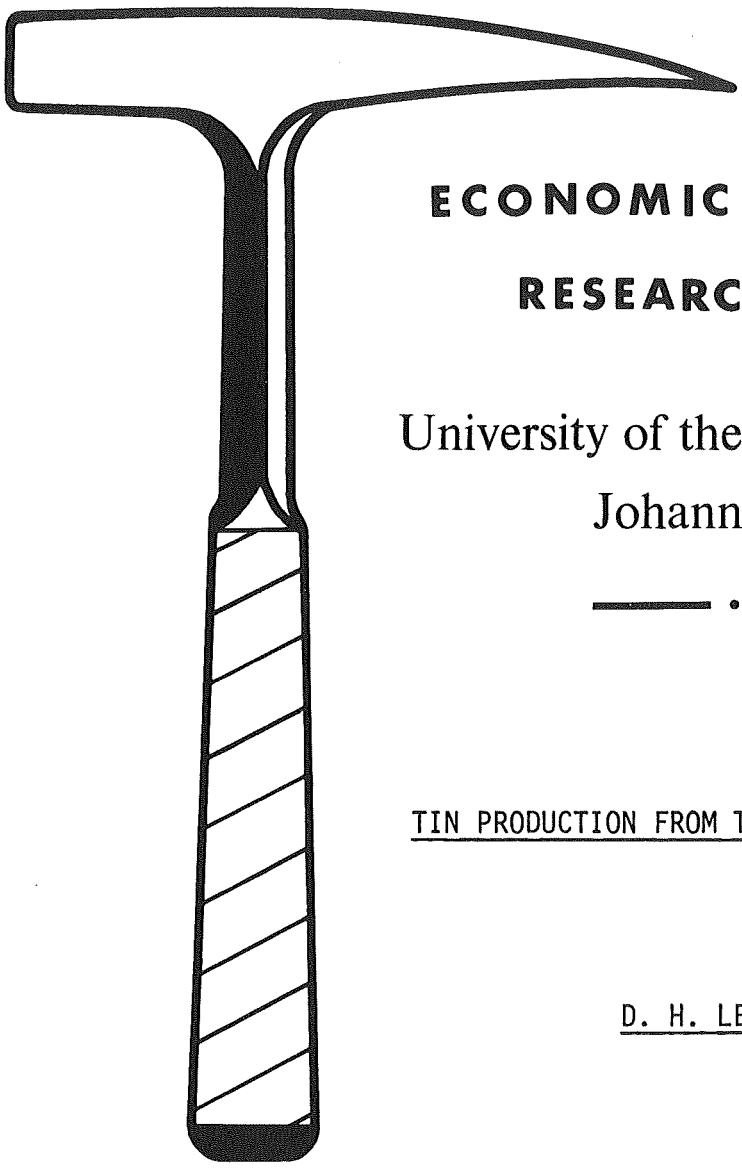


ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

TIN PRODUCTION FROM THE BUSHVELD COMPLEX

D. H. LENTHALL

INFORMATION CIRCULAR No. 93

UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG

TIN PRODUCTION FROM THE BUSHVELD COMPLEX

by

the late D. H. LENTHALL
(formerly Research Fellow)

ECONOMIC GEOLOGY RESEARCH UNIT
INFORMATION CIRCULAR No. 93
October, 1974

Editor's Note : The late Dave Lenthall was engaged at the time of his death on the completion of his doctoral thesis that was to have dealt with the salic phase of the Bushveld Complex and its associated tin mineralization. This Information Circular represents one of the preliminary chapters that Dave had completed and which has now been edited so that it could stand on its own. In preparing this chapter for presentation as an Information Circular the editor has endeavoured to represent Dave's opinions and conclusions accurately. Where there are errors or omissions, the editor is solely responsible.

D. R. H.

TIN PRODUCTION FROM THE BUSHVELD COMPLEX

ABSTRACT

Analysis of tin production figures from mines, operating and defunct, shows that exogranitic deposits have contributed 64% of the total metallic tin won from deposits in the Bushveld Complex; deposits in sedimentary rocks having contributed 56% and those in acid volcanics nearly 8%. Tin production has been dominated by two mines, one of which mines ore-bodies located in sedimentary rocks and the other which is in an endogranitic environment. If the production from these two major producers is deducted, the remaining tin production has been won in almost equal proportions, ± 38%, from granites and sedimentary rocks with nearly 25% of the production having come from deposits located in the felsites.

The production of metallic tin from 1904 to 1971 amounts to 69 748,396 tonnes and was won from a total of 21 properties, only 5 of which produced or have produced more than 1 000 metric tonnes.

* *

TIN PRODUCTION FROM THE BUSHVELD COMPLEX

CONTENTS

* *

TIN PRODUCTION FROM THE BUSHVELD COMPLEX

INTRODUCTION

The objective of mineral exploration is to locate a maximum number of economic deposits with minimum expenditure of time and money. In order to achieve this goal it is essential to define a strategy, the details of which will obviously vary depending upon the particular mineral sought, but in each case the end-product is the definition of exploration targets and the design of search procedures.

A first step is to define the most favourable environment, i.e. structural or lithologic, in which mineralization is known to occur. In the case of tin, mineralization may be endo- or exogranitic, and it is necessary to establish in any particular tin-field which of these environments has the greater potential. In this way an order of priority for the selection of prospecting targets can be prepared. The next stage is to examine in more detail the controls that have led to tin concentration in economically viable amounts in the particular environment which is shown to be the most favourable. In this account the tin production figures from mines, both operating and defunct, are reported in order to establish which lithologic units, spatially or temporally associated with the Bushveld Complex, are the most favoured hosts for tin mineralization.

