are considered in this address and they are dealt with separately. Short notes are also included on other mineral deposits.

In dealing with the various minerals, I have included statistical tables giving World and Empire production, for the last few years, as well as local production and value. World and Empire figures have been taken from the statistical summaries of the Imperial Institute, whereas South African and Rhodesian figures are from the local government returns. In the latter case sales production has been taken as production, and while this may not be exactly equivalent to the actual output in any one year, the general average would be about the same over a period of years.[1]

To attempt to give more than the briefest description of the principal deposits would be beyond the scope of this address and such descriptions as I shall give are merely intended to afford an insight into their nature and geological background. Detailed descriptions of most of the deposits are available in numerous publications, a list of which is included.

GOLD.

	1936	1937	1938	1939
PRODUCTION— (Troy Ounces)				
World	35,000,000	35,500,000	36,750,000	—
Empire	18,600,000	19,720,000	21,200,000	—
Union of S.A. ..	11,336,215	11,734,575	12,161,392	12,821,507
S. Rhodesia ..	797,061	804,219	814,078	795,613
VALUE—	£	£	£	£
Union of S.A. ..	79,494,202	82,556,604	86,669,623	98,942,800
S. Rhodesia ..	5,632,444	5,656,693	5,820,531	6,227,282

Union of South Africa :

It is unnecessary to elaborate on the recognised importance of the gold deposits of the Union, but it is interesting to note that the total gold produced in South Africa to date, approximately 366 million ounces, is estimated to be more than a quarter of all the gold produced in the world during the last 450 years.

Less than 2 per cent. of the Union's annual gold production is derived from sources other than the Witwatersrand gold fields, and the " Rand," as it is popularly called, only need be considered in this outline.

In 1939 the gold production of the Rand was derived from 43 larger mines ; over 58 million tons of ore was milled and the average recovery grade was 4·23 dwt. per ton. The Crown Mines, the Rand's largest mine, and the largest gold mine in the world produced nearly

[1] This accounts for certain differences in production figures given in the Imperial Institute publications and those of the Union of South Africa. It should also be noted that the former are in long tons and have been converted to short tons to conform with local records.

one million ounces of gold from about 4 million tons of ore milled. An "average mine," in a Witwatersrand sense, is one in which milling would be at the rate of about 100,000 tons of ore per month.

The producing mines are grouped in what is called the Central Rand, the West Rand and the East Rand Basin.[2] The gold deposits occur as auriferous interbedded conglomerates in a succession of sedimentary rocks known as the Witwatersrand system. The Witwatersrand sediments, in the typical section of the Central Rand, attain a thickness of about 25,000 feet and are divided into the Lower Witwatersrand Beds, with a thickness of about 15,000 feet comprising a succession of quartzites, shales, and argillaceous quartzites, and the Upper Witwatersrand Beds with a thickness of about 10,000 feet, consisting of quartzites with a single important shale member known as the Kimberley Shales. A typical Central Rand section is given in Plate I showing in graphic form, the character of the sedimentary succession and the lesser sub-divisions of the System.

The gold-bearing interbedded conglomerates, locally known as "reefs," are wonderfully regular and persistent; they occur for the most part in the Upper Witwatersrand Beds, and consist of highly indurated conglomerates with 2 or 3 per cent. of sulphides mostly pyrite. Of these, the conglomerates of the Main Reef Group and of the Kimberley Reef Group are the most important. The Main Reef Group, or Main Reef Series, as it is popularly though less correctly called, is the source of by far the major portion of the Rand's gold.

On the Central Rand this Group consists of three separate conglomerates which are, in ascending order, the Main Reef, the Main Reef Leader and the South Reef. The Main Reef is usually 4 or 5 feet thick and occurs a few hundred feet above the upper contact of the Jeppestown Shales, which is the line of demarcation between the Upper and Lower divisions of the Witwatersrand System. The Main Reef Leader is usually less than three feet above the Main Reef but frequently in contact with it though invariably separated from it by a well defined parting plane. It is on the whole narrower than the Main Reef but more compact and better defined. The South Reef occurs from less than 60 feet to more than 120 feet above the Main Reef and is usually from 2 to 5 feet wide. All three reefs have yielded large amounts of gold on the Central Rand, but the Main Reef Leader has been the most productive.

On the East Rand, the Main Reef Group is represented by a single conglomerate bed and it rests directly on the Jeppestown Shales and consequently at the contact between the Upper and Lower divisions of the Witwatersrand System.

[2] Venterspost is the only large producing mine outside these limits.

The Kimberley Reef Group is much less important than the Main Reef Group as a gold producer but is mined on the West Rand and to a small extent on the East Rand. It is also less well defined, consisting of one or two economic horizons, associated with numerous other conglomerate bands of low gold content, spread over 500 feet or more of the sedimentary sequence. The lower members of the Group usually occur a few hundred feet above the Kimberley Shales.

Outcrop areas of Witwatersrand rocks are relatively few and mark the peripheral portions of a major synclinal basin nearly all of which is buried beneath younger formations. From Johannesburg the rim of the syncline extends eastwards to Benoni, then around the East Rand Basin to the outcrop areas of the Heidelberg district, where it becomes greatly fragmented by faulting, but extends southwards and eastwards to beyond Greylingstad, where its further course is uncertain. Westwards from Johannesburg the base of the syncline trends to Krugersdorp, and southwards and westwards to the Vaal River near Klerksdorp. Beyond Klerksdorp in the west and Greylingstad in the east, the extent and southern limits of the synclinal basin are unknown. The Vredefort-Parys area is an elevated dome within the major synclinal basin in which overturned Witwatersrand sediments encircle an upthrust plug-like mass of granite (Fig. 1).

The Witwatersrand, as a mining field, came into being on the Central Rand, where the system, and particularly the productive reef horizons, are well exposed at the surface. Within a few years of the original discovery in 1886 mining operations spread over the Central and West Rand. Mining activity also took place near Nigel at an early date, and outcrop areas of Witwatersrand rocks in the Heidelberg, Vredefort and Klerksdorp areas were actively prospected. Towards the end of the century mining operations began to extend from the Central Rand to the northern portions of the East Rand, and the presence of a basin-like area, in which Witwatersrand sediments were covered by a relatively small thickness of younger rocks, was soon suspected. The major structural features of the East Rand Basin were established as early as 1910, but it was not until about 1920 that this portion of the Rand came into its own.

At the close of 1930 the mines were still confined to the Central Rand, the East Rand Basin and the West Rand, but beyond these boundaries, where exploration had been dormant for many years, investigations were being initiated to the west in what subsequently was to become known as West Witwatersrand Areas.

The abandonment of the Gold Standard by the Union in December, 1932, gave rise on the Rand to a period of activity and expansion, second only to that which followed the original discoveries. The most important results which have taken place have been the increased

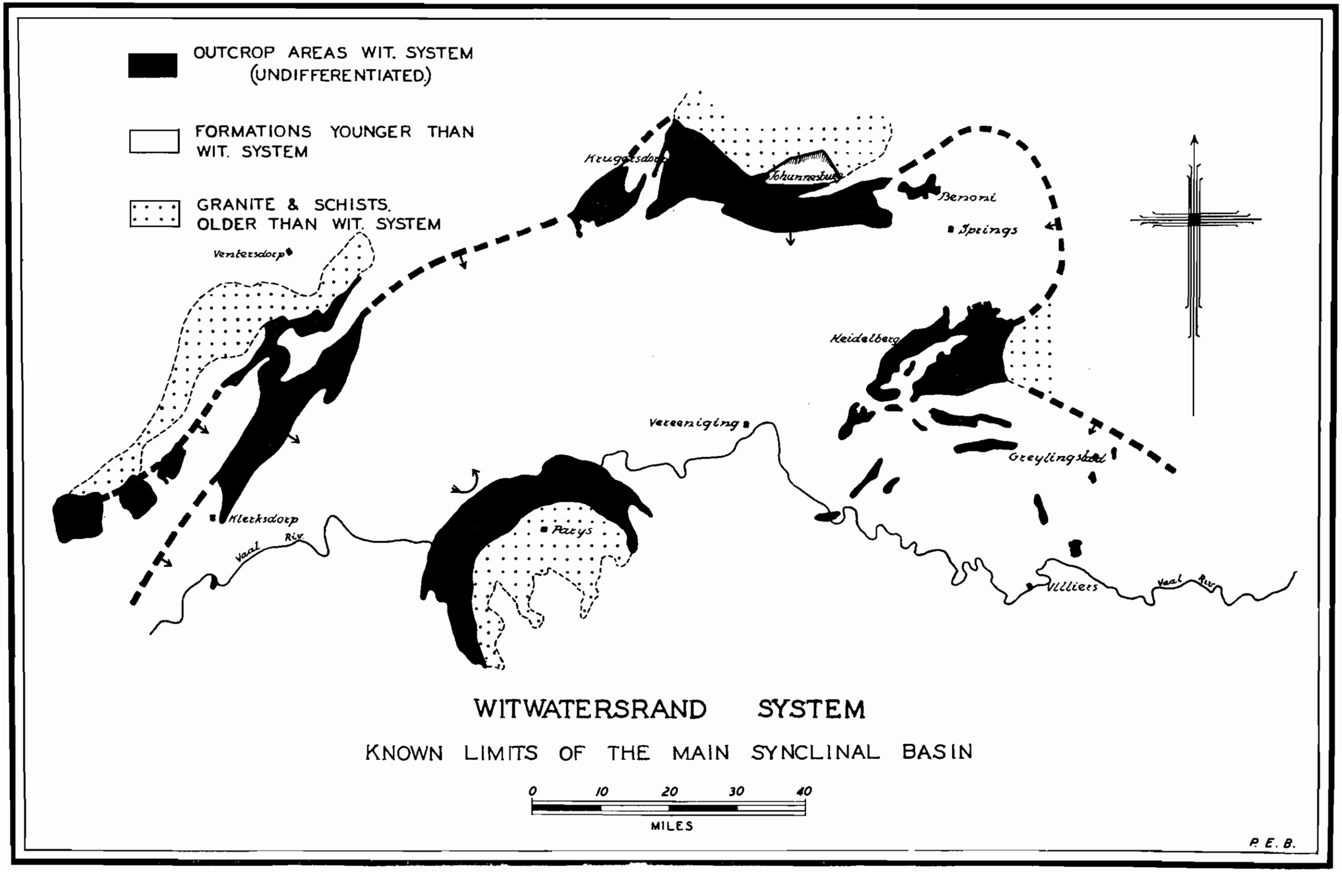
OUTCROP AREAS WIT. SYSTEM (UNDIFFERENTIATED)
FORMATIONS YOUNGER THAN WIT. SYSTEM
GRANITE & SCHISTS. OLDER THAN WIT. SYSTEM
Ventersdorp
Johannesburg
Benoni
Springs
Heidelberg
Vereeniging
Greylingstad
Klerksdorp
Parys
Vaal Riv.
Villiers
Vaal Riv.
WITWATERSRAND SYSTEM
KNOWN LIMITS OF THE MAIN SYNCLINAL BASIN
0 10 20 30 40
MILES
P. E. B.

FIG. 1.

scale of operations on most of the existing mines, the establishment of new mines particularly in the East Rand, and, most important of all, exploration on a vast scale for extensions of the productive horizons of the Witwatersrand System, under cover of more recent formations, far beyond the traditional boundaries of the Central, West and East Rand.

In the existing mines, the increased scale of operations has been primarily directed to mining a larger proportion of lower grade ore, and between 1932 and 1939 the tonnage milled increased by nearly 70 per cent., whereas the amount of gold produced increased by only 10 per cent., and the average grade of ore mined decreased from 6·37 dwt. to 4·23 dwt. The higher gold price has enabled existing mines to exploit large quantities of hitherto unpayable ore and will greatly add to their life.

On the Central Rand one large mine, Rand Leases, and a smaller mine, Rietfontein Consolidated, were reopened and brought into production, and on the West Rand the East Champ d'Or mine was revived. On the Central Rand, and on the West Rand, future expansion is largely a question of mining down the dip to progressively greater depth. The increased price of gold has been of particular benefit to these mines, which have the advantage of being able to exploit at least two, and sometimes three or more reef horizons.

Within the East Rand Basin, development was carried out on no less than sixteen properties, most of them virgin ground (Fig. 2). Of these, eight were brought into production during this period, namely, Nigel, Vogelstruisbult, Van Dyk, S.A. Lands, Grootvlei, East Daggafontein, Marievale, and Wit. Nigel. Of the remainder, Vlakfontein will be brought to production in the near future ; development has been suspended on the others in some cases owing to war conditions, and before sufficient reef development could be carried out to adequately define their possibilities.

The limits of the East Rand Basin will ultimately be determined by the reef becoming too deep to mine, on account of the westerly dip resulting in the progressive increasing thickness of the cover in this direction. While this still holds, the work of the last few years has shown that these factors operate more slowly than was previously supposed, and the depth of reef in the most westerly of the East Rand properties has proved to be less than was expected. This is owing to the fact that the westerly dip of the Witwatersrand sediments in this area is not uniform, and recurring local anticlines, interrupting the continuity of the basin, bring the reef to shallower levels so that the westerly limit of the basin, from a mining point of view, has been appreciably extended.

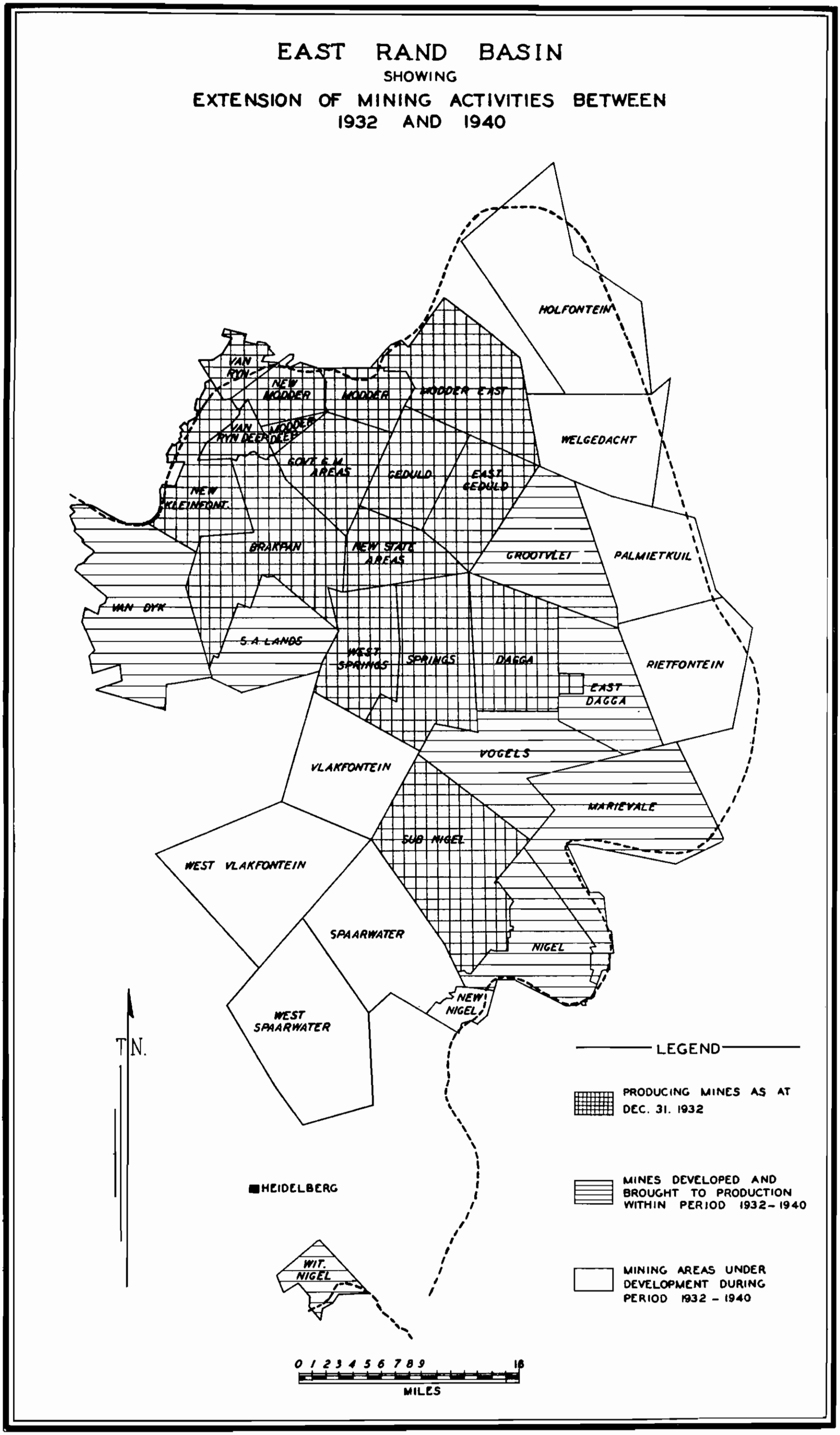
EAST RAND BASIN
SHOWING
EXTENSION OF MINING ACTIVITIES BETWEEN
1932 AND 1940
HOLFONTEIN
VAN RYN
NEW MODDER
MODDER
MODDER EAST
VAN RYN DEEP
MODDER DEEP
WELGEDACHT
GOVT. G.M. AREAS
GEDULD
EAST GEDULD
NEW KLEINFONT.
BRAKPAN
NEW STATE AREAS
GROOTVLEI
PALMIETKUIL
VAN DYK
S.A. LANDS
WEST SPRINGS
SPRINGS
DAGGA
RIETFONTEIN
EAST DAGGA
VOGELS
VLAKFONTEIN
MARIEVALE
SUB NIGEL
WEST VLAKFONTEIN
SPAARWATER
NIGEL
NEW NIGEL
WEST SPAARWATER
T.N.
LEGEND
PRODUCING MINES AS AT DEC. 31. 1932
MINES DEVELOPED AND BROUGHT TO PRODUCTION WITHIN PERIOD 1932-1940
MINING AREAS UNDER DEVELOPMENT DURING PERIOD 1932 - 1940
HEIDELBERG
WIT. NIGEL
0 1 2 3 4 5 6 7 8 9 18
MILES

