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South Africa's position in the world's supply of minerals*

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SYNOPSIS

A wide range of minerals is found within the Republic of South Africa, many of which are exploited to a greater extent than in similar deposits found elsewhere. It is often asked whether this is attributable to the high grade of the ores encountered in this country, or whether such factors as fiscal and infrastructural incentives create an economic climate that has enabled the mining industry to successfully extract and market minerals at a profit.

This paper views South Africa's mineral resources in a regional and global context in an attempt to place the country's geological wealth in perspective. It represents the author's own views, and not necessarily those of the Department of Mineral and Energy Affairs.

SAMEVATTING

Daar kom 'n groot verskeidenheid minerale in die Republiek van Suid-Afrika voor waarvan baie in 'n groter mate as in dergelike afsettings elders ontgin word. Die vraag word dikwels gestel of dit toe te skryf is aan die hoë graad van die ertse wat hier te lande voorkom, of faktore soos fiskale aansporingsmaatreëls en die infrastruktuur 'n ekonomiese klimaat skep wat die mynboubedryf in staat gestel het om minerale suksesvol te ekstraheer en met 'n wins te bemark.

Hierdie referaat gee 'n oorsig oor Suid-Afrika se minerale-hulpbronne in 'n streeks- en globale verband in 'n poging om die land se geologiese rykdom in perspektief te stel. Dit is die skrywer se eie menings, en nie noodwendig dié van die Departement van Mineraal- en Energiesake nie.

Introduction

Through the years, geologists, mining engineers, and others concerned with minerals and their exploitation have sought a basis for the quantification of the extractable portion of orebodies. Various terms have been used, but the nomenclature most widely adopted is that proposed by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey, which is based on what is commonly known as the McKelvey Diagram[1] (Fig. 1). Using this as a basis, the USBM annually publishes reserve base figures for the more commonly mined minerals in most countries; frequently updated, these are broadly regarded as the most authoritative source of such information[1].

However, it should not be assumed that this information is always reliable. With even the best intelligence, statistics for such countries as the USSR, China, and many in the Third World cannot be assessed with any degree of accuracy. Virtually no information is published; in fact, in the Comecon countries, official government policy precludes the issuing of such data. It must therefore be accepted that the reserve figures published by the USBM are compiled from the best information that they are able to obtain.

The security of mineral supplies is a prime consideration among all industrial nations. The ability of a producing country to supply minerals is judged by the size of its reserve base and the success with which it exploits and exports its minerals. This paper examines the reserve base and export performance of major mineral producers. Full definitions of the important terms used are given in the Addendum.

Assessment of Reserve Bases

Reserve base is a term first coined by the USBM to indicate that part of an identified resource which can be extracted economically in the medium to long term (Fig. 1). In short, the reserve base comprises the reserves that are considered to be mineable under current economic circumstances, as well as those expected to become mineable within planning horizons. These reserves are determined from analyses of samples taken from outcrops, trenches, workings, and drill cores. They include demonstrated (measured and indicated) economic and marginally economic resources, and a portion of the sub-economic resources.

Reserves must at all times be regarded as dynamic in that they require reassessment wherever economic, political, infrastructural, and other circumstances change. A notable example of an uneconomic resource that has become a reserve is offered by the Carajas iron and manganese ores of Brazil. It was only recently that these deposits became economically exploitable through the completion of the export railway and harbour, which required their reclassification into the reserve-base category.

South Africa's Reserve Base

Estimates of South Africa's Reserve base as published by the Minerals Bureau are assessed by the Mineral Resources Committee, which comprises representatives

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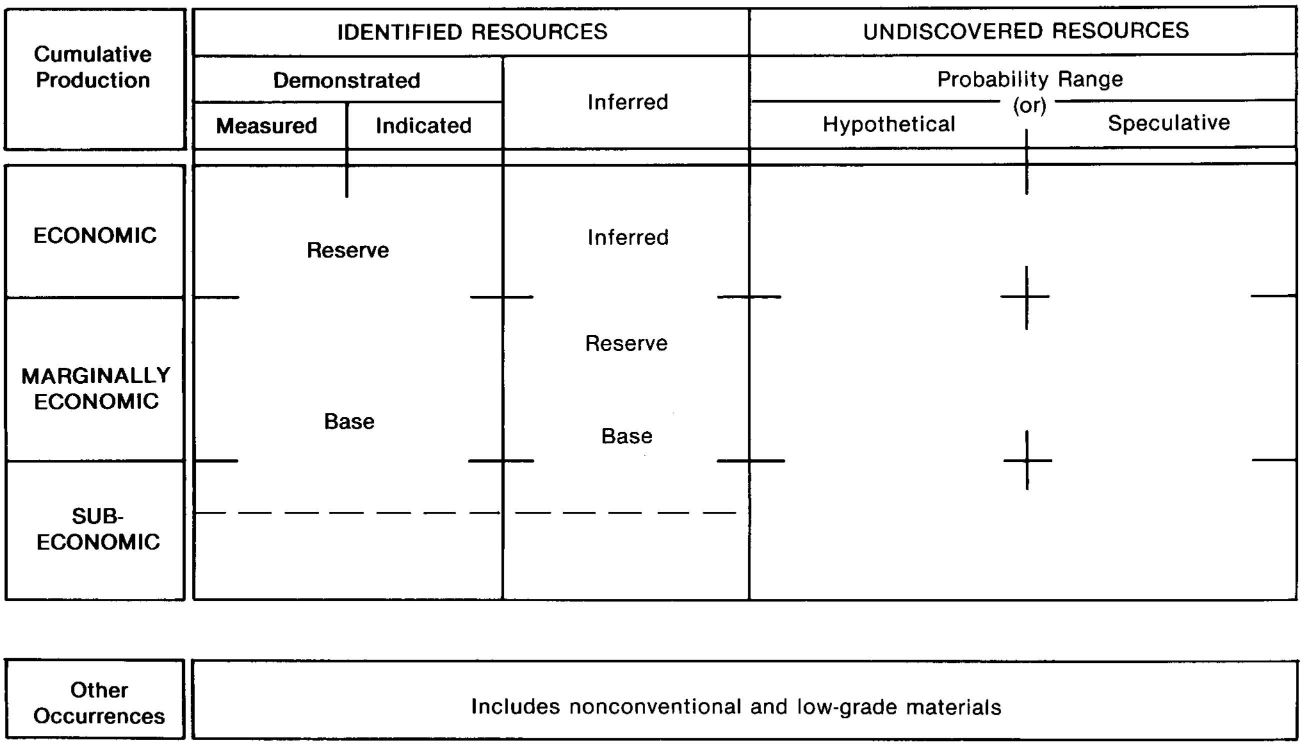