Primary tin mineralization occurs in a wide variety of host rocks. However, it can be shown that the tin is spatially and, presumably therefore, genetically related to either acid extrusive or intrusive magmas. The factors which determine whether or not a particular granite is likely to have associated tin mineralization or not are as yet not clearly understood and very probably vary from tin-field to tin-field. The Bushveld granites and, in particular, their latest phase, the so-called Bobbejaankop granite, are known to carry tin mineralization so that logically the first step in the formulation of a strategy for the exploration of tin in the Bushveld Complex would be to establish the characteristics that distinguish the mineralized Bushveld granites (the Bobbejaankop granite) from their barren counterparts. One further consideration that must be taken into account is the fact that tin-bearing granites may well, and often do, lose their tin to the surrounding country rocks into which they are intruded. Therefore, in addition to establishing the characteristics of stanniferous granites, it is also imperative to define the optimum sites of mineralization. The records of previous production from deposits in the Bushveld Complex are available to establish an order of priority. For this reason production figures for all known tin producers, both active and defunct, were compiled from the records at the Government Mining Engineer's Office, Johannesburg. The writer would like to place on record his appreciation to the following organizations who kindly granted permission for access to these records :

1. Gold Fields of South Africa Limited.
2. Rooiberg Minerals Development Company.
3. Union Tin Mines Limited.
4. Zaaiplaats Tin Mining Company Limited.

The production figures at the Government Mining Engineer's Office, at the time of compilation covered the period from 1904 to September, 1971, and as far as can be established they are virtually complete.

The total tin production from the Bushveld Complex between 1904 and September, 1971, amounted to some 110 503,863 metric tonnes of concentrations which have yielded 69 748,396 metric tonnes of metallic tin. Of a total of 21 producing properties, eight have produced more than 100 metric tonnes of metallic tin, and of these five have produced in excess of 1 000 metric tonnes of metallic tin. The production from these five mines accounts for 99,5 per cent of the total production of tin from the Bushveld Complex.

TIN-FIELDS WITHIN THE BUSHVELD COMPLEX

Economic deposits of tin are not uniformly distributed through the salic rocks of the Bushveld Complex but tend to cluster together in discrete groups which, combined, constitute a tin-field.

Altogether, six separate tin-fields exist within the Bushveld Complex (Figure 1) and are, in order of decreasing economic importance :

(i) the Rooiberg tin-field situated approximately 35 km to the west of Warmbaths,

(ii) the Zaaiplaats tin-field situated approximately 35 km to the north-northwest of Potgietersrus,

(iii) the Nylstroom tin-field situated approximately 25 km west of Naboomspruit,

(iv) the Olifants tin-field situated approximately 30 km to the north of Marble Hall,

(v) the Elands tin-field occurring to the northwest of Warmbaths, and

(vi) the Moloto tin-field located approximately 46 km to the north of Cullinan.