FIG. 2.

Notwithstanding the expansion within the known portions of the Rand, the most notable achievement of the last ten years has been, in my opinion, the results of the extensive exploration for the productive horizons of the system in virgin areas, under cover of more recent formations, and in some cases far remote from the producing Witwatersrand. The Main Reef Group having proved by far the most consistently profitable economic horizon was naturally the prime objective. It will be recalled that this horizon occurs at or just above the dividing line between the Lower and Upper divisions of the system. The Main Reef Group was not exposed in the majority of areas under investigation, and the problem was to locate it beneath the cover of younger rocks, guided in some cases by exposures of Lower Witwatersrand rocks, and in other cases in the absence of such assistance.

Geophysical methods of prospecting were for the first time extensively employed on the Rand, the magnetometric method proving particularly valuable on account of the presence at several horizons within the Lower Witwatersrand of well defined magnetite-rich shales which could be detected, and from which the position of the Main Reef Group could be approximated.

Explorations outside the producing Witwatersrand can be grouped in respect to the following areas :—

(*a*) South and south-east of Heidelberg and in the Vredefort district (Outcrop Areas).

(*b*) East of the East Rand Basin.

(*c*) South-west from Randfontein to the Vaal River beyond Klerksdorp.

(*d*) The northern portion of the Orange Free State.

(*e*) Between Krugersdorp and Lichtenburg.

Plate No. I has been drawn up to illustrate the position and approximate extent of the territory covered by the more important of these investigations, relative to the producing portion of the Witwatersrand. Only areas in which drilling or intensive geophysical investigation took place have been taken into account, on the basis of including the farm boundaries within which such work was done. It will be appreciated how widespread this work has been, and the large extent of the area investigated, in comparison with the entire producing portion of the mining field. The area so investigated is furthermore relatively small compared with the area which has been held under option at one time or another during this period by a large number of companies and a host of speculators. Had all the ground under option been included, the producing Rand would by comparison have appeared very small indeed.

The outcrop areas south and south-east of Heidelberg, and the extensive exposures in the Vredefort district, were actively prospected towards the beginning of the century, but work was eventually abandoned and these areas were largely forgotten in the face of much more promising developments in other portions of the Rand. It was believed that they might hold out some promise in view of the increased price of gold, and the relatively small capital outlay required, and they became the scene of renewed activity on the part of numerous small mining companies. These activities did not, however, produce discoveries of importance, and most of the investigations were abandoned at an early date.

East of the East Rand Basin, large scale activities, including detailed magnetometric investigations, followed by diamond drilling, were carried out to investigate the possibility of the existence of a further synclinal basin of Witwatersrand sediments beyond the granite boss east of Heidelberg. The existence of Witwatersrand sediments in this position was actually established but only Lower Witwatersrand rocks were encountered in drilling, and the cover of younger rocks proved much greater than anticipated. The inference to be drawn is that the productive horizons of the system would sub-outcrop further east under increasing cover and probably at great depths.

To the south-west of Randfontein an extensive tract of country up to the Mooi River was intensively explored for the most part by West Witwatersrand Areas. The north-easterly portion of this area had been investigated before, but work was abandoned in 1910, mainly owing to shaft sinking difficulties. West Witwatersrand Areas was the pioneer in the exploration of outside districts, activities having begun in 1930 before the abandonment of the gold standard, and it was here that geophysical investigations were first applied on a large scale on the Rand. A large amount of exploratory work and drilling was carried out up to the beginning of the war, and the position of the Main Reef Group and the general geological structure have been defined over practically the whole of this area, equivalent to a strike distance of about 30 miles, constituting an important potential extension to the Witwatersrand mining field. Three subsidiary mining companies, Venterspost, Libanon and Blyvooruitzicht were formed to develop portions of this area, and Venterspost, the first large mine to be brought into production outside the hitherto traditional boundaries of the Rand, began crushing eighteen months ago.

Beyond the Mooi River in the direction of Klerksdorp a considerable amount of exploration was carried out by Middle Witwatersrand Areas, but the results have been inconclusive.

In the Klerksdorp district a great deal of work was done, principally by Western Reefs. This district was the scene of mining activity as far back as the earliest days of the Rand, and a number of small mines have been in production, at one time or another, on various reef horizons in the Witwatersrand System, which forms extensive outcrops in the neighbourhood. The prime objective of Western Reefs, in the beginning, was to explore the Main Reef Group of conglomerates, which occurs beneath younger formations. Results were not promising as the conglomerates of the Main Reef Group were found to be poorly developed, but encouraging borehole intersections were obtained south of Klerksdorp on a reef group in the Elsburg Series, much higher in the stratigraphic succession. The initial results were confirmed by further drilling over a considerable area, justifying the formation of a subsidiary mining company, which will shortly be brought to the producing stage.

In the northern portion of the Orange Free State exploration has taken place in widely separated areas, from the Vaal River south of Klerksdorp to Theunissen. For several years results were disappointing, except over a small area immediately adjoining Western Reefs on the south side of the Vaal River. The tide turned in 1938, when spectacular intersections were obtained from drilling by Western Holdings south of Odendaalsrust, which has since disclosed over a strike distance of more than 10 miles, two potentially valuable reef horizons at moderate depths, and about 60 feet apart. Any final correlation of these reefs is premature in the present state of our knowledge, and might be the subject of controversy, but a large section of geological opinion tentatively assigns them to the Elsburg Series, possibly equivalent in a general way to the reef horizons at Western Reefs. Had these results been available at an earlier date, mining development would no doubt have been under way by now, this venture having been affected by the unavoidable financial restrictions imposed by the war. Nevertheless, an area of great potential value has already been indicated.

West of Krugersdorp and north of Lichtenburg, investigations were carried out in certain areas, on the assumption that a further syncline of Witwatersrand rocks might be present to the north of the existing Witwatersrand basin, under cover of more recent formations. The presence of Witwatersrand rocks was neither proved nor disproved, but in the areas investigated it was shown that the reef horizons, if present, must occur beyond mining depths.

The period of intensive development continued unabated till April, 1937, when on a certain Friday, of painful memory to many speculators, the stock market received a heavy setback owing to rumours of pending restrictions in the gold production. These rumours ultimately proved unfounded, but the market never recovered, owing to the progressive and rapid deterioration of the international situation which followed. Though at present, and for some time to come, further exploration and expansion on the Witwatersrand must of necessity be largely curtailed, the Witwatersrand Mining Industry may look forward to large potentially valuable fields for future expansion.

In concluding these remarks, I would like to recall the view expressed to us, as mining students at McGill University in 1922, by our lecturer in mining, that the Rand had probably passed its peak and that the future outlook would be one of slow but progressive decline. To-day, nearly twenty years later, the same cannot be said. Even on the Central Rand many of the oldest mines have, with the increased price of gold and the ever greater depths to which mining becomes possible, a long life before them and in the East Rand Basin many new mines have recently come into production. For the first time, large mines with a promising future have been proved in extensions of the Witwatersrand System outside the Rand proper, and new fields for future expansion have been discovered, which give promise of offsetting for a considerable period retrogression owing to the exhaustion of existing mines.

Southern Rhodesia :

Southern Rhodesia has for many years claimed fourth place after the Union, Canada and Australia, among the gold producing countries of the Empire. The colony's output is distributed amongst more than 1,500 individual producers. The Cam & Motor is Rhodesia's largest gold mine and returned 86,898 ounces during 1939. The larger mines are the mines yielding over 10,000 ounces per annum ; there were eleven such mines in 1939, and they accounted collectively for 41 per cent. of the total output. A further 34 per cent. of the output was from 117 mines, with outputs of between 1,000 and 10,000 ounces per annum. The remaining 25 per cent. was made up from over 1,400 producers, generally known as the "smallworkers." The small-worker constitutes a characteristic, and rather colourful, section of the Rhodesian mining community ; he operates on the scale of a five stampmill or less, is usually a self-trained man, and has frequently taken to mining from other walks of life. Rhodesian gold deposits with their widespread distribution and sporadic values, frequently enriched in their upper levels owing to the agency of surface waters, and the added advantage of cheap native labour, afford a field of operations for this class of worker, which is perhaps unrivalled any-where else in the world.

The gold deposits are found in the Basement Schists, or as they are popularly called the "Gold Belt Schists" of Southern Rhodesia, and to a lesser extent, in the marginal areas of the granite batholiths which enclose them. The Basement Schists include a great variety of very ancient and intensely altered volcanic and plutonic rocks, together with associated sediments, now represented by greenstones, epidiorites, banded ironstones, altered tuffs, and many varieties of schists. They occur as remnants of erosion in irregular, though widely distributed, belts or ribbon-like areas, constituting the deeper portions of the original formation, preserved as roof pendants within the granite which intruded and enfolded them. Plate II shows the distribution of these belts and their relationship to the enclosing granite. The Basement Schists from Gwelo to Hartley are the most productive of the Colony.

The outcrop portions of almost all the larger Rhodesian mines were marked by ancient workings. The origin of these workings, and the identity of the people responsible for them, still remains largely a matter of conjecture.

It is impossible in an outline such as this to do more than allude to a few important types of deposits, as exemplified by the larger mines, both past and present, as the most remarkable feature of Rhodesian gold deposits, as a whole, is their dissimilarity. Among the most important are the shear zones, with impregnation and replacement of the country rock by gold-bearing sulphides and quartz. The Cam & Motor, Shamva, Rezende, and to a large extent the Wanderer, belong to this class. The well-defined quartz vein, approximating the true fissure vein type, finds an outstanding example in the Globe & Phoenix, which has produced more gold than any other Rhodesian mine to date, and where a truly remarkable branching quartz vein has been mined continuously for 40 years. Other mines in this class are the Lonely, the Fred, the Queens and the Tebekwe. This type of deposit is very popular with the small worker, and well suited to his requirements, being easy to mine and frequently high grade. Gold deposits within the banded ironstones are also a very common type, and are extensively mined in their shallower portions, where they have been enriched, by surface agencies, but they become, as a class, unpayable below the water table.

The abandonment of the gold standard by Southern Rhodesia in September, 1931, gave, as in South Africa, great stimulus to the expansion of the gold mining industry. The gold production which in 1931 was 532,111 ounces had by 1936 increased to 797,061 ounces, which figure had previously been exceeded only during the years 1914 to 1917. Since then the rate of production has not varied a great deal, and it seems that the maximum increase, due to the higher gold price, has now been reached. The increased gold output has been largely due to the re-opening of many of the older mines, and it is a matter of regret that, notwithstanding all this increased activity, no large gold mines have been discovered in Southern Rhodesia for many years.

COPPER.

	1936	1937	1938	1939
PRODUCTION— (in Short Tons)				
World	1,890,000	2,600,000	2,250,000	—
Empire	395,000	516,000	524,000	—
N. Rhodesia ..	159,413	233,169	238,595	237,068
Union of S.A. ..	12,196	13,920	14,683	16,378
VALUE—	£	£	£	£
N. Rhodesia ..	5,669,142	11,564,571	8,885,629	9,444,371
Union of S.A. ..	385,571	610,192	464,466	537,306

Northern Rhodesia has taken its place in recent years among the world's most important copper producers despite the almost crippling conditions of world depression and exceptionally low copper prices under which the mines first came into production. That they were able to establish themselves on a sound and profitable basis in the face of these difficulties, and of restricted outputs, was a notable achievement indeed.

The copper output is derived at present from the N'Kana, Roan Antelope, and Mufulira mines[3], and another large mine, the N'Changa mine, is being brought into large scale production. The resources of these copper fields are very great, ore reserves aggregating to more than 500 million tons averaging 4·0 per cent. copper have already been proved and there is no doubt that Northern Rhodesia will in time assume still greater importance in the world's production of copper.

The rise of the Northern Rhodesian deposits from doubtful prospects to recognition as one of the world's most valuable copper fields, in the space of about five years, from 1926 to 1931, is one of the most interesting chapters in the recent history of mining. It is a chapter of particular interest to us as members of this Society, as geology played an outstanding part in this development.

The Copper Belt of Northern Rhodesia which is understood to include the area within which the principal mines are situated, is a narrow strip of country adjoining the province of Katanga in the

[3] Including the Chambishi property.

Belgian Congo, to the west and south-west. It forms part of the great plateau embracing the major portion of Northern Rhodesia, which is an ancient peneplain uplifted in a comparatively recent geological epoch.

The copper occurrences, which were subsequently to develop into such important mines, were known since the early years of the colony. Notwithstanding cursory development work carried out on them at various times, they attracted little attention, their true character and potentialities remaining unsuspected until the present investigations were instituted, which can be said to have resulted in their re-discovery. The reason for this neglect can be readily understood, when it is realised that the earlier investigators must necessarily have contrasted them with the copper deposits of the Belgian Congo. Though both the Congo and Rhodesian deposits belong to the same metallogenetic epoch, local conditions have been very different, resulting in the formation of deposits of very dissimilar type. In the Congo the deposits occur in dolomitic rocks under conditions that favour the development of rich oxidised ore at the surface, and experience had shown that these deposits passed, without secondary enrichment, into lean and worthless primary ore at a relatively shallow depth. The Rhodesian deposits, on the other hand, occur in more siliceous rocks, in an environment conducive to a certain amount of leaching at the surface and development of secondary sulphides in depth. This was a feature which the earlier investigators can hardly have been expected to appreciate, and by comparison with the Congo, where oxide ore averaging as much as 6 or 7 per cent. copper was already considered of doubtful value, the lean outcrop ores of the Rhodesian deposits appeared of little consequence, especially as the inference was that the best ore was on the surface and that the grade would diminish with depth. These facts, apart from their interest from the historical standpoint, show in a striking manner the importance of a proper understanding of the genesis of ore deposits, from the point of view of practical estimates of the value of mining prospects.

