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GREENBUSHES MINERAL FIELD

BY

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PREFATORY NOTE.

This bulletin deals with the geology and mineral resources of the Greenbushes Mineral Field, the principal area in Western Australia from which cassiterite has been produced from the year 1888 up to the present date.

Previous collated information on the Greenbushes Mineral Field was published in G.S.W.A. Bulletin No. 32 in 1908, now out of print.

Both lode and alluvial cassiterite have been worked practically continuously with varying degrees of intensity from the year 1888 onwards, and the rare metals of the tantalum-niobium combination have been produced as by-products from lode and alluvial workings.

There are still some parts of the field discussed by the author in appropriate sections of the publication, in which there is scope for further prospecting with reasonable hopes of success.

The information contained herein is of a detailed nature and is the result of careful field work and an exhaustive search of available literature, bringing together in one publication our knowledge of the field up to July 1943. Production figures are quoted up to the end of 1943.

Information additional to that contained in this bulletin and referring to mining activity or new mineral occurrences on the field will be found in the Annual Reports of the Western Australian Mines Department from 1943 (incl.) onwards.

Ore-dressing investigations were carried out in 1944 at the Kalgoorlie Metallurgical Laboratory, Western Australia, with the object of attempting to find a satisfactory method for the separation of cassiterite from cassiterite-tantalite concentrate produced from the Greenbushes Mineral Field. The results of these investigations are contained in Parts I, II and III of Investigation No. 271 of the Joint Investigations of the Council for Scientific and Industrial Research and the Kalgoorlie School of Mines, Western Australia.

H. A. ELLIS,
Government Geologist.

March 26th, 1946.

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FIGURES—*continued.*

Chapter I.

GENERAL INFORMATION.

INTRODUCTION.

After the loss of the Malayan and Netherlands East Indies tin fields in 1942 there was renewed interest in Australian fields, and in this State attention was once more directed to Greenbushes. Prospects on M.C. 47 appeared encouraging (Forman, 1942), and accordingly Messrs. Hobson and Matheson commenced detailed mapping in the central portion of the Field during 1942. This work was later extended and additional work undertaken during 1943. Details are given in the next section of this bulletin. As no bulletin dealing with Greenbushes had been published since Bulletin 32 (now out of print) in 1908 it was later decided to collect together all the available information in the form of a bulletin.

The Greenbushes Mineral Field is located in the extreme south-western corner of the State and is portion of a laterite capped highland. Its legal boundary was defined in March 1907 (Government Gazette) as follows:—

> Bounded by lines starting from a point on the East boundary of Nelson Location 868 and situate about 18 chains North from its South-East corner; thence North about 495 chains to the South boundary of Location 98; thence East about 500 chains to a point North of the North-West corner of C.P. 48/1603; thence South, passing along the West boundary of C.P. 48/1603 about 495 chains to the South boundary of Location 733; thence West about 500 chains to the starting point.

Throughout this bulletin the Greenbushes Mineral Field will be referred to as the Field.

The township of Greenbushes is in the centre of the Field and on the main road from Bunbury to Bridgetown. The nearest port is Bunbury, which is approximately 50 miles away. The Bunbury to Northcliffe railway passes through the Field.

PRESENT WORK.

Field work was commenced in June, 1942, on an area including all the principal lode workings and extending from the township of Greenbushes in a south-easterly direction, parallel to the Greenbushes-Bridgetown road, to within approximately one mile of the boundary of the Field. The area was mapped on two plane table sheets on a scale of five chains to an inch. The maps are reproduced in this bulletin as plates II and III and the area mapped is indicated on plate I. Contours were drawn at 20 feet intervals and all old workings were located. Geological boundaries were also mapped.

Soon after the commencement of this work Mr. Matheson was withdrawn for special work on M.C. 47, the details of which are given in a later section of this bulletin (p. 110). After some preliminary investigations early in 1942 (Forman, 1942) it was decided to sink a line of shafts and cross cut between them on what then appeared to be a large lode. This work was supervised in the field and sampled by Mr. Matheson. On its completion he returned to the five chain plane table mapping.

During the course of the five chain mapping it became evident that the earlier geological map (Bulletin 32) required amending and that the Old Alluvium covered a much greater area than shown. On the completion of the five chain mapping Mr. Hobson was instructed to extend the mapping on a suitable scale over the remaining portion of the Field. This mapping was done on a scale of 10 chains to an inch as suitable base maps on that scale were available. In 1903 a topographical survey, extending over the whole of the Field, had been carried out by H. W. B. Talbot[1]. Talbot's contours were transferred from his original field sheets to the present base maps. In the 10 chain mapping use was made of the boundaries of locations, mineral claims and mining leases. Use was also made of topographic features and of air photos of the Field, which were made available to the Geological Survey. The geological boundaries shown on this map (plate I.) are sketched and do not claim any

[1]At that time topographical surveyor to the Geological Survey.

great accuracy in detail. It is thought, however, that the picture obtained is a correct one and that it would be modified only in minor detail by more careful mapping.

In November, 1942, a small amount of drilling was done in Bunbury Gully (M.C. 6).

During May, June and July of 1943, Mr. Hobson was again at Greenbushes. During this period a number of samples were taken from old shafts and dumps in the vicinity of D.C. 95 and M.C. 48. A certain amount of preliminary sampling was also done at other localities indicated by the 1942 work.

Both the general arrangement and the details of this bulletin have been discussed by the authors, but the actual text has been written, except where indicated, by Mr. Hobson. Mr. Matheson is concerned primarily with the area shown on plate III and also with the work done on M.C. 47 during 1942. The remainder of the field work done during 1942 and 1943, was carried out by Mr. Hobson.

GENERAL DESCRIPTION OF THE FIELD.

The Field forms portion of a laterite capped highland dissected by numerous rivers and their tributaries. The highest point in the Field is just over 1,080 feet above sea level and is situated immediately south of the Townsite. The drainage radiates from this point, but eventually all the small creeks find their way into the Blackwood River. The striking feature of all these small creeks is that, while at their headwaters they meander through broad open valleys, often swampy, yet further down they flow rapidly through steep-sided V-shaped valleys. The country in the central portion of the Field is much less rugged than that towards the margins.

The field lies between the 30 and 40 inch isohyets and has an average rainfall of approximately 39 inches, most of which falls during the winter months. During the winter the climate is wet and cold, but during the summer months conditions are very pleasant.

Tin was discovered in 1888 by D. W. Stinton in Bunbury Gully, on what is now M.C. 6. The total recorded production of the Field to 1943 is 11,322 tons of tin concentrates, of which 10,738 tons are from alluvial ground and 584 tons from lode material. The total value of these concentrates is £995,355. They have been produced from an area approximately 15 square miles. The maximum production was

in 1906, when 783 tons of concentrates, valued at £79,195, were produced. During the last 10 years (1933-1943) the production has varied from a minimum of 1.55 tons in 1934 to a maximum of 57.02 tons in 1937.

The principal production has been from sediments of younger Cainozoic age, which are referred to as the Old Alluvium. It is believed that the Old Alluvium, which consists of sands, clays, pebble and boulder beds, was deposited in a shallow sea or lake and that the tin deposits are beach deposits. There has also been some production from Recent Alluvium, deposited by existing creeks, and from lode material.

Basement rocks consist of metamorphosed greenstones and sediments, replacement and injection gneisses together with numerous granitic dykes of varying composition. There are also epidiorite and dolerite dykes, similar to those occurring elsewhere in the Darling Range. The basement rocks are of probable Pre-Cambrian age.

In addition to tin both tantalite and ironstone have been produced from the Field.

Tantalite was first noted in some concentrates by Simpson in 1900 (Simpson, 1901, p. 32: 1908, p. 453). Since that date small quantities have been produced at various times mainly from the vicinity of the "Enterprise" workings, near the head of Bunbury Gully. The recorded production to the end of 1943 is 9.55 tons valued at £A.7724. It is generally believed that much of the tantalite produced in the early days of the Field was not reported to the Department and consequently that the actual production is greater than the recorded production. It is improbable that the actual production exceeds 16 tons, but no precise figure can be given.

From 1899 to 1904 ironstone was produced for use as a flux by the Fremantle Smelters from quarries situated about 30 chains north-east of the railway station. The recorded production is 7,481 tons valued at £4,629.

During 1942 and 1943 the only mining activity was on M.C. 1, M.C. 4 and M.C. 6. Late in 1942 there was a small production of tantalite from M.C. 1, from the vicinity of the late "Enterprise" workings. During 1943 more work was done in the same vicinity and approximately 2¼ tons of tantalite were produced.

On M. C. 4 (("Vulcan" workings) sluicing operations on a lode were in progress (1942). The lode had been worked, by means of an open cut, to a depth of 70 feet. From 1937 to February 1943 the

production from these workings was 132.49 tons of tin concentrates valued at £A17,430. In addition 3.18 tons of tantalum concentrates were separated from the tin concentrates.

In 1934 a sluicing plant was erected on M.C. 6, but up to the time of writing (February 1944) no sluicing had been done.

It was evident that within fairly recent years there had been some sand sluicing done in the vicinity of E.A.C. 960, where there is an extensive shallow open cut. No work was in progress during 1942 or 1943.

Beyond the limits of the Field much of the country has been taken up for dairying or for orchards. Some of the farms extend within the boundary of the Field.

The whole of the country is covered with dense timber, mainly jarrah and red gum, and the undergrowth is usually thick.

Water supplies for mining have been obtained by building walls across the valleys and by storing water in the cuts produced as a result of sluicing. Supplies have frequently been short during the summer months. Water for domestic purposes is obtained from wells and supplies are adequate.

PREVIOUS GEOLOGICAL WORK.

No bulletin dealing with the Field as a whole has been published since Bulletin 32 by H. P. Woodward in 1908. Since that time officers of the Mines Department have visited Greenbushes to examine individual mines or to report on proposed work at one or more localities. During this same time various minerals have been noted from Greenbushes, mainly by E. S. Simpson (1908, 1910, 1911, 1912, 1918, 1929, 1931, 1936, 1937) and H. Bowley (1927, 1933, 1937). Reports dealing with all these activities are to be found in the Annual Reports of the Mines Department.

The principal reports dealing with individual mines are by E. D. Cleland (South Cornwall—1908), F. R. Feldtman (Kapanga—1914, 1915), R. A. Farquharson (Kapanga—1914, 1915), R. C. Wilson (Cornwall—1926, 1928) and H. A. Ellis (Vulcan—1939).

Short reports dealing with the Field generally were published by E. D. Cleland (1910), by A. Gibb Maitland (1910), and by H. A. Ellis (1940—M.C.'s 34, 36 etc.).

The principal works undertaken or subsidised by the Mines Department since the publication of Bulletin 32 are the completion of the "South Cornwall" main shaft in 1908 (p. 204), the sinking of the "Cornwall" main shaft in 1926 and 1927 (Wilson, 1926, 1928. Refer also this report p. 196), diamond drilling of the main lodes in 1928 and 1929 (Wilson, Larcombe, Simpson, Bowley, 1929: Howe, 1929 and 1930), and the drilling for deep leads in the vicinity of the Three C's area and the Battler's Hope Workings in 1936 (Forman, 1934, 1937: Simpson and Bowley, 1937).

Some reference is made to Greenbushes in a number of reports written between 1908 and 1941. A full list of these appears in the bibliography published in this bulletin.

HISTORY OF THE FIELD.

It is not intended in this section to give a detailed history of the Field. To do this would require a considerable amount of research—old records would have to be examined and information collected from old residents of Greenbushes. Even if this were done it is doubtful if a complete record could now be obtained. While such information would be very interesting the amount of time necessary to get it would be greater than can be reasonably allotted for this section of the present bulletin. It is intended to give only a few of the more significant facts, which have come to the writer's notice since his association with Greenbushes.

Tin was discovered at Greenbushes in Bunbury Gully, on what is now M.C. 6, by D. W. Stinton in 1888 (Woodward, 1891, p. 42). It appears that Stinton was told by E. T. Hardman (Government Geologist) in 1884 that the locality was likely to be tin bearing (Woodward, 1895, p. 128. 1908, p. 7: Maitland, 1900, p. 84). Hardman was, at that time, examining various localities, thought to be gold bearing, in the south-western portion of Western Australia. He makes no mention in his report of the possible tin bearing country in the vicinity of what is now Greenbushes.

Stinton's first prospects were obtained from the shallow surface alluvium of Bunbury Gully. He found that by sinking he could get tin in the laterite under the shallow alluvium and also in the grit under the laterite (Woodward, 1890, p. 49).

The events of the next 18 years are summarised by Woodward (1908, p. 8) as follows:—

> Upon this discovery becoming known a large number of persons visited it from Perth and elsewhere, and made applications for mineral leases under the old Mineral Land Act, whereby they they could take up blocks of 100 acres in extent without the necessity of fulfilling labour conditions, the consequence being that a very large number of areas was secured for purely speculative purposes, but in spite of this we find that 504 tons of black tin were produced in the year 1891.
>
> From this time onward to 1896 the price of tin gradually fell and,....., in that year it only realised the low figure of £31 12s. 0d. per ton (tin oxide), the consequence being that mining came practically to a standstill, and the field was nearly deserted.
>
> With the revival to £78 2s. 0d. per ton in 1899, a great influx of population took place, and the mining laws having been re-cast, the field was taken up as a number of small holdings.
>
> Subsequently to this, in spite of the fall in 1901 to £55 10s. 0d. per ton, this field as a mining centre became permanently established, whilst the annual output steadily increased year by year, the maximum being reached in 1906, when 783½ tons of ore were shipped, which realised the high price of £101 per ton.

Lode tin was discovered in 1893, but does not appear to have attracted much attention, as it was not mentioned in the Mining Handbook published in 1895 (Woodward, 1895). It was not until about 1899, when the "Cornwall" and "South Cornwall"' leases were pegged that there was much interest in lode mining.

The maximum production for any year was in 1906, when 783 tons of concentrates, valued at £79,195, were produced. From 1906 onwards the production declined, more or less steadily to 1920, after which there was a rapid drop. In 1920 the total production was 190.99 tons, while in 1921 it had dropped to 52.87 tons. Since then there has been an almost continuous small production, which reached a maximum of 61.41 tons in 1926 and a minimum of zero in 1931. In 1932 the amount of lode concentrates exceeded that of alluvial concentrates for the first time. Since 1937, however, the amount of lode concentrates has always exceeded that of alluvial concentrates (see table 4, p. 82, and fig. 12, p. 108).

The only activity on the field during 1942 and 1943 was, as already outlined, on M.C. 1, M.C. 4 and M.C. 6. There has been no production recorded from M.C. 4 since February 1943, and it is probable that activity on that claim has ended. Although a sluicing plant was erected on M.C. 6 during 1943 it had not commenced operations at the time of writing (Feb. 1944). The work on M.C. 1 was concerned with the production of tantalite, the demand for which is urgent owing to the war.

Many different methods have been adopted to recover the tin from the alluvial ground. These have included puddling and sluicing; sluicing with a small box, either fixed or portable; ground sluicing; hydraulic sluicing, using either a portable plant or one mounted on a floating pontoon; and shaft sinking in deeper ground (Cleland, 1910). Ground, which was worked by means of shafts in the early days of the Field, was often later worked by hydraulic sluicing methods. During 1938-39 a bucket dredge was assembled on M.C. 6, but was not a success owing to ground being unsuitable.

In the Field's busy days both privately owned and Departmentally owned treatment plants were available for use of prospectors. At the present time there is a State Battery reserve in Floyd's Gully, but it is many years (since 1926?) since the battery worked and the plant has fallen into a state of disrepair. During recent years some of the plant has been removed.

CLIMATE.

It is not intended here to give a detailed discussion of the climate of the Field, but merely to present such information as has some bearing on tin mining.

Rainfall.

The Field lies between the 30 inch and 40 inch isohyets and has an average rainfall of 38.72 inches. The monthly and yearly rainfall from 1893 to 1943 together with the average monthly and average yearly rainfall for this period are set out in table 1 (p. 20). The information is also shown graphically in figures 1 and 2. Figure 1 shows that the yearly rainfall is erratic. The maximum rainfall recorded—66.2 inches—was in 1917 and the minimum—24.0 inches—was in 1940. Although Greenbushes lies between the 30 and 40 inch isohyets the annual rainfall frequently exceeds 40 inches. Figure 1 shows that the yearly rainfall has exceeded 40 inches 21 times during period 1893-1943 (51 years). On the other hand it has only been below 30 inches on five occasions during the above period. Most of the rain falls during the winter months (see fig. 2).

Because of the low rainfall during the summer months it was the practice to confine sluicing operations to the winter. In the early days of the field ore was broken during the summer and puddled and sluiced during the winter.

Temperature.

During the winter months the weather is generally cold and miserable, but during the summer it is warm and pleasant.

Temperature data for Greenbushes have not been recorded. Table 2 gives temperature data for Bridgetown, Donnybrook and Manjimup, which are the nearest centres for which temperature data are available. The highest temperature recorded at any of these places is 115° F. at Bridgetown, on 8th February, 1933, and the lowest temperature is 25.5° F. also at Bridgetown, on 13th July, 1914.

RAINFALL, GREENBUSHES, 1893-1943.

Table I.

Rainfall in points. Information supplied by Divisional Meteorologist, Perth.