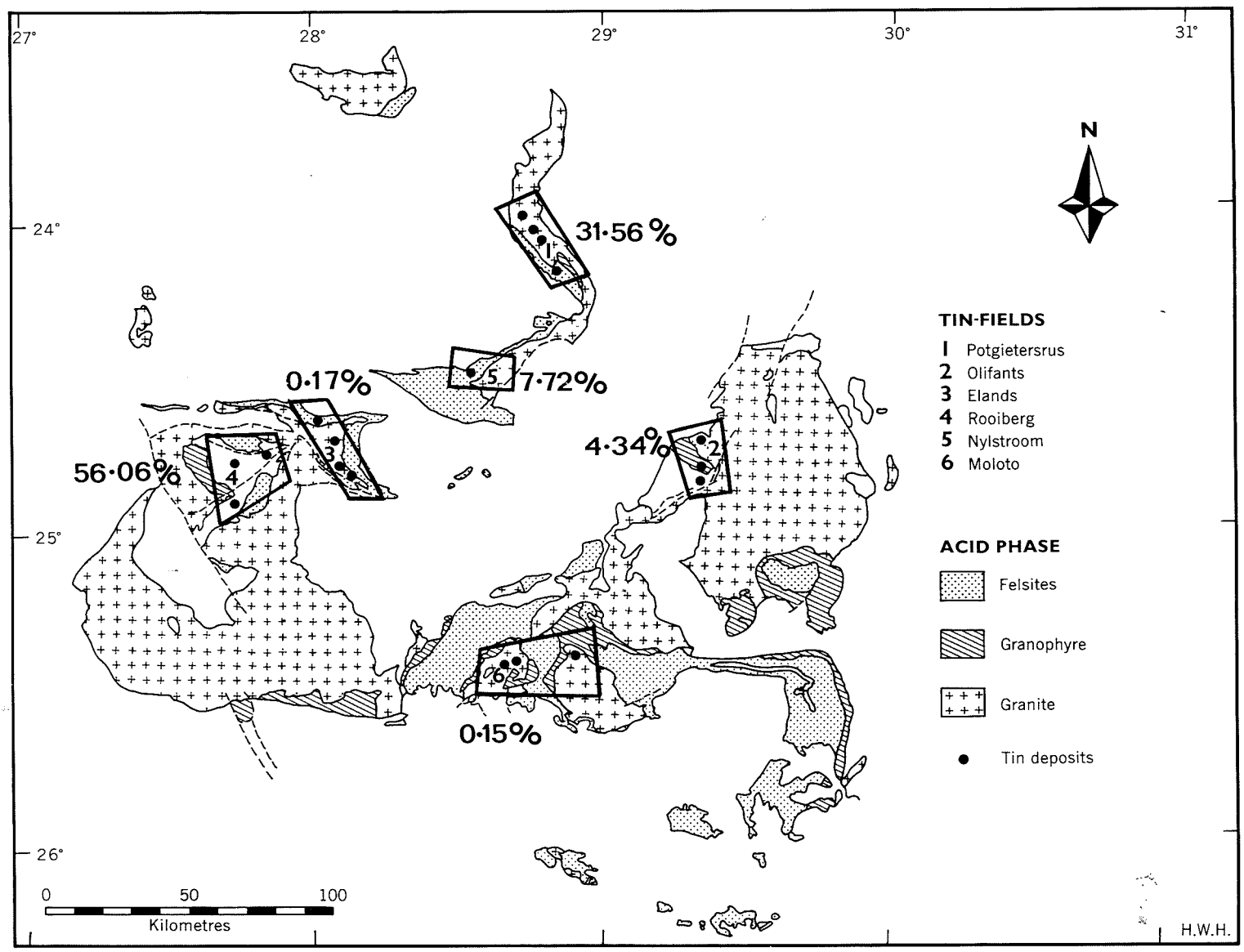


Figure 1 : The tin-fields in the Bushveld Complex and the percentage contribution of the total production each tin-field has made in period 1904-1971.

A. The Rooiberg Tin-Field

The Rooiberg tin-field is the largest contributor to the total production of tin from the Bushveld Complex. Mineralization occurs chiefly within quartzo-feldspathic sediments correlated with the upper formation of the Transvaal Supergroup. In addition, small 'showings' of tin mineralization are found in granites surrounding the Rooiberg pendant, but none as yet, have proved to be of any economic importance. Tin deposits in the Rooiberg fragment occur as irregular pipe-like bodies located along, or at the intersections of steeply-dipping fractures, as stockworks, as fracture fillings and as replacement lodes in the sediments. All mineralization is located immediately beneath a well developed shale band, known locally as the "Main Shale", which appears to have formed an effective trap for ascendant mineralizing solutions, leading to the precipitation of cassiterite together with fluorspar and copper-iron sulphides.

Ancient tin workings were discovered near Rooiberg in 1905. The start of mining is estimated to have been between 300 and 5 000 years ago, but the most recent research tends to disprove any great antiquity (McDermott and Oxley Oxland, 1961). It has been calculated that during this period about 2 000 tons of metallic tin were produced from 30 000 tons of ore. On a small hill approximately one kilometre from the present Rooiberg Mine, an ancient smelting site was discovered. This site (today known as Smelter's Kop) was probably the most important of the ancient smelting sites.

The discovery of the ancient tin workings led to the "re-discovery" of the tin deposits and the Rooiberg Minerals Development Company Limited was formed in 1908. The Leeuwpoort Tin Mines Limited was formed in 1911 but went into liquidation in 1932 when the mineral rights over the property were acquired by the Rooiberg Company.

Several other mines were started in 1908 and 1915 but the majority closed down. The Vellefontein tin mine began producing in 1952 but closed down in 1964.

The production figures of the individual mines that have at one stage or another been active in the area, together with other relevant information, are summarized in Table 1.

B. The Zaaiplaats Tin-Field

Cassiterite was first discovered in 1906 on the farm Zaaiplaats 223 KR in the Potgietersrus district by Moore, a prospector of the Transvaal Consolidated Lands and Exploration Company (Strauss, 1954). Apparently claims were pegged simultaneously by Messrs. Maggs and Munro who later amalgamated interests to form the Zaaiplaats Tin Mining Company. At the same time the Transvaal Consolidated Lands and Exploration Company started operations on the adjoining farms Roodepoort and Groenfontein.

Shortly after the discovery of tin in this area exploration and mining operations were extended onto the farms Solomons Temple, Groenvley and Appingendam. Like Zaaiplaats, Appingendam is State land and at one stage more than forty prospectors were working there simultaneously. Most of their claims were later combined to form the now defunct Appingendam Tin Mining Company.

The area of prospecting activity was extended farther afield in the felsite hills on Solomons Temple, Welgevonden, Welgelegen, Waterval, Grootrivier and Domdraai. Minor amounts of ore were dressed on Waterval, but on the other farms operations never advanced beyond the prospecting stage. During the course of prospecting for cassiterite, small deposits of arsenopyrite, molybdenite, bastnaesite, sphalerite, scheelite, bornite, and chalcocite were discovered. Mineralization occurs predominantly in, and is genetically related to the younger stocks and bosses of Bushveld granite which have been named the Bobbejaankop granite [Strauss and Truter, (1944); Strauss (1954)]. The presence of small showings of cassiterite in the felsites at Welgevonden and Welgelegen was taken by Strauss to indicate the presence of an, as yet unexposed, body of Bobbejaankop granite in the area.

The endogranitic mineralization is restricted to the upper parts of the Bobbejaankop granite, and to a lesser degree in its fine-grained microgranitic, hood facies, the Lease granite. A number of varieties of ore are developed but these may be broadly subdivided into the disseminated- and pipe-type deposits. The pipes are long, roughly cylindrical bodies varying in

TABLE 1

PRODUCTION FIGURES FOR CONFIRMED TIN PRODUCERS IN THE ROOIBERG TIN-FIELD

Organization	Locality	Duration of Operations	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metallic Tons)	Quoted Value (Rands)
Anglo Rand	Vellefontein 517 KQ	1952		11,102	6,918	
Blaaubank Tin Mine	Blaauwbank 515 KQ	1935-1940	9 782	116,488	69,180	29 612
Leeuwpoort Tin Mine Ltd.	Leeuwpoort 554 KQ; Rietfontein 536 KQ	1911-1930*	897 425	11 123,799	7 027,336	3 310 780
Rooiberg Minerals Development Co. Ltd.	Blaauwbank 515 KQ; Olievenbosch 506 KQ; Hartebees-fontein 511 KQ; Leeuwpoort 554 KQ; Nieuwpoort 516 KQ; Rietfontein 536 KQ	1909-1971	4 293 158	48 015,645	30 701,729	38 931 613
Vellefontein Tin Mining Co. Ltd.	Vellefontein 517 KQ	1953-1964	215 561	3 090,020	1 339,833	1 641 299
Weynek Tin Co. Ltd.	Weynek	1909-1911	14 336	8.929	4,488	1 774
			5 430 262	62 365,983	39 149,484	43 915 078