The copper deposits occur within the lower portion of a succession of sediments which has been variously called the Bwana M'Kubwa Series and the Roan Series. It has now been established that this series corresponds to the Serie des Mines (Mines Series) of the lower portion of the Katanga System as previously established by Belgian geologists in adjoining parts of the Congo.

The System of the Katanga is sub-divided into the Mines Series and the Kundelungu Series. The Mines Series is over 5,000 feet thick, consisting of a lower group of feldspathic quartzites, argillaceous sandstones, dolomitic shales and dolomite, followed by a middle group, mainly of dolomite, and an upper group of dark shales with a few beds of sandstone. The copper deposits of Northern Rhodesia occur within the lower group, and those of the Congo within the middle group, of the Mines Series. The Kundelungu Series has a thickness of about 15,000 feet and rests disconformably on the Mines Series. It consists of a basal conglomerate of the nature of a tillite, succeeded by dolomites and shales and eventually by great thicknesses of sandstones of a marked purplish colour.

In the Copper Belt the Katanga System was originally laid down on a floor composed of extremely ancient granites, gneisses and schists constituting the Basement Schist complex of Northern Rhodesia, analogous to the archaean basement complex of many countries (Plate III). Subsequent earth movements, accompanied by granite instrusions (younger granites) folded the Katanga sediments into synclines and anticlines trending north-west by south-east. Prolonged denudation has served to strip the greater part of these sediments from the Copper Belt, where they now appear as remnants in the former synclinal areas within the older rock. The largest of these synclinal areas can be traced from Bwana M'Kubwa north-westwards to beyond Mufulira near Mokambo. Remnants of other synclinal basins are the Roan Antelope basin, the N'Kana-Chambishi basin and the N'Changa basin.

The geological mapping of the Copper Belt and the delimitation of the principal copper deposits was worked out for the most part from 1927 to 1929, when the Copper Belt was the scene of extensive and well planned geological investigations. In this region outcrops are scarce, and a deep blanket of residual soil 50 to 100 feet deep almost always masks the character of the underlying rocks. Even in the case of the larger mines, outcrops of the lode were few and inconspicuous, representing but a small fraction of the actual extent of the orebody, as subsequent investigations were to disclose. The possibility that the deposits would occur on definite sedimentary horizons was suspected at an early date. Certain beds of more resistant rocks, giving rise to more frequent outcrops, served as markers and proved of great assistance in approximating the position of other horizons including the ore-carrying beds. Prospect pits were extensively used, in advance of drilling, to pick up the ore horizon beneath the cover of soil. These pits were usually sunk to depths of 50 to 100 feet which, in most cases, was sufficient to enable identification of the underlying bedrock. Many miles of pits were put down and the extensions of the deposits first proved in this way. Pitting was also widely used in conjunction with general geological mapping throughout the Copper Belt.

Diamond drilling followed closely upon the delimitation of the outcrop position of the orebodies by pitting. The boreholes were disposed in a grid pattern so as to section out the orebodies in regular blocks (Fig. 3). Drilling was begun in the second half of 1927 and was continued on an enormous scale during the three years that followed. As early as 1929 the future position of the Roan Antelope, N'Kana, Mufulira and N'Changa had been assured amongst the world's large copper mines. The deposits were, in addition, so regular in structure and so uniform in their copper content, as to allow of the estimation of ore reserves on drilling results alone, and reserves running into hundreds of millions of tons were built up in this manner. This was almost uprecedented in a virgin mining field and was the subject of some criticism at the time, but subsequent mining developments confirmed ore reserves calculated in this way.

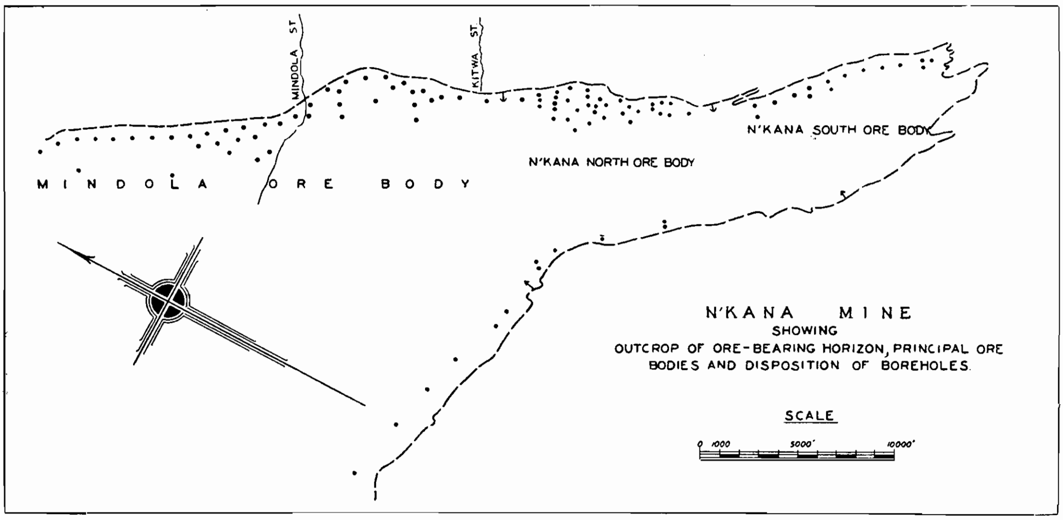

FIG. 3.

The Northern Rhodesian copper deposits occupy the same general stratigraphic position in the lower group of the Mines Series, just above the feldspathic quartzites and interbedded conglomerates which form the lowermost division of the Series. At the Roan Antelope, N'Kana, and Chambishi mines, the ore-bearing horizon consists of sandy and slightly dolomitic shales, about 20 to 120 feet in thickness, known as the " ore shale." At Mufulira the corresponding horizon is represented by more arenaceous and more dolomitic rocks, and three separate horizons have been mineralised within a stratigraphic interval of about 100 feet. At N'Changa the ore shale gives rise to the river lode, and feldspathic quartzites slightly higher in section, to the Dambo lode on opposing limbs of the same syncline.

The Roan Antelope, N'Kana, and N'Changa mines are situated close to the nose of tightly folded and pitching synclines. At the Roan Antelope, the syncline is very narrow and shallow and the entire synclinal basin is ore-bearing. At N'Kana only the northern limb of the syncline has been exploited to date, and the Chambishi deposit occupies a further extension of the same limb. At N'Changa slightly different horizons are mineralised on either limb. Mufulira is situated on the westerly limb of the extensive syncline trending from Bwana M'Kubwa towards Tshinsenda.

In the Rhodesian deposits surface oxidation usually extends to depths of from 250 to 300 feet where finely disseminated malachite is the predominant copper mineral. Near the surface leaching is usually in evidence and copper values are impoverished. Below the oxidised zone mixed oxide and sulphide minerals occur over a vertical distance of about 100 feet, below which the proportion of the sulphide minerals increases to the rapid exclusion of the oxides. N'Changa is an exception and the oxidised zone is much deeper than average, and mixed sulphide and oxide ores persist to considerable depths. In view of the relatively shallow depth of the oxidised zone, oxidised ore is of little consequence in the Copper Belt, and the ore mined consists almost exclusively of sulphides. These sulphides consist of chalcocite, bornite, and chalcopyrite. Secondary sulphide enrichment has been an important factor, but the extent to which this has taken place is a subject of controversy. The chalcopyrite is primary, most of the chalcocite is undoubtedly secondary, but opinions are divided as to whether the bornite is primary or secondary, and whether a portion of the chalcocite might not be of primary origin. The copper sulphides are very uniformly disseminated in minute crystals, throughout the ore shale or other host rocks.

It is generally agreed by geologists who have studied the deposits in detail that they owe their origin to copper-bearing solutions emanating from the instrusions of younger granite. The localisation of the deposits to definite stratigraphic horizons is ascribed to the impounding effects of these beds, with the resulting slow percolation into them of the metalliferous solutions and the re-deposition within them, of the copper-bearing minerals in the neighbourhood of intrusions of younger granites.

Union of South Africa :

Copper has been produced at Messina in the Northern Transvaal for a long period of years. The Messina deposits occur in the granite gneiss within a well-defined shear zone up to 1,000 feet in width, extending in a north-easterly-south-westerly direction for many miles. A persistent dolerite dyke occurs within the shear zone and is credited by some as being the source of the copper mineralisation. The rocks in the shear zone are extremely altered and the orebodies take the form of lenticular quartz replacements, and parallel quartz veins within the shear zone with chalcocite, chalcopyrite and bornite in nodular masses or disseminated crystals. An interesting feature of this deposit is the exceptional purity of the copper produced which is comparable in this respect to electrolytic copper. These deposits supply the entire output from the Union at the present time.

The historical deposits of Namaqualand discovered by Governor Simon van der Stel in 1685, which produced copper to a value of over £21,000,000 between 1852 and 1935, are also about to recommence production on a fairly large scale under the aegis of an American company. The available reserves are estimated at 10 million tons of ore containing about 2·45 per cent. copper. These deposits, of which the O'okiep mine is the most important, are typical examples of syngenetic ores consisting of magmatic segregations of chalcopyrite and bornite in basic dykes, intrusive into granitic gneisses and metamorphosed sediments.

South-West Africa :

The principal copper occurrence in the Mandated Territory is at the Tsumeb mine from which the Ovambo native tribes mined copper ore prior to 1851. The Tsumeb deposit consists of two large elliptical ore-lenses dipping at about 60°, and roughly parallel to the bedding planes of the Otavi Dolomite in which the deposit is located. The orebodies were found to be oxidised to a depth of over 400 feet, the minerals comprising the usual copper, lead and zinc carbonates. The sulphide ores comprise mainly chalcocite, argentiferous galena, zincblende, pyrite, enargite and chalcopyrite. The increase in the proportion of zinc in the ore from the deepest levels introduced serious metallurgical problems.

High grade ores are shipped direct to the consumers while the lean ores are concentrated, smelted and shipped as a copper-lead-silver matte. Substantial quantities of piglead and cadmium dust are produced as by-products.

Most people still think of diamonds exclusively as gems. To obtain a proper understanding of the present position and future of the diamond industry, it is important to realise that during the last ten years the utilisation of diamonds for industrial purposes has enormously increased, so that the larger proportion of the world's diamond output by weight now consists of industrial diamonds or boart. Unfortunately most statistics do not yet discriminate between the

DIAMONDS.

	1936	1937	1938	1939
PRODUCTION— (Metric Carats)				
World	8,258,000	9,617,000	11,620,000	11,330,000
Empire	2,883,488	3,757,491	3,415,946	3,005,728
Union of S.A. ..	623,923	1,030,434	1,238,608	1,246,670
S.W. Africa ..	184,917	196,803	154,856	35,470
VALUE—	£	£	£	£
Union of S.A. ..	2,125,216	3,444,678	3,496,243	2,604,172
S.W. Africa ..	918,113	1,015,536	767,159	—

two classes of stone, which renders any analysis in terms of total production, as given in the table above, distinctly misleading, unless these factors are taken into consideration. Previous to 1930 the Union of South Africa and South-West Africa together consistently produced over half the world's diamonds, whereas in the last five years this proportion has only been from 9 to 13 per cent. Undoubtedly competition from diamond fields in other parts of the world, notably the Belgian Congo, the Gold Coast, Sierra Leone, Angola and British Guiana has, to some extent, deprived South Africa of her privileged position in the diamond market, yet it must be realised that industrial diamonds, of which South Africa does not produce a large amount, have accounted for the apparent large increase in the diamond output in recent years. The bulk of the production from the Belgian Congo, which is now more than half that of the world by weight, and about six times that of South Africa, is of this class. As regards stones of gem quality, South Africa and South-West Africa still produce the larger proportion of the world's requirements and, as the value of stones of gem quality is proportionately much higher, the South African production is over one-third of the total value of the world's annual output, though in quantity only about one-tenth.

With the disturbed conditions of the world in recent years and the consequent decline in the sales of gem quality diamonds, the increasing use of industrial diamonds has been a great asset to the diamond industry, and is likely to be more so in the future, especially as diamonds for gems and for industrial uses are not competitive, the two classes being devoted to entirely different uses, the economic factors affecting the demand for the one bearing no relation to that for the other.

Industrial diamonds include cleavage fragments, waste from cutting operations, and inferior stones from the gem deposits, but these constitute only a small proportion of the supply. The principal source of supply is from diamond fields producing small diamonds of a quality unsuitable for use as gems, and generally designated as "boart." Boart is graded in sizes and quality in much the same manner as gem diamonds.

Boart is chiefly used in diamond drilling, the technique of which has been revolutionised in recent years by the substitution of boart for "carbons" in drilling crowns and in the manufacture of diamond-set tools, particularly lathe tools and diamond dies. The successful application of boart-set crowns, or diamond-impregnated alloys, in drilling is of particular importance in that it may lead to the adaptation of diamond drilling methods for rock breaking, which has received considerable attention, particularly in Canada. Should this prove successful the demand for industrial stones would be enormously increased.

In the South African diamond fields in general the proportion of industrial diamonds to gem stones is, on the whole, probably about one-third of the present production, and a good proportion of this amount is made up of waste from cutting operations, together with other material which can only be crushed. Industrial stones could, however, be obtained from deposits not at present being worked—notably the Premier Mine—should the demand justify this.

Union of South Africa and South-West Africa :

No other branch of mining has captivated the popular imagination so vividly as that of the diamond fields of South Africa. The element of romance that characterised the initial finds in river gravels, followed by the discoveries of diamond-bearing pipes from 1870 to the end of the century, has been kept alive by discoveries of new alluvial fields, those of South-West Africa in 1908, Lichtenburg in 1926, and Namaqualand in 1927, and by occasional spectacular discoveries of large stones by individual diggers up to the present day.

The diamond deposits fall into two well defined classes, volcanic pipes and alluvial deposits.

The name of Kimberlite has been applied to the porphyritic ultrabasic lava, which forms the filling of these pipes ; it is a variety of peridotite, characterised by an unusual number and diversity of accessory minerals. From the surface down to a maximum depth of about 150 feet the Kimberlite weathers to a yellowish clay, the "yellow ground" of the early miners, grading into "blue ground," as weathering becomes less intense, and finally in parts or wholly into "hardebank," a less altered type, which refuses to weather.