Year.	Jan.	Feb.	Mar.	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year.
1893 ...	26	140	222	418	614	252	590	565	599	438	68	86	4,018
4 ...	3	41	43	7	601	734	233	515	370	166	10	130	2,853
5 ...	37	187	9	179	211	1,194	550	874	565	242	71	174	4,293
6 ...	18	...	275	97	372	686	647	352	160	214	68	141	3,030
7 ...	14	19	102	167	403	497	712	436	297	180	274	55	3,156
8 ...	156	59	27	25	266	525	747	701	326	775	162	32	3,801
9 ...	3	43	80	424	474	560	588	514	243	479	151	71	3,630
1900 ...	196	28	49	285	347	1,242	891	943	406	223	69	176	4,855
1 ...	24	16	166	286	659	425	508	657	281	169	285	251	3,727
2 ...	7	22	53	58	580	374	908	105	445	189	36	134	2,911
3 ...	...	...	45	152	157	734	551	660	915	723	34	74	4,045
4 ...	83	15	334	299	477	649	310	302	314	292	82	44	3,201
5 ...	30	...	21	262	1,025	601	615	311	885	397	158	56	4,361
6 ...	139	77	58	183	433	1,056	702	412	422	131	26	37	3,676
7 ...	16	80	96	69	591	383	818	951	555	682	96	20	4,357
8 ...	41	181	45	124	335	720	562	538	295	310	167	19	3,337
9 ...	70	6	151	238	587	497	470	700	534	304	48	1	3,606
10 ...	106	18	48	150	948	1,081	971	526	358	199	213	16	4,634
11 ...	4	11	105	344	275	354	807	436	411	239	64	31	3,081
12 ...	14	12	47	51	389	346	860	312	690	207	73	106	3,107
13 ...	48	51	198	352	270	478	957	1,043	296	354	61	295	4,403
14 ...	Nil	196	35	170	338	613	681	317	136	186	276	47	2,995
15 ...	19	249	268	184	345	645	814	867	663	410	114	17	4,595
16 ...	158	125	22	916	358	553	603	838	51	343	310	12	3,464
17 ...	59	95	131	421	950	1,574	946	818	1,046	354	4	222	6,620

18 ...	157	340	123	189	927	1,182	193	555	429	269	62	35	4,461
19 ...	44	45	70	265	251	519	905	610	272	355	113	13	3,462
20 ...	7	21	130	40	625	860	506	1,126	242	181	47	44	3,829
21 ...	41	166	151	187	702	569	653	379	431	330	243	187	4,039
22 ...	29	139	106	123	386	380	830	873	401	330	204	235	4,036
23 ...	145	3	189	273	1,017	1,219	539	597	856	195	47	13	5,093
24 ...	21	58	24	20	805	549	626	704	377	695	297	5	4,181
25 ...	108	74	96	147	513	473	675	166	554	390	81	59	3,336
26 ...	Nil	125	122	487	564	652	1,289	468	532	557	200	61	5,057
27 ...	96	36	357	196	455	689	571	631	526	329	34	19	3,939
28 ...	188	16	16	319	457	391	755	741	606	307	77	100	3,973
29 ...	9	314	157	289	1,090	827	353	395	220	152	190	70	4,066
30 ...	8	8	52	131	381	973	867	354	526	284	134	45	3,763
31 ...	8	17	76	218	588	524	602	726	691	224	28	43	3,745
32 ...	60	12	138	159	613	775	796	572	280	183	71	40	3,699
33 ...	88	24	120	133	370	1,377	600	556	534	541	75	47	4,465
34 ...	59	39	287	89	380	729	938	535	496	185	139	116	3,992
35 ...	35	42	27	164	274	423	1,058	525	529	374	61	74	3,586
36 ...	60	11	26	106	385	648	413	780	231	198	21	42	2,921
37 ...	10	74	167	319	866	584	320	561	274	250	115	73	3,613
38 ...	3	34	210	146	571	300	669	574	303	211	133	55	3,209
39 ...	421	133	7	113	450	726	691	820	80	456	300	19	4,216
40 ...	37	28	27	63	227	467	540	311	309	221	53	117	2,400
41 ...	6	15	189	362	544	748	640	556	621	174	204	15	4,074
42 ...	14	15	257	319	791	1,016	740	909	621	339	39	79	5,139
43 ...	94	35	527	309	294	578	549	379	505	79	16	61	3,426
Monthly* average for 51 years ...	59	69	123	200	520	685	674	590	445	314	116	77	3,872

* Average calculated by R. A. Hobson and subject to confirmation when official figures are available.

FIG. 2

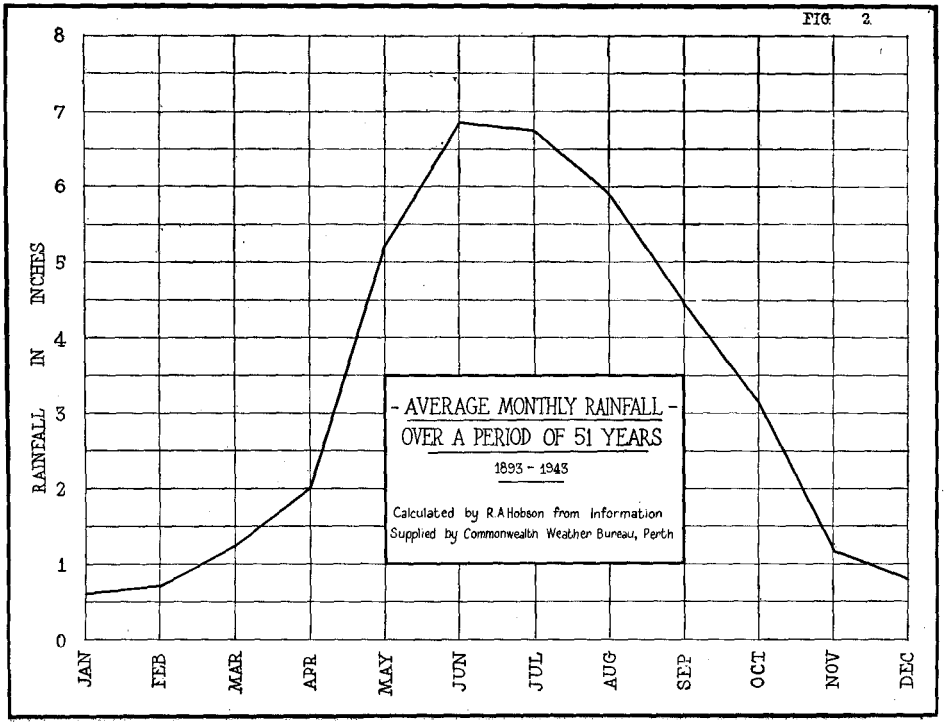
RAINFALL IN INCHES
0
1
2
3
4
5
6
7
8
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
- AVERAGE MONTHLY RAINFALL -
OVER A PERIOD OF 51 YEARS
1893 - 1943
Calculated by R.A Hobson from information
Supplied by Commonwealth Weather Bureau, Perth

TABLE 2.

TEMPERATURE DATA, BRIDGETOWN, DONNYBROOK AND MANJIMUP.

Temperatures in degrees Fahrenheit. Information supplied by the Divisional Meteorologist, Perth. Complete to 1943.

BRIDGETOWN.

(Number of years of record = 40.)

	Years.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year.
Mean Max.	40	85·5	85·3	80·4	74·6	66·0	61·5	59·8	61·3	64·7	68·6	76·4	82·3	72·2
Mean Min.	40	52·8	51·9	50·3	46·3	43·6	40·8	39·6	40·1	42·1	43·9	47·3	50·4	45·8
Extreme Max.		109·0	115·0	105·0	98·4	89·1	75·3	71·5	78·0	85·5	96·5	103·0	105·5	115·0
Date		20–1–30	8–2–33	15–3–19	10–4–10	2–5–07	9–6–09	21–7–21	21–8–40 19–8–35	29–9–13	31–10–36	24–11–36	5–12–31 11–12–27	8–2–33
Extreme Min.		33·6	32·9	30·5	29·2	27·5	25·8	25·5	26·5	29·6	29·9	30·5	32·5	25·5
Date		2–1–21	16–2–19	22–3–22	23–4–39	11–5–14	15–6–31	13–7–14	30–8–25 12–8–29 2–8–37	23–9–16	20–10–19	5–11–37	1–12–32	13–7–14

DONNYBROOK.

(Number of years of record = 39.)

	Years.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year.
Mean Max.	39	85·6	85·6	81·1	75·4	67·2	62·4	61·0	62·6	65·4	68·9	76·4	82·2	72·8
Mean Min.	39	55·8	55·9	53·8	49·7	46·0	43·1	41·5	42·6	44·8	46·7	50·1	53·7	48·6
Extreme Max.		108·2	112·2	104·8	99·2	87·0	79·0	72·0	78·1	88·9	95·2·	102·2	104·0	112·2
Date		20–1–30	8–2–33	14–3–22	9–4–10	1–5–12	2–6–14	6–7–24	20–8–40	10–9–16	31–10–36	24–11–36	25–12–15	8–2–33
Extreme Min.		38·0	33·4	33·0	32·0	29·2	28·0	28·0	28·8	30·6	31·4	34·5	35·8	28 0
Date		24–1–29 1–1–35	11–2–05	20–3–05	23–4–39	23–5–36	24–6–08 16–6–16 15–6–31 17–6–38	16–7–16	6–8–38	11–9–06	15–10–16	5–11–10	1–12–32	24–6–08 16–7–16 15–6–31 17–6–38

MANJIMUP.

(Number of years of record = 5.)

	Years.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year.
Mean Max.	5	77·8	80·1	73·9	69·7	62·4	58·9	57·4	58·4	61·4	64·9	70·8	75·9	67·6
Mean Min.	5	54·2	53·8	52·7	49·7	46·3	43·6	41·7	43·1	43·5	46·2	49·5	52·0	48·0
Extreme Max.		100·2	105·0	93·0	90·2	78·0	72·0	65·0	73·2	78·0	83·0	98·2	96·4	105·0
Date		22–1–42	8–2–40	9–3–41	1–4–37	25–5–41	10–6–40	29–7–42	20–8–40 21–8–40	12–9–39	27–10–43 28–10–43	25–11–36	1–12–38	8–2–40
Extreme Min.		42·0	40·0	40·0	36·0	34·0	33·8	27·0	30·5	32·0	34·0	35·0	41·0	27·0
Date		3–1–39	20–2–38	31–3–40	6–4–40	26–5–40	10–6–37	3–7–39	5–8–40	11–9–42	5–10–39	5–11–37	29–12–39	3–7–39

VEGETATION.

Greenbushes comes within the jarrah forest zone as defined by Kessel (1928). The vegetation of this zone is described as follows (Kessel, 1928):—

Jarrah (Eucalyptus marginata) is the principal tree species, growing on an area of some 13,000,000 acres, but the prime jarrah forest having a high merchantable value is limited to about 2,500,000 acres. This forest, which forms a compact belt some 20 miles wide and 200 miles long, stretching along the Darling Range from Perth in the North to Manjimup in the South, is probably the most valuable hardwood forest in Australia. The two important factors limiting the habitat of the better class forest are rainfall and soil conditions. A rainfall of over 30 inches per annum is necessary for optimum development. A capping of laterite boulders or laterite gravel is characteristic of the jarrah forest, giving soil conditions which render any form of agricultural development a hopeless undertaking. Practically the whole of prime jarrah forest remains the property of the Crown and is now being dedicated State Forest. Jarrah is found in practically pure stand, and throughout the prime region referred to above shows uniform development, reaching to a height of 150 feet, with a diameter of three to five feet. In virgin forest the volume of mature timber suitable for sawmilling, measured in the round, may reach 5,000 to 6,000 cubic feet per acre over extensive areas, but the average is nearer to 1,000 cubic feet per acre.

Associated with it are marri (E. calophylla), blackbutt (E. patens), and bullich (E. megacarpa), while, in some of the poorest situations, south of the Preston River, mountain marri (E. haematoxylon) becomes a component of the forest.

It is only in the better class laterite and alluvial soil that marri and blackbutt are predominant. Elsewhere jarrah forms the bulk of the growing stock.

Both marri and blackbutt attain the same size as jarrah but blackbutt establishes itself on the richest soil pockets and is at its best in diorite valleys and gullies.

Bullich grows in the laterite gullies and forms pure stands, but it is occasionally found on poor laterite plateau-like ridges in mixture with jarrah. Along the banks of the larger perennial streams and rivers grow flooded gum (E. rudis), of little timber value, and river banksia (Banksia verticillata), a tree attaining a height of 50 feet, and providing one of the few softwood cabinet timbers found in the State.

The prime jarrah forests contain a number of small trees, of which sheoak (Casuarina Fraseriana) is the tallest, attaining a height of 45 feet. In the same storey are found Banksia grandis, native pear (Xylomelum occidentale), Dryandra floribunda, Christmas tree (Nuytsia floribunda), while Emu bush (Persoonia elliptica and P. longifolia) form a still lower storey, attaining about 15 feet. Below these again are found a wealth of shrubs, prickly mimosa (Acacia pulchella), Hibbertias, Hakeas, and many other Proteaceous species, Acacias, Mirbelia, Thomasia, Leocopogons, and many other Epacridaceous and Myrtaceous species, Daviesia spp., several unique Liliaceous plants, the blackboy (Xanthorrhoea preissii), grass tree (Kingia australis), and Dasypogon Hookeri, and Zamia palm (Macrozamia Fraseri).

Much of the best jarrah has been cut from the vicinity of Greenbushes. There is a small mill immediately south-east of the town, which is not now (1942, 1943) operating, but which was working a few years ago. North of the railway on location 890 there are the remains of a large mill, which appears to have been destroyed by fire some years ago.

Ample supplies of timber for fuel are available in the vicinity of the Field. The cutting of timber for this purpose is controlled by the Forests Department. Information can be obtained from the branch office of the Forests Department at Kirup.

WATER SUPPLIES.

Because of the low summer rainfall the provision of adequate water supplies for mining purposes has always been a difficulty. In the early days of the Field it was the practice to mine the pay dirt during the summer and to puddle and sluice it during the winter. In 1900 two schemes (Walter, 1901: Mines Dept. file 5351/00) were being considered for pumping water from the Blackwood River. One of these schemes (W.A. s. 185 and 1^{H}) was completed in 1903 (Walter, 1902: King, 1903: Crockett, 1904) and continued in intermittent operation until 1917 (Cleland, 1910: Hudson, 1933: Cullingworth, 1914). It is not known just how much water was pumped under this scheme, but it appears likely that the water was not used by many plants. In most places walls were built across the valleys and the water dammed back. In this way adequate supplies were obtained. At other places water was stored in the cuts formed as a result of sluicing operations. Supplies were sometimes short during the summer months.

Within recent years a wall has been built across Westralia Gully and large quantities of water are stored there. This supply was used for sluicing on M.C. 4. There are also permanent pools in Spring Gully.

At many localities suitable walls could be readily built (refer plate I), but at others the problem appears more difficult. Reference to water supplies at individual localtities will be made when assessing the present possibilities of the Field in a later section of this report.

Water for domestic purposes is obtained from wells. Supplies are adequate.

ACKNOWLEDGMENTS.

It has already been pointed out that the text of this bulletin has been written by Mr. R. A. Hobson, except where otherwise indicated. The authors have, however, had numerous discussions about the Field, both during the progress of the field work and later in the office. They are in complete agreement regarding the geology of the Field. The general arrangement and contents of the bulletin have also been fully discussed.

The petrographic section has been contributed by Dr. K. R. Miles.

The production information for tantalite given in table six was originally collected together by Dr. Miles, for use in another publication (Miles, Rowledge and Carroll, 1944). Later additional information regarding tantalite was given to the authors by Mr. J. S. Foxall, the Assistant State Mining Engineer, (now State Mining Engineer).

Chemical work has been done in the Government Chemical Laboratory.

The plans have been drafted in the Mines Department drafting office by Mr. McLean, assisted by Mr. Salas. The principal plates and text figures have been drawn by Mr. McLean. He has given a lot of thought to the arrangement of the information, and the clearness and pleasing appearance of the plates and text figures are due to his careful and patient work.

During the course of the field work, information regarding the old workings was freely given by the older residents of Greenbushes—in particular, the authors would mention Messrs Huitson, McKay. Patterson, Thomas and the late Mr. Barrymore.

Mr. J. Collett has supplied some information regarding boring on M.C. 6 and Mr. P. Birchley regarding boring in the vicinity of D.C. 95.

BIBLIOGRAPHY.

SECTION I.

THE PRINCIPAL REFERENCES.

1890 WOODWARD, H. P.: Bunbury to Bridgetown, the tinfields and Albany. *Ann. Gen. Report* for 1888-1889 by H. P. Woodward, Govt. Geologist, pp. 49-50, Western Australia.

1891 WOODWARD, H. P.: The Greenbushes tinfield. *Ann. Gen. Rept.* for 1890, by H. P. Woodward, Govt. Geologist, pp. 37, 42-47, Western Australia.

1893 EAST, J. J.: A new mineral from the Greenbushes tinfield, Western Australia. *Aust. Min. Standard*, vol. VII, 1893, p. 234.

GOYDER, G. A.: On a new mineral (*stibiotantalite*). *Trans. and Proc. and Rept. Royal Soc. South Australia*, vol. XVII, 1892-93, pp. 127, 128, also *Jour. Chem. Soc., London*, vol. LXIII, p. 1076.