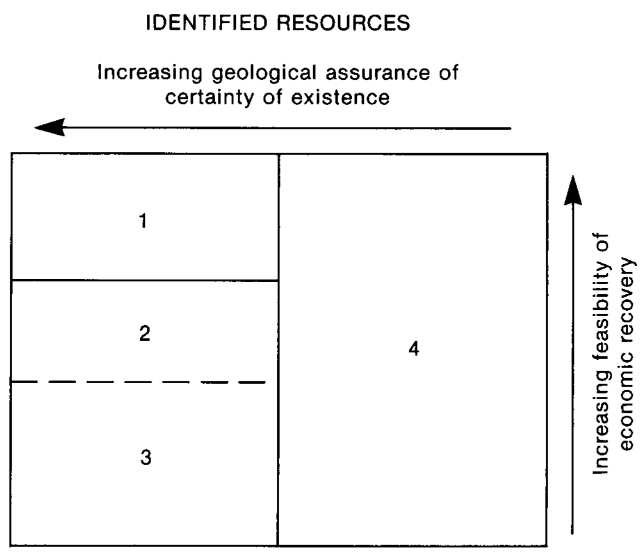
Fig.1—Classification of reserve bases and inferred reserve bases[1]

of the Minerals Bureau, the Geological Survey, and the office of the Government Mining Engineer. These assessments, which are re-evaluated periodically, are determined in close liaison with the respective mining companies and holders of mineral rights; all the available information gained from such activities as mining, boreholes, and geological prospecting is used. The basis is somewhat simpler than that adopted by the USBM in that only demonstrated economic and marginally economic resources are included. The only variation to the McKelvey approach is that the portion of sub-economic resources that is included in the USBM assessments is excluded (Fig. 2). Hence, the South African statistics can be regarded as somewhat more conservative than those of other countries.

South Africa's Reserves in a World Perspective

It will be observed from Table I and Fig. 3 that the Republic of South Africa (RSA) possesses the world's largest reserves of no fewer than seven minerals, and that several others feature high on the list. If Southern Africa is regarded as a single infrastructural region, the picture becomes even more impressive, with several minerals, notably chromium, uranium, asbestos, lead, zinc, and diamonds, increasing substantially, and copper and cobalt making their appearance on the list.

This is illustrated in Table II, which places the RSA, South Africa, and Southern Africa in the perspective of the African continent as a whole. There is little doubt that extensions to the infrastructure and increased exploration would result in the reclassification of more mineral deposits as reserves. Over the past three decades, political and other considerations have acted as a deterrent in the development of many African countries, and have thus inhibited the active exploration for minerals and the mining of minerals in these countries.



1. Demonstrated Reserves (economic)
2. Demonstrated Marginal Reserves
3. Demonstrated Subeconomic Resources
4. Inferred Resources

Fig. 2—South Africa's accepted definitions

The RSA exports no less than 85 per cent by value of its mineral production, and Table III illustrates its position as a world supplier of minerals.

TABLE I
THE ROLE OF THE RSA* IN THE WORLD'S MINERAL SUPPLIES
RESERVE BASE

Commodity	Unit	RSA	World		Market economies†	
			%	Rank	%	Rank
Manganese[a]	Mt	12 700	78	1	92	1
Platinum-group metals[b]	t	26 700	70	1	83	1
Chromium[a]	Mt	2 400	55	1	57	1
Gold[b]	t	20 000	51	1	64	1
Vermiculite[a]	kt	73 000	na	na	40	2
Alumino-silicates[a]	kt	51 600	38	1	47	1
Vanadium[b]	kt	5 400	33	1	50	1
Fluorspar[c]	kt	31 000	6	6	11	3
Diamonds[d]	M car.	365	24	2	27	2
Zirconium minerals[b]	kt	6 900	18	3	21	3
Coal[f g]	Mt	58 404	11	4	20	2
Uranium[b,e]	t	191 000	na	na	12	2
Titanium minerals[b]	kt	31 100	11	4	12	4
Phosphate rock[h]	Mt	2 310	7	3	7	3
Asbestos[j]	kt	7 800	6	4	8	3
Nickel[b]	kt	5 480	6	6	11	3
Antimony[b]	t	254 000	6	4	12	2
Iron[a]	Mt	9 400	5	6	7	5
Zinc[b]	kt	16 000	6	4	6	4
Lead[b]	kt	5 400	4	4	5	4

* Excluding Bophuthatswana, Ciskei, Transkei, Venda, and South West Africa/Namibia

† Excluding Centrally Planned Economies, which comprise Albania, Bulgaria, China, Cuba, Czechoslovakia, Germany DR, Hungary, Kampuchea, Korea DPR, Laos, Mongolia, Poland, Romania, U.S.S.R., and Vietnam. (Also referred to as Western World)

a Ore *in situ*
b Contained metal
c Contained CaF_2
d Gem and industrial
e Recoverable at a cost of less than U.S.$ 80/kg U
f Bituminous and anthracite
g Proved recoverable reserves
h Contained concentrate (38% P_2O_5)
j Contained fibre
na Not available

TABLE II
THE ROLE OF SOUTHERN AFRICA IN THE SUPPLY OF MINERALS FROM AFRICA
RESERVE BASE

Commodity	Percentage of Africa		
	RSA	South Africa*	Southern Africa†
Antimony[a]	98	98	98
Vermiculite[b]	98	98	98
Manganese[b]	88	88	88
Titanium minerals[a]	66	66	66
Gold[a]	90	90	95
Alumino-silicates[b]	91	91	91
Coal[c]	86	89	98
Platinum-group metals[a]	85	97	99
Zirconium minerals[a]	93	93	93
Iron[b]	73	73	74
Vanadium[a]	69	99	99
Chromium[a]	61	81	99
Asbestos[e]	60	60	99
Zinc[a]	68	68	69
Fluorspar[d]	79	79	79
Lead[a]	53	53	65
Diamonds[f]	43	43	72
Uranium[a,g]	36	36	58
Phosphate rock[h]	9	9	9
Nickel[a]	84	90	99

* Including RSA, Bophuthatswana, Ciskei, Transkei, and Venda

† Including Botswana, Lesotho, Mozambique, South Africa, South West Africa/Namibia, Swaziland, Zambia, and Zimbabwe

a Contained metal
b Ore *in situ*
c Bituminous and anthracite
d Contained CaF_2
e Contained fibre
f Gem and industrial
g Recoverable at a cost of less than U.S.$ 80/kg U
h Contained concentrate (38% P_2O_5)

Geopolitical Distribution of Minerals

Major concentrations of minerals are found in a relatively few countries; the USSR, China, the USA, Canada, Australia, Brazil, and the RSA are particularly well endowed in this regard, although two small nations have remarkable mineral wealth—Finland and Albania.