The diamonds occur as an original, if infinitesimal constituent of Kimberlite, in amounts according to one authority averaging less than one twenty-two thousandth of 1 per cent.[4]

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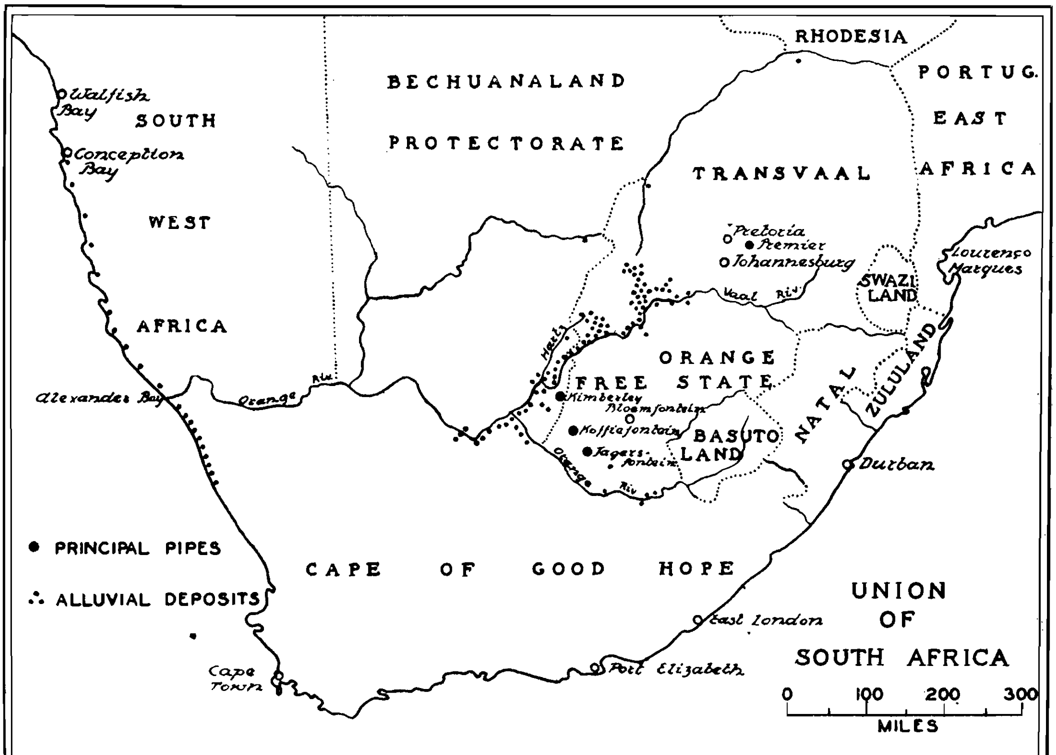
[4] A. L. du Toit, *Geology of South Africa*, p. 463.

About 150 Kimberlite pipes have been discovered so far, of which 25 have been rich enough to mine, though most of the production has been from the following eight: Kimberley, Premier, Jagersfontein, Koffiefontein, Dutoitspan, Wesselton, Bultfontein and de Beers, distributed over a distance of 300 miles from Jagersfontein in the Orange Free State to beyond Pretoria in the Transvaal (Fig. 4).



DIAMOND PIPES AND ALLUVIAL DEPOSITS

Fig. 4.

It was the fortuitous occurrence of the Bultfontein, Dutoitspan, Kimberley, de Beers and Wesselton pipes, within a radius of a few miles from one another which led to the establishment of the town of Kimberley, which was built around them just as Johannesburg was to be built around the gold mines about 15 years later.

The Kimberlite pipes are of Cretaceous age and range from less than 100 feet to over half a mile in diameter; they are cylindrical or steeply funnel-like in shape, and in some cases are connected by Kimberlite filled fissures. Almost everyone has seen pictures of the

Kimberley opencast and has read accounts of how, in the early days, each individual miner worked his small claim independently and to different depths resulting in an impossible situation which was resolved by the ultimate merging of all individual interest into the De Beers Consolidated Mines.

The alluvial fields of the Union and of South-West Africa can be divided into those of the Orange and Vaal River basins, the Lichtenburg fields, the coast of South West Africa and Namaqualand.

The deposits of the Orange, Vaal and Harts rivers are distributed from Prieska to Vereeniging and occur on terraces bordering the present river channels, and high level terraces up to 400 feet above the river and several miles from it, and in gravels constituting former channels of the Vaal and Harts rivers. The gravels are unstratified consisting of boulders in a sandy or clayey matrix. These diamonds have clearly originated from diamond bearing pipes, and in some cases it has been possible to assign individual diamonds to known pipes.

In the Lichtenburg and Ventersdorp districts diamonds are found in irregular patches of gravel, or in "runs" which are the gravel remnants marking the course of ancient streams, which have been preserved from erosion not infrequently in sink-holes and solution-channels in the dolomite. The quality of the Lichtenburg diamonds is generally inferior to that of the Vaal River stones.

In South-West Africa alluvial diamonds occur along and slightly inland from the coast over a distance of some 300 miles from the Orange River in the south to Conception Bay in the north. From the Orange River mouth to near Bogenfels the diamonds occur in ancient marine terraces similar to, but slightly younger than, those at Alexander Bay and frequently covered by a heavy blanket of loose sea sand. From Bogenfels northwards, and particularly in the Pomona and Kolmanskuppe area, the diamonds occur in wind-swept depressions where they have been concentrated in the upper layer of sand and grits through the removal by wind of the lighter and finer materials.

The Namaqualand deposits occur along the coast south of the mouth of the Orange River for a distance of about 200 miles. The diamonds are found in marine gravels along the course of ancient beaches up to 200 feet above the present sea level. In the State Alluvial Diggings at Alexander Bay, an ancient beach about 125 feet above sea level is being worked, where diamonds of exceptional quality are recovered from a gravel run a few feet to 100 feet wide. The origin of the Namaqualand diamonds is still a matter of uncertainty, though they are most probably due to redistribution from the gravels of the Orange, Buffels and other rivers. Though the Namaqualand fields were discovered as recently as 1927, diamonds to a value of nearly 20 million pounds have already been recovered from them.

ASBESTOS.

	1936	1937	1938	1939
PRODUCTION— (in Short Tons)				
World	564,000	689,000	513,000	—
Empire	395,000	513,000	386,000	—
S. Rhodesia ..	56,346	57,014	58,810	58,313
Union of S.A. ..	25,237	28,069	22,282	23,220
VALUE—	£	£	£	£
S. Rhodesia ..	836,468	840,026	1,020,921	1,088,782
Union of S.A. ..	337,229	430,761	424,078	523,198

Southern Rhodesia comes second to Canada as an Empire producer of asbestos and takes third place, after Canada and Russia, in the world's production of this commodity. The asbestos industry of Southern Rhodesia ranks next to gold as the territory's most important mining industry, and the yearly value of the output is at present in the order of one million pounds.

From 1936 to 1939 asbestos fibre produced from Southern Rhodesia has been from one-seventh to one-fifth of the Canadian production for the same years. Corresponding figures for the Union of South Africa were somewhat less than half of the Rhodesian production. In comparison to Canada, Rhodesia suffers from being situated far away from the manufacturing centres, and cannot dispose of large amounts of inferior fibre, which constitutes a large proportion of the Canadian production.

Southern Rhodesia :

Asbestos is found in numerous localities in Southern Rhodesia, but the principal deposits occur at Shabani and in the Mashaba Hills about 26 miles west of Victoria.

In the Shabani district the deposits occur in a mass of dunite, partly altered to serpentine, about 9 miles long by 1½ to 3 miles broad and completely surrounded by intrusive granite (Fig. 5). Close to the granite contact the dunite and serpentine have frequently been converted to talc and calcareous schists. The greatest development of talc schists and serpentine occurs along the north-east rim of the mass and it is within this zone that the more important deposits occur, notably those of the Shabani and Nil Desperandum mines.

The Shabani Mine is by far the largest asbestos mine in Southern Rhodesia and has been in production since 1916. In this mine, and in the adjoining Nil Desperandum mine, the deposits occur in the form of lodes which are in the nature of stock-works consisting of innumerable ramifying seams and veinlets of asbestos sufficiently close together to permit the entire body to be mined. The lodes occur intermittently over a distance of several miles close to the contact of the serpentine and the surrounding talc schists and within half a mile or less of the granite contact. The boundaries of the orebodies are irregular and are defined economically by the pro-

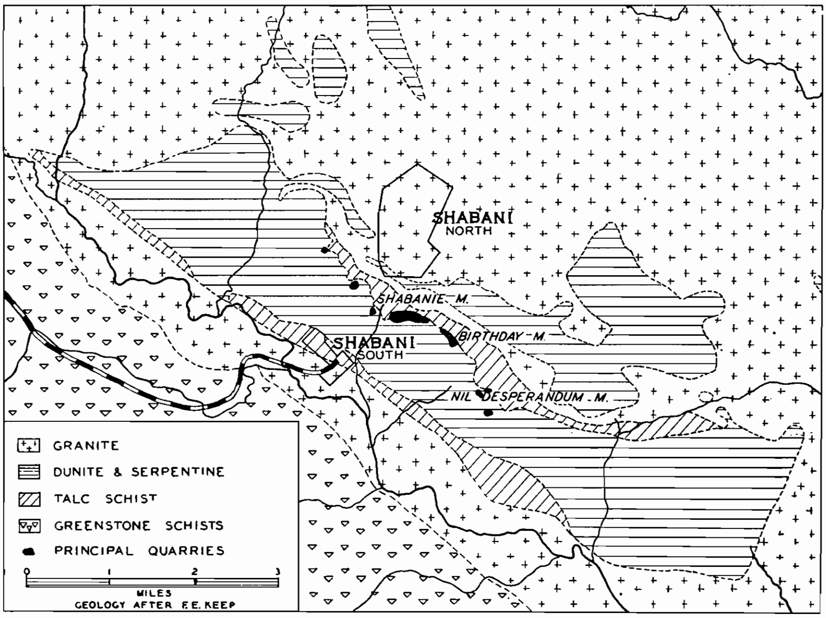


FIG. 5.

gressive diminution of the asbestos content to an unprofitable grade. The largest individual lode at the Shabani Mine has a length of about 2,000 feet and a width of 200 to 300 feet.

Until recent years mining operations have been conducted from huge opencasts ; while opencast mining is still being pursued most of the output is now derived by a cut and fill method of stoping with preliminary sorting underground and packing of the waste as stope fillings. The ore is handcobbed to a product containing 40 to 50 per cent. recoverable asbestos, which is sent to the mill for crushing and grading to conform with market specifications. The recovery of fibre is said to average from 2·5 to 3·75 per cent.

The deposits of the Mashaba Hills, where the Gath and King mines are the principal producers, also occur in a belt of serpentine and talc schists enveloped by granite.

Deposits of asbestos are worked in a small way in several other localities in Southern Rhodesia notably in the Umvukwe and Filabusi districts.

Union of South Africa :

A distinctive feature of the asbestos deposits of the Union is that in addition to chrysotile or serpentine asbestos, which is the common form of commercial asbestos the world over, they include economically important deposits of crocidolite and amosite asbestos which are fibrous forms of minerals of the amphibole group. In comparison with the best grades of chrysotile asbestos, crocidolite and amosite are not so easily spun or woven but are more resistant to acids and sea water and are better insulators, being mostly used in the manufacture of insulators and also in asbestos cement products. Their geological associations are also very different, chrysotile always occurring in serpentine or in serpentinized limestones or dolomites, whereas crocidolite and amosite are to be found associated with banded ironstone formations.

Chrysotile has been produced in the Union from the New Amianthus and Munnik-Myburg mines about 29 miles north-west of Barberton. These mines have become depleted in recent years, but this deficiency is being made good by the recently developed deposits at the Havelock mine in Swaziland which has now come into production. This orebody is from 4,000 to 4,500 feet long by 70 to 130 feet wide and ore reserves said to amount to some 14 million tons have been developed. All these occurrences are within belts of serpentine.

Crocidolite is known in the trade as blue asbestos on account of its characteristic blue colour. Large deposits of crocidolite are to be found in Griqualand West in the Cape Province, where they occur scattered over an area 250 miles long and about 30 miles wide, and are worked in numerous small mines. The crocidolite occurs in cross fibre veins up to about 2 inches wide in banded ironstones of Griquatown age. Important deposits of crocidolite also occur in portions of the Pietersburg and Letaba districts of the Transvaal in banded ironstones of the Pretoria Series and frequently intermixed with amosite asbestos.

Amosite resembles crocidolite in many of its properties, but it possesses the advantage over other types of asbestos of having a much longer length of fibre. Fibre 5 or 6 inches long is quite common in contrast to other types of asbestos, and it is, therefore, not graded on length of fibre, but on colour and quality. The best quality is the white fibre of great tensile strength, while the lower grades are progressively more yellow in colour.

The principal deposits are situated in the Pietersburg, Letaba and Lydenburg districts of the Transvaal, in the banded ironstones at the base of the Pretoria Series coinciding to some degree both stratigraphically and geographically with the crocidolite occurrences, both types of asbestos being frequently associated in the same deposits. The most important producing centre is near Penge in the Lydenburg district, where three groups of seams parallel to the bedding planes of the sediments are being exploited.

The Union's resources of crocidolite asbestos are enormous and those of amosite are also very great; there are also large areas of serpentine in the Union and Swaziland which have not been adequately prospected and within which additional reserves of chrysotile asbestos may be expected to occur.

COBALT.

	1936	1937	1938	1939
PRODUCTION: (Cwt.)				
World ..	44,100	68,300	76,400	—
Empire ..	22,900	27,400	36,900	—
N. Rhodesia	9,078	17,409	28,762	29,719
VALUE:				
N. Rhodesia ..	£228,809	£665,553	£1,369,076	£1,482,149

Northern Rhodesia:

The production of cobalt from Northern Rhodesia has risen rapidly in recent years, and constitutes the Empire's largest source of this metal and indeed is competing with that of the Belgian Congo for first place in the world's production of cobalt.

The entire Rhodesian output is derived from the N'Kana Mine, where cobalt occurs as the sulphide linnaeite in the copper ore. It is separated from the copper sulphides and concentrated by differential flotation.

Cobalt is used, alloyed with steel and other metals, for various purposes, notably for machine tools, rustless steels and permanent magnets. Alloyed with chromium and tungsten it is used to produce alloys of the Stellite type. The uses of cobalt are increasing and, particularly at the present time, the Rhodesian production is undoubtedly a very welcome asset to the Empire.

CHROME ORE.

	1936	1937	1938	1939
PRODUCTION :				
(Short Tons)				
World ..	1,164,000	—	—	—
Empire ..	453,000	567,000	457,000	—
S. Rhodesia ..	202,159	303,817	205,052	153,314
Union of S.A.	107,198	186,379	128,899	184,006
	£	£	£	£
VALUE :				
S. Rhodesia ..	250,739	367,386	242,217	186,577
Union of S.A.	182,909	344,037	239,888	347,604

Southern Rhodesia and South Africa are richly endowed with deposits of chromium. From 1913 to 1937 Southern Rhodesia has produced a total tonnage of chrome ore well over twice that of any other country in the world, and in recent years South Africa has come to rank amongst the world's largest producers.

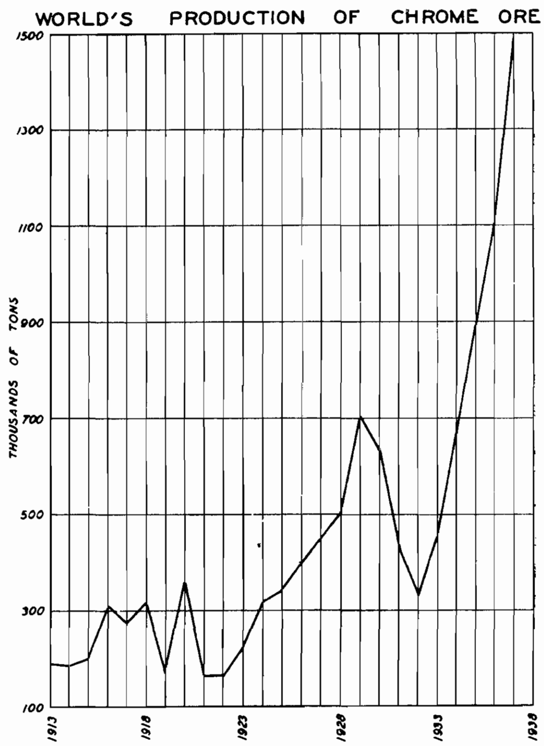


FIG. 6.

The uses to which chromium has been put have increased enormously in recent years as reflected by figures of world production shown in the accompanying graph (Fig. 6). This has been caused by the great development of chromium steels and other chromium alloys, particularly stainless steels, which contain from 12 to 30 per cent. chromium. Previous to this chromium ore was principally used for refractories and in the chemical industries.