WALTER, W. A. G.: Half-yearly report of the Mining Registrar, Greenbushes (dated 20/12/93). Unpublished report on Mines Dept. file 645/93.

1894 EAST, J. J.: On stibiotantalite, a new mineral from the stanniferous gravel at Greenbushes, Bunbury, Western Australia. *Trans. Aust. Inst. Min. Engineers*, vol. I, pp. 139-142.

GOYDER, G. A.: Stibiotantalite, a new mineral. *Ann. Rept. South Aust. School of Mines and Industries* for 1893, pp. 163-165.

WOODWARD, H. P.: Report on the Greenbushes tinfield. *Ad Interim Rept. Dept. Mines* for half year ending 30th June, 1894, appendix II, pp. 11-13, Western Australia.

1896 WACHSMUTH, R.: Report on the condition of mining operations and future prospects of the tin deposits near the Blackwood River. *Rept. Dept. Mines* for 1895, Appendix 6, p. 32, Western Australia.

1899 SIMPSON, E. S.: Annual report. *Ann Prog. Report. Geol. Survey* for 1898, pp. 53-57, Western Australia.

1900 MAITLAND, A. GIBB: Notes on the Greenbushes tinfield. *Ann. Prog. Rept. Geol. Survey* for 1899, pp. 15-20, Western Australia.

MAITLAND, A. GIBB: The mineral wealth of Western Australia. *Geol. Survey West. Aust., Bull.* 4, pp. 84-89.

SIMPSON, E. S.: Greenbushes tin ore. *Ann. Prog. Rept. Geol. Survey* for 1899, pp. 52-54, Western Australia.

1901 FELDTMANN, W. R. (?): Report on some properties at Greenbushes, Western Australia. Unsigned M.S. report to Bewick Moreing & Co., now in possession of State Mining Engineer, folder number 9, p. 84.

MAITLAND, A. GIBB: The present condition and future prospects of the Greenbushes tinfield. *Ann. Prog. Rept. Geol. Survey* for 1900, pp. 12-16, Western Australia.

SIMPSON, E. S.: Note on tantalite included in Government Geologist's report. *Ann Prog. Rept. Geol. Survey* for 1900, p. 32, Western Australia.

WALTER, W. A. G.: Report on the Greenbushes tinfield for the year 1900. *Rept. Dept. Mines* for 1900, p. 134, Western Australia.

1902 SIMPSON, E. S.: Notes from the departmental laboratory. *Geol. Survey, West. Aust., Bull.* 6, pp. 33-34, 42-43.

WALTER, W. A. G.: Report on the Greenbushes mining district for year 1901. *Rept. Dept. Mines* for 1901, pp. 86-87, Western Australia.

1903 MULHOLLAND, C. A.: The Greenbushes tinfield, Western Australia. *Aust. Min. Standard*, vol. XXIX, pp. 159-160, 192.

1904 MONTGOMERY, A.: Greenbushes. *Rept. Dept. Mines* for 1903, pp. 81-84, Western Australia.

MAITLAND, A. GIBB.: Miscellaneous mineral notes—cobaltiferous asbolite. *Ann. Prog. Rept. Geol. Survey* for 1904, p. 21, Western Australia.

1906 CAMPBELL, W. D.: Recent mining developments at Greenbushes. *Ann. Prog. Rept. Geol. Survey* for 1905, pp. 18-19, Western Australia.

PENFIELD, S. L., and FORD, W. E.: On stibiotantalite. *Amer. Jour. Science,* vol. XXII. pp. 61-77, also in *Zeits. Kryst, vol.* XLII, pp. 334-350.

SIMPSON, E. S.: Miscellaneous mineral notes. *Ann. Prog. Rept. Geol. Survey* for 1905, p. 20, Western Australia.

1907 *Government Gazette* of Western Australia, 22nd March, 1907, p. 938.

SIMPSON, E. S., and GIBSON, C. G.: The distribution and occurrence of the baser metals in Western Australia, *Geol. Survey West Aust. Bull.* 30, pp. 49, 50, 61-74, 76, 93, 100, 102, 105, 107, 112-114.

1908 CLELAND, E. D.: The Greenbushes tinfield—report on the South Cornwall Mine. Unpublished report in Dept. Mines file 2067/20, p. 95, Western Australia.

SIMPSON, E. S.: Tantalum and niobium in Australia. *Rept. 11th Meeting Aust. Assoc. Adv. Science,* pp. 452-455; also in *Chem. News,* XCIX, pp. 49-52, 77-80.

WOODWARD, H. P.: Notes on the geology of the Greenbushes tinfield. *Geol. Survey West. Aust. Bull.* 32, part I.

1909 ONGEMACH, H.: Sur la stibiotantalite. *Bull. Soc. Fr. Min.,* vol. XXXII, pp. 92-101.

1910 CLELAND, E. D.: Greenbushes tinfield. *Rept. Dept. Mines* for 1909, pp. 55-56, Western Australia.

CLELAND, E. D.: Methods of dredging for alluvial tin. *Rept. Dept. Mines* for 1909, appendix III, pp. 88-91, Western Australia.

MAITLAND, A. GIBB: The condition of mining on the Greenbushes tinfield. *Ann. Prog. Rept. Geol. Survey* for 1909, pp. 14-15, Western Australia.

SIMPSON, E. S.: Miscellaneous mineral notes—beryl. *Ann. Prog. Rept. Geol. Survey* for 1909, p. 9, Western Australia.

SIMPSON, E. S.: Further occurrences of tantalum and niobium in Western Australia. *Rept. 12th Meeting Aust. Assoc. Adv. Science, Brisbane,* 1909, p. 315.

1911 SIMPSON, E. S.: Zircon, Greenbushes. *Ann. Prog. Rept. Geol. Survey,* for 1910, p. 6, Western Australia.

1912 SIMPSON, E. S.: Miscellaneous mineral notes—Xenotime. *Geol. Survey West. Aust. Bull.* 48, pp. 105-106.

MAITLAND, A. GIBB, and MONTGOMERY, A.: The geology and mineral industry of Western Australia. *Geol. Survey West. Aust. Bull.* 50, pp. 30, 31.

1913 HUDSON, —, in MONTGOMERY, A.: Report of the State Mining Engineer for year 1912. *Rept. Dept. Mines* for 1912, p. 47, Western Australia.

1914 CULLINGWORTH, S., in MONTGOMERY, A.: Report of the State Mining Engineer for the year 1913. *Rept. Dept. Mines* for 1913, p. 50, Western Australia.

FELDTMANN, F. R.: The ore occurrence of the Kapanga Mine, Greenbushes tinfield. *Geol. Survey West. Aust. Bull.* 59, report 42, pp. 156-167.

FARQUHARSON, R. A.: Petrographical notes on some specimens from Greenbushes. *Geol. Survey West. Aust. Bull.* 59, report 43, pp. 168-175.

1915 FELDTMANN, F. R.: Greenbushes. *Ann. Prog. Rept. Geol. Survey* for 1914, p. 25, Western Australia.
FARQUHARSON, R. A.: Greenbushes tinfield. *Ann. Prog. Rept. Geol. Survey* for 1914, p. 36, Western Australia.

1918 SIMPSON, E. S.: Laboratory report—Apatite. *Ann. Prog. Rept. Geol. Survey* for 1917, p. 17, Western Australia.

1919 MAITLAND, A. GIBB: The tin deposits of Western Australia, extract from the Mining Handbook. *Geol. Survey West. Aust. Memoir, No. 1*, pp. 7-9.
SIMPSON, E. S.: Rare metals, extract from the Mining Handbook. *Geol. Survey West. Aust. Memoir, No. 1*, pp. 6, 7-8.

1924 MAITLAND, A. GIBB, and MONTGOMERY, A.: The geology and mineral industry of Western Australia. *Geol. Survey West. Aust. Bull.* 89, pp. 60-61, 71, 73, 76.

1926 WILSON, R. C.: Report on Greenbushes. *Rept. Dept. Mines* for 1925, pp. 80, 81, Western Australia.

1927 BOWLEY, H.: Annual report of the Chemical Branch—sillimanite. *Rept. Dept. Mines* for 1926, p. 244, Western Australia.

1928 ROCKETT, H. D.: Annual report—Greenbushes. *Rept. Dept. Mines* for 1927, p. 40, Western Australia.
WILSON, R. C.: Cornwall tin mine. *Rept. Dept. Mines* for 1927, appendix 2, p. 59, Western Australia.

1929 BOWLEY, H. (?): Annual report of the chemical branch, tin boring, Greenbushes, and mineral analysis. *Rept. Dept. Mines* for 1928, pp. 107-108, Western Australia.
HOWE, A. M.: Report of the State Mining Engineer. *Rept. Dept. Mines* for 1928, pp. 39-40, Western Australia.
LARCOMBE, C. O. G.: Boring at Greenbushes. *Ann. Prog. Rept. Geol. Survey* for 1928, p. 15, Western Australia.
SIMPSON, E. S.: Annual report of the Chemical Branch—bore cores. *Rept. Dept. Mines* for 1928, p. 105, Western Australia.
SIMPSON, E. S.: Contributions to the mineralogy of Western Australia—Series IV. *Jour. Roy. Soc. West. Aust.*, vol. XV (1928-29), pp. 101-102, 111-112.
WILSON, R. C.: Boring at Greenbushes. *Rept. Dept. Mines* for 1928, appendix 1, p. 43, Western Australia.

1930 HOWE, A. M.: Report of the State Mining Engineer. *Rept. Dept. Mines* for 1929, p. 42, Western Australia.

1931 SIMPSON, E. S.: Contributions to the mineralogy of Western Australia—Series VI. *Jour. Roy. Soc. West. Aust.*, vol. XVII (1930-31), p. 144.

1933 BOWLEY, H.: Annual report of the Chemical Branch—mineral analysis. *Rept. Dept. Mines* for 1932, p. 62, Western Australia.

1934 FORMAN, F. G.: Suggested boring for "deep leads," Greenbushes tinfield. *Ann. Prog. Rept. Geol. Survey* for 1933, pp. 13-14, Western Australia.

1935 SIMPSON, E. S.: The mineral resources of Western Australia, pamphlet, 1935, pp. 6, 10.

1936 SIMPSON, E. S.: Contributions to the mineralogy of Western Australia—Series IX. *Jour. Roy. Soc. West. Aust.*, vol. XXII (1935-36), pp. 14-16.

1937 Tin Mining in Western Australia. *Chem. Eng. and Mining Review*, vol. XXIX, pp. 346-348. Tait Publishing Co. Pty. Ltd., Melbourne.

BOWLEY, H.: Annual report of the Chemical Branch—tantalum ores and tin ores. *Rept. Dept. Mines* for 1936, p. 114, Western Australia.

FORMAN, F. G.: Boring for "deep leads," Greenbushes, South-West Division. *Ann. Prog. Rept. Geol. Survey* for 1936, pp. 11-15, Western Australia.

SIMPSON, E. S.: Annual Report of the Chemical Branch—Greenbushes tin ores. *Rept. Dept. Mines* for 1936, p. 109, Western Australia.

1938 BOWLEY, H.: Annual report of the Chemical Branch. *Rept. Dept. Mines* for 1937, p. 94, Western Australia.

1939 BOWLEY, H.: Annual report of the Chemical Branch. *Rept. Dept. Mines* for 1938, p. 114, Western Australia.

ELLIS, H. A.: Report on the Vulcan Tin Mine, Greenbushes. *Ann. Prog. Rept. Geol. Survey* for 1938, pp. 9-13, Western Australia.

SIMPSON, E. S.: Annual report of the Chemical Branch. *Rept. Dept. Mines* for 1938, p. 109, Western Australia.

1940 Edwards, A. B.: A note on some tantalum-niobium minerals from Western Australia, *Proc. Aust. Inst. Min. and Met.*, New Series, number, 120, pp. 738–743.

ELLIS, H. A.: Report on Mineral Claims numbers 34, 36, 37, 38, 39, 40, Greenbushes tinfield, *Ann. Prog. Rept. Geol. Survey for* 1939, pp. 7-8, Western Australia.

BOWLEY, H.: Annual report of the Chemical Branch—tin ores, *Rept. Dept. Mines for* 1939, p. 145, Western Australia.

1942 FORMAN, F. G.: Tin prospects on M.C. 44 (47), Greenbushes tinfield, unpublished report on Geol. Survey, West. Aust., file 12/42.

1944 ELLIS, H. A.: Recent developments on a columbite and cassiterite lode, M.C. 9, Greenbushes, unpublished report on Geol. Survey, West. Aust., file 8/1943.

HOBSON, R. A.: Investigations in the Greenbushes tinfield (Summary), *Rept. Dept. Mines for* 1942, pp. 54–55, Western Australia.

HOBSON, R. A.: Boring on M.C. 6—Greenbushes (Summary), *Rept. Dept. Mines for* 1942, p. 55, Western Australia.

MATHESON, R. S.: Investigations in the Greenbushes tinfield (Summary), *Rept Dept. Mines for* 1942, p. 55, Western Australia.

MILES, K. R.; ROWLEDGE, H. P. and CARROLL, DOROTHY: Tantalum and niobium, *Dept. Mines Mineral Resources, West. Aust. Bull.* 3 p.p. 18, 40–43, 104, 115–119, 122, 132, 144.

FOXALL, J. S.: Plan and section of tin-tantalite lode, M.C. 9, Greenbushes, on Geol. Survey West. Aust. file 35/43.

1944 WILSON, R. C.:—Report of the State Mining Engineer for the year 1943, *Rept. Dept. Mines* for 1943, pp. 35–36 (tantalite and tin), Western Australia.

FORMAN, F. G.: Alluvial tantalite, Mineral Claim 1, Greenbushes. *Rept. Dept. Mines* for 1943, pp. 58–59, Western Australia.

ELLIS, H. A.: Recent developments on a columbite and cassiterite lode, M.C. 9, Greenbushes, W.A. *Rept. Dept. Mines* for 1943, p. 66, Western Australia.

BOWLEY, H.: Annual report of the Government Mineralogist, Analyst and Chemist for the year, 1943. *Rept. Dept Mines* for 1943, pp. 104 (tin), 106 (tantalum ores).

SECTION II.

BRIEF REFERENCES.

Reports of the Department of Mines, Western Australia, for the following years contain brief references to Greenbushes.

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References to production statistics are not included above, except for the years (1930–1935) in which complete mining statistics were not published.

SECTION III.

GEOLOGICAL SURVEY AND MINES DEPARTMENT FILES.

The list of Mines Department files does not include all files having reference to Greenbushes, but only such as the writer has examined and used.

(i) Geological Survey Files—263/1900, 265/03, 206/07, 379/07, 77/14, 89/14, 34/28, 39/33, 12/38, 36/39, 12/42, 40/42, 8/43, 23/43, 27/43, 33/43, 35/43, 43/43.

(ii) Mines Department Files—2585/99, 1005/04, 2211/04, 603/14, 2034/17, 1553/19, 755/23, 1557/25, 227/27, 2211/34. (These files have reference to the old Cornwall workings). 4487/99, 5139/99, 3687/02, 3487/07, 1095/08, 1932/10, 979/12, 244/14, 1421/16, 2067/20. (These files have reference to the South Cornwall workings.) 218/29. (Deals with the diamond drilling at Greenbushes, 1928–29.

SECTION IV.

GENERAL REFERENCES.

1884 HARDMAN, E. T.: Report on the geology and supposed gold bearing rocks in the neighbourhood Bunbury, Blackwood, etc., Western Australia, 1884.

1895 WOODWARD, H. P.: Report on the south western portion of the colony. *Rept. Dept. Mines for* 1894, *appendix* 1, p. 9, Western Australia.
WOODWARD, H. P.: Mining handbook to the colony of Western Australia, 2nd edition, pp. 59, 128–134.

1903 KING, H. S.: Summary by the Under Secretary for Mines, *Rept. Dept. Mines for* 1902, p. 37, Western Australia.
KRUSCH, P.: Beitrag zur Kenntniss der nutz-baren lager—starten West-Australiens (Contributions to a knowledge of the useful ore deposits of W.A.), *Zeits. prakt. geol*, 1903, pp. 321–331.

1904 CROCKETT, L. L.: Summary by the Under Secretary for Mines, *Rept. Dept. Mines for* 1903, p. 28, Western Australia.

1907 TALBOT, H. W. B.: Report on the new tin discoveries near Nelson Grange, unpublished report on Geol. Survey, West. Aust. File 89/07.

1905 SIMPSON, E. S.: Minerals of economic value, *Geol. Survey, West. Aust., Bull.* 19, pp. 31, 54.

1909 GILES, W. B.: Tantalum, niobium and titanium—observations on, *Chem. News, Vol. XCIX*, p. 4.

1912 SAINT-SMITH, E. C.: A geological reconnaissance of portion of the South-West Division of Western Australia, *Geol Survey, West. Aust. Bull* 44, p. 48.

1915 WOODWARD, H. P.: The geology and mineral and allied resources of the coastal plains of the south-west division, *Ann. Prog. Report, Geol. Survey for* 1914, p. 17, Western Australia.
MAITLAND, A. GIBB: The mining fields of Western Australia, *Geol. Survey, West. Aust. Bull* 64, *report* 59, p. 104.