* In 1932, the Leeuwpoort Tin Mine Limited, went into liquidation at which stage the mineral rights over the property were acquired by the Rooiberg Minerals Development Company Limited. From 1932 the production of the old Leeuwpoort Tin Mine is included with that of Rooiberg Minerals.

diameter from less than 1 metre to more than 10 metres, but with a mean of between 1 and 2 metres. Lengths vary from 5 metres to more than 1 000 metres and their attitude may vary from horizontal to vertical. The most striking feature of the pipes is their annular structure that results from a pronounced mineralogical zoning. The pipes are located within the granite from a few metres to nearly 300 metres below the pegmatites lying at the upper contact of the roof of the Bobbejaankop stock. Pipes display a bewildering complexity of shape and attitude, frequently branching and uniting with one another, pinching and swelling, rising and falling, and twisting and turning in every conceivable direction. Cassiterite is irregularly and erratically distributed through the pipes, and may disappear and reappear without warning. Cassiterite does, however, disappear completely at depth.

Disseminated mineralization occurs both in the Bobbejaankop granite and in the Lease microgranite. The ore consists of normal granite with disseminated grains of cassiterite. Individual grains attain lengths of up to 6 mm. A feature of the mineralized granite is the prevalence of patches of dark, intensely chloritized and epidotized granite and irregular flat vugs. Strauss (1954) held the view that mineralization was restricted to three gently-dipping zones situated at various levels beneath the roof of the Bobbejaankop granite plug. Recent mining operations have however tended to indicate that the disseminated cassiterite is most abundant immediately beneath the roof and decreases gradually and uniformly with increasing depth.

The production figures of the individual mines which have, at one stage or another, been operative in the area, together with other relevant information are summarized in Table 2.

TABLE 2

PRODUCTION FIGURES FOR CONFIRMED TIN PRODUCERS IN THE ZAAIPLAATS TIN-FIELD

Organization	Locality	Duration of Operation	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metric Tons)	Reported Value (Rands)
African Farms Ltd.	Welgevonden	1913-1914	9 738	187,051	97,466	32 152
Gilfonia Tin Mine	Appingendam	1918-1919	141	2,486	1,530	630
Groenfontein Tin Mine	Roodepoort	1906-1913 1939-1967	207 165	6 394,728	4 463,227	2 687 479
Groenvlei Minerale (Edms.) Bpk.	Groenvley	1943	?	0,958	0,703	378
Groenvlei Tin Mine	Groenvley	1916-1918	2 149	15,359	9,640	?
Leonora Tin Tribute	Solomon's Temple	1913	?	7,013	4,801	1 944
Maggs and Munro	Zaaiplaats	1906-1909	?	945,365	432,589	99 376
Maxwell Tin Mine	Welgevonden	1951	198	0,158	0,018	6
Solomon's Temple Tin Mine, Ltd.	Solomon's Temple	1909-1912 1920	6 102	35,397	30,529	6 604
Solomon's Temple Tin Mine, Ltd.	Solomon's Temple	1950-1952	2 765	72,632	12,138	?
Sterk River Tin Mines	Welgevonden	1914-1916	6 264	47,756	27,535	9 624
Mr. van der Merwe Tributor	Groenvley	1942	?	0,176	0,105	?
Waterval Tin Myne	Waterval	1952	?	0,730	0,396	?
Waterval Tin Myne	Waterval	1951-1952	?	0,193	0,123	374
Zaaiplaats Tin Mining Co. Ltd.*	Zaaiplaats Groenfontein	1909-1971	2 198 569	23 577,863	16 867,537	?
			2 433 091	31 287,865	21 948,337	2 838 567

* The production of the Government tin workings which were worked by the Zaaiplaats Tin Mining Company Limited, has been included in the latter's production records.

C. The Nylstroom Tin-Field

The Nylstroom tin-field is situated approximately 25 kilometres northwest of Nylstroom. Tin deposits are located in fissures, in felsites and an intercalated sedimentary horizon - the Union Tin Shale - which in the vicinity of the producing mine, is siliceous. The deposits are replacement bodies located close to the fractures although not actually filling them. The cassiterite is extremely fine-grained, and is associated with haematite and magnetite. Chalcopyrite, arsenopyrite, and galena are also present.

The Nylstroom tin-field was first worked with little success during the period 1909-1913 and on subsequent occasions but the fineness of the cassiterite, and its association with haematite and magnetite proved then to be an insurmountable extraction problem. It was not until 1951 when these problems of extraction were overcome that the Nylstroom tin-field became a significant producer.

The production figures of the individual tin mines which have, at one stage or another, been operative in the area together with other relevant information, are summarized in Table 3.

TABLE 3

PRODUCTION FIGURES FOR CONFIRMED TIN PRODUCERS IN THE NYLSTROOM TIN-FIELD

Organization	Locality	Duration of Operation	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metric Tons)	Reported Value (Rands)
Doornhoek Platinum Mines	Doornhoek	1927-1928	-	10,507	6,164	3 128
Doornhoek Tin Mines Ltd.	Doornhoek	1914	1 042	35,276	15,352	5 518
Protea Tin Mining Syndicate	Doornkom 376 KR	1929	1 342	36,464	17,561	6 986
South African Tin Mines, Ltd.	Doornhoek	1909-1913	23 500	540,788	270,682	99 039
Union Tin Mines Ltd.	Doornhoek	1951-1971	790 087	10 076,367	5 085,497	8 703 455
			815 971	11 599,402	5 395,256	8 818 125

D. The Olifants Tin-Field

The first systematic prospecting in the area referred to as the Olifants tin-field (Figure 1) was carried out shortly after the cessation of the South African War by Oceanic Development Company Limited, when a number of pits and shafts were put down on conspicuous copper-stained gossans. Discouraging results caused this undertaking to be abandoned. Interest in the area was renewed in 1912 when cassiterite was discovered near the Olifants River in the bed of a dry water-course by which the farms Stavoren, Gaasterland and Tambootieboom are drained. Through systematic prospecting the source of cassiterite was soon traced to what was to become known as the "A" workings on Stavoren. This success gave impetus to prospecting operations which in turn resulted in the rapid discovery of the deposits on the farms Mutue Fides, Gaasterland and Roodewal.