Chrome steel on account of its hardness and toughness is used in production of armour plate. For armour plate and stainless steels there are no satisfactory substitutes.

Southern Rhodesia :

The principal deposits are situated around the town of Selukwe and in the Umvukwe range of hills in the Lomagundi district about 55 miles north-west of Salisbury.

At Selukwe the chromite occurs in rocks of the Basement Schists Complex consisting of talc and carbonated talc schists associated with serpentine and chlorite schists.

Mining activity is mainly centred in the immediate vicinity of the town in what is known as the Railway Block and about four miles further south around Selukwe Peak.

The chromite bodies range from vein-like occurrences to rounded and lenticular masses up to 400 feet long and 100 feet broad. Generally very irregular in outline, they may lie in any position enclosed in talc schist, but have a tendency to occur in groups, roughly parallel to one another and along the direction of foliation in the schists.

For many years mining operations consisted of quarrying and opencast mining, for which the deposits were well suited on account of the hilly nature of the country, but with greater depth, top slicing methods of mining have been increasingly used.

The grade of ore mined is said to average about 45 per cent. chromic oxide, but is raised by concentration to a product averaging about 50 per cent. of chromic oxide.

The Umvukwe deposits are genetically related to the Great Dyke, which in this vicinity is an enstatite-rock, partly or completely serpentinized, varying in width from two to three miles and flanked on either side by granite.

Chromite occurs in seams on both sides of the dyke, roughly parallel to its margins and dipping into it at angles of from 10 to 15 degrees, and thus simulating the structure of synclinal sedimentary beds. The seams are relatively narrow, a width of 30 inches being exceptional, but they are very persistent. The grade of ore from this field is very high and ore averaging as much as 54 to 57 per cent. chromic oxide is being mined.

The Great Dyke of Southern Rhodesia is intimately related to the Bushveld Igneous Complex of the Transvaal which contains the chromium deposits of the Union of South Africa. The deposits are practically identical in their origin and general mode of occurrence, and these aspects, which are dealt with more fully in the description of the deposits of the Union, apply equally to the Umvukwe occurrences.

Union of South Africa :

The chromium deposits of the Union are found in the Transvaal, where they occur in the marginal portions of the Bushveld Igneous Complex. They can be grouped in a western belt extending northwards from Brits and Rustenburg for about 100 miles and an eastern belt, in the Lydenburg district, extending in a north-south direction for 70 miles.

The chromite occurrences take the form of seams, from less than 1 inch to over 6 feet wide, in the lower portion of the gabbroidal rocks of the Bushveld Igneous Complex within a " stratigraphic " interval of 2,500 feet or less below the well-known platinum-bearing Merensky Reef horizon, which is a regional marker of great importance.

They owe their origin to magmatic differentiation, which is exemplified in this portion of the Bushveld Igneous Complex to a degree probably unequalled anywhere else in the world, giving rise to pseudo-stratification of igneous rocks of different composition as regular as the bedding of stratified sediments. The regularity of the seams and the fact that they frequently outcrop along hillsides, are conducive to inexpensive methods of mining.

In South Africa the designation of chromitite is usually given to chrome ore which is composed of closely packed granular chromite crystals, usually about 0·5 of a mm. in size, with gangue of pyroxenes or basic feldspar. Most of the South African ores are classed as friable in that they disintegrate rapidly in storage or in transit, but a certain portion of hard lumpy ore is sorted out and commands a higher price.

South African chrome ores are medium to low grade, averaging about 44 to 45 per cent. chromic oxide. The best quality washed ore attains a chromic oxide content of just under 50 per cent. Most of the South African ore is used in refractories and in the chemical industries.

At present most of the chrome production comes from the eastern belt in the Lydenburg district which is nearer to Lourenço Marques where the ore is sent for shipment, but high-grade deposits are also being worked in the western belt.

Reserves of South African chrome ore are enormous, the principal limitations to the expansion of the industry being transportation costs coupled with a somewhat low average grade of ore. In recent years gravity concentration has frequently been introduced resulting in an increase in the chromium oxide content of 1 or 2 per cent.

MANGANESE ORE.

	1936	1937	1938	1939
PRODUCTION :				
(In short tons) :				
World ..	5,900,000	6,700,000	6,500,000	—
Empire ..	1,700,000	2,500,000	2,100,000	—
Union of S.A.	236,861	557,210	422,757	388,154
VALUE :				
Union of S.A.	£259,461	£603,623	£560,602	£490,556

Union of South Africa :

In recent years the Union has become an important exporter of manganese ore, following the development of the extensive manganese deposits of the Postmasburg region. Production began in 1929 and, since 1930, exports of South African manganese have played an important part in the supply of this commodity. A record output was attained in 1937, when South Africa ranked third amongst the world's producers with an output exceeded only by Russia and India.

Manganese is of particular importance at the present time. Almost the entire world's output is consumed by the steel industry either as a desulphurising or deoxidising agent in the production of ordinary steels, or in manganese steel alloys, and manganese is classed as a strategic mineral of the first importance in the steel industry. Before the war Germany was the principal importer of South African manganese, but since the outbreak of hostilities exports have gone to the United Kingdom and to the United States.

The Postmasburg deposits are situated about 130 miles by rail north-west of Kimberley. They occur intermittently along the base of two parallel lines of hills for a distance of many miles. These parallel occurrences are known as the eastern and western belts, respectively, the latter following the Gamagara ridge for a distance of nearly 40 miles. The discovery of a third and more westerly belt, the Aucamprust-Kameelhoek belt has recently been made.

The Campbell Rand dolomitic limestones are the oldest rocks exposed in this vicinity and are overlain by a distinctive formation of brecciated banded ironstones, usually less than 200 feet in thickness, locally called the Blinkklip breccia. Both the dolomite and the breccia belong to the Transvaal System. The Blinkklip breccia is overlain unconformably by shales and quartzites of the lower Matsap Series of the Waterberg System.

The manganese deposits occur as irregular disconnected masses frequently tabular or funnel-like in shape, at or close to the contact between the dolomite and Blinkklip breccia. Meteoric waters have leached the manganese and iron constituents from the dolomite and redeposited them, as metasomatic replacements, in the rocks along this horizon.

The ore minerals consist mostly of manganite and braunite. The phosphorus content is low, usually less than 0·15 per cent. and the chief impurities are silica and iron. The bulk of the ore is of medium to low grade with 40 to 48 per cent. manganese, but first grade ores containing 50 per cent. or more of manganese with an iron content of from 5 to 8 per cent., are also mined. South African manganese ores have the great advantage, from the export point of view, of being unusually hard and not subject to losses in handling or in transit and they do not tend to disintegrate after prolonged storage.

The Postmasburg manganese deposits have been as yet imperfectly explored as there is ample ore available for mining to meet the present demands. This, together with the irregular nature of these deposits, renders it difficult to give estimates of ore reserves, but in the opinion of the Geological Survey these fields could sustain an annual output of half a million tons for at least 30 years.

PLATINUM GROUP METALS.

	1936	1937	1938	1939
PRODUCTION : (Troy Ounces)				
World ..	456,000	471,000	552,000	—
Empire ..	274,000	306,000	351,000	—
Union of S.A. :				
Plat., etc. ..	29,045	30,125	38,862	47,912
Osmiridium	5,371	5,667	5,884	6,076
VALUE :	£	£	£	£
Union of S.A. :				
Plat., etc. ..	176,292	237,663	223,776	302,370
Osmiridium	28,445	37,254	36,523	36,456

Union of South Africa :

It appears anomalous at first sight that the Union of South Africa, which possesses the world's largest platinum deposits, should produce only a comparatively small proportion of the world's supply. The limited demand for the metal, resulting in a sharp tendency to over-production and the fact that one-third of the world's output is derived as a by-product from the refining of copper and nickel ores of the Sudbury district in Canada, and therefore not competitive as regards costs of production, and that most of the remainder is from alluvial deposits, has prevented the large expansion predicted some fifteen years ago for the Union's platinum industry.

Although the world's consumption of platinum has on the whole increased in recent years, outputs and prices have fluctuated greatly and the expectation of a greatly increased demand for industrial uses has not been fulfilled, owing to the discovery of satisfactory substitutes for many uses for which it was believed to be indispensable. Over half the world's production is used in jewellery, and a large portion of the remainder in the chemical and electrical industries and in dentistry.

In the Union, platinum occurs in deposits of several types nearly all related to the Bushveld Igneous Complex, but those of the Merensky Reef are by far the most important.

The Merensky Reef is a distinctive band of pseudo-stratified igneous rock in the lower portion of the norite zone of the Bushveld Igneous Complex ; it is composed of hypersthene and bronzite, with small amounts of feldspar, and is usually studded with large crystals of diallage. It varies from a few feet to over thirty feet in thickness and is overlain and underlain by light coloured varieties of norite in comparison with which its dark colour stands out in considerable contrast, and it constitutes an invaluable marker for the correlation of the various pseudo-stratified igneous differentiates of the norite zone. It has been followed more or less continuously for a distance of about 100 miles in the Lydenburg and Pietersburg districts and about 180 miles in the Rustenburg district.

The platinoids are contained in the sulphides of the Merensky Reef, principally nickeliferous pyrite, pyrrhotite and pentlandite. Where the band is thin it carries platinum throughout but where the thickness becomes considerable, the platinum tends to be segregated in parts of the band. A thin chromite seam often marks the richest portion of the reef.

The richest sections of the Merensky Reef so far discovered are in the Rustenburg district where, over selected stretches, 5 and 7 dwt. per ton have been proved for several miles of strike.

The platinum deposits of the Union attracted a great deal of attention and there was a veritable platinum boom following the discoveries of the principal deposits about 15 years ago. Numerous mines were brought into production and the output rose from about

10,000 ounces in 1926 to 55,000 ounces in 1930. Following the collapse in the price of the metal to about one-third of its value many of the existing properties closed down. Three contiguous properties near Rustenburg amalgamated into the Rustenburg Platinum Mines Ltd., which since then has been the only producer. The output from this mine has been increasing in the last few years and in 1938 was over 53,000 ounces of platinum metals.

Osmiridium occurs in minute amounts in the Witwatersrand gold ores and between 5,000 and 6,000 ounces is recovered yearly as a by-product of the gold mining industry.

VANADIUM.

	1936	1937	1938	1939
PRODUCTION : (Short Tons : Metal)				
World ..	1,021	2,652	3,657	—
Empire ..	829	913	1,027	—
S. W. Africa ..	604	653	615	—
N. Rhodesia ..	225	259	412	423
VALUE :				
N. Rhodesia ..	£105,048	£132,708	£323,641	£333,709

The entire Empire production of Vanadium is derived from South-West Africa and Northern Rhodesia.

Vanadium is used in amounts up to 3 and 4 per cent., usually in conjunction with tungsten and chromium, or molybdenum and chromium, in high speed steel alloys and a growing demand may be expected from this source. It is also used to an increasing extent in the production of acid-resisting vessels, and as a catalytic agent in the chemical industries, and to a lesser extent in the electrical and ceramic industries.

South-West Africa :

Vanadium ores in the form of mottramite, descloizite and vanadinite are widespread in the Grootfontein district. The most important deposits are those of Abenab, Baltika and Tsumeb-West. The ore occurs as vanadates of copper lead and zinc in the form of concretions varying from pea-size up to blocks as large as a man's head. The concretions together with blocks of silicified dolomite lie in a base of reddish sand filling narrow but frequently very deep and extensive solution fissures in the dolomites of the Otavi Series, which are correlated with the Dolomite Series of the Transvaal System. In the Abenab Mine the deposits are being explored at a depth of over 600 feet from the surface. The walls of the solution fissures, in which the vanadium ores occur, are often encrusted with a thin layer of small crystals of these vanadates, while blocks of dolomite occurring in the fissures are frequently completely coated with the vanadium minerals.

The vanadium ore is recovered by mechanically concentrating the vanadium-bearing sands and the product is shipped as a concentrate containing about 19 per cent. vanadium pentoxide.

Northern Rhodesia :

Important deposits of vanadium are associated with the oxidised portions of the zinc and lead deposits at Broken Hill. The zinc and lead deposits occur as lenticular bodies replacing dolomitic limestones and having a core of massive sulphides, principally sphalerite and galena, surrounded by a shell of oxidised ore consisting of quartz, iron oxides, hemimorphite, with lesser amounts of zinc and lead carbonates, and vanadium minerals, principally descloizite and vanadinite. The vanadium minerals, in addition to being distributed in small amounts throughout the oxidised ore, are locally concentrated along fissures and cavities in the oxidised and even in the sulphide ore, and in the broken ground between the orebodies and the dolomite. Vanadium is recovered as a concentrate from selected vanadium-rich ore and in the form of fused pentoxide in the electrolytic treatment of the ordinary run of oxidized ore.

Coal and Iron.

The coal and iron deposits, and particularly those of the Union of South Africa, must be viewed in a different light from that in which the other mineral resources have been considered in this address. Exports of coal are proportionately small and practically no iron ore has been exported, but the coal mining industry of the Union is second only to that of gold in the value of production and in its importance in relation to the economic life of the Union, and the iron deposits have become a vital asset with the establishment of important steel industries in this country in recent years. Furthermore, the Union ranks among the leading countries of the world in respect of its reserves of coal and iron ore and these constitute an important source of potential mineral wealth of the Empire and are even of world importance.

Coal :

The Union of South Africa is richly endowed in deposits of coal which occur in all of the four provinces of the Union. The available reserves of South African coal have been estimated at the enormous figure of 225 thousand million tons, and, though a very large proportion of this tonnage is in respect of coal of inferior quality, sufficient good quality coal has already been proved to last this country for hundreds of years, even at a greatly increased rate of consumption, and no doubt more detailed investigations would disclose further large reserves.

In general, South African coals are of the bituminous or semi-bituminous type, with a tendency on the whole to a high ash content. The best quality coals come from Natal. First-grade Natal coals have a calorific value of 13·1 to 14 lbs./lb. and contain from 10 to 14 per cent. of ash. Next in quality are the first-grade coals of the Witbank area in the Transvaal with a calorific value of from 12·8 to 13·2 lbs./lb. and with 10 to 14 per cent. of ash. Anthracite coal is represented in considerable amounts in the Natal coal fields, due to the metamorphic effect of igneous intrusions within the coal-bearing strata. Coals suitable for coking, and gas production, especially the former, occur mostly in Natal but compared to other varieties, reserves of this type of coal, are rather limited.

In 1939, about 18 million tons of coal were produced in the Union of a total value of over $4\frac{3}{4}$ million pounds ; the Transvaal accounted for 66 per cent. of the production, Natal 25 per cent., and the Orange Free State 9 per cent.

Of this amount about 12 per cent. was exported, including bunker coal supplied to ships at local ports. Coal produced in the Transvaal and the Orange Free State, was distributed as follows : Electricity and industrial undertakings, 38 per cent., railways 28 per cent., the mining industry 16 per cent., general and domestic uses 13 per cent., bunker and export 5 per cent. Of the total coal sold in Natal, approximately half was exported and the balance taken by the railways, municipalities, industries and domestic consumers.

In recent years, the utilisation of the coal resources of the Union has received much careful consideration, notably by the Fuel Research Institute established in 1930 to investigate the fuel resources of the Union and their utilisation. A feature of particular importance has been the increasing use of coals of inferior quality situated close to large mining and industrial centres for the generation, on the spot, of electrical power by large power stations situated at the coal mines, a practice which has been attended with very great success.