1917 WILSON, R. C.: Report to the State Mining Engineer, dated 12th December, 1917, unpublished report on Geol. Survey, West. Aust. file 89/07 and Dept. Mines file 259/17.
WOODWARD, H. P.: Notes on a portion of the South-West Division, *Ann. Prog. Rept., Geol. Survey for* 1916, p. 11, Western Australia.

1919 MAITLAND, A. GIBB:—A summary of the geology of Western Australia, *extract from The Mining Handbook, Geol. Survey, West. Aust., Memoir No.* 1, p. 50.

1921 CRABB, J.: Report to the State Mining Engineer, dated 10th July, 1921, unpublished report on Geol. Survey, West. Aust. file 89/07 and Dept. Mines file 520/21.

1925 JONES, W. R.: Tinfields of the world, p. 38, London.

1928 HOLMES, A.:—The nomenclature of petrology, 2nd edition, London.
KESSEL, S. L.: Forestry and forest resources of Western Australia, *Forest Dept. Bull* 42, p. 7, Western Australia.

1932 Blatchford, T.: Report on the discovery of tin, 9 miles south-west of Greenbushes, *Ann. Prog. Rept., Geol. Survey for* 1931, pp. 12–13, Western Australia. *See* also Geol. Survey, file 20/31, for map.

1934 JACKSON, C. F. AND KNAEBEL, J. B.: Sampling and estimation of ore Deposits, U.S. Bureau of Mines Bull 356.
JUTSON, J. T.:—The physiography of Western Australia, *Geol. Survey, West. Aust. Bull* 95, pp. 75, 113, 167.

1937 FORMAN, F. G.: A contribution to our knowledge of the Pre-Cambrian succession in some parts of Western Australia, *Jour. Roy. Soc., West. Aust., Vol. XXIII.*, pp. *xxii.–xxvii.*

1941 EDWARDS, A. B.: Some basalts from the north Kimberley, Western Australia, *Jour. Roy. Soc., West. Aust., Vol. XXVII.*, 1940–41, pp. 79–93.
Prider, R. T.: The contact between the granitic rocks and the Cardup Series at Armadale, *Jour. Roy. Soc., West. Aust., Vol. XXVII.*, pp. 27–55.
GRACE, J. N. A.: The occurrence of xenotime in Western Australia, *Jour. Roy. Soc., West. Aust., Vol. XXXVII.*, pp. 95–98.

1942 CARVER, S. R.: Official year book of the Commonwealth of Australia, No. 34, 1941, p. 399.
MATHESON, R. S.:—Unpublished notes on Geol. Survey, West. Aust., file 24/41.
MATHESON, R. S.: Report on the Meaney's Bridge soapstone deposit, unpublished report on Geol. Survey, West. Aust., file 24/42.
MILES, K. R.: Metasomatism near the Corinthian ore body, Western Australia, *Proc. Aust. Inst. Min. Met.*, new series, number 125, 1942, pp. 71–83.
PALMER, A. G.: The estimation of gold and tin alluvials in Malaya, *Proc. Aust. Inst. Min. Met.*, new series, number 128, pp. 201–220.

1944 HOBSON, R. A.: Proposed drilling in the vicinity of the Clackline (Baker's Hill) ironstone deposits, *Rept. Dept. Mines for* 1942, p. 51, Western Australia.
PRIDER, R. T.: The geology and petrology of part of the Toodyay district, *Jour. Roy. Soc., West. Aust., Vol. XXVIII.*, pp. 83–137.

Chapter II.

GEOLOGY AND PHYSIOGRAPHY.

TOPOGRAPHY.

Introduction.

The Field is part of a laterite-capped plateau, which, in the south-western portion of Western Australia, is dissected by numerous rivers and their tributaries. The drainage of the extreme south-western part of Western Australia is shown in figure 3. It will be seen that the principal river is the Blackwood River and that the drainage is dendritic. This part of Western Australia is part of the physiographic division of Swanland as defined by Jutson (1934).

Drainage.

The Field is drained by a number of creeks, which radiate from the high ground in the central portion of the Field, and which eventually find their way into the Blackwood River.

The northern portion of the Field is drained by the headwaters of north flowing creeks, which are tributaries of Balingup Brook. The area to the west and south-west of Greenbushes is drained by Norlup Brook and its tributaries—Cowen Brook, Spring Gully, Gibney's Gully, Dumpling Gully, Boronia Gully, and other smaller unnamed creeks. South-eastward from Greenbushes, the principal creeks are Saltwater Gully and Bunbury Gully, both of which flow into Dalgarup Brook just beyond the boundary of the Field. A small area in the north-eastern corner of the Field is drained by tributaries of Hester Brook, which is itself a tributary of Dalgarup Brook.

The striking feature of all these creeks is, that, while in the vicinity of their headwaters they flow through broad open valleys, often swampy, yet lower down, they flow in steep-sided, V-shaped valleys, often with small waterfalls. This feature is well illustrated by Norlup Brook and its tributaries. A north-westerly flowing tributary of Spring Gully, for example, flows through Paperbark Swamp, which is portion of a wide flat valley. Below the point where this tributary joins Spring Gully, the valley becomes steeper and steeper until at the junction of Spring Gully and Norlup Brook, the valley is steep-sided and V-shaped.

As can be seen from plate I, good exposures of basement rocks are very few, even in the steep-sided valleys. There is generally a shallow deposit of alluvium (Recent Alluvium). It is interesting to note that, in Norlup Brook, Bunbury Gully and Saltwater Gully, this alluvium is not continuous downstream, but that before the boundary of the Field is reached, the alluvium is no longer present. Reference will be made to this later, when discussing the geological history of the Field.

General.

Figure 4, which has been compiled from plate I, shows quite clearly the remnants of the once more extensive plateau. The ridges between the valleys are all comparatively flat-topped. It also shows that there is a main central ridge trending in a north-westerly direction.

The highest point in the Field, which is in the vicinity of the townsite, is 1080 feet above sea level, while the lowest, where Norlup Brook flows out of the Field, is 400 feet above sea level.

GENERAL GEOLOGY.

Summary.

The principal alluvial tin deposits at Greenbushes occur in the Old Alluvium, which consists of horizontal, lenticular, clays, sands, pebble, and boulder beds, believed to have been formed in a shallow sea or lake in middle or late Tertiary times. The Old Alluvium is not in any way associated with the present drainage system. Some Recent Alluvium consisting mainly of unconsolidated clays and sands, has been deposited by the present streams, and a small amount of tin has been won from this.

The basement rocks, on which the Old Alluvium was deposited, consist of greenstones and gneisses (metamorphosed basic lavas and sediments), together with granitic rocks of varying types and basic dykes, similar to those occurring elsewhere in the Darling Range. Exposures of the basement rocks are very poor.

Laterite covers extensive areas and overlies everything except the Recent Alluvium.

There are also fairly extensive areas covered with a clayey soil and laterite and rubble. The nature of the underlying rock, within these areas, is not known.

Recent Alluvium.

The Recent Alluvium consists of unconsolidated sands and clays, deposited by the existing creeks. Its thickness is not known, but it is improbable that this exceeds 20 feet. Its distribution is shown on plate I, but it should be noted that it is sometimes difficult to decide just where the Old Alluvium ends and the Recent begins. The distribution, as shown on plate I, is therefore open to some doubt. In distinguishing between Recent Alluvium and Old Alluvium the following points have been taken into consideration:—

(1) The presence or absence of laterite—As will be pointed out later the Old Alluvium is covered with laterite. The laterite capping may not always be at the present land surface, but is always within a few feet of it.

(2) The topography—The Recent Alluvium is associated with the present drainage and occurs in the steep-sided V-shaped valleys. Any alluvium in the broad open valleys at the headwaters of the creeks is regarded as Old Alluvium.

It will be seen from plate I that the principal deposits of Recent Alluvium are in Saltwater Gully and in Bunbury Gully. It is likely, that the Recent Alluvium in Bunbury Gully, at its junction with Elliott's Gully, is only a very thin skin overlying Old Alluvium. There are a number of old sluicing cuts hereabouts, in all of which alluvium below solid laterite has been worked. It is interesting to note that in both Saltwater Gully and in Bunbury Gully the Recent Alluvium is not continuous downstream, but ends in both the creeks, before the boundary of the Field is reached.

The amount of Recent Alluvium in Norlup Brook and its tributaries is small. Here again it is not continuous downstream, but has practically ended at the point where mapping was stopped.

A small amount of tin has been produced from the Recent Alluvium, but no figures can be given, as details have been lost in "Sundry Claims" (refer p. 101). The greatest production has been in Spring Gully from C. 798 to W.R. 291. This portion of Spring Gully has been worked continuously, over a width of from one to three chains, and to a depth of from 10 to 12 feet. It is difficult hereabouts to tell just where the *recent* alluvium ends and the *old* alluvium begins. The problem is made more difficult, because where the boundary might be expected to be, there are extensive areas of tailings. The boundary as shown on plate I is arbitrary.

Tin has also been produced from Recent Alluvium in Saltwater Gully and the lower portion of Floyd's Gully.

Laterite.

Almost the entire Field is covered with either solid laterite or laterite rubble occurring in a clayey soil. Within the areas of clayey soil and laterite rubble, there are no solid outcrops of laterite, nor are there any indications of the nature of the underlying rocks. Further, these areas occur on the sides of valleys, and it is thought that the laterite rubble may have rolled from the areas of solid laterite on the higher ground. These areas have therefore not been mapped as laterite, but are shown separately on plate I.

In much of the laterite, rounded boulders or small rounded pebbles of quartz are abundant. Such laterite, which is almost always non-pisolitic, can be seen overlying the Old Alluvium in many of the old sluicing cuts and is also found covering extensive areas away from the workings. In mapping, these areas have been excluded from the areas mapped as laterite, and included in the areas mapped as Old Alluvium. In this way the true extent of the Old Alluvium has been indicated.

The areas mapped as laterite are those in which there are frequent outcrops of solid laterite. which is almost certainly overlying basement rocks. The extent of these areas is shown on plate I. It will be seen that one boundary of the laterite corresponds very closely with the 800 feet contour.

The laterite may be either pisolitic or non-pisolitic and varies in composition from a ferruginous laterite to an aluminous laterite. (Matheson, 1942). Seven thousand four hundred and eighty-one (7481) tons of ironstone (limonite) were produced, between 1899 and 1904, from quarries approximately 30 chains north-east of the railway station, and in an area of laterite. The ironstone is merely a very ferruginous portion of the laterite, and the occurrence is similar to the occurrences of ironstone in the vicinity of Clackline and thereabouts (Hobson, 1944). At various times, samples of what appeared to be the more aluminous types of laterite, have been collected and submitted for analysis. Some of the early analyses are now not considered reliable[2] and are, therefore not quoted here. In 1942, a number of samples were collected by Mr. Matheson, and the analyses of these are given in table 3, (Matheson, 1942). It will be seen that sample number 1189/42 has the highest Al_2O_3 content, but this sample should not be taken too seriously, as it was collected more as a specimen than a true sample.

During sluicing operations the laterite overlying the Old Alluvium was undercut and allowed to fall. It was then hauled out of the cut by means of a winch. Tin was frequently recovered from sandy pockets in this laterite. The thickness of this laterite, as seen in the various sluicing cuts, varies from two to 15 feet (approximate) with an average of about three to six feet.

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[2] Refer to letter from Government Mineralogist and Analyst to Government Geologist dated 6/4/44, G.S. File 24/41.

TABLE 3.

ANALYSIS OF SOME LATERITES FROM GREENBUSHES.

		1188/42.	1189/42.	1190/42.
Al_2O_3 :	Acid sol.	32·03	41·86	29·62
	5% NaOH sol.	28·41	39·07	25·93
	Total	32·38	42·02	29·96
Fe_2O_3 :	Acid sol.	17·73	24·18	11·29
	Total	17·73	24·18	11·29
SiO_2 :	Free	27·81	1·32	38·86
	Combined	0·13	1·26	Nil
	Total	27·94	2·58	38·86
Insol. in acids :	Not SiO_2 ...	0·38	0·56	0·38
	Total	28·32	3·14	39·24
H_2O +	... ...	16·81	23·39	14·38
H_2O —	... ...	2·01	1·98	1·68
TiO_2 :	Acid sol.	1·82	4·66	1 89
	Total	1·85	4·76	1·94

1188 From pit on the main road between Balingup and Greenbushes about 155 miles from Perth. Probably on Nelson location 108—north of Padbury Hill.

1189 Laterite overlying tin lode on M.C. 44, Greenbushes.

1190 From top of ridge on east side of road about two miles from Greenbushes, on the road to Bridgetown.

Old Alluvium.

The Old Alluvium consists of a series of lenticular clay, sand, grit, pebble, and boulder beds, having a maximum known thickness of approximately 100 feet. It is the principal source of the alluvial tin, which occurs almost entirely in the pebble or boulder beds (wash). While the maximum known thickness is approximately 100 feet, the average is appreciably less. In many parts of the Field numerous shafts have been sunk through the Old Alluvium to basement at depths of from 20 to 50 feet. In sluicing cuts the thickness of the Old Alluvium is frequently seen to be from 15 to 20 feet, while in shallow cuts, from which the material has been carted, it is only from one to six feet.

It has already been pointed out that the Old Alluvium is overlain by laterite. Where the Old Alluvium is seen in the sides of sluicing cuts, it usually consists of rounded quartz pebbles in a white clayey matrix. A typical section, exposed in a cut towards the head of Bunbury Gully, is shown in figure 5.

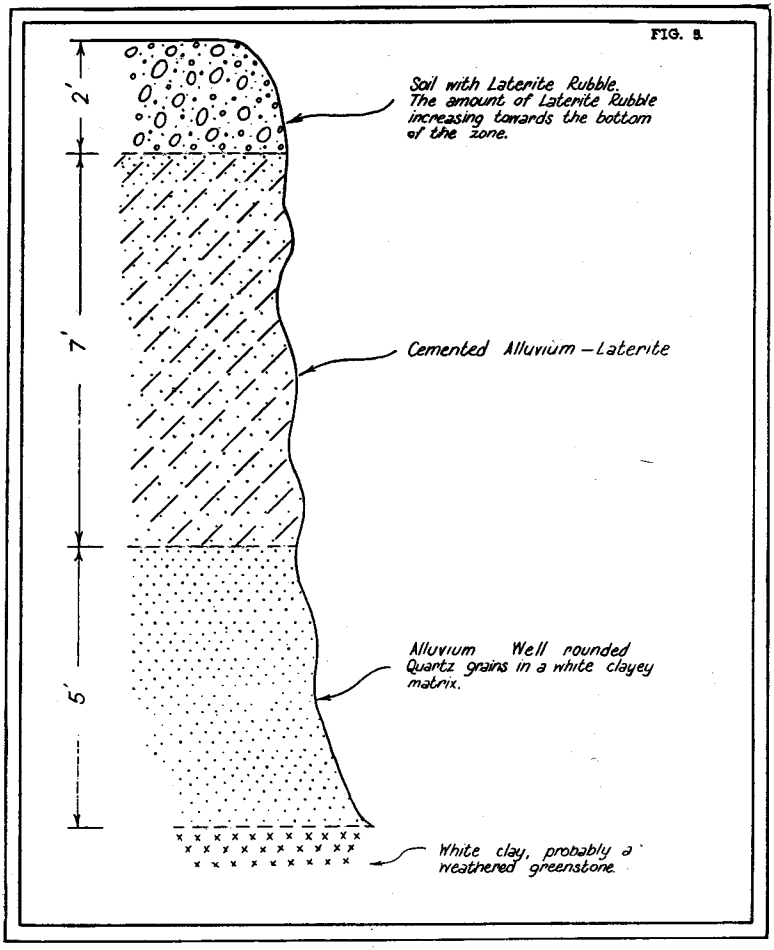


Figure 5.

Section through Old Alluvium, M.C. 1, Bunbury Gully.

West and south-west of Greenbushes, there are extensive areas of white sand, underlain at a depth of a few feet by laterite. Within this area there are numerous open cuts, from which very appreciable quantities of tin have been produced, The sand above the laterite usually contains some tin and has frequently been worked by means of shallow cuts. The larger cuts have worked alluvium below the laterite. All this alluvium is believed to be portion of the Old Alluvium.

While almost all the sluicing cuts and shafts examined have bottomed on basement rocks at depths not exceeding 50 feet, there are a number of shafts and working in the Three C's area which have bottomed on a blue clay. This blue clay is portion of a clayey zone, which was penetrated by a number of deep bores put down in 1936 (Forman, 1937), and under which pebble and boulder beds have been found. The bores ultimately entered basement at depths, varying from 58 feet (?) to 103 feet (?). It is not easy to tell from an inspection of the logs of these bores just when basement was reached, and hence the figures given above are only approximate. More will be said regarding these bores in a later section of this bulletin (p. 119). The thickness of the clayey zone, penetrated by the bores, varied from 20 to 72 feet.

Most of the shafts in the vicinity of D.C. 95 (p. 119), bottomed on blue clay, and it would seem likely that the Three C's workings (M.L. 529 &c), and the Battler's Hope workings (D.C. 35) have also bottomed on this same blue clay. The bottoms of these cuts cannot be seen at present because of drifted sand and of water.