Major producing countries are often asked whether the success of their mining industries is attributable to a rich endowment of minerals with easily exploitable deposits, or to an entrepreneurship that has enabled them to make the most of low-grade resources or resources that need exceptional mining expertise. Finland can be cited as a country that has exploited inferior resources to a maximum and by so doing has become a world leader in metallurgical technology.

In regard to many of its deposits, the RSA claims to be well-endowed. The platinum, chromium, and vanadium of the Bushveld Complex are indeed unique, as are the diamonds, manganese, fluorspar, and asbestos deposits. The central Witwatersrand goldfield is certainly unusual, but one wonders whether the deeper goldfields would have been mined, or even discovered, if they had occurred in a Central African State.

What is important about mineral deposits is not the fact that they exist, but that they are successfully exploited and marketed; minerals in the ground are of no value to anyone. Large mineral producers such as the USA, the USSR, and China consume most of their mineral output, and hence what they produce is of little consequence to countries seeking to import these products. The RSA, Australia, Canada, and Brazil, on the other hand, are essentially export-orientated, and account for the lion's share of the world's mineral trade. The reserve bases given in Table IV illustrate the magnitude of the combined reserves of South Africa and the USSR, and of South Africa and China.

Analysis by Countries

In the following section, mineral supplies are analysed by countries, and geopolitical aspects of each territory's mineral industry are discussed.

Australia

In terms of value, Australia[2] is a large supplier of minerals with exports in 1984 amounting to R13 billion

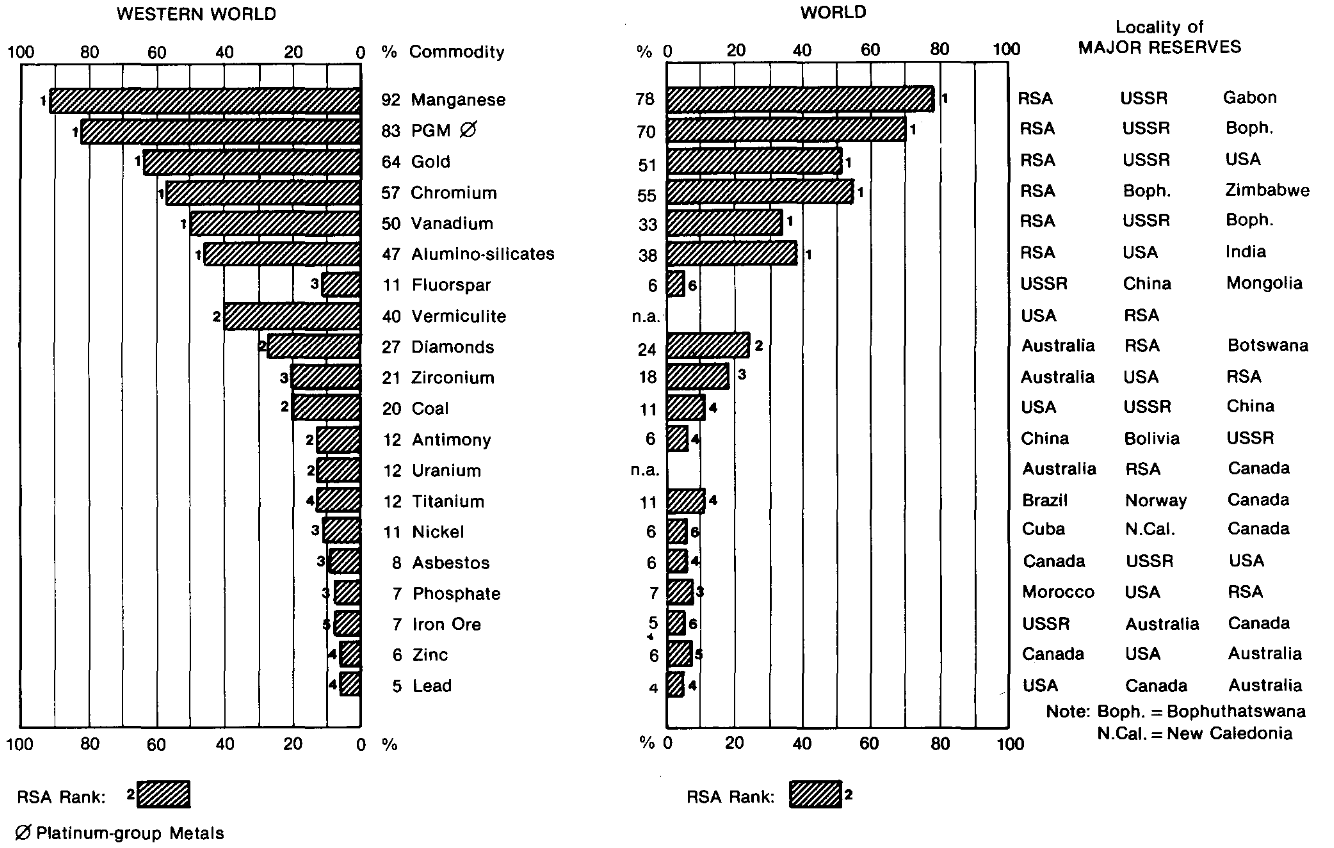


Fig.3—The role of the RSA in the world's mineral supplies (based on information available at 30th June, 1985)

(1A\$ = R1,29), against R16,063 billion for the RSA (Fig. 4 and Table V). The two countries are in competition as regards several of their largest foreign-exchange earners; these include coal, iron ore, manganese ore, and uranium, titanium, and zirconium minerals. Recently, after the opening of the large Argyle Mine, diamonds were added, but a marketing agreement with the Central Selling Organization (CSO) has blunted the competitive edge. The reserves of these minerals are extensive, and there is therefore no constraint on their future production (Table VI).