Original extravagant expectations were never realized and production proved so disappointing that by 1920, except for Transvaal Consolidated Land and Exploration Company's Mutue Fides Tin Mine, all other operations had virtually ceased. During the World War II, when the supply of tin from Malaya was cut off by enemy action, the Olifants tin-field was re-investigated as a possible source of tin. As a result of this exploration programme, largely undertaken by the Government, a number of short-lived undertakings came into production none of which lasted for more than four years.

The primary tin deposits of the Olifants tin-field occur in the granites, granophyres, and sediments presently correlated with the Smelterskop Formation of the Transvaal Supergroup.

The deposits in the granites occur as disseminations and as irregular pipe-like bodies which, according to Wagner (1921), are located on or at the intersections of steeply-dipping joints and fractures. Important replacement bodies were located beneath two flat-lying sheets of pegmatite.

Pipe-like deposits are also found in the granophyres and overlying quartzo-feldspathic sediments and these too show a close spatial relationship to steeply dipping fractures. The pipes in the granite are roughly cylindrical or funnel-shaped and display an annular structure that results from a pronounced mineral zoning. The core consists of calcite and/or fluorite often containing patches of arsenopyrite, or vugs lined by quartz. A ring of tin-scheelite-arsenopyrite ore surrounds the core and is itself surrounded by feldspar-rich pegmatite.

A vertical mineralogical zonation is also apparent in the area with high temperature mineral assemblages occurring in or near the granite and the lowest temperature assemblages being encountered in the quartzites.

The production figures for bona fide tin producers in the Olifants tin-field, together with other relevant information are listed in Table 4.

TABLE 4

PRODUCTION FIGURES FROM CONFIRMED TIN PRODUCERS IN THE OLIFANTS TIN-FIELD

Organization	Locality (Farm)	Duration of Operation	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metric Tons)	Reported Value (Rands)
African Mining Trust Co. Ltd. (Gras Valley Tin Mine)	Mutue Fides	1956-1959	20 008	224,095	151,189	218 084
Mr. Colville (Tributor)	Stavoren	1942-1943	Alluvial workings	2,461	1,371	800
Mutue Fides Tin Mines	Mutue Fides Tygerpad	1913-1949	188 446	4 346,680	2 719,619	1 129 856
Northern Transvaal Tin Mine	Mutue Fides	1915	Alluvial workings	3,085	1,591	2 618
Mr. Praeg (Tributor)	Mutue Fides	1952-1953	Alluvial workings	2,990	1,732	2 448
Stavoren Base Metals	Stavoren	1943-1944	?	1,239	0,694	394
Stavoren Tin Mining Co. Ltd.	Stavoren Gaasterland	1913-1921 1934-1936	12 150	196,932	119,611	43 629
Transvaal Tin Areas Ltd.	Roodewal Tambootieboom	1948-1949	1 626	10,398	6,320	5 114
Union Tin Mines Ltd.	Roodewal	1918-1920	1 422	19,223	12,803	4 504
Zaaiplaats Tin Mining Co. Ltd.	Stavoren	1956-1959	7 224	53,692	18,521	*
			230 876	4 861,795	3 033,451	1 407 446

* Value included with Zaaiplaats Tin-field values.

E. The Elands Tin-Field

The Elands tin-field, situated to the northwest of Warmbaths (Figure 1), is one of the two minor tin-fields of the Bushveld Complex. There is little information to indicate the exact time of discovery but all indications are that it was at about the same time that the Rooiberg and Zaaiplaats tin-fields were discovered, namely around 1908.

In the Elands tin-field, isolated traces of cassiterite occur in the granites in close proximity to the overlying Rooiberg felsites which also contain showings of tin mineralization. However, the total confirmed production has all come from the farm Elandsfontein 440 KR.

Mineralization within the granites is found as irregular pipe-like bodies, associated with pegmatite sheets and aplite dykes, and as disseminations within the granite.

Tin in the felsites is found in replacement bodies immediately beneath the tuffaceous shale horizon, probably the lithological equivalent of the Union Tin Shale in the Nylstroom tin-field.

The production figures of confirmed tin producers in the Elands tin-field, together with other relevant information are reproduced in Table 5.

TABLE 5

PRODUCTION FIGURES FROM CONFIRMED TIN PRODUCERS IN THE ELANDS TIN-FIELD

Organization	Locality	Duration of Operation	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metric Tons)	Reported Value (Rands)
Eland Tin Myn	Elandsfontein 440 KR	1951	?	2,004	1,344	2 478
Elandsfontein Tin Mine	Elandsfontein 440 KR	1964-1965	?	14,938	5,949	?
Northern Tin Mining Co. Ltd.	Elandsfontein 440 KR	1936-1940	8 838	80,363	41,559	15 860
Warmbaths Tin Syndicate	Elandsfontein 440 KR	1925-1929	5 793	120,552	66,210	34 688
Waterberg Tins	Elandsfontein 440 KR	1909-1910	?	4,394	3,076	870
			14 631	222,251	118,138	53 896

F. The Moloto Tin-Field

The first indications of the presence of cassiterite in economically viable quantities in the Bushveld Complex were reported from this tin-field. Despite these encouraging signs, the Moloto tin-field never achieved a significant production and remained the smallest contributor.