It is not always easy to distinguish between this blue clay and a very weathered greenstone, such as is found in the dumps on D.C. 90, or in the dumps immediately east of the east boundary of M.C. 34. The following features are, however, quite characteristic of the weathered greenstone:—

(1) The presence of portions of less weathered material, which can be definitely recognised as being weathered greenstone. When completely weathered, the greenstones produce a white, yellow, or blue-grey clay. If a search is made from dump to dump fragments of this clay can often be found in which unmistakable remnants of greenstone can be seen.

(2) The presence of quartz veins. Quartz veins can often be found on the floors of the sluicing cuts, where these have bottomed on weathered greenstone. In Cole's cut, for example, in which the bottom is a white clay, there can be found in some places, vertical quartz veins, up to ½ inch in diameter. In dumps, which have bottomed on greenstone pieces of clay, frequently blue-grey in colour, can be found containing this quartz stringers, perhaps only 1/16 inch in thickness.

The Old Alluvium was followed to the boundary of the Field and was seen to extend still further. Near Kirup, 25 miles north-west of Greenbushes, sandy areas can be seen in the vicinity of the main road, and a boulder bed is exposed in a deep railway cutting. No geological examination was made of this vicinity, but is probable that these sands and boulder beds are to be correlated with the Old Alluvium at Greenbushes. The occurrence of these beds at Kirup

was previously noted by Woodward (1917, p. 11), who also noted similar beds on Nelson location 161 (Capeldene), which is four-and-a-half miles west-south-west of Kirup railway station. Matheson (1942, File 24/42) records the occurrence of rounded quartz boulders on Nelson location 1650, near Meaney's bridge, five miles north of the Greenbushes railway station. It is evident that the Old Alluvium has quite a wide distribution and that additional mapping would be necessary to find out its extent beyond the boundary of the Field.

It is not unlikely that the Old Alluvium can be correlated with the lake beds at Collie, which are described (Maitland, 1919, p. 50) as consisting of horizontal conglomerates, grits, sands and clays overlain by a ferruginous laterite. The total thickness of these beds is at least 100 feet.

Basement rocks.

It has already been pointed out that basement rocks are almost completely obscured by laterite, by clayey soil with laterite rubble, and by Old Alluvium. Outcrops are therefore rare, and are found, with one or two exceptions, only in the steep sided, V-shaped valleys. In the central portion of the Field there are no outcrops of basement rocks, but some information regarding these rocks can be obtained from the workings, and from the bores put down in 1928-29 to test the lodes below the then existing workings. All the old workings are now abandoned and inaccessible. They are confined, with a few exceptions, to the oxidized zone and are not extensive. There are no complete plans of these workings in existence and very few reports are available. During 1942 and 1943 the writer inspected the dumps of many of the shafts and examined the bottoms of most of the sluicing cuts. A few specimens of unweathered rocks were collected from the deeper shafts.

Away from the central portion of the field some information can be obtained from railway cuttings in addition to that from the outcrops in the steep-sided valleys.

During 1943 Dr. K. R. Miles, made a petrographic examination of the specimens collected during 1942 and 1943, and also re-examined a number of Greenbushes rocks already in the Geological Survey collection. Dr. Miles' petrographic notes are given in the next section of this bulletin. Full use has been made by the writer of these notes in preparing the section of this bulletin dealing with basement rocks.

The basement rocks consist, so far as is known, of metamorphosed lavas and sediments together with some granitic rocks of varying types and also some basic dykes. They will be described under the following headings:—

Basic dykes—Epidiorites and dolerites, similar to those occurring elsewhere in the Darling Ranges.

Granite rocks—Aplitic granites, aplites, pegmatites, greisens, quartz veins and also granitic gneisses and schists referred to at various times as foliated granites (Woodward, 1908, pp. 27, 29), replacement gneisses and schists (Ellis, 1939, p. 10), injection gneisses (Miles, refer p. 49).

Greenstones—Mainly amphibolites and amphibolite schists, believed to be metamorphosed basic lavas. It should be noted that the basic dykes are described under a separate heading and are excluded from the rocks described under the heading greenstones.

Meta-sediments—The principal rocks described under this heading are the granulitic gneisses. Reference is also made to injection gneisses, formed by the intrusion of granitic material, along the planes of gneissosity of the granulitic gneisses. Occasional occurrences of quartzite are noted and also the probable existence of other types of metamorphosed sediments.

Basic dykes.—Fair exposures of these are to be seen in the vicinity of the 161 and the 162 mile posts on the railway line (location 9815) and in Cowan Brook. Individual outcrops are generally small and completely surrounded by soil. Nevertheless there is a suggestion, in one or two places close to the 161 mile post, that the outcrops are portions of dykes transverse to the general strike of the country. Quite a number of specimens have been collected from various localities in the past, and are referred to in Dr. Miles' report (p. 58). Petrographically those rocks vary from dolerites to epidiorites, and are identical with similar basic dykes from elsewhere in the Darling Ranges.

Granitic rock.—The only lode being worked during 1942 and 1943 was at the Vulcan workings on M.C. 4. The old workings were all abandoned and quite inaccessible. Generally the ore bodies have not been worked right to the surface and all that can now be seen is a series of old shafts, partly or wholly fallen in or full of water. The granitic rocks do not outcrop. While there have been numerous references to the ore bodies worked in the past, precise information is lacking and no complete plans of any workings appear to exist. Consequently information regarding the granitic rocks and the lodes is very meagre.

Almost all the early writers (e.g. Woodward, 1908, pp. 27, 29) refer to the foliated granites, but no information is available regarding the distribution of these. Ellis (1939, pp. 9 to 13) gives a very complete description of the Vulcan workings and notes the occurrence there of "replacement gneisses and schists and migmatites." It would

seem likely that these are identical with the foliated granites of early writers and are also related to Miles' injection gneisses (refer p. 57). The rocks at the Vulcan workings are intensely weathered. Referring to these rocks Ellis, (1939, p. 10) says:—

> The rock exposed in the open cut at the main mine workings on Mineral Claim No. 4 is a highly felspathic, decomposed quartz mica schist showing marked schistosity, striking N. 30° W., and dipping W. 30° S., at an average dip of 35°. This rock grades imperceptibly, in parts of the open cut, into what appears to be a massive kaolin formation, with or without granular quartz. The whole rock mass is liberally impregnated with black tourmaline, ranging in size from irregular patches, some 6 inches across, down to specks so small as to be only just recognisable. It is in this combined schistose and massive kaolinised rock that black tin-oxide occurs in payable quantities, irregularly disseminated throughout the mass.
>
> A tunnel driven in a north-easterly direction through the eastern wall of the tin-bearing formation passed through a red clayey formation devoid of quartz and mica. This material represents the weathered portion of a rock type, the nature of which cannot be determined on present available evidence.

Similar rocks can be seen in the Fremantle Cut, in some of the old workings on M.C. 1 in Bunbury Gully, and it is reported that recent work (late 1943 and 1944) has shown the probable existence of quite extensive areas of similar rocks in this vicinity.

In addition to the foliated granites Woodward (1908, pp. 27-30) makes reference to pegmatite dykes. Referring to these, he says (1908, p. 29):—

> The pegmatite dykes are roughly of three types, 1st those which are largely composed of white felspar; 2nd, those of a red colour (ferruginous) and heavily charged with tourmaline; and 3rd, those of a highly micaceous character. The first of these are well illustrated in the South Cornwall, where a large dyke has been worked in the soft ground for a considerable length. The second class are more common at the Bunbury end, carrying tin in large crystals, the red colour being in all probability due to the decomposition of arsenical pyrites which has caused chemical reaction to take place upon the tourmaline, which, although occurring in large crystals, is usually soft and friable, whilst the cassiterite crystals are usually dull and etched upon thin surfaces.
>
> The mica lodes (greisen) are particularly well developed in the Cornwall Mine, upon which property one out of a series of three or four dykes has been worked for a length of several chains.
>
> The quartz or quartz tourmaline veins (altered pegmatite) sometimes contain crystals of mica and cassiterite. One of these has been met with at South Greenbushes not far from the State Battery, and another to the westward of Hester's troughs, but nowhere, so far, have they been proved to be of sufficient value to be worked profitably.

Specimens of granitic rocks in the Geological Survey collection obtained from the deep workings and from the 1928-1929 boring vary from aplitic granites through pegmatites, aplites and greisens to quartz veins, the first and last named being quite uncommon (p. 50). The principal minerals in specimens examined either at

the Geological Survey or the Government Chemical Laboratory are quartz, microcline and/or albite, tourmaline and muscovite. In addition, a number of other minerals have been recorded and described. References to and brief comments on the various minerals, which have been described, are given below:—

Albite.—Simpson and Gibson, 1907, pp. 63, 72, 73: Farquharson, 1914, p. 169: Bowley, 1929, p. 107: Simpson, 1929, pp. 101 to 102: Larcombe, 1929, p. 87: Miles, refer p. 50. Some of the dykes consist almost entirely of albite.

Apatite.—Simpson, 1918, p. 7; 1929, p. 101. Bowley, 1929, p. 107: Miles, refer p. 50. Both Simpson and Miles record lazur-apatite in crystals up to 1 inch in diameter. Apatite occurs as a common accessory and Bowley records up to 1.5 per cent. in the dykes intersected in the 1928, 1929 bores.

Arsenopyrite.—Maitland, 1919, p. 7: Woodward, 1908, p. 72. Recorded as an accessory mineral.

Asbolite.—Maitland, 1905, p. 21. Sample assayed 0.15 per cent. Ni and 1.04 per cent. Co.

Beryl.—Simpson, 1910, p. 9. In addition to the specimen referred to by Simpson (10826) there are two other specimens in the Survey collection 1/5319 and 2/2646. Small crystals (2/2646) were fairly abundant in the face of the "Vulcan" workings (M.C. 4) in 1943. They have previously been noted by Ellis (1939).

Biotite.—Simpson, 1929, p. 101: Miles refer p. 55. Generally only present in small quantities.

Cassiterite.—The only tin mineral found at Greenbushes. More information about cassiterite on page 57.

Corundum.—Simpson, 1929, pp. 101 to 102. Corundum was recognised by Simpson in cores from two of the 1928-29 bores. It occurred as prisms and bipyramids about 0.2 mm. by 0.06 mm.

Eastonite.—Bowley, 1933, p. 62. Analysis of Eastonite.

Garnet.—Simpson, 1899, pp. 52 to 54; 1902, p. 33; 1929, p. 101: 1931, p. 144: Maitland, 1900, p. 87: Simpson and Gibson, 1907, pp. 63, 66, 69, 72: Woodward, 1908, pp. 20, 22: Farquharson, 1914, p. 169: Bowley, 1929, p. 101. Occurs as an accessory in many of the granitic dykes.

Glaucophane.—Bowley, 1929, p. 107: Simpson, 1929, p. 101: Miles, refer p. 55. Glaucophane was quite abundant in portion of one of the pegmatite dykes intersected by bore number 5 (1928) on "Dixie", M.L. 632. It is also a common constituent of some of the amphibolites (p. 55).

Ilmenite.—Bowley, 1929, p. 107: Simpson, 1929, p. 101. Occurs as an accessory mineral.

Microcline.—Miles (refer p. 57).

Muscovite.—Simpson, 1899, pp. 52 to 54; 1902, p. 33: Simpson and Gibson, 1907, pp. 63, 72, 74: Woodward, 1908, pp. 28, 29, 69, 70, 71: Miles, refer p. 52. Muscovite is an essential constituent of many of the granitic dykes.

Orthoclase.—Simpson, 1902, p. 33. This is the only record of the occurrence of orthoclase in the granitic dykes.

Pyrite.—Simpson, 1929, p. 101. Pyrite is recorded as a minor accessory mineral associated with glaucophane on M.L. 632.

Pyrrhotite.—Miles, refer p. 52. Occurs in a quartz vein.

Pyrochlore and Polycrase.—Bowley, 1929, p. 107. Doubtful occurrence only.

Rutile.—Simpson, 1902, p. 33; 1919, p. 6; 1929, p. 101; 1931, p. 144: Woodward, 1908, p. 21: Miles refer p. 51. Occurs in an accessory mineral.

Siderite.—Simpson, 1929, pp. 101, 102, Recognised by Simpson from portion of a pegmatite dyke intersected in bore number 5 (1928), on "Dixie," M.L. 632.

Sphene.—Simpson, 1929, p. 101. Occurs as as accessory mineral.

Spodumene.—Miles, refer p. 51. Spodumene is noted in two specimens from the Survey collection. One from the South Cornwall workings and the other from "Cosgrove Consolidated,". M.L. 46.

Stibiotantalite
Tantalite } Refer to page 75.

Topaz.—Simpson and Gibson, 1907, p. 73: Woodward, 1908, pp. 28, 71. Has been noted in two specimens from the South Cornwall Mine.

Tourmaline.—Woodward, 1908, many: Farquharson, 1914, p. 169: Larcombe, 1929, p. 87: Simpson, 1929, pp. 111 to 112: Miles, refer p. 50. Tourmaline is abundant in most of the granitic dykes. It is not decomposed during the formation of the laterite and has been extensively used an an "indication" in prospecting. Two varieties—dravite and schorl—have been described by Simpson.

Zircon.—Simpson, 1929, p. 101. Occurs as a minor accessory.

Greenstones.—The rocks included under this heading do not outcrop anywhere in the Field. Unweathered specimens have been obtained from the deeper workings and as a result of diamond drilling during 1928 and 1929. During 1942 the writer examined the dumps of the old main shafts of the Cornwall and South Cornwall workings, and noted the similarity of the rocks to those of the eastern goldfields. In an old reservoir, close to the south-west corner of the townsite, metamorphosed pillow lava is exposed. The beds face west.

It will be seen from Dr. Miles' petrographic notes (pp. 48-62) that while the majority of the greenstone specimens are amphibolites

or amphibolite schists, some are biotite or chlorite schists. These latter types are thought to be merely local variations of the first two. All are considered to be metamorphosed basic lavas.

The distribution of the greenstones cannot be mapped, but it is likely that they constitute the major portion of the belt of country, containing the primary tin deposits, which extends from Westralian Gully to the railway station. What are probably very weathered greenstones can be seen at the bottom of many of the old sluicing cuts and also in many of the old dumps.

Meta-sediments.—The principal rocks included under this heading are the granulitic gneisses. These are dark coloured banded rocks, with a sandy appearance and with abundant flakes of biotite. Good exposures are found in Dumpling Gully at its junction with Gibney's Gully (2/2667)[2], in the lower portion of Spring Gully (2/2669) and in Cowan Brook. They are also known to occur in the South Cornwall workings (2/2666, 13109) and specimens have been obtained from the 1928, 1929 bores. There are good exposures of these rocks in the railway cuttings north-west of Padbury's Hill.

The granulitic gneisses have been converted in part to injection gneisses, by the intrusion of granitic material along the planes of gneissosity. Specimens of injection gneiss have been described from Salt Water Gully (2/2670), from Dumpling Gully (7668) and from the Mill Brook (7665). The specimen from Salt Water Gully was collected from the northern end of a series of outcrops, some of which appeared identical with those occurring at the junction of Dumpling Gully and Gibney's Gully, while others, such as the one from which the specimen was collected, were more acidic in composition. The precise locality of the specimen from Dumpling Gully (7668) is not known, but it is not improbable that it was collected from the same locality as specimen number 2/2667—i.e., the junction of Dumpling Gully and Gibney's Gully. The only other outcrops in Dumpling Gully are small and very inconspicuous. Mill Brook is not known to the writer and does not appear on any of the Greenbushes maps. It is probably a local name in use at the time the specimen was collected.

Quartzite was seen on the dump of Elias' tunnel, which is situated approximately 13 chains south-east of the south-east corner of M.C. 22. The tunnel is now inaccessible. The position of the pieces of quartzite on the dump suggests that they were among the last material to come out of the tunnel.

Kyanite, staurolite and andalusite (?) have been recognised in the alluvial concentrates, but rocks containing these minerals have not been seen in situ. Their occurrence is further evidence of the existence of bands of metamorphosed sediments associated with the greenstones in the belt of country containing the primary tin deposits.

[2] Registered number of specimens in geological survey collection.

PETROGRAPHY.

By K. R. Miles, D.Sc., F.G.S.

INTRODUCTION.

No systematic description of the petrology of rocks from the Greenbushes tinfield has yet been attempted, despite the fact that this has now been a mineral field of considerable interest, for over half a century. Probably the general absence of abundant fresh outcrops in the mining areas has been responsible for the lack of interest in the country rocks, but, with a revival in lode mining in the district, it is to be expected that more attention may be paid to the general geology, to the composition of the rock types and to their associations with the tin-bearing lodes.

In the following notes representative specimens of the Greenbushes rock types from the Geological Survey collection have been briefly described and classified. A few notes on the writer's interpretation of the origin and inter-relationships of the various types have also been added. Probably one of the most interesting features of this investigation is the evidence afforded of the existence of metamorphic basic lavas comparable with recognisable basic lavas from the Older Greenstone Series of the Eastern Goldfields. Furthermore the general assemblage of country rocks of the tin lodes appears to bear close comparison with that of the auriferous belts of the Yilgarn and other Goldfields.

The specimens examined during the preparation of these notes include (1) a suite collected by R. A. Hobson in 1942, (2) representatives of bore core from bores numbers 1-8 put down in 1928, and (3) a number of specimens collected during departmental examinations of the Greenbushes district by Woodward, Feldtmann and others in earlier years.

PREVIOUS LITERATURE.