Torbanite is also present in certain of the coal measures of the Transvaal and Natal. Torbanite yields on distillation from 20 to 100 gallons of crude oil per ton and a torbanite seam with an average thickness of 17 inches and an average yield of 40 gallons per ton is being mined 8 miles north of Ermelo. The torbanite is distilled at the mine and the crude oil refined on the Rand, the main product being petrol.

The principal coal deposits of the Union occur in the coal measures of the middle Ecca Series of the Karroo System.

The more important coal fields are those of the Witbank, Ermelo-Carolina, and Springs areas in the Transvaal, the Vereeniging area, on the borders of the Orange Free State and the Transvaal, and the Vryheid, Klip River and Utrecht coal fields in Natal. In addition there are several other coal fields of lesser importance, or still largely undeveloped, such as those of the northern portion of the Cape Province, the Lebombo and Waterberg areas of the Transvaal, and in Zululand.

The Witbank coal field is the most important producing field and accounts for about 40 per cent. of the total output at the present time. There are five distinct coal seams, four of which have been worked, but most of the production has been derived from the two lower seams, the Nos. 1 and 2 seams. The No. 1, or bottom seam, is from 4 to 10 feet thick and produces a bituminous coal eminently suitable for steam raising and is extensively worked in a number of mines. The No. 2 seam, or main seam, is the principal seam and is worked in most collieries. It averages about 19 feet in thickness and is separated from No. 1 seam by about 7 feet of coarse sandstones and shales. The coal from the lower portion of this seam is very hard, the calorific value varies between 12·6 to 13·1 lbs./lb., moisture from 1·5 to 2·0 per cent. and volatile matter from 25 to 35 per cent. It is a good steam coal and is at times a source of coking and gas coal.

In the Ermelo-Carolina area five seams are present, though in general only one seam, designated as seam " C," is worked. This seam is 5 to 6 feet thick and has an average calorific value of 12·1 lbs./lb. with a relatively high volatile content of 30 per cent. and an ash content of 13 per cent. It is a bituminous coal suitable for use as domestic coal, for steam raising and as a fuel for gas producers.

The Springs coal field is of small extent and the coal is of relatively inferior quality with an average calorific value of 9 to 11 lbs./lb., 7 per cent. moisture and high ash content, but on account of its situation on the Witwatersrand it is of considerable importance. There are three workable seams and most of the output is utilised in generating electric power for the use of the gold mining industry.

In the Vereeniging area, 10 to 30 feet of the lower portion of a low-grade coal seam averaging 60 feet in thickness is being worked. The coal is of an inferior quality, high in moisture and ash and varies in calorific value between 9 and 11 lbs./lb., but after washing most of the output is utilized for the generation of electrical power.

The Vryheid coal field is the most important in Natal and produces 50 per cent. of the coal output of that province. There are four important seams, the Alfred, Gus, Dundas and Coking seams. The

Gus seam averages 4 feet in thickness and is more consistent in width and quality than any of the others. Washed coal from this seam has good coking properties. The calorific value is high, 13·5 lbs./lb., the volatile content is about 20 per cent. and it is very suitable as bunker coal for marine purposes. The coking seam is narrow, being less than two feet, but is worked on account of its excellent coking qualities.

In the Klip River coal field a top and bottom seam varying from 2 to 6 feet and from 5 to 7 feet in thickness respectively are mined though the bottom seam is the more important. Two types of coal are produced ; the first is a hard coal high in volatile matter (about 30 per cent.) with a high ash fusion temperature and suitable for export and as bunker coal ; the second is a soft coal with a high calorific value (14·0 lbs. per lb.) and low volatile content and ash fusion temperature but with good coking properties.

The Utrecht coal field is a very large one, but has not as yet been properly investigated on account of its greater distance from rail. Five coal seams are present and are identical with those of the Vryheid area. The Gus and Dundas seams are being worked in portions of this coal field.

Southern Rhodesia has also deposits of coal in the Zambesi Valley and in the Limpopo basin. At present there is only one colliery, at Wankie about 45 miles south of Livingstone, which is producing slightly over one million tons annually and has very large reserves of coal of a quality equal to the best in South Africa. The output of the Wankie Colliery is absorbed locally and in the copper mines of Northern Rhodesia. In previous years it was an important factor in opening up the copper mines of the Belgian Congo.

Iron Ore :

The reserves of iron ore of the Union have been estimated at approximately 6,000 million tons, a figure only exceeded by the United States, France, Brazil and India. Of this amount, 120 million tons is high-grade hematite ore averaging about 60 per cent. iron, and from 1 to 5 per cent. silica, and low in sulphur and phosphorus. The remainder is made up of ores with 40 to 60 per cent. iron and between 5 to 25 per cent. silica. These estimates do not include several thousand million tons of titaniferous ores of the Bushveld Igneous Complex and Zululand, or the " near ores " of the Witwatersrand and Swaziland systems averaging less than 40 per cent. iron and high silica, reserves of which are almost inexhaustible and which in the far distant future might be rendered available by processes of benefication.

Iron ore is not exported from the Union[5] and mining of this

[5] Since the war small quantities of iron ore are being exported from the Union.

ore has been in conjunction with development of the iron and steel industry. Previous to 1917 practically no iron ore was mined as the only steel manufactured in the country was from scrap metal. From 1917 to 1926 a few thousand tons a year was mined for use in a small blast furnace at Newcastle, but it is only since 1934, when the large steel works of the South African Iron and Steel Industrial Corporation, better known as "Iscor," began operations that the mining of iron ore became at all important. In 1939 over half a million tons of iron ore was used for the manufacture of iron and steel in the Union.

The iron ores of the Union can be conveniently grouped as follows :—

(1) High-grade ores of the Lake Superior type, the principal deposits of which occur near Rustenburg and Postmasburg.
(2) Medium grade ores of the Pretoria Series and of the Ecca Series in the Transvaal and in Natal.
(3) Titaniferous magnetite deposits of the Bushveld Igneous Complex and in Zululand.
(4) Miscellaneous deposits.

The high-grade ores of the Rustenburg and Postmasburg districts are sedimentary ores, enriched by secondary iron oxides, and they resemble in their origin and mode of occurrence the well-known Lake Superior type of deposits.

In the Rustenburg district they occur along the Vliegepoort area on the Crocodile River as lenticular and tabular orebodies in banded ironstones at the top of the Dolomite Series. The ore is of exceptional purity and is mined at Thaba Zimbi for the blast furnaces at "Iscor." In the Postmasburg deposits the ore is similar and occurs in the same district as the manganese deposits already alluded to, either as enriched hematised portions of the Blinkklip breccia, or in the conglomerates and shales of the basal portion of the Gamagara Series, immediately overlying the breccia.

The Pretoria Series constitute the largest source of iron ore in the Union and the iron deposits are distributed over several hundred miles from Lydenburg in the east to Rustenburg in the west. The iron deposits are particularly well developed in the immediate neighbourhood of Pretoria, where they can be referred to three principal horizons, the Magnetic Quartzite, the Clay Band and the Daspoort horizons. The Magnetic Quartzite is a very persistent bed of arenaceous ironstone, from 7 to 20 feet thick, interbedded with quartzites and shales of the Timeball Hill division of the series. It forms the crest of the hills south of Pretoria and can be traced for hundreds of miles. According to one authority it is one of the greatest iron development of the country's base mineral resources, and the encouragement of secondary industries. A big step forward was the creation of an important national steel industry and, had not Iscor been available to us when war broke out, we should by now have been seriously handicapped in several branches of our industries and in our armament effort. War time, when certain articles are difficult or impossible to obtain, is particularly propitious for the development of new industries. In Canada there is taking place at present, a truly enormous industrial expansion and, though most of this work is in connection with armaments and will largely cease on the termination of the war, the plant will no doubt be converted to other manufacturing uses. South Africa in her present state of development and with her small European population cannot expect to become industrialised to the same degree, but there is, nevertheless, ample scope for advancement in this direction, especially in view of our very valuable and diversified mineral assets, and we may expect in the near future an increasing utilization of our mineral resources by South African industry, as well as increasing exports of raw materials to the markets of the world.

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GOLD :

Literature on the Witwatersrand gold deposits is very extensive, a selected list of references is given in *Mineral Resources of the Union of S.A.* For developments on extensions of the Witwatersrand in recent years, the following may be consulted :—

P. F. W. Beetz, "Contributions to the Geology of the Klerksdorp District," *Trans. Geol. Socy. S.A.*, Vol. XXXIX, 1936.

deposits of the world, if not the greatest.[6] Iron is also mined from this horizon for the steel works at Iscor. The Clay Band is a thin body of oolitic ironstone about 180 feet above the Magnetic Quartzite and from less than one foot to three feet thick. The Daspoort horizon is made up of two beds of oolitic ironstone and is best developed near Potchefstroom where the main bed is from two to eight feet thick. It is considerably above the Magnetic Quartzite and Clay Band horizons.

Iron ore, often of excellent quality, occurs interstratified with sandstones and shales of the Ecca Series of the Karroo System in many localities in Natal and the Transvaal. The ore mined for the New-castle blast furnace is from these deposits.

The titaniferous magnetite deposits of the Bushveld Igneous Complex are stratiform segregations in the gabbro zone of the complex, and identical in origin and mode of occurrence to the chrome and platinum horizons already described, but much higher in the norite body. They extend for hundreds of miles and constitute a vast reserve containing from 40 to 55 per cent. iron, but with about 16 to 19 per cent. of titanium oxide and therefore unsuited to present metallurgical requirements as an iron ore. There is an important deposit of titaniferous magnetite of magmatic origin in the Tugela Valley, near Middle Drift in Natal, containing from 9 to 20 per cent. of titanium oxide and 42 to 54 per cent. of iron and up to 0·75 per cent. of vanadium pentoxide.

Among the miscellaneous deposits may be mentioned the strati-form deposits interbedded with sediments of the Rooiberg Series in the Pretoria district, and hematite and limonite deposits occurring as metasomatic enrichments of ferruginous shales of the Lower Wit-watersrand beds near Wolmaransstad in the Transvaal.

In this connection it is of interest to note that several deposits of iron ore are known to exist in South-West Africa. Thus extensive deposits of high-grade magnetic Itabirites occur in the Damara System to the south-east of Windhoek and rather lower-grade deposits near Walfish Bay. Enormous deposits of high-grade hematite ores are known to exist in the Kaokoveld. As these deposits are within 200 miles of the Atlantic seaboard they may at some future date acquire considerable importance to the United Kingdom.

MISCELLANEOUS MINERALS.

Zinc and Lead :

The zinc and lead deposits of Broken Hill, Northern Rhodesia, which have already been mentioned in connection with vanadium,

[6] P. A. Wagner : *Union S.A. Geol. Surv.*, Memoir No. 26, 1928, p. 78.

have produced between 11,000 and 15,000 tons of electrolytic zinc annually in recent years together with a minor quantity of lead, most of which is exported to the Union. This mine has large reserves of high-grade lead and zinc ore which cannot be mined at present owing to water difficulties, but this is being overcome and a greatly increased production may be expected from this deposit in the future.

Tin :

Tin concentrates have been produced in the Union for over 30 years and are shipped mostly to the Straits Settlements for smelting. Average production in recent years has been about 1,000 tons of concentrates per annum, averaging from 60 to 70 per cent. metallic tin; in 1939 the production was 809 tons of concentrates valued at £93,306. The tin deposits of the Union occur in widely separated districts. In the Transvaal the principal deposits occur in the form of pipes, replacements along fissures and irregular impregnations within, and genetically associated with, the red granite of the Bushveld Igneous Complex, as in the Potgietersrust and Mutue Fides tin fields. Tin also occurs as fissure lodes in the quartzites of the Rooiberg Series which overlie the Bushveld Complex, in the Rooiberg and Leeuwpoort tin fields, about 40 miles west of Warmbaths. Alluvial tin deposits have been worked over a long period near Mbabane in Swaziland and in the Stellenbosch district of the Cape Province.

Alluvial tin deposits are also being worked in Southern Rhodesia from the Victoria district, where in 1939, 721 tons of concentrates were produced which realised £86,188.

Corundum :

The Union has been a producer of natural corundum for many years. The deposits cover an area of over 3,000 square miles in the Northern Transvaal and are related to pegmatitic intrusions and impregnations in basic rocks. Alluvial concentrations of corundum from these deposits are also worked. The product is marketed as crystal corundum consisting of crystals and fragments $\frac{1}{8}$ of an inch or more in diameter. Production is very variable but usually in the order of two or three thousand tons annually and is mostly exported to the United States.

Silver :

Slightly over one million ounces of silver is recovered annually from the refining of the gold bullion produced from the Witwatersrand and other gold mines of the Union of South Africa, and over 150,000 ounces from Southern Rhodesia gold bullion.

Other Minerals :

Among other minerals produced in relatively small quantities may be mentioned tungsten concentrates, nickel ore, iron pyrites, mica and tantalum concentrates and antimony ore from Southern Rhodesia, and fluorspar, nickel, tungsten, and iron pyrites from the Union of South Africa. In most cases production could be considerably augmented to meet an increased demand.

Conclusion.

I trust that this outline of the mineral resources of South Africa and the Rhodesias will have conveyed to you a realisation of their extreme importance and their remarkable diversity. The southern portion of the continent of Africa is one of the world's greatest storehouses of minerals and the major portion of this wealth falls within the territories we have been considering.

Gold dominates the picture, the value of the gold produced amounting to about four times the value of all the other minerals, but great importance must also be attached to the increasing exploitation of base metals in recent years. Fifteen years ago the great importance of the Northern Rhodesian copper fields was not even suspected, the chrome, manganese, asbestos and platinum mining industries of the Union have to a large extent been developed within a similar period, and iron ore has only become economically important during the last few years.

Base metals are likely to become much more important in future. The Rhodesian copper mines have not yet produced to full capacity and the copper belt still holds great additional resources. The same is true of many of the base metal resources of the Union. Exports of base metals are handicapped by transportation charges—particularly rail charges to the coast—and, of course, there is the long transport by sea to the principal consuming centres in Europe and America. These disabilities can only retard the great expansion that must eventually take place owing to the depletion of more favourably situated deposits in other countries, and to the increased demand for these commodities, notably metals used for steel alloys. I believe that even our iron ores will find an important export market before many years have passed.