The mineral policies of an exporting country can be of paramount importance to the successful exploitation and marketing of its minerals. South Africa and Australia are both free-enterprise orientated and have enlightened mineral policies, although there are essential differences. In brief, there are a few Australian mining regulations that vary significantly from those prevailing in South Africa. However, there are definite differences in the investment and marketing rules, some of which can be summarized as follows.

- In Australia, expenditure on exploration is tax deductible against income from any source, not only from mining. This does not apply in South Africa, where exploration costs are tax deductible only against mining income.
- Once development starts, at least 51 per cent of the participation is required to be held by an Australian company. There is no such restriction in South Africa.
- The Australian State establishes and maintains the infrastructure. However, proponents of new mining projects are generally required to provide the necessary capital, unlike the position in South Africa, where this outlay is not required.
- Special tax deductions for new plant serve as an incentive for beneficiation projects in Australia.
- Grants for the development of export markets provide a direct incentive to the establishment of overseas markets for Australian minerals.
- The Australian State exercises surveillance over the exportation of a number of minerals to ensure that fair and reasonable world prices are achieved. This control is not exercised in South Africa.
- The central and provincial governments in Australia impose a host of taxes over and above normal company tax. This is not done in South Africa.

It is of interest that the Australian gold mines were, until very recently, not subject to company taxation. This was a traditional ruling of many years' standing, and also applied to enterprises that derive significant income from gold where the metal occurs as a co-product or byproduct of other minerals.

Perhaps the greatest competitive disadvantage suffered by Australia's mining industry is provided by the frequent, long labour disputes, which inhibit the reliability of supply and have given rise to high labour costs. These are undoubtedly a matter for concern on the part of importing countries; although Japan, for example, is a natural market for Australia's products, her degree of diversification is an indication of a lack of confidence and has been of considerable benefit to South African exporters.

Canada

Canada is endowed with extensive mineral resources and, being a relatively small consumer, is a large supplier of minerals (Tables VII and VIII). Exports of coal, uranium, iron ore, titanium, asbestos, gold, and platinum-group metals are areas of severe competition with the RSA. Canada is also a large supplier of nickel, lead, zinc, potash, and sulphur on world markets, and could be a future threat to vanadium exporters. The total value of Canada's exports in 1984 amounted to some R14 819 million (1C$ = R1,1374). Canada's mining regulations fall largely under the jurisdiction of the provinces, and hence vary considerably. In general, however, they tend to be more restrictive than those of the RSA, with taxation much higher. As with Australia, strong trade unions are a factor.

Brazil

Extensive reserves of a great variety of minerals are present in Brazil, and the increasing degree to which these are being exploited—and likely to be exploited in the future—makes this country a fast-growing mineral supplier and ever-increasing competitor in world markets. Table IX does not do justice to Brazil's true mineral potential; for example, the Carajas iron ore deposits, not yet included in the USBM statistics, are claimed to be the world's largest. The area also contains extensive resources of other minerals such as manganese, copper, nickel, and bauxite, all of which are now available for exploitation as a result of the new rail link to the coast. With a surplus of low-priced hydro-electric power, the adding of value to mineral exports through beneficiation appears to be a national priority, and substantial additional smelting capacity, particularly for the production of ferrosilicon, is in the offing. Huge foreign investment in Brazil's mineral projects virtually ensures their future markets, and the impact of her exports is being felt increasingly by other suppliers to world markets.

USA

The USA has a substantial resource base (Table X) and for many decades has been the world's largest producer of minerals, a position she retains to this day. However, the USA is also the largest consumer of minerals, and is a net importer of many commodities of which she is also a major producer—copper is a prime example. Having had a thriving mining industry for so long, the USA has some resources that are badly depleted, while others have been rendered uneconomic because costs are rising faster than for their competitors. Where adequate reserves exist, the USA is an aggressive exporter, being the largest supplier of coal, molybdenum, and rare-earth metals, and the second-largest supplier of phosphate.

Such minerals as chromium, manganese, and platinum are not produced, although the threat of mining for platinum-group metals in the Stillwater Complex is ever present. The rising cost of electrical energy has caused the USA to become a large importer of ferro-alloys, whereas she was formerly substantially self-sufficient. This also applies to imports of ferrous metal ores, which have given way to beneficiated products. Uncertainty on the part of politicians regarding the reliability of future mineral supplies from the RSA provides the incentive for greater mineral self-sufficiency, although the exploitation of borderline local resources and subsidized mining of the most strategic minerals are becoming increasingly possible. For example, the substantial amounts devoted to research into marine mining has placed the USA in the forefront of technological developments in that field. Deep-sea resources offer inexhaustible supplies of two highly strategic minerals, manganese and cobalt, though the production is uneconomic at present.

TABLE III
THE ROLE OF THE RSA IN THE WORLD'S MINERAL SUPPLIES
EXPORTS 1983

			World		Market economies	
Commodity	Unit	Exports	%	Rank	%	Rank
Alumino-silicates	t	71 820	52,4	1	52,4	1
Antimony concts[a]	t	2 904	16,1	2	17,3	2
Antimony trioxide[a]	t	***	40,3	1	47,6	1
Asbestos	t	183 946	9,2	3	14,0	2
Chromium ore	kt	803	26,5	1	44,6	1
Coal[b]	Mt	30	11,4	4	15,2	3
Copper[a]	kt	131	2,7	11	2,7	11
Diamonds[c,j]	k car.	8 479	31,9	1	33,9	1
Ferrochromium	t	741 824	54,3	1	58,8	1
Ferromanganese	t	304 100	23,1	2	23,4	2
Ferrosilicon	t	22 000	2,6	10	2,6	10
Fluorspar	t	246 462	9,7	4	19,3	2
Gold[d,j]	t	649	61,9	1	76,8	1
Iron ore	kt	7 811	2,5	8	2,8	5
Lead[a]	t	85 984	16,0	2	16,3	2
Manganese metal[e]	t	24 634	79,5	1	81,6	1
Manganese ore	kt	1 996	29,5	1	35,4	1
Phosphate rock	kt	306	0,6	12	0,7	11
Platinum-group metals	–	***	28,4	3	42,2	2
Silicon metal	t	27 000	13,0	3	14,3	3
Silver[a]	t	215	3,5	7	3,7	6
Titanium[f]	kt	188	18,0	3	18,0	3
Vanadium[g]	t	13 162	49,0	1	55,8	1
Vermiculite	t	113 154	86,3	1	86,9	1
Zinc[a]	t	15 065	0,7	14	0,7	13
Zirconium[h]	t	132 765	25,0	2	25,0	2

a Contained metal
b Bituminous and anthracite
c Gem and industrial, rough
d Production
e Electrolytic
f Metal content of minerals and slag
g Contained V_2O_5
h Concentrate
j 1982 statistics