Comparatively little work has been done on the description and classification of rock types from the Greenbushes area, the attention of most investigators being principally confined to the individual mines, to the tin deposits themselves and to the mineralogy of the lodes. Notes on the general geology of the field by different writers have usually included but very brief descriptions of the rock types viz., Woodward (1908, pp. 26 et. seq.), Feldtmann (1914, p. 156). Farquharson in 1914 (pp. 168-175) published petrographical notes on

some specimens from several localities in the district. In this report he summarised previously published information regarding the rocks and gave brief petrographical descriptions of three classes of rocks —pegmatites, dolerites, and amphibolite and hornblende schists. Farquharson included no notes on the granites or gneisses in his report.

In 1928 Larcombe (1929, p. 87) gave a brief petrographical classification of the lode and country rock passed through during the boring of a number of holes to test the possibilities of tin lodes on the Cornwall (Bores 1-4), South Cornwall (Bore 6), Dixie (Bore 5) and Lost and Found Leases (Bores 7-8). Larcombe subdivided these rocks into—1. Granitic and allied pegmatites (including tourmalinised acid granite, greisen, pegmatite, alaskite, and white albite rock) and 2. Country rocks (reconstructed amphibolites and hornblende schists), which he considered to represent "products of dynamic metamorphism and recrystallisation from basic rocks of the dolerite-gabbro type."

PETROGRAPHY.

The hand specimens examined by the present writer may be subdivided, for convenience of description, under the following headings—1. Granitic Rocks, which include the intrusive and metasomatic replacement types such as pegmatites, aplites and greisen, constituting the stanniferous lode formations. Normal granite was not represented amongst the specimens examined; 2. Basic Country Rocks including amphibolites, amphibolite-schists, biotitic and chloritic schists and sandy hornblendic and/or biotitic granulite gneisses; 3. Acid Country Rocks—injection gneisses; 4. Basic Intrusives—normal dolerites and epidiorites.

Granitic rocks.

Granite.—No specimens of normal massive equigranular or porphyritic granite were seen. The nearest approach to this comes from No. 5 bore on the late "Dixie" M.L. 632, which at a bore depth of about 400 feet passed through a tongue of fine grained aplitic biotite granite. This rock has a distinctly granulated appearance and the biotite flakes show signs of segregation and a rude banding. (No. 5, 400′) [1/4878]. (No. 5, 402′) [1/4569][4].

[4] Numbers in square brackets refer to specimens registered in the general rock and mineral collection of the Geological Survey of W.A.

Pegmatites, aplite, greisen, quartz veins.—The "pegmatites" from Greenbushes apparently range from coarse almost granitic, apparently barren types, through highly stanniferous, rather granulated types, and fine granular, albitic varieties of aplite, to stanniferous highly micaceous and tourmalinised varieties of greisen.

[7667] is a specimen of the first variety of pegmatite. It consists of dark glassy quartz and white felspar (? microcline) in coarse intergrowths, together with scattered books of black biotite.

Representatives of stanniferous granulated pegmatite include [703], [1990], [13624], the first consisting essentially of granular albite, a little quartz, cassiterite and tourmaline, the two latter specimens containing irregular blebs of clear dark glassy quartz set in a matrix of fine granular sugary textured felspar (? albite) and plentifully sprinkled with red garnet, tourmaline and a little cassiterite.

A few scattered aggregates of blue-green apatite crystals are also visible. It may be noted that Farquharson (*Op. cit.*) records the presence of the green spinel, gahnite in [13624] but an examination of several fragments of these green crystals reveals an uniaxial anisotropic mineral with weak birefringence and negative optical character—undoubtedly apatite. Pale greenish muscovite occurs in these rocks in a few scattered tiny flakes.

Two further specimens of interest are [4860] from late M.L. 46 "Cosgrove Consolidated," and [13108A] from 70 feet level South Cornwall Mine. These are both irregularly streaked with granular quartz in a white, medium—fine granular aggregate of felspar, quartz and a creamy white mineral. They are plentifully sprinkled with crystals of black tourmaline whilst [13108A] contains a number of rectangular deep blue coloured crystals up to one inch across, of apatite (variety lazur-apatite). Garnet is moulded upon the margins of the larger crystals. Smaller scattered fragments of blue apatite were also visible in [4860].

Under the microscope the felspar was seen to consist of an aggregate intergrowth of microcline and albite. The creamy white mineral, which showed a distinctly prismatic habit and a vitreous to pearly lustre on cleavage faces, constituted a considerable proportion of both specimens. The following optical properties were determined:—Colourless, prismatic elongated parallel to c, sections showing one perfect cleavage. Basal sections show two cleavages (110) intersecting at 88°. Relief moderately high. Birefringence moderate ($< .02$). Crystals length — slow. Biaxial + ve; 2V moderate (about 50°); Y = b, Z $\wedge$ c = 25°-26°. Shows some marginal alteration to a fibrous mineral.

FIG 6.

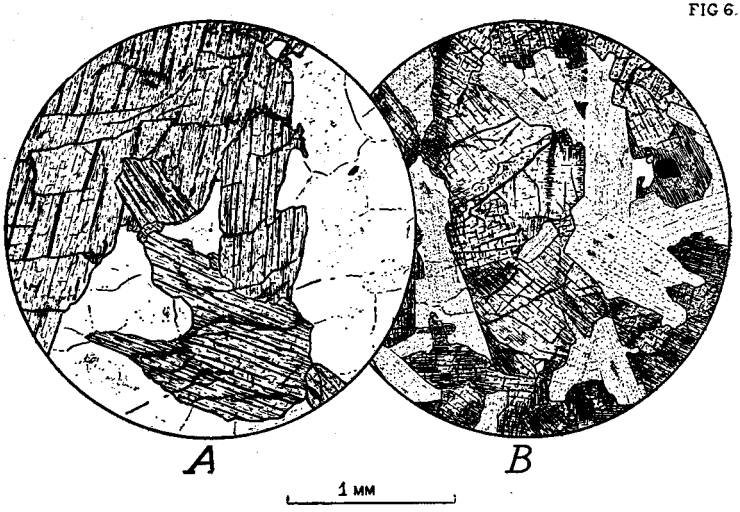


Figure 6.

A. (13108A)—Spodumene-apatite bearing pegmatite showing large plates of spodumene and (colourless) felspar-microcline and albite. Other portions of this specimen contained large crystals of blue lazurapatite and small quantities of tourmaline and garnet.

B. (2/2660)—Typical partially uralitised dolerite showing augite altering to uralite, and slightly clouded andesine-labradorite laths in typical ophitic intergrowth. Iron ore is ilmenite. Quartz (clear) is interstitial, rare accessory.

These properties correspond with those of spodumene (silicate of lithium and aluminium) (see fig. 6A). In order to test for the presence of lithium some of the powdered mineral was fused with fluorite and potassium bisulphate on a platinum wire. A distinct red lithium flame resulted. To the writer's knowledge this is the first record of spodumene from the Greenbushes tinfield.

Specimens of stanniferous pegmatites in the bore cores come from Bore No. 2 (265 and 267 feet) [1/4569] and [2/2671], Bore No. 4 (200 feet) [2/2671] and Bore No. 6 (234 feet) [2/2671]. Blue apatite is an accessory in several of these specimens whilst traces of spodumene and accessory brown rutile were seen in the core from Bore 2 (267 feet). The pegmatite in Bore 4 (200 feet) contains abundant books of muscovite and granular red garnet.

A medium-fine equigranular aplitic phase of the normal stanniferous lode formations is represented by specimens of a dyke from M.L. 632—No. 5 Bore (253 feet and 264 feet) [2/2671]. This rock

is an albite aplite, which is very rich in albite in interlocking granular crystals with only accessory quartz, biotite and rare apatite. Larcombe (*op. cit.* p. 87) has described this under the name "albite rock."

The greisens are characterised by an abundance of scaly muscovite apparently replacing felspar in an original pegmatitic rock. They consist essentially of muscovite, quartz and some felspar (albite?) usually arranged in a rude gneissic structure. They are commonly well tourmalinised, and stanniferous. Typical specimens are [2/2658] from the dump of the old main shaft on the "Cornwall" lease and Bore 1 (246 feet) [1/4569] from the same area. The former specimen is highly tourmalinised, whilst the latter, in addition to the minerals mentioned above contains abundant red garnet.

Finally mention may be made here of glassy vein quartz, the acidic end product of granitic magma. A typical specimen of such vein quartz intersecting amphibolite schist is seen in core from Bore No. 6 (226 feet) [2/2671] (South Cornwall lease.) The quartz is thinly sprinkled with crystals of pyrrhotite. Larcombe (*op. cit.* p. 87) refers to alaskite by which he denotes an almost pure glassy quartz rock containing little or no felspar, from the Cornwall Lease. This is not the true definition of alaskite (Holmes, 1928) and the present writer prefers to include this rock type under the classification of vein quartz.

Basic country rocks.

From an examination of the core of bores 1 to 8 referred to and from an inspection of the logs of these bores published in 1928 (Larcombe, *op. cit.*) it is apparent that the basic rocks described below form the country rocks into which the pegmatites and other acid stanniferous dykes and lodes described in the foregoing section, have been introduced. Rock types represented amongst the basic country rocks are:—

Amphibolite and amphibolite-schists.—These are all thoroughly recrystallised rocks in which orientation of the mineral constituents ranges from incipient or slight (in the amphibolites) to very distinct (in the amphibolite schists). Specimens of these rocks have been described by Farquharson (*op. cit.* pp. 172-5) under the heading of amphibolite and hornblende schist and by Larcombe (*op. cit.* p. 87) under the heading reconstructed amphibolite and hornblende schist. It may be noted here that the term amphibolite has been defined as "A granulose or glomero-blastic metamorphic rock, consisting essentially of amphibole and plagioclase, and often containing quartz, epidote or garnet." (Holmes, *op. cit.*). Consequently the present writer is of the opinion that the term "reconstructed amphibolite" is redundant and should be discarded. The term "amphibolite schist" is preferred to "hornblende schist" since it indicates the genetic relationship to the amphibolite.

The structure of these rocks is granulose or granulitic to granulitic gneissic and schistose. The normal simple amphibolite (see Fig. 7A) is a medium to medium-fine grained dark green rock consisting essentially of green to bluish-green pleochroic hornblende in zenoblastic aggregates often showing imperfect orientation, with interstitial aggregates often showing imperfect orientation, with interstitial zenoblastic granular basic plagioclase, predominantly anorthite (optically — ve with maximum extinction angles of albite twins normal to (010) 57°-69° hence An_{96}-An_{100}). The felspar may show zonal structures—twinning being rather infrequent in many specimens. Quartz is an occasional interstitial constituent. Magnetite is sometimes present in tiny clustered aggregates, whilst accessory minerals include apatite and sphene in granules, and rare epidote. Scattered grains of later pyrite are common.

Relict structures in the amphibolites are very scarce but in a few specimens traces of original structures have been preserved—giving some clues as to the origin of the rocks from which the amphibolites and amphibolite schists have been derived. One specimen [2/2663], from near the old reservoir, 8.5 chains west of post M.C. 5, which is a dense, very fine grained amphibolite shows needle laths of plagioclase (andesine-labradorite, Ab_{56} An_{44}-Ab_{42} An_{58}) arranged in a distinct igneous texture—partial ophitic intergrowth with ferromagnesian minerals, and also a suggestion of flow orientation characteristic of a basic lava—probably doleritic but possibly basaltic. All original structures have been lost in the more schistose specimens.

Variations of the normal amphibolites are biotite amphibolites and glaucophane-bearing amphibolites. In the former, tiny flakes of brown to yellow-brown biotite (variety phlogopite?) can be seen scattered throughout the thin slice usually intergrown with and apparently replacing some of the green amphibole. A typical specimen is portion of Bore No. 1 (272 feet) [1/4878]. In hand specimen this rock appears more distinctly granulose than some of the normal amphibolites. In Bore 3 (145 feet) [1/4569] biotite is more abundant than the amphibole—a further stage in the replacement. Glaucophane occurs in many specimens of amphibolite and biotite amphibolite, e.g., specimens [2/2664] [2/2665] (fig. 7A) from the dumps of the main shafts on the old Cornwall and South Cornwall leases respectively, Bore 2 (279 feet) [1/4563] Bore 4 (189 feet) [2/2671]. The glaucophane usually occurs in xenoblastic forms in plates and laths moulded upon and in places apparently forming from the green hornblende. It is pleochroic X = neutral, Y pale violet blue, Z = pale blue X < Y < Z. Crystals are length slow, c > Z = 6°. Optically negative, 2V about 50°; b = Y. Axial plane (010). These optical properties undoubtedly identify the mineral as glaucophane and not

crocidolite as suggested by Farquharson (*op. cit.* p. 173). In specimen [2/2664] it is noticeable that sphene is abundant in granular aggregates[5].

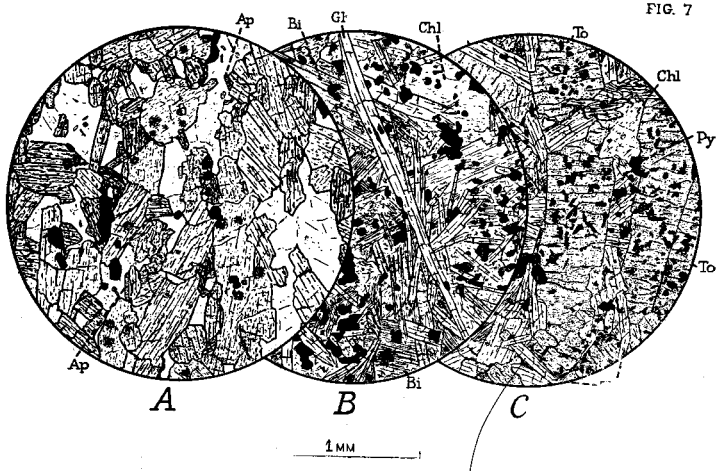


Figure 7.

A. (2/2665)—Typical medium grained amphibolite showing characteristic granoblastic gneissic structure of green hornblende (with pleochroic haloes about zircon granules) and (clear) plagioclase (anorthite). Other minerals include magnetite (black opaque) and residual apatite (Ap) fragments. Glaucophane occurs in other portions of this slice.

B. (1/4569: Bore 2,252′)—Glaucophane-biotite-chlorite schist showing interlacing glaucophane needles (Gl) in a matrix of shredded brown biotite (Bi) and pale chlorite (Chl). Black opaque magnetite is abundant.

C. (1/4569: Bore 1,225′)—Tourmaline-bearing tremolite-chlorite schist showing large crystals of tourmaline (To) studded with inclusions of iron ore, set in an aggregate intergrowth of tremolite needles (Tr) and shredded chlorite (Chl). One grain of pyrite (Py) is shown in the field.

In one specimen from Bore No. 2 (279 feet) [1/4563] which contains long needles of glaucophane, microscopic examination revealed scattered rounded clear areas filled with interlocking crystals of basic plagioclase-anorthite, and scattered flakes of biotite. These clear areas have every appearance of representing re-crystallised remains of original filled-in vesicles in an original basic lava. Rock from Bore No. 4 (189 feet) [2/2671] may finally be mentioned here as representing the end product of glaucophane and biotite replacement of original schistose amphibolite. This is a fine grained glaucophane-biotite schist

[5]It may be noted that the late Dr. E. S. Simpson recorded and described glaucophane from a bore core at Greenbushes in 1928-9. (Simpson, 1929, pp. 101-2).

consisting of well oriented aggregates of needle glaucophane, biotite, a little remaining chloritic amphibole and scattered magnetite, set in a very fine granular felspathic groundmass.

The amphibolites and amphibolite schists are well represented in available core from all bores, 1 to 8.

Biotite and chlorite schists.—These rocks in many cases probably represent localised metamorphic products of the same rocks from which the amphibolites were derived. They include biotite schist forming the contact margin of an intrusive aplitic granite tongue (Bore 5, 273 feet) [1/4563] and biotite-chlorite schist, a typical specimen of which comes from Bore 2 (254 feet) [2/2671]. This consists almost entirely of coarse interlocking plates of brown biotite and pale green chlorite with a little interstitial quartz. Magnetite is sparsely sprinkled through the ferromagnesian minerals. Glaucophane-biotite-chlorite schist—(Bore 2, 252 feet) [1/4569]. This rock is probably a further metamorphic alteration product of the glaucophanic amphibolite series, closely related to the type of glaucophane-biotite schist described above. It consists of interlacing glaucophane needles scattered through a matrix of shredded brown biotite and pale chlorite with occasional fragments of pale, altered looking green amphibole (see fig. 7B). Abundant magnetite is plentifully scattered throughout and unlike in the amphibolites plagioclase felspar is present only as a very rare interstitial accessory mineral. Specimens of tourmaline-bearing tremolite-chlorite schist and biotite chlorite schist come from Bore 1 (225 feet) [1/4569] and Bore 4 (186 feet) [1/4563] respectively. The former is medium fine grained and contains abundant brown tourmaline crystals set in an interlocking network of colourless amphibole (tremolite) laths and needles with interstitial chlorite. Fragments of a black opaque metallic mineral (magnetite?) are particularly abundant in the tourmaline (see fig. 7C.) The latter rock consists of coarsely crystalline biotite and chlorite with large crystals of tourmaline running in random directions through it.