Tin was first discovered in salic rocks of the Bushveld Complex on the farm Enkeldoorn 217 JR. Further traces of mineralization were reported on the farms Vlaklaagte 221 JR, Allemansdrift 162 JR, Hartebeesfontein 224 JR, and Vaalbank 163 JR.

Hall (1904) reported that cassiterite was disseminated in granite and that individual orebodies were related to fissures. The cassiterite is accompanied by one or more of the following minerals : topaz, zircon, tourmaline, fluorite, wolframite, haematite, molybdenite, and chalcopyrite.

A small deposit of cassiterite in granophyre was worked on the farm Zustershoek 246 JR but closed down in 1955 after only three years of operation.

Production figures of the mines that have operated in the area together with other relevant information are summarized in Table 6.

THE TOTAL TIN PRODUCTION OF THE BUSHVELD COMPLEX

The combined production figures available from all the tin-fields within the Bushveld Complex, listed above, are summarized in Table 7.

The apparently low value of the production from the Zaaiplaats Tin-field is because the value of the production from the Zaaiplaats Tin Mining Company Limited is not included. The reason being that the figures recorded at the Government Mining Engineer's Office are not sufficiently detailed to enable a distinction to be made between the actual mining production and the smelter production, the latter includes concentrates purchased from other mines. Clearly the pattern of tin production from the Bushveld Complex has been dominated by the contributions of the Rooiberg and Zaaiplaats tin-fields respectively.

In an unsophisticated way an attempt has been made to assess the relative importance of the different rock-types that act as host to tin mineralization within the Bushveld Complex by analysing the production figures that reflect their past performance. In this way it is hoped that it may be possible to assign to each rock-type an order of priority for their investigation in the search for tin.

TABLE 6

PRODUCTION FIGURES FROM CONFIRMED TIN PRODUCERS IN THE MOLOTO TIN-FIELD

Organization	Locality	Duration of Operation	Ore (Metric Tons)	Concentrates (Metric Tons)	Metallic Tin (Metric Tons)	Reported Value (Rands)
Bushveld Tin Mines Ltd.	Enkeldoorn 217 JR	1904-1910	11 834	19,021	12,800	3 044
Cambrian Tin Mines	Allemansdrift 162 JR	1915-1916	?	15,820	5,620	?
Mr. Davies (Tributor)	Vlaklaagte 221 JR	1919	Alluvial workings	1,039	0,580	?
Enkeldoorn Tin Mine	Enkeldoorn 217 JR	1951-1968 (inter-mittent)	415	14,094	9,077	?
Leeuwkop Tin Maatskappy (Edms.) Bpk.	Leeuwkop 228 JR	1951	26	1,758	0,105	?
Mass Tin Co. Ltd.	Vlaklaagte 221 JR	1927-1928	1 998	28,981	18,322	10 648
New Pretoria Silver and Lead Co.	Allemansdrift 162 JR	1928-1929	545	1,582	1,072	?
Pioneer Tins Ltd.	Hartebeesfontein 224 JR	1914	?	0,440	0,088	?
Roberts Tin Mine	Allemansdrift 162 JR	1917-1920	193	9,944	6 960	658
Transvaal Cons. Land & Explor. Co. Ltd.	Allemansdrift 162 JR	1921-1923	398	6,942	4,998	2 274
Vaalbank Tin Mines	Vaalbank 163 JR	1935 and 1940	Alluvial workings	1,710	1,088	456
Vaalbank Tin Syndicate	Vaalbank 163 JR	1915	?	0,369	0,214	82
Vlaklaagte Tin Mine	Vlaklaagte 221 JR	1934-1938	363	21,161	14,300	2 866
Zustershoek Tin and Minerals Dev. Co.	Zustershoek 246 JR Enkeldoorn 217 JR	1952-1954	17 041	46,706	28,506	?
			32 813	169,567	103,730	20 028

TABLE 7

TIN PRODUCTION FIGURES FROM THE INDIVIDUAL TIN-FIELDS WITHIN THE BUSHVELD COMPLEX

	Concentrates	% of Total	Metallic Tin	% of Total	Quoted Value
Rooiberg Tin-field	62 365,983	56,43	39 149,484	56,06	43 915 078
Zaaiplaats Tin-field	31 287,865	28,32	21 948,337	31,56	2 838 567*
Nylstroom Tin-field	11 599,402	10,50	5 395,256	7,72	8 818 125
Olifants Tin-field	4 861,795	4,40	3 033,451	4,34	1 407 446
Elands Tin-field	222,251	0,20	118,138	0,17	53 896
Moloto Tin-field	169,567	0,15	103,730	0,15	20 028
	110 506,863	100,00	69 748,396	100,00	

* For reasons for excluding value of the Zaaiplaats Tin Mining Company's production, see text. The value quoted is that of the rest of the tin-field.

In the foregoing discussion, one fact that has clearly emerged is the complete dominance of the pattern of tin production from the commencement of operations by the Zaaiplaats and Rooiberg tin mines. For this reason the production data was analyzed initially with the production figures of the two mines included and subsequently excluding their production figures.

The results of these analyses are presented in tabulated form in Table 8, and diagrammatically in Figures 2 and 3. The first four columns of Table 8 summarizes the results of the analysis that includes the Rooiberg and Zaaiplaats tin mines' production and the second four columns summarizes the results of the analysis with their production excluded.