USSR

The USSR is self-sufficient in most minerals (Table IV), and its imports are of a minor and somewhat spasmodic nature. The hard-currency foreign-exchange requirements are substantial, and in the past these were obtained through exportation to the West of mineral commodities

TABLE IV

THE ROLE OF SOUTH AFRICA, THE USSR, AND CHINA IN SUPPLYING THE WORLD WITH MINERALS RESERVE BASE

Commodity	Position in world									
	South Africa		USSR		China		South Africa and USSR		South Africa, USSR, and China	
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank
Antimony[a]	5,5	4	5,9	3	47,3	1	11,4	2	58,7	1
Chromium[b]	73,9	1	3,0	4	na	na	76,9	1	na	na
Coal[c]	11,0	4	20,4	2	18,6	3	31,4	1	50,0	1
Cobalt[a]	0,7	10	8,0	3	0,7	11	8,7	3	9,4	3
Copper[a]	1,2	11	7,0	3	na	na	8,2	3	na	na
Diamonds[d]	24,0	2	8,0	5	1,7	6	32,0	2	33,7	2
Fluorspar[e]	6,0	6	11,3	3	7,5	4	17,3	1	24,8	1
Gold[a]	50,8	1	19,7	2	na	na	70,5	1	na	na
Iron ore[b]	4,8	6	29,3	1	4,5	7	34,1	1	38,6	1
Manganese[b]	78,3	1	14,0	2	0,6	7	92,3	1	92,9	1
Nickel[a]	6,5	6	8,2	4	8,0	5	14,7	3	22,7	2
Platinum-group metals[a]	78,7	1	15,4	2	0,7	7	94,1	1	94,8	1
Phosphate rock	6,7	3	3,7	4	0,6	6	10,4	3	11,0	3
Silver[a]	2,9	7	14,9	2	na	na	17,8	1	na	na
Titanium minerals[a]	10,8	4	1,3	11	7,7	6	12,1	4	19,8	1
Vanadium[a]	47,1	1	24,7	2	9,8	5	71,8	1	81,6	1
Zinc[a]	5,7	4	4,7	4	2,5	10	10,4	3	12,9	3
Zirconium minerals[a]	17,9	3	11,7	4	2,3	6	29,6	2	31,9	1

a Contained metal
b Ore *in situ*
c Recoverable reserves of black coal only
d Gem and industrial
e Contained CaF_2
na Not available

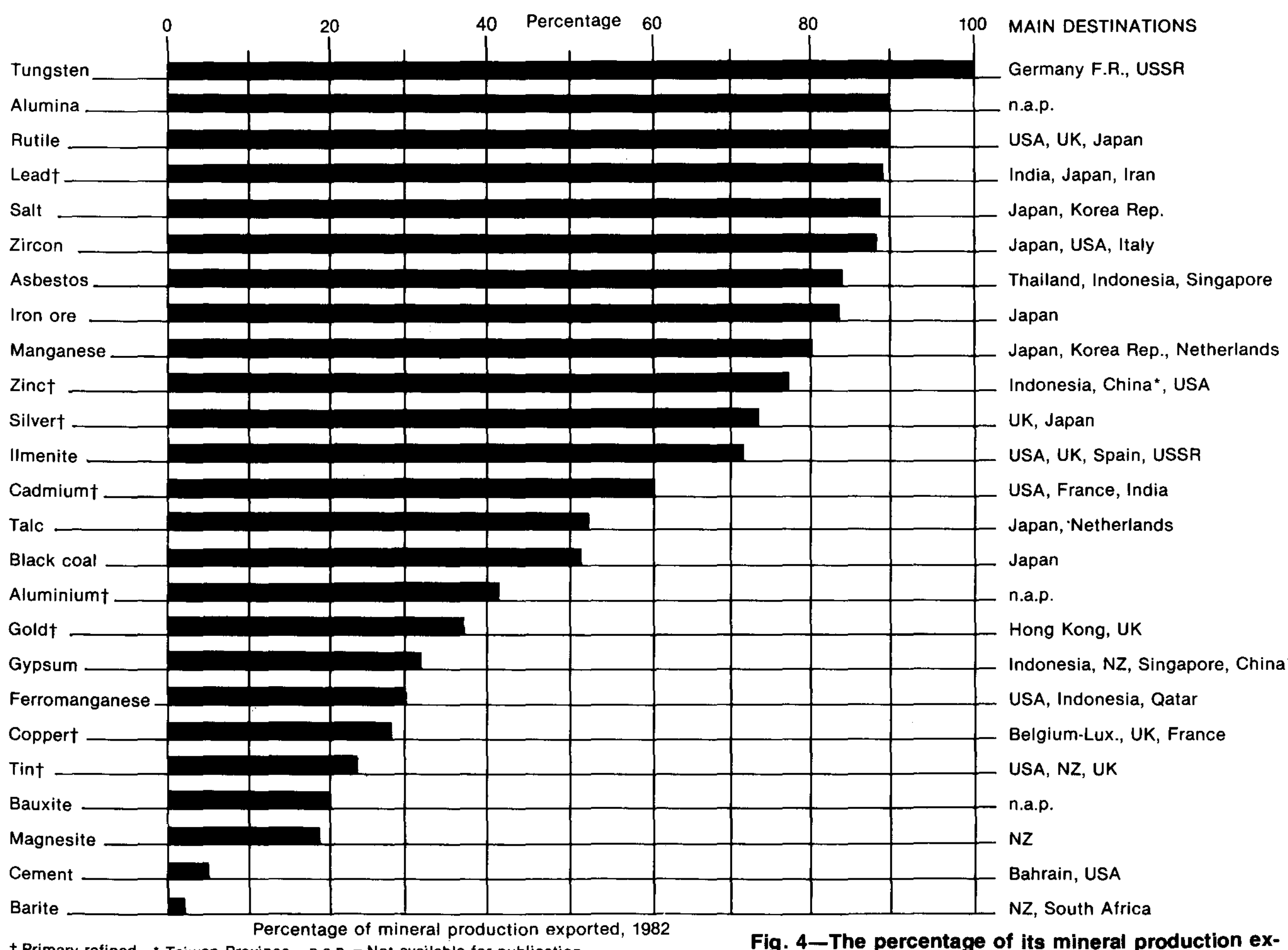


Fig. 4—The percentage of its mineral production exported by Australia, 1982[2]