Granulite-gneisses.—Included under this heading is a group of fine grained rocks characterised by a distinctly granulose (saccharoidal) texture, which in some specimens grades into gneissic or banded, due to the presence of alternate layers of different mineral composition. These rocks range from hornfelsic sandy biotite and hornblende granulite-gneisses to granulose sandy biotite gneiss and granulose felspathic hornblende schist [2/2672A]. The textures are those characteristic rather of recrystallised sedimentary rocks than igneous rocks. The chief mineral constituents are biotite, plagioclase felspars—albite, oligoclase ($Ab_{77}An_{24}$) and andesine ($Ab_{66}An_{34}$), and quartz (fairly abundant) in an even granular mosaic. Accessory mineral is zircon in rounded grains. Typical specimens of the sandy biotite gneiss are [2/2667] from the south side of Dumpling Gully near the south-east corner of loc. 203,

(See fig. 8B.) [2/2668] from Cowan Brook, north of north-east corner of M.H.L. 8 and [2/2672C]. Red garnet occurs scattered sporadically through one specimen of quartz biotite gneiss [2/2669] from the south bank of Spring Gully about the centre of C 645 (see fig. 8A), and in another specimen of bore core [2/2672B] segregated and thickly studded through a biotite rich band.

FIG. 8.

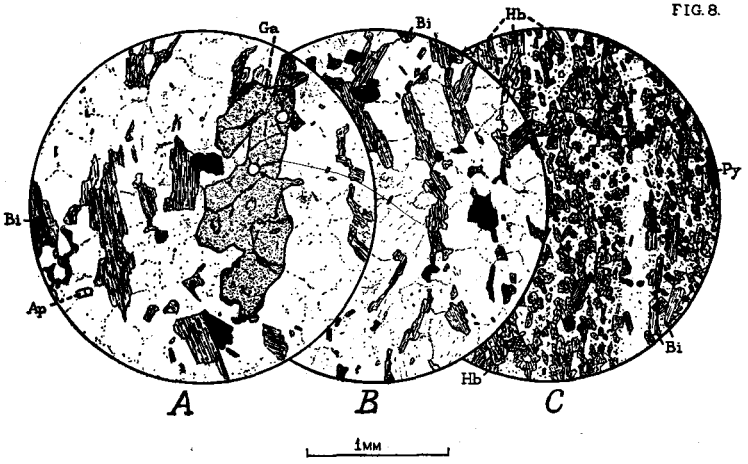


Figure 8.

A. (2/2669)—Garnetiferous quartz-biotite gneiss showing a ragged crystal of garnet (Ga) with flakes of brown biotite in a granoblastic gneissic matrix of quartz and oligoclase andesine (clear). Apatite (Ap) is a rare accessory.

B. (2/2667)—Typical sandy biotite granulite-gneiss consisting of brown biotite (Bi), oligoclase and some quartz, in a distinctly gneissic granulitic structure.

C. (2/2672A)—Hornblende-biotite granulite-gneiss showing fine granular green hornblende (Hb), brown biotite (Bi) and albite (clear) with a little quartz, in well oriented granulitic structure. Magnetite occurs in small rounded black opaque grains and the field includes one or two crystals of pyrite (Py).

The hornblende-bearing sandy biotite-gneisses or schists contain green hornblende usually associated with flakes of biotite and a little epidote in felspathic mosaic groundmass containing limited amounts of quartz. Typical specimens are [2/2666] from the dump of the old South Cornwall main shaft and [13109] also from the South Cornwall Mine, described by Farquharson (*op. cit.* pp. 173-4) and [2/2672A], bore core whose precise locality is unknown (fig. 8C). These sandy hornblende bearing gneisses differ from the biotite amphibolite schists described above principally in the almost total absence of iron ores (magnetite), the more acid nature of the felspar, the more markedly granulose mosaic texture of their constituent minerals, and in general their more distinctly banded and laminated character.

Acid country rocks.

Injection gneiss. Included amongst the specimens examined were a group of gneissic rocks which have the appearance of being composite in origin. The rude banding is produced by irregular layers of alternating composition—fine granular bands characterised by abundance of biotite flakes, interspersed with light coloured, medium to medium-coarse granular granitic material—quartz, felspar and a few flakes of biotite, with occasional larger porphyroblasts (?) of felspar (microcline). Specimens [7668] from Dumpling Gully, [2/2670] from near the north-east corner of C 788, and [7665] from the Mill Brook, represent a series from a basic type [7668] to an acid granitic type [7665]. In the former biotite is abundant in green yellow flakes distributed in roughly oriented layers and occasionally segregated into clusters. The biotite flakes are moulded upon crystals of felspar in places, and are set in a granular interlocking matrix of quartz, poorly twinned oligoclase and possibly a little orthoclase. Interstitial irregular clear layers consist of larger anhedral crystals of albite or oligoclase and quartz. Associated with the darker portions of the rocks are numerous tiny crystals of sphene and occasional larger broken needles of apatite and some fragments of epidote. It was noticed that microcline was a rare constituent of this rock.

In specimen [2/2670] the biotitic portions of the rock appear to be drawn out into irregularly clustered streaks whilst the quartz-felspar groundmass is finely granulated. Accessory epidote and sphene occur associated with the biotite whilst occasional aggregates of magnetite are also to be seen. The interstitial felspathic portions of the rock are more abundant than in the previous specimen and it contains veinlets of quartz and felspar and scattered larger crystals of quartz, oligoclase and rare microcline in a finely granulated groundmass.

Specimen [7665] consists principally of medium-coarse granitic material—intergrowths of quartz, microcline, and albite-oligoclase with widely separated thin streaks of finely laminated biotite flakes. Occasional segregations of magnetite occur within the acid bands. A thin section through one of these shows that it represents a remnant of a basic band, the magnetite being set in a narrow zone of altered granulated felspar and quartz, and surrounded by clusters of sphene crystals and flakes of green biotite. It is noticeable that microcline is an abundant constituent of this rock. Apatite is a rare accessory mineral. No myrmekite was noticed.

Basic intrusives.

Dolerites and epidiorites.—Quite a number of examples of this type were amongst the specimens examined. They include [5198] from Bunbury Gully, [7000] from the south side of loc. 991, [12775] from railway cutting near Quarry Reserve, line to Bridgetown, [12777] from well near C. 670, Floyd's Gully, [13622] from dump of shaft east of Bridgetown Road and north of Reserve 8098, [2/2660] and [2/2662] from near S. E. corner of loc. 9815 and [2/2661 from] vicinity of N. E. corner of M.C. 32. No specimens of dolerite or epidiorite were seen amongst the core of bores 1 to 8. Two of the above listed specimens viz. [5198], [13622], were described by Farquharson (*op. cit.* pp. 169 to 172) and he pointed out that one of these [5198] was not a "bronzite diabase" as it had been previously described by Woodward in 1908, (pp. 27, 74), but an ophitic hornblende dolerite closely related to [13622].

These rocks range from coarse, or medium-coarse normal augite dolerites and hornblende and hornblende-augite dolerites [7000], [1277], [2/2661]—consisting essentially of purplish augite and often clouded andesine-labradorite (optically + ve, maximum extinction angles in the symmetrical zone 26°-28° hence Ab_{45}-Ab_{50}) laths intergrown in typical ophitic texture, together with ilmenite, an occasional crystal of primary green-brown hornblende and accessory quartz, rare brown biotite and apatite ([7000] also contains a little hypersthene)—through uralitised dolerites in which the augite is partly altered to uralitic amphibole, [12775], [2/2660] (see fig. 6B), to epidiorites, in which, while the general texture of the rock largely remains unaltered, the original augite of the dolerite has been almost completely replaced by pale green fibrous uralite [5198], [12776], [13662], [2/2662]. These rocks are petrographically identical with the uralitised dolerites and quartz dolerites found as dykes intruding older (Pre-Cambrian) metamorphics, granite and younger sediments (Cardup Series), in various portions of the Darling Range, and described in detail from many areas east of Perth, ranging from the Chittering Valley and Toodyay, down to Armadale and Cardup.

RELATIONSHIPS AND ORIGIN OF ROCK TYPES.

The oldest rocks exposed in the Greenbushes district appear to be the basic country rocks—which form the host rocks for the tin bearing lodes. Of these it is probable that the amphibolites and amphibolite schists, etc., represent metamorphosed basic igneous rocks—probably basalitic lava flows with perhaps some doleritic sills—whilst the sandy hornblende biotite and garnetiferous granulite-gneisses probably represent original interbedded pelitic sediments. This sequence of rock

types is very closely similar to that found in many of the Eastern Goldfields greenstone belts. Indeed the writer has seen rock types petrographically indentical with the amphibolites and granulite-gneisses of Greenbushes amongst the rather highly metamorphosed rocks of the Yilgarn Greenstone Series.

Farquharson (*op. cit.*) makes no comment on the origin of the amphibolites and hornblende schists described by him but Feldtmann in a contemporary report (*op. cit.* p. 158), has followed the opinions of Woodward that the hornblende schists "represent sheared and somewhat metamorphosed portions of the dolerite." This theory is not in accord with the recognisable petrographical evidence, viz. that for the most part the amphibolites etc. have been completely recrystallised under fairly high grade regional metamorphic conditions. It is inconceivable that shearing or dynamic metamorphism could have been both so localised and so intense as to produce rocks similar to the amphibolites and amphibolite schists, and at the same time leave relict bands of the original doleritic rock showing almost no signs of alteration, either structural or mineralogical. Furthermore this theory takes no account of the granulite-gneisses—which have hitherto not been recognised as distinct from the amphibolites but which, whilst showing metamorphic characters and degrees of recrystallisation equivalent to those seen in the amphibolites have in many cases e.g. the garnetiferous sandy biotite gneisses, a mineralogical (and presumably chemical) composition very different from that of the dolerites.

Larcombe (*op. cit.* p. 87) stated that the amphibolites were "products of extreme dynamic metamorphism and recrystallisation from basic rocks of the dolerite-gabbro type." Although it is possible that some of the amphibolites examined by the writer may have been derived by recrystallisation of a dolerite-gabbro type of original basic igneous rock, the evidence of original structures noted in several specimens and the general fine grained character of the bulk of the specimens suggests that at least in part the amphibolites were derived from original fine grained basic (basaltic or andesitic) lavas, i.e. extrusive rather than intrusive rocks. The writer is strengthened in this opinion by his observation of the close similarity of some of these Greenbushes amphibolites to undoubted metamorphosed basic lavas (some of which show pillow structures in the field) in the Yilgarn, Coolgardie, Mt. Margaret and other goldfields[6].

[6]Pillow lava can be seen in outcrops of fine grained amphibolite near the Old Reservoir 8.5 chains W. of post M.C. 5, the source of specimen 2/2663 described above. Refer p. 53.

The presence of a little glaucophane in a number of the amphibolites and amphibolite schists is possibly an indicator of more than the normal proportions of soda in the original basic magma (the presence of albite instead of the more calcic plagioclase felspars supports this indication) such as is found in the spilitic type of basic lavas and intrusives. If such is the case then these rocks may be comparable with the Older Greenstone lavas (including pillow lavas), calc schists and porphyrites of Kalgoorlie which are often characterised by high soda contents. Another explanation of the presence of glaucophane is that it has formed as a result of metasomatic alterations involving appreciable soda addition, accompanying the emplacement of the undoubtedly sodic (i.e., albite rich) stanniferous pegmatites.

A third possibility is that glaucophane has been formed as a result of a metasomatic alteration and redistribution of the soda content of the plagioclase in the original rock prior to its metamorphism and recrystallisation to amphibolite. By such an alteration the plagioclase may have been changed to saussurite, epidote and/or zoisite, and possibly a little albite, some of the soda being set free to combine with original pyroxene in the rock to form a soda amphibole. On later recrystallisation of the whole rock to produce the existing amphibolites and amphibolite schists, the pyroxene which had already been attacked by the soda would tend to recrystallise out as glaucophane, the residual pyroxene and other ferromagnesian minerals as green hornblende, and the remaining saussuritised plagioclase and epidote, etc., would probably combine to form a more calcic plagioclase. This would explain the presence of glaucophane in a recrystallised rock containing the very basic felspar—anorthite. In the case of the glaucophane-bearing chlorite-mica schists described above, the trend of recrystallisation may have been towards the formation of, not hornblende and anorthite, but chlorite and biotite.

It is interesting to note, in this connection, that A. B. Edwards (1941, pp. 79-93) recently described the occurrence of a soda-amphibole, presumably iron-rich glaucophane, in a specimen of altered two-pyroxene dolerite from the North Kimberley. The original labradorite in this rock had been largely converted to epidote, and much of the soda set free during this alteration had attacked adjacent pyroxene to form the glaucophane. The presence of pyrite and carbonates in the rock suggested to Edwards that it "had undergone local metasomatism or possibly autopneumatolysis."

Without chemical analyses further speculation on the origin of the glaucophane and of the amphibolites and schists in which it has been found at Greenbushes is not warranted. When sufficient chemical analyses of these rocks have been prepared it should be possible to come to some definite conclusions and to enter into a more detailed discussion of the petrogenesis of these rocks

Replacement of hornblende by biotite in the biotitic amphibolites and the glaucophane-bearing amphibolites and amphibolite schists may be largely a localised contact (mainly thermal) metamorphic effect produced as a result of injection of the country rock by heated quartz and pegmatite solutions as was found in the wall rock of the Corinthian ore body (Miles, 1942). The addition of tourmaline to form the tourmaline-biotite-chlorite schists was probably a result of hydrothermal or pneumatolytic alteration of the original schists by boric emanations concomitant with the introduction of the stanniferous tourmaline-bearing pegmatites and with the formation of the stanniferous greisens.

The sandy biotite and hornblende granulite gneisses were probably originally beds of sandy clay. Their presence in several bore cores suggests a fairly close field association with the amphibolites —probably original sediments interbedded with lavas (some of which were probably submarine). The garnetiferous phases of the biotite gneisses may represent either more aluminous (clayey) bands in the original sediments or localised zones of higher thermal (contact) metamorphism.

The acid country rocks or injection gneisses have probably been formed by intimate injection of granitic magma along planes of parting into the amphibolite schists, and associated granulite-gneisses etc. There is little indication, from the few specimens available for examination whether the granite magma producing these hybridised gneisses was the same as that whose emanations were responsible for the emplacement of the stanniferous lodes, pegmatites and aplites, and for the accompanying tourmalinisation of the biotite schists described above, or whether it represents an earlier period of granitic intrusion, or "granitisation."

It is interesting to note here that evidence for at least two distinct periods of granite intrusion in the Pre-Cambrian history of Western Australia has been gradually accumulating during the last few years (Prider, 1941—includes other references on p. 29, 1944), and to the writer's mind there seems every possibility that the tin-bearing pegmatites and greisens, undoubtedly introduced at a late period of granitic magma activity, will prove to be the end products of a younger granite magma not otherwise represented (except perhaps for the aplitic granite specimens described above) or not yet recognised in the Greenbushes district.

As has already been mentioned the Greenbushes dolerites and epidiorites are identical in all essential petrographical character with the dolerites, quartz dolerites and uralitised dolerites etc., already described from many other parts of the Darling Range, particularly in the vicinity of Perth. These rocks at Greenbushes show

the lowest grade of metamorphism of all the basement rocks so far examined—the only alteration, i.e., uralisation of the pyroxene, is clearly a deuteric process carried out prior to final consolidation of the magma—while lack of any sign of strain in the felspars and rare interstitial quartz suggests that these dolerites have not taken part in any tectonic movements nor been subjected to any considerable stress. On the other hand, as has been pointed out above, the amphibolites and other recrystallised basic country rocks forming the hosts for the tin-bearing lodes have obviously undergone intense regional metamorphism (probably accompanying considerable orogenic movements) involving complete breaking down of original structures and thorough recrystallisation under fairly high temperature and pressure conditions, which indicates that they must be considerably older and quite unrelated to the unaltered dolerites.

Even the tin-bearing pegmatites, quartz lodes and greisens show notable signs of granulation, cataclasis and strain probably resulting from stress associated with earth movements. The writer is convinced that the dolerites are the youngest of the basement rocks at Greenbushes, and represent post-tin intrusives in all probability comagmatic with the doleritic dyke rocks of the Darling Range near Perth and Toodyay, which are considered to be late Pre-Cambrian (Nullagine—Prider, 1944, p. 13, or post Nullagine—Forman, 1937) in age.

GEOLOGICAL AND PHYSIOGRAPHICAL HISTORY.

Before commencing to outline the geological history of the Field, the writer (R. A. H.) would like to remind readers that its area is only 40 square miles and that the deductions made in the following paragraphs are based on observations made entirely in the Field. The Field is but a small portion of south western Western Australia, and, no doubt, when an examination of a more extensive area is made, the history of the Field as outlined below, will require modification.

A brief geological history of the Field is given in the following paragraphs.

(1) The history of the Field commences in Pre-Cambrian times with the formation of a series of basic lavas and associated sediments. No estimate can be given of the thickness of this series, but is probably very appreciable.

(2) During a subsequent orogenic period this series was folded and intruded by a granitic magma. The granitic dykes, the replacement and/or injection gneiss, formed at this time, and the tin and tantalite were introduced.

Subsequently, probably at the end of the period of folding and after the granite had solidified, the basic dykes were injected.

(3) The period of orogeny must have been followed by one of erosion, during which the mountains were slowly eroded away. The land surface, which was ultimately produced, was similar to the present land surface away from the V-shaped valleys i.e. above the 800 feet contour.