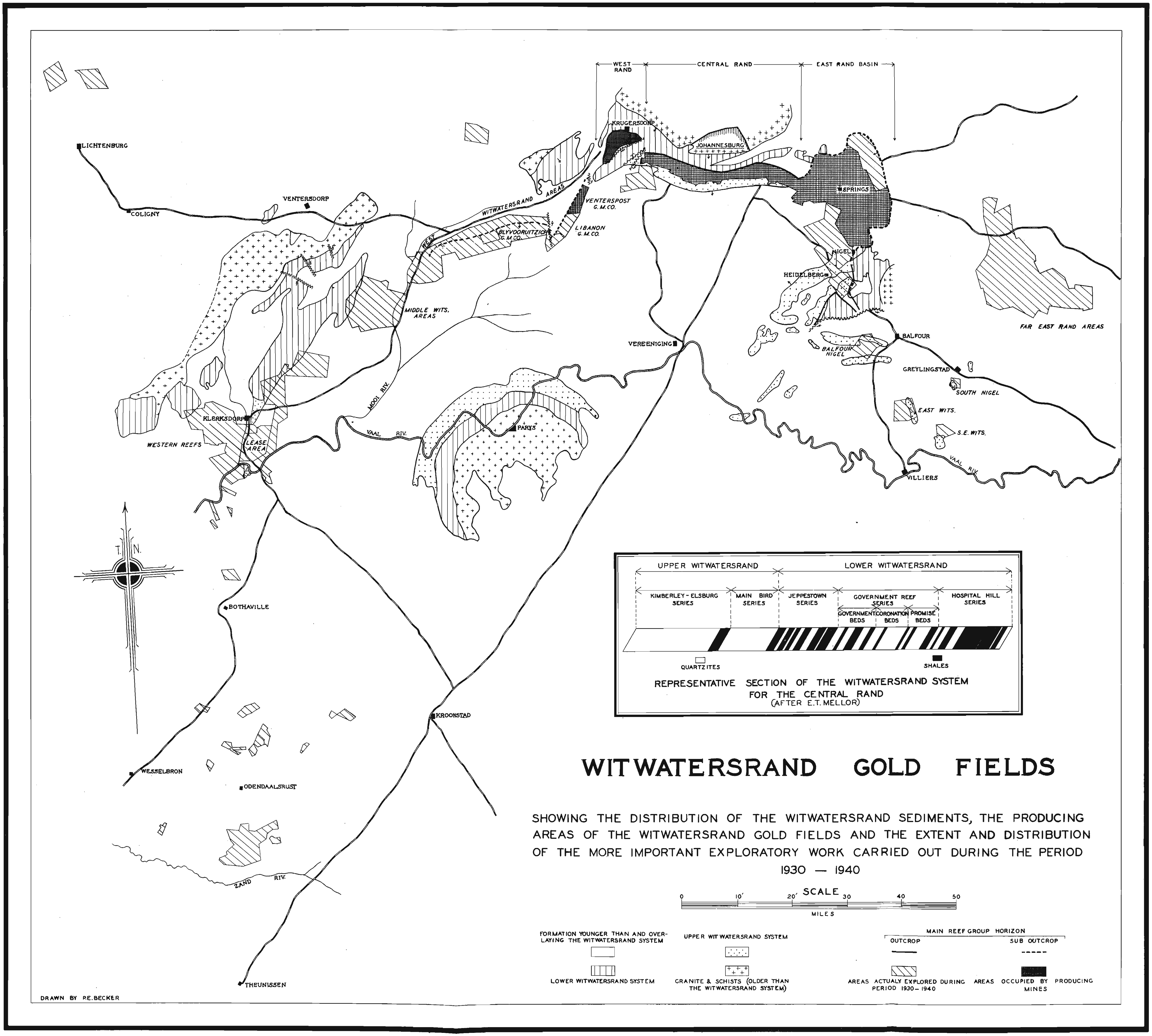
Our mineral resources should be of particular value to the United Kingdom in the years following the conclusion of the war, modern warfare entailing so much destruction of shipping and non-military material which will have to be replaced.

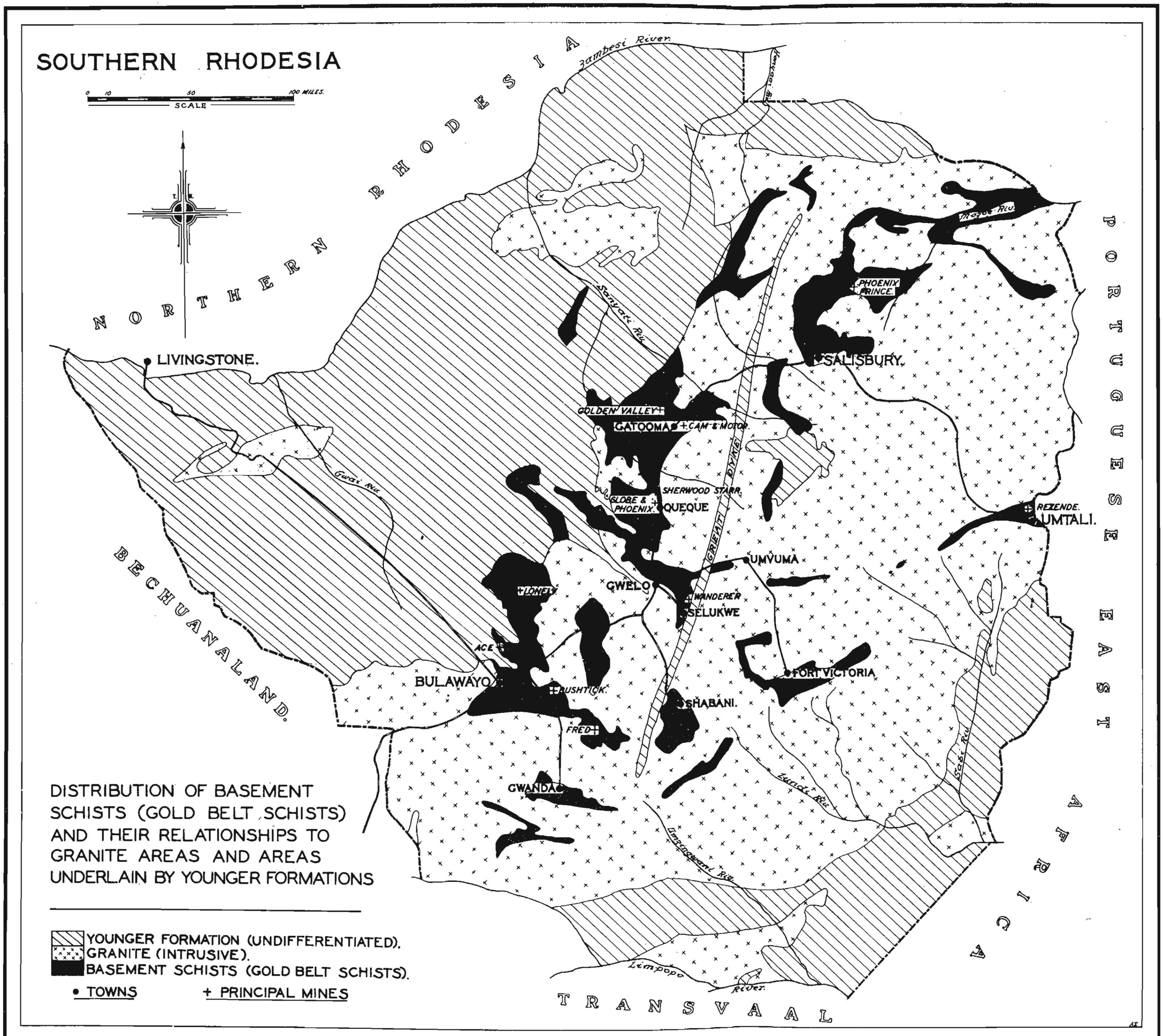
At the present time our immediate concern should be the contribution we can make to the war effort in the way of mineral supplies.

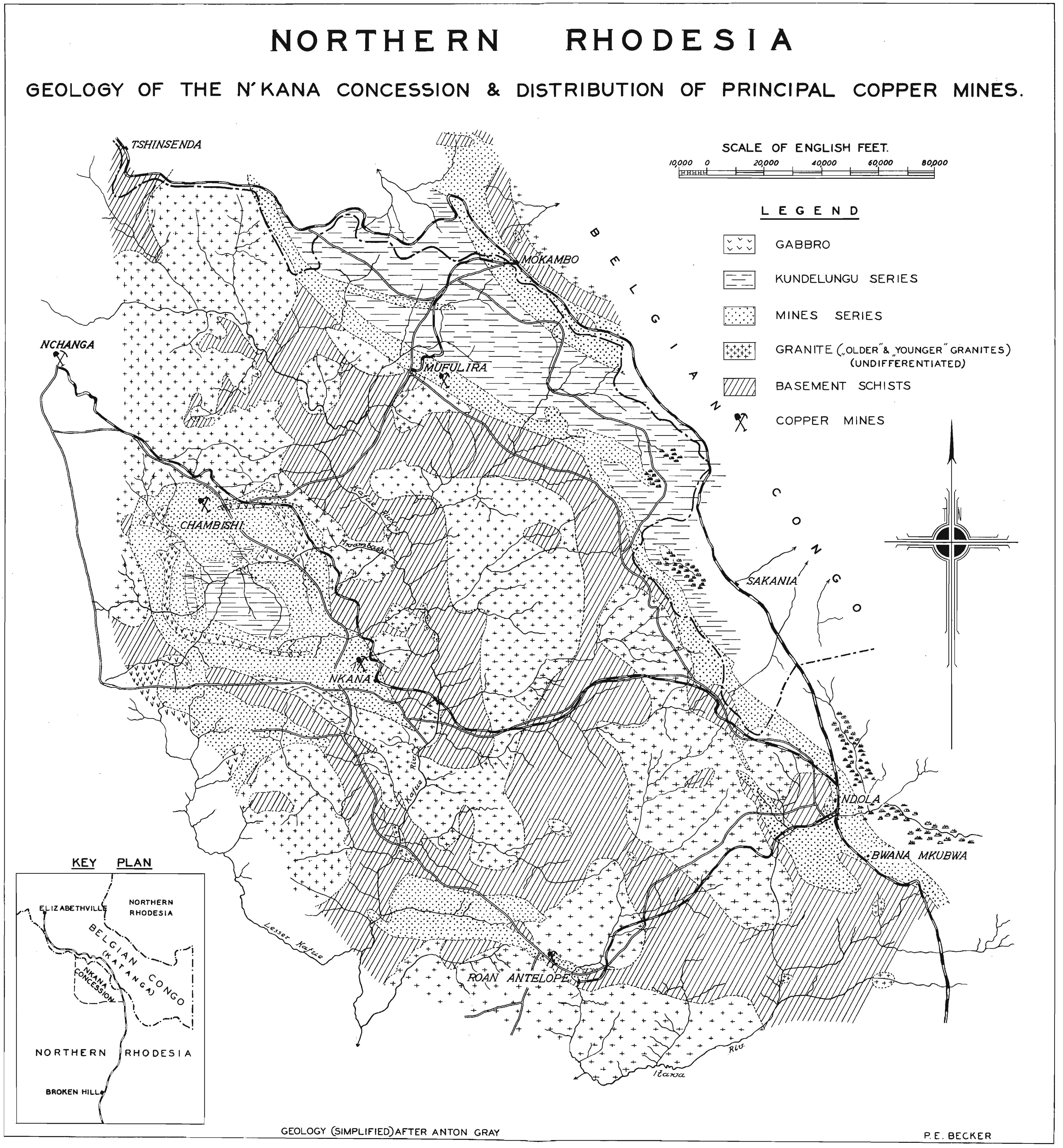
In this respect the gold mining industry is playing a vital part inasmuch as the gold produced can be converted immediately into foreign currencies and used for the purchase of war supplies, and we are assured that maintenance of our gold output at the highest possible level is of paramount importance. In Northern Rhodesia the entire output of the copper fields has been taken over by the British Government and, while production figures are no longer published, it is no secret that the mines are working to a greater capacity than ever before. The Union and the Rhodesias can supply many of the mineral requirements used more specifically for war purposes, but the extent to which our minerals will be utilised in the present conflict depends on other factors as well. In the years just before the war stocks of raw materials were accumulated in view of such an eventuality and, at the moment, the problem of shipping space renders it desirable for Great Britain to obtain raw materials from sources as near to her as possible. It is yet too early to predict how these various factors will operate, but it is reassuring to know that we could supply many of the so-called strategic minerals if the need for them became acute. It may well be that certain of these minerals will find an increasing market in the United States in view of their armament programme, and in this connection it is of interest to note that American shipping services to the Union have increased since the war. Expansion of the American market, for South African base metals, besides contributing to a rearmament effort which is in our own interest, would naturally lead to an increased post-war market in America for these products, a considerable proportion of which was exported to Germany before the war.

I would like to conclude this address with a word about the Union of South Africa and the part that her mineral resources should play in her future development.

Everyone realises, I think, the importance of the gold mining industry on which our national prosperity largely depends. Owing to her situation on the main trade routes to the East, her healthy and temperate climate and her many natural resources, the future of the Union would seem destined to be one of great expansion and largely increased population. This must depend to a considerable extent on the increased industrialisation of the country and in such a process the Union's mineral resources will give her a great initial advantage. Coal and iron are the first necessities to industrialisation and the Union has an abundance of both ; and, in addition, she has most of the minerals which are the necessary complements of a highly specialised steel industry, as well as adequate resources of many other important minerals. There has been a growing realisation of this in recent years and considerable attention has been devoted to the


WEST RAND
CENTRAL RAND
EAST RAND BASIN
KRUGERSDORP
JOHANNESBURG
LICHTENBURG
VENTERSDORP
COLIGNY
WEST WITWATERSRAND AREAS
VENTERSPOST G.M.CO.
LIBANON G.M.CO.
BLYVOORUITZICHT G.M.CO.
SPRINGS
NIGEL
HEIDELBERG
MIDDLE WITS. AREAS
FAR EAST RAND AREAS
VEREENIGING
BALFOUR
BALFOUR NIGEL
GREYLINGSTAD
SOUTH NIGEL
EAST WITS.
S.E. WITS.
VILLIERS
VAAL RIV.
MOOI RIV.
PARYS
KLERKSDORP
LEASE AREA
WESTERN REEFS
T.N.
BOTHAVILLE
KROONSTAD
WESSELBRON
ODENDAALSRUST
ZAND RIV.
THEUNISSEN
UPPER WITWATERSRAND
LOWER WITWATERSRAND
KIMBERLEY – ELSBURG SERIES
MAIN BIRD SERIES
JEPPESTOWN SERIES
GOVERNMENT REEF SERIES
GOVERNMENT BEDS
CORONATION BEDS
PROMISE BEDS
HOSPITAL HILL SERIES
QUARTZITES
SHALES
REPRESENTATIVE SECTION OF THE WITWATERSRAND SYSTEM FOR THE CENTRAL RAND
(AFTER E.T. MELLOR)
WITWATERSRAND GOLD FIELDS
SHOWING THE DISTRIBUTION OF THE WITWATERSRAND SEDIMENTS, THE PRODUCING AREAS OF THE WITWATERSRAND GOLD FIELDS AND THE EXTENT AND DISTRIBUTION OF THE MORE IMPORTANT EXPLORATORY WORK CARRIED OUT DURING THE PERIOD 1930 — 1940
SCALE
0
10
20
30
40
50
MILES
FORMATION YOUNGER THAN AND OVERLAYING THE WITWATERSRAND SYSTEM
UPPER WITWATERSRAND SYSTEM
MAIN REEF GROUP HORIZON
OUTCROP
SUB OUTCROP
LOWER WITWATERSRAND SYSTEM
GRANITE & SCHISTS (OLDER THAN THE WITWATERSRAND SYSTEM)
AREAS ACTUALLY EXPLORED DURING PERIOD 1930 – 1940
AREAS OCCUPIED BY PRODUCING MINES
DRAWN BY P.E. BECKER


SOUTHERN RHODESIA
0 10 50 100 MILES.
SCALE
NORTHERN RHODESIA
BECHUANALAND.
PORTUGUESE EAST AFRICA
TRANSVAAL
Zambesi River.
Sanyati Riv.
Gwai Riv.
Mazoe Riv.
Lundi Riv.
Sabi Riv.
Limpopo River.
GREAT DYKE
LIVINGSTONE.
SALISBURY.
PHOENIX PRINCE.
GOLDEN VALLEY
GATOOMA
CAM & MOTOR.
SHERWOOD STARR.
GLOBE & PHOENIX.
QUEQUE
REZENDE.
UMTALI.
UMVUMA
GWELO
LONELY
WANDERER
SELUKWE
ACE
BULAWAYO
BUSHTICK.
FORT VICTORIA
SHABANI.
FRED
GWANDA
DISTRIBUTION OF BASEMENT SCHISTS (GOLD BELT SCHISTS) AND THEIR RELATIONSHIPS TO GRANITE AREAS AND AREAS UNDERLAIN BY YOUNGER FORMATIONS
YOUNGER FORMATION (UNDIFFERENTIATED).
GRANITE (INTRUSIVE).
BASEMENT SCHISTS (GOLD BELT SCHISTS).
• TOWNS
+ PRINCIPAL MINES


NORTHERN RHODESIA
GEOLOGY OF THE N'KANA CONCESSION & DISTRIBUTION OF PRINCIPAL COPPER MINES.
SCALE OF ENGLISH FEET.
10,000 0 20,000 40,000 60,000 80,000
LEGEND
GABBRO
KUNDELUNGU SERIES
MINES SERIES
GRANITE („OLDER" & „YOUNGER" GRANITES) (UNDIFFERENTIATED)
BASEMENT SCHISTS
COPPER MINES
TSHINSENDA
MOKAMBO
BELGIAN CONGO
NCHANGA
MUFULIRA
CHAMBISHI
SAKANIA
NKANA
NDOLA
BWANA MKUBWA
ROAN ANTELOPE
Lesser Kafue
KEY PLAN
ELIZABETHVILLE
NORTHERN RHODESIA
BELGIAN CONGO (KATANGA)
NKANA CONCESSION
NORTHERN RHODESIA
BROKEN HILL
GEOLOGY (SIMPLIFIED) AFTER ANTON GRAY
P.E. BECKER

Dr. A. L. du Toit, in moving a vote of thanks to the President for his address, said that it was useful from time to time to take stock of the mineral output and resources of one's country, and not more so than at this moment when such outputs constituted a vital factor in the defence of civilisation.