TABLE V

THE ROLE OF AUSTRALIA IN THE WORLD'S MINERAL SUPPLIES EXPORTS 1983

Commodity	Unit	Exports	World %	World Rank	Market economies* %	Market economies* Rank
Alumina	kt	6 381	54,6	1	57,9	1
Aluminium[a]	kt	216	5,6	5	6,6	4
Bauxite	kt	4 100	14,2	2	14,6	2
Asbestos[e]	kt	35	1,8	7	2,7	6
Coal[b]	kt	60 500	22,9	2	30,5	2
Copper[a]	kt	160	3,1	9	3,2	9
Diamonds[c]	k car.	3 015	6,7	5	7,5	4
Gold[a,f]	t	12	1,1	10	1,4	9
Gypsum[e]	kt	600	5,0	5	5,0	5
Iron ore	kt	74	24,1	1	27,0	1
Lead[a]	kt	45	8,4	4	8,5	4
Manganese ore	kt	1 004	14,8	4	17,8	3
Platinum-group metals[e]	kg	135	0,1	5	0,1	4
Silver[a]	t	887	14,3	4	15,4	4
Titanium[a]	kt	366	35,0	1	35,0	1
Zinc[a]	kt	390	17,1	2	17,5	2
Zirconium[d]	kt	383	72,2	1	72,2	1

* Western World; excludes Centrally Planned Economies comprising Comecon Bloc and China

a Contained metal
b Black coal
c Gem and industrial, rough
d Concentrate
e Estimate
f 1982 statistics

TABLE VI

THE ROLE OF AUSTRALIA IN THE WORLD'S MINERAL SUPPLIES[1,3,4]

RESERVE BASE*

Commodity	Unit	Reserve base Australia	World %	World Rank	Market economies %	Market economies Rank
Antimony[a]	kt	22	0,5	15	1,1	12
Asbestos[b]	kt	6 900	5,1	5	7,4	4
Bauxite	Mt	3 590	16,9	2	17,6	2
Black coal[c,d]	Mt	27 442	5,2	6	9,3	4
Brown coal[d]	Mt	37 000	14,6	na	na	na
Cadmium[a]	kt	73	8,8	3	8,8	3
Copper[a]	kt	17 760	3,5	8	4,0	7
Diamonds[e]	k car.	513 660	33,8	1	37,4	1
Gold[a]	t	1 047	2,6	5	3,3	4
Ilmenite	kt	49 580	5,7	na	na	na
Iron ore	Mt	26 860	13,6	2	20,7	1
Lead[a]	kt	15 690	13,0	3	16,8	3
Manganese ore	kt	393 000	2,4	4	2,8	3
Nickel[a]	kt	2 910	3,8	9	5,6	6
Phosphate rock[f]	Mt	2 800	7	–	–	–
Rutile	kt	10 230	7,6	na	na	na
Silver[a]	t	35 800	10,7	5	13,2	4
Tin[a]	kt	288	8,7	3	9,3	3
Tungsten[a]	kt	159	4,6	6	9,7	4
Uranium[a]	kt	474	na	na	31,8	1
Zinc[a]	kt	26 160	9,4	3	10,6	3
Zircon	kt	15 800	28,9	1	na	na

* Demonstrated economic and para-marginal resources as at 31st December, 1983

a Contained metal
b Contained fibre
c Demonstrated economic reserves only
d Recoverable
e Gem and industrial
f Para-marginal reserves only
na Not available

TABLE VII

THE ROLE OF CANADA IN THE WORLD'S MINERAL SUPPLIES[1,4,5]

RESERVE BASE

Commodity	Unit	Reserve base	World %	World Rank	Market economies %	Market economies Rank
Antimony[a]	kt	64	1,4	13	3,1	11
Asbestos[b]	kt	48 000	35,6	1	51,6	1
Black coal[f]	Mt	1 607	0,3	14	0,5	10
Cadmium[a]	kt	170	20,5	1	20,5	1
Cobalt[a,e]	kt	190	6,7	4	7,9	3
Copper[a]	kt	32 000	6,2	5	7,1	4
Gold[a]	t	1 555	3,9	4	5,0	3
Iron ore	Mt	24 700	12,5	3	19,0	2
Lead[a]	kt	17 000	13,8	2	17,9	2
Molybdenum[a]	t	907	7,7	na	9,6	3
Nickel[a]	kt	10 344	11,6	3	19,9	2
Platinum-group metals[a]	t	280	0,7	6	0,9	5
Potash[c]	Mt	9 700	57,1	1	73,6	1
Silver[a]	t	43 500	13,0	3	16,0	2
Sulphur[a]	kt	300 000	11,1	na	20,7	1
Tantalum[a]	t	2 268	na	na	6,6	5
Thorium[d]	t	240 000	20,7	2	21,3	2
Titanium[a]	kt	40 200	14,0	3	15,5	3
Tungsten[a]	t	670 000	19,3	2	21,7	1
Uranium[a,g]	kt	176	na	na	10,8	3
Zinc	kt	56 000	20,2	1	22,9	1

a Contained metal/mineral
b Contained fibre
c K_2O equivalent
d Thorium oxide (ThO_2)
e Minerals Bureau estimate
f Recoverable reserves
g Recoverable at a cost of less than U.S.$ 80/kg U
na Not available

TABLE VIII

THE ROLE OF CANADA IN THE WORLD'S MINERAL SUPPLIES[6–8]