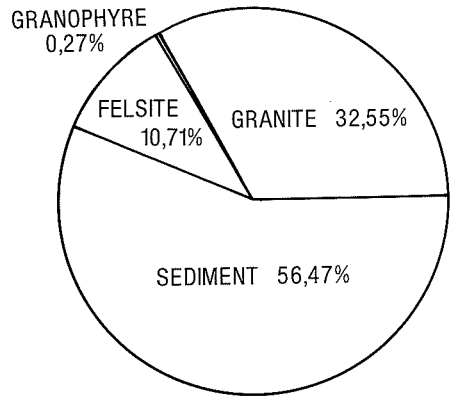
TABLE 8

TIN PRODUCTION FROM DIFFERENT HOST ROCKS IN THE BUSHVELD COMPLEX

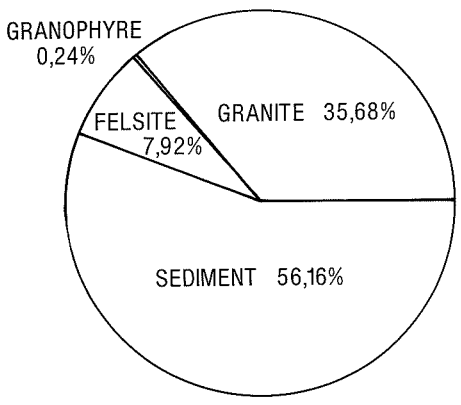
Host Rock	Concentrates	% of Total	Metallic Tin	% of Total	Concentrates*	% of Total*	Metallic* Tin	% of Total*
Granites	35 964,746	32,55	24 885,087	35,68	11 441,518	30,12	7 584,961	34,89
Granophyres	298,569	0,27	167,332	0,24	298,569	0,86	167,332	0,77
Felsites	11 835,290	10,71	5 520,794	7,92	11 835,290	31,16	5 520,794	25,39
Sediments	62 395,604	56,47	39 168,607	56,16	14 379,959	37,86	8 466,878	38,95
	110 494,209	100,00	69 741,820	100,00	37 955,336	100,00	21 739,965	100,00

The second set of figures marked with an asterisk are those in which the contributions of the Zaaiplaats and Rooiberg tin mines have been removed.

In the first instance it is clearly evident that the production from sedimentary rocks outweighs that of the combined production of the remaining three categories. The production from the granites is second to that of the sediments while that for the felsites and granophyres is distinctly subordinate. However, when the production figures of the two largest mines are excluded an interesting pattern emerges in which production from the granites and the sediments is virtually equal, but significantly the felsites now emerge as a potentially important source of tin contributing 25,39 per cent by weight to the total production of the complex. The contribution from granophyre, however, remains minimal.

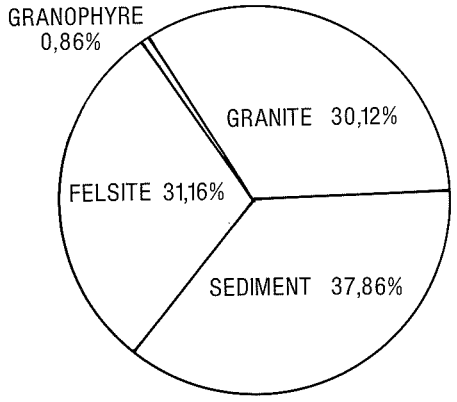


A CONCENTRATES 110 494,209 METRIC TONNES

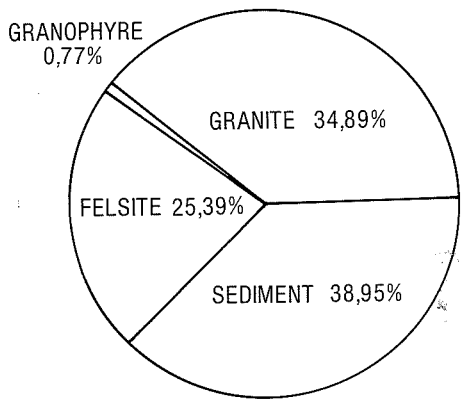


B METALLIC TIN 69 741,820 METRIC TONNES

Figure 2 : Percentage contributions by different host rocks to the total production of tin from the Bushveld Complex 1904-1971.



A CONCENTRATES 37 955,336 METRIC TONNES



B METALLIC TIN 21 739,965 METRIC TONNES

Figure 3 : As for Figure 2 but with the production from the Zaaiplaats and Rooiberg mines excluded.

The question now posed is, is there any geological significance to the pattern of tin production which has emerged from this study? To answer this question one must consider these results in conjunction with the possible origin of the tin together with its spatial distribution within the Bushveld Complex.

Detailed investigations of the various exogranitic tin deposits in the Bushveld Complex (Menge, 1963; Wagner, 1921; Boardman, 1946; Leube and Stumpfl, 1963; and Coetzee, 1970) all indicate that the most probable source for tin is the granites which intrude the different cover rock. In other words these deposits appear truly epigenetic and unrelated to the formation of the host rocks in which they are found. This applies particularly to the Rooiberg felsites.

Significantly all endogranitic tin deposits in the Bushveld Complex are located in close proximity to the preserved roof of the granites. There is an absence of economic tin mineralization in the granites where they have been completely unroofed. Tin mineralization in the Bushveld Complex, as it is known today, is a phenomenon exclusively restricted to the upper margins of the granites of the Bushveld Complex and to their immediate roof rocks.

This observation is common to tin-fields of any age throughout the world, but the recognition of its significance must have a strong influence on the formulation of any strategy aimed at the search for tin. The large areas of granites in the Bushveld Complex that have been completely unroofed by erosion and are well removed from any preserved cover rocks must be relegated to a low priority for investigation while all activities concerned with the exploration for tin should be focused along those areas in which the granites and their original rocks are preserved.