Their President had given them in abstract an admirable review of the situation as regards those key minerals in British South Africa. He had given its geological background, and had also set it out in proper perspective within the far larger output from the British Commonwealth of Nations. He had shown that the Union stood only second to the United Kingdom itself in this repect.

Dr. Pelletier had pointed out also in his text, which the meeting had not had the privilege of hearing in full, the surprisingly short time within which those mines in South Africa had been developed, and his conclusions with regard to our reserves were most encouraging. He had stressed the immense value, too, of those important war minerals, not only at the present time, but after the war, in reconstruction and industrial expansion. His account, when printed in full, would indeed be a great contribution among the Addresses which had been presented before the Society.

In his Presidential Address, in Johannesburg in 1929 as President of the British Association for the Advancement of Science, that eminent geologist, Sir Thomas Holland, pointed out that the United Kingdom and the United States of America together produced over two-thirds of the world's mineral output. He stressed, further, that those two nations were the only ones which, in the case of war, could carry on for long on their own natural resources. He made a plea, in concluding, that there should be a working agreement between those two great mineral Powers that had the desire and the ability to ensure the peace of the world. But a few years had elapsed, and his wish was gloriously fulfilled. Dr. Pelletier had assured them that British South Africa had large outputs of strategic materials in the productive stage and that these could be expanded substantially should the situation so demand.

For this detailed, heartening and opportune review by their retiring President, one which must have involved a great deal of time and labour in its preparation, they were greatly indebted, and it was a privilege to propose, on behalf of the members, a very sincere vote of thanks to Dr. Pelletier for having so ably treated this highly important subject.

Dr. T. W. Gevers, in seconding the vote of thanks, said that just about a year ago, on an occasion like the present one, he had had the privilege of seconding the nomination of Dr. Pelletier as President of the Society for the year 1940. He had remarked on that occasion that they would be fortunate in having a President who combined in an unusual measure wide practical experience in the fields of geology and mining engineering, and who had achieved a particularly happy blend of the two professions.

Looking back on the year of office of Dr. Pelletier as President of the Society and Chairman of the Council, he was confident of speaking in the name of all members of Council and every member of the Society, when he said that in Dr. Pelletier they had *indeed* been privileged to have a President who on every occasion had displayed a rare degree of scientific and scholarly attainment. It was not necessary to enlarge on the acknowledged status of their President as a Mining Geologist. The fact that he was employed in that capacity by one of the most prominent, progressive and enterprising Mining Houses on the Rand was sufficient testimony to that effect. To every one who attended the ordinary monthly meetings of this society, at which papers were read and over which Dr. Pelletier presided, it must have become evident that Dr. Pelletier had achieved a particularly happy blend of practical experience and scholarly erudition. Seldom had they had such an able Chairman, who in such a ready and easy way took part in and generally led the discussion on a large variety of subjects. Dr. Gevers thought that he spoke with the enthusiastic approval of all active supporters of the monthly meetings, when he said that under the chairmanship of Dr. Pelletier they had taken a very considerable step nearer their ultimate and most desirable goal of enlivening these meetings and stimulating discussion. He thought that Dr. Pelletier deserved a full measure of gratitude for this very notable achievement alone.

Dr. du Toit had already dealt with Dr. Pelletier's outstanding Presidential Address. In acquitting himself of this task Dr. Pelletier had maintained the high standard which they had come to expect of and associate with him. He had given them the most concise and at the same time informative and readable account of the Mineral Industry of Southern Africa.

In conclusion, Dr. Gevers assured Dr. Pelletier of the deep gratitude of the Society for his outstanding services as President, and also of their great appreciation of his very notable Presidential Address, and finally requested the members present to indicate their approval of his remarks in the usual way.

Mr. G. Carleton Jones, in associating himself with the remarks Dr. du Toit and Dr. Gevers had made about Dr. Pelletier's Address, said that he happened to have been associated with Dr. Pelletier now for some years, and when he knew that the Presidential Address was to be given this evening he was quite satisfied that the audience would hear something quite out of the ordinary. He knew that it would be a very painstaking, thorough and solid study that would be presented to them, and he was sure that none of those present had been disappointed. He felt that the address would be used as a standard in South Africa relative to our mineral resources, and also would be used in other parts of the Empire, and in many parts of the world outside the Empire.

Dr. Pelletier had dealt at some length with the base metal resources of the Union. He pointed out that we had vast potential resources which in the course of time would be developed on a great scale. In that connection it had been brought to his notice, as it had been to that of many others in the gold mining industry, that the mining houses of the Witwatersrand were regarded as essentially gold-minded and as having made very little attempt to develop base metals.

It was known from Government sources, through the Geological Survey and in many different ways, that there was a general feeling that more should be done by the mining houses to develop these resources. He had himself discussed this matter at length with Dr. Pelletier. Ever since the beginning of the goldfields of the Witwatersrand, all the mining houses had been endeavouring to find base metal propositions which, in their opinion, would give them a fair return on capital. Only last week he and Dr. Pelletier had been looking over a special book which the New Consolidated Gold Fields had kept since 1895, which recorded all base metal propositions submitted. There were many hundreds of them, and a number of eminent mining engineers and geologists, mostly now departed, had investigated these propositions, and, in nearly every case, had been unable to suggest that there would be a fair return on capital. One of the main considerations in these investigations has been that the company has not been too sure of the position in respect of assistance to be received from the Government.

They all knew the distances that our deposits were from the coast. They all knew the great sea distances that we had to contend with before we could compete on the overseas markets. All concerned should keep these circumstances well before them before they even asked for Government assistance in the development of base metal resources. If, however, all the geologists who were assembled here this evening did their utmost to see that the Government of South Africa endeavoured to develop base mineral resources by assisting to ensure a reasonably fair return on capital, then he felt that these wonderful resources which undoubtedly we had in this country, would be developed in course of time. Dr. Pelletier would then be able to feel that he had really done something for South Africa in assisting to prove the potentialities of our base metals. He believed that the day would come when Dr. Pelletier would fully reap the fruits of his studies.

He had very much pleasure in supporting the vote of thanks to Dr. Pelletier.

DRAPER MEMORIAL MEDAL.

The President said he had much pleasure in announcing the award of the Draper Memorial Medal to Dr. S. H. Haughton.

Sidney Henry Haughton was educated at Essex County Technical Institute, Walthamstow, and Trinity Hall, Cambridge, whence he graduated with honours in 1909. He was appointed geological assistant at the South African Museum, Cape Town, in 1911, and became Assistant Director in 1914. He came into contact with Dr. Robert Broom and developed an interest in the fossil vertebrate remains of the Karroo System with which Southern Africa has so richly been endowed. From 1913 onwards—associated at first with Broom and later with Boonstra—he penned a long series of illuminating contributions on the reptiles, amphibians and fishes of the Karroo Beds not only of the Union, but also of Rhodesia, Nyasaland, Tanganyika, Central Africa and Madagascar, and has incidentally presented us with vistas of the conditions under which such life existed. His attention became thereafter directed to the pleistocene vertebrates, resulting in accounts of the fossil Equidae and Proboscidae of South Africa and South West Africa, and of the famous Boskop skull.

The Cretaceous marine mollusca of South West Africa, Angola, and Zululand and their relationships, were systematically described by him and also the raised beaches of South West Africa and the Southern Cape and their faunas.

Joining the geological survey as senior geologist in 1920, he mapped considerable areas between Cape Town and Port Alfred and assisted by Dr. Frommurze, of the southern part of South West Africa, as set forth in various " Sheet explanations." He has moreover written on the Zuurberg volcanics, and Glacial bed of the Table Mountain Series, on galena and phosphate deposits, and on the river systems of Gordonia.

He took a share in the preparation of Volume VII, part 7*a*, of the " Handbuch der regionalem Geologie (the Union of S.A.) 1929." The lengthy " Report of the Commission on the Distribution of the Karroo System " (International Geological Congress XVII, 1936), was largely from his hand, while he edited the " Lexicon de Stratigraphie, Vol. I, Africa," 1938.

In 1934 he was appointed Director of the Geological Survey and under his able guidance that institution has expanded vastly in its personnel and activities, more especially in respect to the investigation of mineral deposits, applied geophysics, water supply, aerial base mapping and pleistocene geology. Much of that marked progress has been due to Dr. Haughton's initiative and persuasive character.

He is a D.Sc. of the University of Cape Town. He is a fellow of the Geological Society of London, from which he received in 1927 the Murchison Fund, and of the Royal Society of South Africa. He was President of the Geological Society of South Africa in 1925, and in 1937 he represented the Union at the Seventeenth International Geological Congress in Russia. He is also a member of the Committee for the preservation of National Monuments.

I am sure I have said enough to convey to you an appreciation of Dr. Haughton's attainments in the field of geology, where apart from his outstanding palaeontological work, he has rendered conspicuous contributions to South African geology in the branches of stratigraphy, morphology and economic geology and in addition has latterly proved himself an extremely able administrator as Director of the Geological Survey.

His extensive and diversified contributions to South African geology are now fittingly recognised in the award of the Draper Memorial Medal which the Geological Society of South Africa reserves for its most distinguished members.

Dr. S. H. Haughton expressed his gratitude to the President for the manner in which he had presented him with the medal and also expressed to the Society, through him, his deep sense of appreciation of the honour which the Society had conferred upon him, an honour which, as his predecessor in this award remarked, placed one among the geological giants of South Africa.

He did not know why he should be placed among the "geological giants," and in trying to seek reasons therefor, he felt that he had not been born a geologist but had been made one, almost entirely through the work of the people with whom he had come into contact.

For a man who was, possibly, not quite middle-aged, it was hardly appropriate to be autobiographical. Nevertheless, he thought he should explain himself in what would be a very brief autobiography.

As a schoolboy geology was very far from his thoughts until he had the good fortune to spend a holiday with a schoolmaster in the Isle of Wight, one of the most beautiful spots on this earth. There his eyes were opened to some of the things that were underneath the grass and the trees, and to some of the things that were in the earth itself, and he collected, among other things, a few fossils from the cretaceous beds, which may be considered as the foundation of his interest in palaeontology.

From school he passed to Cambridge and took geology as a major subject, sitting at the feet of Marr, Harker, Woods and others; and then he came to South Africa, rather longer ago than he cared to think. Immediately upon his arrival in South Africa he came into contact with Dr. A. W. Rogers and Dr. A. L. du Toit in Cape Town. The two of them constituted themselves his mentors, and no better mentors could any young man have had who desired to make a career for himself in geology. He also came into contact with Dr. Robert Broom, who stimulated an interest he had in vertebral palaeontology.

From that time onwards he got to know the members—very few members there were in those days—of the Geological Survey, and a number of geologists who were not actually associated with the Geological Survey, and he began to know personally and to get into correspondence with numerous geologists in countries other than South Africa. And then, by the influence probably of what those friends had done for him, he became Director of the Geological Survey. From the time he became Director, he had been stimulated daily by contact with a band of young, enthusiastic and capable geologists who had opened his eyes to a large number of problems that previously he had hardly known to exist in South African geology.

The object of this autobiography was to explain to members that this medal was really a tribute to those who had assisted him rather than to anything which he had done himself. He felt that during the last few years his contributions to geological knowledge had been very few, if any, and in these days, as Dr. Pelletier had pointed out in his Presidential Address, our geological attention was given almost entirely to what one might call the more strictly economic side of geology. To that he had to give a certain amount of attention to-day, but, nevertheless, he hoped that in the years to come, and at a period which would not be too far off from this present moment, it would be possible for him and for his associates, and for all geologists, to turn once again, with renewed vigour, to those more fundamental problems in geology which in this country were awaiting contemplation and discussion.

In his opinion, there was no country like South Africa where geological problems could be studied so easily and under such magnificent conditions, and therefore he hoped that when these troublous days were past, despite the necessity which there would be for considering the economic side of geology rather more largely than we did before the war, there would be time left to him and to other geologists to study and contemplate those more fundamental aspects of our science—the science for whose study this Society exists.

ELECTION OF COUNCIL AND OFFICE-BEARERS.

The President said that, in accordance with the Constitution of the Society, twelve members of the Council retired, but were eligible for re-election. As, however, all those members did not seek re-election, the Council had nominated the following twelve members to fill the vacancies on the Council :—

Messrs. J. A. Bancroft, T. W. Gevers, S. H. Haughton, W. Kupferburger, B. Lightfoot, B. V. Lombaard, E. Mendelssohn, L. T. Nel, R. A. Pelletier, D. L. Scholtz, F. A. Venter, and G. A. Watermeyer.

He formally moved that these twelve gentlemen be elected to fill the vacancies.

Mr. G. Carleton Jones seconded the motion, and, there being no further nominations, these gentlemen were declared duly elected.

The President then called for nominations for the office of President for the year 1941.

Dr. S. H. Haughton said that it was customary in this Society for the Senior Vice-President to be nominated for the post of President; but this year the Senior Vice-President was somewhere in Africa with the armed Forces of the Union, and it was therefore unlikely that he would be able to carry out any of the presidential functions during the succeeding year. He would like, therefore, to propose the name of Dr. R. J. Bridges as President of the Society for the ensuing year. Dr. Bridges was one of the leading Company geologists in South Africa, and it was desirable that occasionally a Company geologist should be made President of the Society in order that, at the end of the year, he might give members some of the benefit of the wide knowledge that he must necessarily obtain from his daily occupation, and which otherwise might not be made public. It gave him great pleasure therefore to propose Dr. Bridges as President for the ensuing year.

Mr. J. H. Taylor, in seconding the proposal, said he was quite sure that Dr. Bridges would follow in the example of Dr. Pelletier as President, in giving the Society a very successful year.

There being no further nominations, Dr. R. J. Bridges was declared unanimously elected.

Mr. C. J. Gray proposed, and Professor Watermeyer seconded, that the following gentlemen be elected Vice-Presidents for the year 1941 :—Dr. R. A. Pelletier, Dr. H. F. Frommurze and Dr. D. L. Scholtz. There being no further nominations, these gentlemen were declared duly elected.

Dr. W. Kupferburger proposed the re-election of Mr. E. Mendelssohn as Honorary Secretary and Treasurer for the ensuing year, which was seconded by Dr. W. P. de Kock.

There being no further nominations, Mr. E. Mendelssohn was declared unanimously elected.

Mr. H. S. Harger proposed, seconded by Mr. E. Meldelssohn, that Messrs. Roberts, Allsworth, Cooper Bros. and Company be re-appointed Auditors for the year 1941, and that their remuneration be left in the hands of the Council.

This concluded the business, and the meeting terminated.