EXPORTS 1983

Commodity	Unit	Exports	World %	World Rank	Market economies %	Market economies Rank
Aluminium[a]	kt	895	23,0	1	27,3	1
Asbestos	kt	754	38,3	1	58,5	1
Coal[b]	kt	16 900	6,4	6	8,5	4
Copper[a]	kt	612	11,9	2	12,2	2
Ferromanganese	t	4 160	0,3	14	0,3	13
Ferrosilicon	t	46 000	5,5	6	5,5	6
Gold[a,d]	t	41	4,0	3	4,9	2
Gypsum	kt	5 187	42,7	1	43,4	1
Iron ore	kt	25 500	8,3	4	9,2	3
Lead[a]	t	85 000	15,9	3	16,1	3
Platinum-group metals	kg	2 875	1,7	4	2,5	3
Potash[c]	kt	8 964	43,0	1	66,9	1
Silicon metal	t	19 000	9,2	4	10,1	4
Silver[a]	t	1 153	18,6	2	20,0	2
Sulphur	kt	5 671	42,9	1	61,7	1
Titanium[a]	kt	225	21,5	2	21,5	2
Zinc[a]	kt	661	29,0	1	29,7	1

a Contained metal
b Black coal
c K_2O content
d 1982 statistics

TABLE IX

THE ROLE OF BRAZIL IN THE WORLD'S MINERAL SUPPLIES[1,5]

RESERVE BASE

Commodity	Unit	Reserve base	World %	World Rank	Market economies %	Market economies Rank
Asbestos[a]	kt	4 000	3,0	8	4,3	7
Bauxite	Mt	2 300	10,3	3	10,7	3
Chromium[b]	kt	9 000	0,2	10	0,2	8
Columbium[c]	kt	3 629	na	na	87,9	1
Diamonds[d]	k car.	6 000	0,4	10	0,5	8
Gold[c]	t	933	2,4	6	3,0	5
Iron ore	Mt	15 400	7,8	5	11,8	4
Magnesite	kt	136 077	5,4	4	20,3	1
Manganese[b]	kt	163 000	1,0	5	1,2	4
Rare-earth metals[f]	t	73 000	0,2	8	0,8	5
Tantalum[c]	t	1 361	na	na	3,9	7
Thorium[g]	t	75 000	6,5	5	6,7	5
Tin[c]	t	70 000	2,3	10	2,5	8
Titanium[c]	kt	55 100	19,2	1	21,2	1
Tungsten[c]	t	20 000	0,6	11	1,2	9
Uranium[h]	t	163 300	na	na	10,0	4
Zinc[c]	kt	2 000	0,7	11	0,8	10

a Contained fibre
b Ore *in situ*
c Contained metal/mineral
d Gem and industrial
f Rare-earth oxide
g Thorium oxide
h Recoverable at a cost of less than U.S.$ 80/kg U
na Not available

TABLE X

THE ROLE OF THE USA IN THE WORLD'S MINERAL SUPPLIES[1,4,5]

RESERVE BASE

Commodity	Unit	Reserve base	World %	World Rank	Market economies %	Market economies Rank
Alumino-silicates	kt	27 200	19,9	2	24,8	2
Antimony[a]	t	91 000	2,0	9	4,3	7
Asbestos[b]	kt	8 200	6,1	3	8,8	2
Barite[a]	kt	54 420	24,6	1	29,9	1
Boron[a]	Mt	209	33,8	1	46,9	1
Cadmium[a]	kt	160	19,3	3	19,3	3
Coal[d]	Mt	125 353	23,6	1	42,6	1
Cobalt[a]	kt	860	10,3	3	13,7	2
Copper[a]	kt	90 000	17,6	2	19,9	2
Fluorspar	kt	46 000	15,7	2	21,8	2
Gold[a]	t	3 110	7,9	3	9,9	2
Titanium minerals	kt	22 900	8,0	5	8,8	5
Iron ore	Mt	24 400	12,3	4	18,8	3
Lead[a]	kt	27 000	22,0	1	28,4	1
Molybdenum[a]	kt	5 350	45,5	1	56,8	1
Nickel[a]	kt	2 540	2,8	10	4,9	7
Phosphate rock	Mt	5 400	15,4	2	16,3	2
Platinum-group metals[a]	t	500	1,3	5	1,5	5
Rare-earth metals[c]	kt	5 200	10,8	2	52,0	1
Silver[a]	t	56 000	16,8	1	20,6	1
Tungsten[a]	kt	290	8,3	4	17,7	2
Uranium[e]	kt	131,3	na	na	8,1	6
Vanadium[a]	kt	2 180	13,2	4	20,1	3
Vermiculite	kt	91 000	na	na	50,0	1
Zinc[a]	kt	53 000	19,1	2	21,6	2
Zirconium[a]	kt	7 300	19,0	2	22,1	2

a Contained metal/mineral
b Contained fibre
c Contained rare-earth oxide
d Recoverable reserves of black coal
e Recoverable at a cost of less than U.S.$ 80/kg U
na Not available

such as chromium ore, manganese ore, iron ore, potash, platinum, palladium, gold, and diamonds. More recently, exports of oil and natural gas have rendered minerals less important, although highly priced, low-bulk commodities such as platinum, palladium, gold, and diamonds continue to reach Western markets. Speculation on the reason for the reduction in high-volume exports varies, but reasonable assumptions can be made. The high-grade manganese and chromium ores that were so eagerly sought appear to have been depleted, and the lower-grade ore is in less demand and hence fetches lower prices. Also, production is not keeping pace with increases in demand, and exports tend to be limited largely to the nearby Comecon countries. Although economics does not appear to feature in Russian planning, the cost of transporting low-priced ores for thousands of kilometres from mines located remote from harbours must be most unattractive in what is reported to be an overloaded transportation system.

It is commonly stated that the USSR complements the RSA in reserves of minerals that are of strategic importance to the West. Table IV bears this out. As an alternative supplier, however, the USSR has minimal potential. She remains a substantial exporter of diamonds and a possible disrupting influence in the market; the USSR is the second-largest supplier of gold and platinum but, as a proportion of overall supply, her share has diminished in recent years. In the sphere of base metals, the impact of the USSR is minimal apart from exports to the Comecon countries.

China

In common with the USSR, China is remarkably self-sufficient in mineral supplies and imports very little in the way of raw and beneficiated minerals; chromium ore, iron ore, and steel are perhaps the only notable exceptions (Table IV). Her resources of chromium ore are refractory in type, and her imports comprise magnesia-rich ores, which are believed to be used for blending. China has a large, well-developed mining industry; she is the world's second-largest producer of coal, and fourth-largest maker of steel, although substantial imports of the latter are still necessary.