The possibility of the Rooiberg felsites containing tin mineralization, genetically related to the felsites must not be excluded. Recent discoveries of economically viable tin mineralization occurring in and genetically related to, acid extrusives have been made at Durango, Mexico, and there would appear to be no reason why the same could not be true for the Rooiberg felsites.

REFERENCES

Boardman, L.G. 1946. The geology of a portion of the Rooiberg tin-fields : Trans. Geol. Soc. S. Afr., Vol. 49, p. 103-132.

Coetzee, G.L. 1970. The Rooiberg felsite series north of Nylstroom : Spec. Pub. No. 1, Geol. Soc. S. Afr., p. 312-325.

Hall, A.L. 1904. The geological survey of the south-eastern portions of the Pretoria district, including the tin-fields : Ann. Rep. for 1904, Geol. Surv. Transvaal, p. 37-45.

Leube, A. and Stumpfl, E.F. 1963. The Rooiberg and Leeuwpoort tin mines, Transvaal, South Africa : Econ. Geol., Vol. 58, p. 391-418, 527-557.

McDermott, E.K. and Oxley-Oxland, G. St. J. 1961. Tin mining in South Africa : Trans. VIIth Comm. Mining and Metall. Cong., Vol. I, p. 145-157.

Menge, G.F.W. 1963. The cassiterite deposits on Doornhoek 342 KR and vicinity, west of Naboomspruit, Transvaal : Unpub. M.Sc. Thesis, Univ. Pretoria.

Strauss, C.A. 1954. The geology and mineral deposits of the Potgietersrus tin-field : Mem. Geol. Surv. S. Afr., No. 46.

Strauss, C.A. and Truter, F.C. 1944. The Bushveld granites of the Zaaiplaats tin mining area : Trans. Geol. Soc. S. Afr., Vol. 47, p. 47-78.

Wagner, P.A. 1921. The Mutue Fides-Stavoren tin-fields : Mem. Geol. Surv. S. Afr., No. 16.

* *

APPENDIX 1

TOTAL PRODUCTION OF METALLIC TIN FROM THE BUSHVELD COMPLEX

			Metallic Tin (Metric Tonnes)
A.	**Moloto Tin-Field**		
1.	Enkeldoorn (with Zustershoek)		50,383
2.	Vlaklaagte		32,622 + 0,580 Alluvial
3.	Allemansdrift		18,650
4.	Vaalbank		- + 1,302 Alluvial
5.	Leeuwkop		0,105
6.	Hartebeesfontein		0,088
		Total	101,848 + 1,882 Alluvial
B.	**Olifants Tin-Field**		
1.	Mutue Fides (with Tygerpad)		2 870,808 + 3,323 Alluvial
2.	Stavoren (with Gaasterland)		138,826 + 1,371 Alluvial
3.	Roodewal (with Tambootieboom)		19,123
		Total	3 028,757 + 4,694 Alluvial
C.	**Elands Tin-Field**		
1.	Elandsfontein		118,138
		Total	118,138
D.	**Nylstroom Tin-Field**		
1.	Doornhoek		5 377,695
2.	Doornkom		17,561
		Total	5 395,256
E.	**Potgietersrus Tin-Field**		
1.	Zaaiplaats		17 300,126
2.	Roodepoort (Groenfontein)		4 463,227
3.	Welgevonden		125,019
4.	Solomon's Temple		47,468
5.	Groenvley		10,448
6.	Appingendam		1,530
7.	Waterval		0,519
		Total	21 948,337

APPENDIX 1 (Continued)

F. Rooiberg Tin-Field

1.	Vellefontein		
	Nieuwpoort		
	Blaaubank		
	Leeuwfontein		
	Rietfontein		
	Olievinbosch		
	Hartebeesfontein		39 144,996
2.	Weynek		4,488
		Total	39 149,484

Producers are listed by farms on which mines were located. In the case of the Rooiberg tin-field, the Rooiberg mines now incorporate the properties on the farms listed although all are not presently in operation.

APPENDIX 2

NUMBER OF PRODUCERS RANKED ACCORDING TO SIZE OF TOTAL PRODUCTION

	No. of Producers	Location
> 10 000 m.t.	2	R(1), P(1)
> 1 000 m.t. < 10 000 m.t.	3	O(1), N(1), P(1)
> 100 m.t. < 1 000 m.t.	3	O(1), P(1), E(1)
> 10 m.t. < 100 m.t.	7	M(3), P(2), O(1), N(1)
> 1 m.t. < 10 m.t.	3	P(1), R(1), M(1)
> 0,1 m.t. < 1 m.t.	2	M(1), P(1)
> 0,01 m.t. < 0,1 m.t.	1	M(1)
Total	21	

Initial letter identifies tin-field in column headed Location.

APPENDIX 3

PRODUCERS RANKED IN ORDER OF TOTAL PRODUCTION

		Metallic Tin (metric tonnes)	Tin-Field
1.	Rooiberg mines	39 144,996	R
2.	Zaaiplaats	17 300,126	P
3.	Doornhoek	5 377,695	N
4.	Roodepoort (Groenfontein)	4 463,227	P
5.	Mutue Fides	2 874,131	O
6.	Stavoren	140,197	O
7.	Welgevonden	125,019	P
8.	Elandsfontein	118,138	E
9.	Enkeldoorn	50,383	M
10.	Solomon's Temple	47,468	P
11.	Vlaklaagte	32,582	M
12.	Roodewal	19,123	O
13.	Allemansdrift	18,650	M
14.	Doornkom	17,561	N
15.	Groenvley	10,448	P
16.	Weynek	4,488	R
17.	Appingendam	1,530	P
18.	Vaalbank	1,302	M
19.	Waterval	0,519	P
20.	Leeuwkop	0,105	M
21.	Hartebeesfontein	0,088	M
	Total	69 748,396	

* *

ISBN 0 85494 285 8