Spasmodic supplies of good-quality low-priced ferrosilicon and silicon metal are sold to Japan. During 1983 considerable quantities of Chinese vanadium pentoxide and slag invaded markets in Western Europe, only to disappear almost entirely during 1984; the price disruption was immense, and may well have been the main reason for the closure of the two producers in Finland. China is a major supplier of tungsten and mercury; antimony supplies are so erratic that they contribute to cyclical surpluses and shortages. Although relatively small amounts of coal are sold on Western markets, the development of a large export mine, railway, and harbour could render China a significant future exporter.

China does not appear to lack resources and, with her thirst for hard currency, could well become a mineral supplier of some consequence in the years ahead.

Conclusion

With an impressive mineral reserve base and solid infrastructure, the RSA is likely to remain a major supplier of minerals in the years ahead. In many of the major minerals, the RSA can be said to be well-endowed, and this factor, combined with sound fiscal policies and a high level of technical expertise backed up by solid research, means that her resources can be exploited at grades that are at least as low as elsewhere in the world. Hence, the extensive exploitation of mineral reserves in the RSA is attributable to a combination of favourable factors, which have enabled deposits that would be regarded as uneconomic in most countries to be turned to good account.

Acknowledgement

The permission of the Director General of the Department of Mineral and Energy Affairs to publish this paper is acknowledged.

Addendum: Definitions

(1) Definitions of Resources and Reserves

A dictionary definition of resource as 'something in reserve or ready if needed' has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present or expected future value.

Resource. A concentration of naturally occurring solid, liquid, or gaseous material in or on the earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource. The amount of a resource before production.

Identified Resource. A resource whose location, grade, quality, and quantity are known or estimated from specific geological evidence. Such resources include *economic, marginally economic*, and *sub-economic* components. To reflect varying degrees of geological certainty, these economic divisions can be subdivided into *measured, indicated*, and *inferred*.

Demonstrated. A term for the sum of *measured* plus *indicated*.

Measured. The quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; the grade and/or quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geological character is so well-defined that the size, shape, depth, and mineral content of the resource are well-established.

Indicated. The quantity and grade and/or quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are further apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough for continuity to be assumed between points of observation.

Inferred. Estimates are based on an assumed continuity beyond measured and/or indicated resources, for which there is geological evidence. *Inferred resources* may or may not be supported by samples or measurements.

Reserve Base. That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The *reserve base* includes those resources that are currently economic (*reserves*), marginally economic (*marginal reserves*), and some of those that are currently sub-economic (*sub-economic resources*). The term *geological reserve* has generally been applied by others to the *reserve-base* category, but it may also include the *inferred-reserve-base* category; it is not a part of this classification system.

Inferred Reserve Base. The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geological character of a deposit, for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserve. The part of the reserve base that could be economically extracted or produced at the time of determination. The term *reserves* need not signify that extraction facilities are in place and operative. *Reserves* include only recoverable materials; thus, terms such as 'extractable reserves' and 'recoverable reserves' are redundant, and do not form part of this classification system.

Marginal Reserves. The part of the reserve base that, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible given postulated changes in economic or technological factors.

Economic. This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Sub-economic Resources. The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources. Resources, the existence of which is only postulated, comprising deposits that are separate from identified resources. *Undiscovered resources* may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or sub-economic. To reflect varying degrees of geological certainty, undiscovered resources can be divided into two parts: hypothetical and speculative resources.

Hypothetical Resources. Undiscovered resources that are similar to known mineral bodies and that can reasonably be expected to exist in the same producing region under analogous geological conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources. Undiscovered resources that may occur either in known types of deposits in favourable geological settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources or Reserves. That part of any resource or reserve category that is restricted from extraction by laws or regulations. For example, *restricted reserves* meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

(2) Definitions of Resources Terminology as Adopted by the Mineral Resources Committee of the Department of Mineral and Energy Affairs, RSA

Identified Resources. The portion of a natural concentration of solid, liquid, or gaseous material (in or on the earth's crust or in the ocean) of which the location, quality, and extent are known to various levels of assurance, ranging from well-established (measured) to inferred from geological projection.

Inferred Resources. The portion of the identified resource that is unexplored and for which estimates of quality and size are based mainly on geological projection.

Demonstrated Reserves (Economic). The portion of the identified resource that can be economically and legally exploited at the time of determination. Its location, quality, and extent are partly well-established (measured) and partly indicated by widely spaced sampling and reasonable geological projections.

Demonstrated Marginal Reserves. The portion of the demonstrated sub-economic resource that borders on being economically producible at the time of determination. Its location, quality, and extent are partly well-established (measured) and partly indicated by widely spaced sampling and reasonable geological projections.

Demonstrated Sub-economic Resources. The portion of the identified resource that has been explored, with the quality and extent partly well-established (measured) and partly indicated by widely spaced sampling and reasonable projection, but for which the concentration, properties, size, or setting have proved to be such that economic exploitation is not currently feasible.

Reserve Base. The *in situ* demonstrated resource from which reserves are estimated. The reserve base includes those resources that are currently economic (reserves), and those that are marginally economic (marginal reserves).

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Where not otherwise referenced, the tables in this paper are attributable to the Minerals Bureau of South Africa.

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Carbon-in-pulp

In view of the interest in this subject from overseas, a third SAIMM carbon-in-pulp school on the use of activated carbon in the recovery of gold will be held from 8th to 12th September, 1986, the week immediately preceding GOLD 100. The School is scheduled to provide overseas delegates with the opportunity of attending a professional school on this important gold-recovery process.

The School will cover the full spectrum of process requirements for the recovery of gold by activated carbon, and the theory and design of the major process operations. Emphasis is placed on the application of modelling techniques. The design features of a number of carbon-in-pulp plants in South Africa and elsewhere will be discussed in detail.

The School will have a strong practical bias, and operating requirements, problems, and results will form major topics for discussion. The following major topics are also covered:

Adsorption	Physical properties of carbon
Elution	Manufacture of carbon
Regeneration	Handling of carbon
Acid treatment	Breakage of carbon
Eluant treatment	Solution applications
Analytical techniques	Materials of construction.

The programme includes a case study of two plants that have utilized the design models.

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