(4) The next event, of which there is any record, is the deposition of the Old Alluvium, probably in middle or late Tertiary times. It is evident that between the end of the period of orogeny and the deposition of the Old Alluvium a very long period of time elapsed.

The Old Alluvium is believed to have been deposited in a shallow sea or lake. It is known to occur at a number of places beyond the boundary of the Field, but its broad distribution is not known. It is likely, however, that it extends over a large area of country.

The high country in the central portion of the Field is considered to have been an island at the commencement of the deposition of the Old Alluvium. Submergence continued slowly and the island gradually decreased in size until, finally, it was probably completely submerged. Submergence was halted from time to time and there were also minor uplifts. The alluvial tin deposits are believed to be shallow water deposits, formed close to the shore line. This would explain the distribution of the alluvial deposits around the central high country, and also the rounding of the quartz grains so close to their point of origin.

It would also seem probable, that there were in addition a number of small islands, from which the tin, at the Mt. Jones workings, at the Boronia Gully workings, and at those workings in the vicinity of M.L. 434 (just south of Spring Gully), was derived.

(5) Uplift of the area now occurred and it became a land surface again. Erosion of the Old Alluvium commenced. Subsequently conditions became favourable for the formation of laterite, which was formed over the whole of the Field.

(6) Further uplift occurred, the streams became rejuvenated and the V-shaped valleys were formed.

(7) There was a deposition of alluvium in the creeks. This is the Recent Alluvium shown on plate I.

(8) There was another small uplift and the streams were again rejuvenated. In this way the absence of Recent Alluvium below certain points in the creeks is accounted for.

SCHEME FOR PROSPECTING BEYOND THE BOUNDARY OF THE GREENBUSHES MINERAL FIELD.

Cassiterite has been found at various localities approximately 10 to 12 miles south-west of Bridgetown (Talbot, 1907: Wilson, 1917: Crabb, 1921: Blatchford, 1932). At all these places a small amount of prospecting has been done, but no development has resulted. It can be assumed, therefore, that the results were disappointing to the prospectors. No examination of these localities was made during 1942 and 1943. A small quantity of cassiterite is recorded from near Nannup (Hardman, 1884), but samples collected later from the same locality (Saint-Smith, 1912) did not contain any cassiterite. While these occurrences are, apparently, of little economic importance they are of interest as showing that cassiterite does occur outside the Greenbushes Mineral Field.

It has also been shown that the Old Alluvium is not a local feature of the Field, and that it is not improbable that it has quite a wide distribution.

While various reconnaissance geological surveys have been made of the south-west of Western Australia (e.g. Saint-Smith, 1912; Woodward, 1915, 1917) no survey has been undertaken having the search for new tin deposits as its principal object. Although this bulletin is intended to deal with the Greenbushes Mineral Field, nevertheless, a brief discussion on such a survey does not seem out of place to the writer. It is not intended to do more than merely outline the scheme, leaving details to be filled in at a later date. Provision would have to be made for the sampling of any localities considered favourable as a result of geological work. This should not be left until the conclusion of the geological mapping, but should be going on all the time.

Because of the wide distribution of the laterite the underlying rocks will be obscured over extensive areas. Nevertheless examination of road cuttings, railway cuttings and creeks, and mapping of the outcrops should give some idea of the distribution of the various rocks.

During the course of the geological mapping particular attention should be given to the following points:—

1. The delineation of the greenstone belts. Owing to the fact that outcrops are very poor this is likely to be a very difficult job, and it is improbable that it will be possible to do more than indicate their general distribution. This will, however, be sufficient. The term greenstone is used here in the same sense as on page 52, and care should be taken to avoid confusion of these rocks with the basic dykes. Within the Field the basic dykes outcrop in a number of places, while the greenstones do not outcrop at all. Dumps of any shafts or wells should be examined.

2. Mapping of any areas of granite. Although there is plenty of evidence within the Field of the existence of a period of granitic intrusion, there are no outcrops of granite nor is there any evidence of the existence of any areas of granite. A search should be made outside the Field for granite outcrops, and if any are found the boundary of granite should be mapped as carefully as outcrops will permit.

3. Areas of laterite overlying the greenstone belts should be carefully examined for tourmaline. The areas to be examined may be further restricted when the distribution of the granite is known. If the distribution of the tourmaline is sufficiently extensive it should be mapped, and the area tested by shallow shafts. Any alluvium in the vicinity should also be tested.

During the examination of the areas of laterite, fragments of angular quartz or mica should be carefully watched for as these indicate the presence of granitic rocks. Any area of granitic rocks so indicated should be carefully examined for tourmaline bearing laterite.

Even if the results obtained by sinking shafts indicate only small or low grade ore bodies the area should not be immediately abandoned. If the ore bodies are sufficiently numerous good alluvial deposits may have formed.

(4) The distribution of the Old Alluvium should be mapped. While it is likely that there are extensive areas of Old Alluvium not containing any tin, it is also likely that the most valuable deposits will be alluvial deposits in the Old Alluvium, rather than lode deposits in the greenstones. Hence, in any area where both laterite and Old Alluvium are known to occur particular attention should be given to any laterite above the level of the Old Alluvium.

Chapter III.

ORE DEPOSITS—GENERAL INFORMATION.

DESCRIPTION AND DISTRIBUTION.

Tin and tantalum concentrates and ironstone are the only mineral products of economic value from the Field. Of these three, tin concentrates are the most important and have been produced from various localities extending over an area of approximately 15 square miles. To the end of 1943 the total production was 11,322 tons valued at £A995,355. Tantalum concentrates have been produced mainly from the vicinity of the head of Bunbury Gully. Lately, there has been some production from the "Vulcan" workings on M.C. 4, and tantalite has been recorded from the vicinity of M.C. 48 (p. 119). The total reported production to the end of 1943 is 9.55 tons valued at £A7,724. Between 1899 and 1904 ironstone was produced, for use as a flux, from quarries located approximately 30 chains north-east of the railway station. The total quantity obtained was 7,481 tons valued at £A4,629.

TIN.

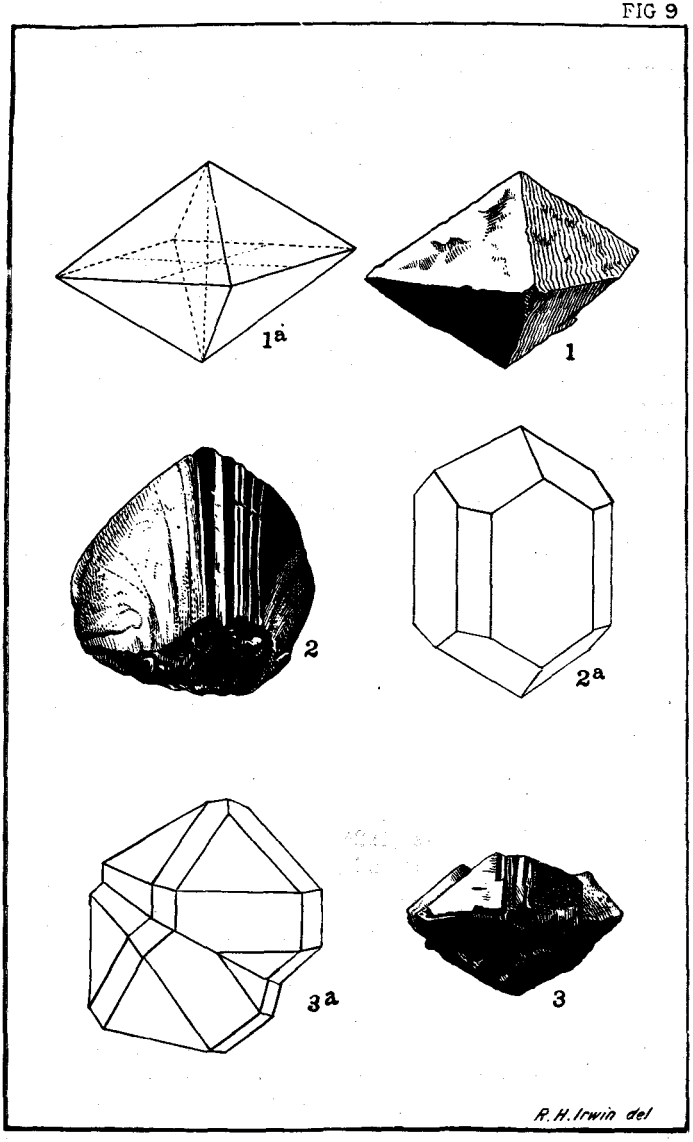
Of a total recorded production of 11,322 tons of tin concentrates 10,738 tons are from alluvial ground, while 584 tons are from lodes, occurring mainly in the central and southern portions of the Field.

Minerals.

The only tin mineral found at Greenbushes is cassiterite (SnO_2). It occurrs either as crystalline, massive or rolled grains, and varies in colour from black to brown. Cassiterite can be recognised by its weight (specific gravity 6.8 to 7.1), by its resinous appearance on a fractured surface, by its crystalline form (see fig. 9), by its appearance under water (this is particularly useful for distinguishing cassiterite from tourmaline. The tourmaline appears quite black in colour, while the cassiterite is grey), by its powder or streak, which is grey or brownish grey in colour. When fused with sodium carbonate or potassium cyanide on charcoal it yields a bead of metallic tin. The most convenient and reliable test for cassiterite is made by using a zinc dish and dilute hydrochloric acid (spirits of salts). A convenient dish can be made from a piece of sheet zinc about six inches square, by bending up the sides. However, any piece of zinc will do, provided it can be slightly hollowed. A piece of galvanised iron can be used if nothing else is available. A suitable dilute acid can be prepared by adding one part of acid to two parts of water. The mineral or concentrate to be tested is placed in the zinc dish *in contact with zinc*, and the dilute acid poured over it. After a short time any cassiterite present will appear silver white in colour, due to the formation of a thin coating of metallic tin. The test is quite characteristic and very simply done.

According to W. R. Jones (1925) cassiterite can be confused with the following minerals:—zincblende, ilmenite, wolframite, hematite, rutile, zircon, tourmaline, garnet, axinite, tantalite. To this list, magnetite can be added. Of these minerals, only ilmenite, rutile, zircon, tourmaline, garnet, tantalite and magnetite have been recognised at Greenbushes. Tantalite is the only one of these minerals, whose specific gravity is equal to that of cassiterite, and experienced miners will readily note that the remaining minerals do not "hang back" in the panning dish as do cassiterite and tantalite. Ilmenite (titanic iron ore) is frequently abundant at Greenbushes. It is usually in smaller grains than the cassiterite, and because of its lower specific gravity tends to wash out of the dish during panning. Tourmaline is also abundant, but is quite readily distinguished from cassiterite by its appearance under water. Magnetite is not abundant and can be separated from other minerals by a horseshoe or bar magnet. The remaining minerals —rutile, zircon, and garnet—all have a lower specific gravity than

FIG 9



CASSITERITE CRYSTALS

(After H.P. Woodward, G.S.W.A. Bulletin N°32)

cassiterite and can be generally distinguished from it by their appearance. The mineral most likely to be confused with cassiterite at Greenbushes is tantalite especially in fine grained concentrates. The purity of tin concentrates can be checked by using the zinc dish test described above, and in all cases where it is doubtful if a mineral is cassiterite this test should be used.

Lode deposits.

During 1942-43 the only work in progress on any of the lodes was at the "Vulcan" workings on M.C. 4 The remainder of the lode workings were inaccessible—most of the shafts having fallen in or filled with water. There are no complete plans of any of the workings, and the descriptions available generally refer only to small portions of the workings on any lease. It is frequently impossible to decide the positions of the shafts or workings, which are being described. Information regarding the lodes is therefore very incomplete.

Of a total production of 11,322 tons of tin concentrates 584 tons (approximately 5 per cent.) are recorded as coming from lodes. The greatest individual production is from the "Vulcan" workings, which, between 1937 and 1943, produced 132.49 tons of concentrates from lode material. At various times between 1899 and 1937, the same ground produced 38.38 tons, making a total production of 170.87 tons. Other lode workings which have produced appreciable quantities of concentrates are as follows:—The Cornwall (95.26 tons), the South Cornwall (82.35 tons), the Lost and Found (46.48 tons), the Kapanga (42.78 tons) and the Dixie (22.34 tons). The figures in brackets are the productions, in tons, of tin concentrates. These five, together with the "Vulcan" workings have produced a total 460.08 tons of concentrates, which is approximately 79 per cent. of the total production from lodes. Available information regarding these workings is summarised in Chapter V.

The deepest shaft anywhere in the Field is one at the South Cornwall workings, which was sunk in 1907 to a depth of 205 feet. At 190 feet a crosscut was put out in an easterly direction for 52 feet, with the object of intersecting an ore body worked at shallow depths off other shafts. No ore body was intersected and the shaft was abandoned. The deepest level, from which ore has been obtained, is the 130 ft. level at the South Cornwall workings (see p. 204).

Most of the ore bodies have not been stoped right to the surface, and consequently very little information regarding the extent of the workings can be obtained by surface inspection. The "Vulcan" open cut on M.C. 4 has a length of 880 feet, a width or from 100 to 200 feet and a maximum depth of 40 feet. The whole of the material from this cut has been sluiced. It is reported that the lode

formation as a whole contained some cassiterite, but that its successful exploitation, was due to the presence of rich shoots. At the late Cornwall workings, there are a series of open cuts extending over a length of 700 feet and having a width of from 20 to 30 feet. These two workings are, however, exceptional and it is probable that most of the ore bodies which have been worked are small rich shoots in granitic rocks. Referring to the lode at the "Vulcan" workings Ellis (1939, p. 11) says:—

> The sides of the cut[1] show a thickness of from two to four feet of ferruginous laterite capping a weathered kaolinitic formation, which shows both a massive and schistose structure in various parts. The general strike of the schistosity is N. 30° W. and the average dip 35° W. 30° S., with a tendency for the dip to steepen as the western side of the cut is approached. The weathered schistose exposures consist essentially of kaolin, quartz and muscovite mica, with a liberal impregnation of tourmaline frequently arranged parallel to the schistosity. They also carry black tin-oxide scattered through them in a very fine state of division. In all probability this weathered schistose material represents a replacement schist formed by a process of granitisation of a pre-existing rock type whose original nature cannot be determined. Grading almost imperceptibly into the schistose material are masses of almost pure kaolin carrying more or less tin-oxide and tourmaline, either with or without small lenses or irregular patches of massive, jointed quartz or granular quartz. Muscovite mica in plates up to 2 inches square occurs unevenly through the whole formation, while occasional crystals of beryl, about 1 inch across were seen . . . .
>
> The eastern wall of the formation is met in a tunnel driven N.E. from the bottom of the open-cut, and consists of an iron-oxide stained clay without noticeable quartz, mica, tourmaline or tin-oxide. The other limits of the formation are not known, although definite evidence is available that it extends for at least 100 feet north, 160 feet west and 500 feet south of the present north, west and south limits of the open cut, and that it is tin-bearing in these localities.
>
> Dish samples taken and washed by the writer from a number of points in the walls and floor of the open cut all showed traces of tin-oxide, together with ilmenite. The tin-oxide appears to be disseminated throughout the entire kaolinised formation in a fairly fine state of division, pieces as big as a wheat grain being occasionally seen. Much of the first grade concentrate consists of pieces of tin-oxide of smaller dimensions than this, while the second grade has some very fine tin-oxide, almost a powder in it.
>
> Crystals of cassiterite up to three-quarters of an inch across are reported as having been found in the workings, recognisable crystals are rare in the heavily tourmalinised kaolinitic formation which constitutes the lode.
>
> Irregular masses of black tourmaline and some partially formed crystals of the same mineral up to six inches across occur, and the formation is liberally impregnated with irregularly shaped masses of tourmaline of smaller dimensions, the finest of which are in the nature of a fine powder.

[1]The cut has been much extended in size since it was examined by Ellis.

Local concentrations of tin-oxide in the form of irregularly shaped shoots of comparatively small dimensions are reported to have been worked in the area now occupied by the open-cut by previous leaseholders. No doubt similar rich shoots have been encountered in the course of hydraulic sluicing operations by the present owners, and other shoots can be reasonably presumed to exist in the formation under the floor and behind the walls of the present workings.

Somewhat similar conditions may exist at the South Cornwall where there is an open cut, approximately 200 feet long, 100 feet in width, and 20-30 feet in depth. Underground, comparatively small rich shoots appear to have been worked, but it is reported (p. 204) that in one crosscut values extended over 78 feet.

Referring to the Cornwall and South Cornwall ore bodies Simpson says (Woodward 1908, pp. 18-19):—

Above the water level these veins are often highly micaceous and foliated to a considerable extent. At the South Cornwall mine a very micaceous and foliated lode composed of pale green muscovite, quartz, topaz and coarse cassiterite yielded from near the surface what was probably the richest lodestuff yet raised on the field; see specimen (4600) in the Geological Museum. A large specimen (7198) from a depth of 130 feet recently received from this mine is a compact banded lode composed mainly of albite with quartz, tourmaline, topaz and cassiterite. A still more recent sample from a depth of 150 feet contained 1.09 per cent. of tin, together with a little arsenical pyrites. The average yield of ore from this lode has been 0.55 per cent. of metallic tin. A crystal of clean cassiterite from this lode was found to contain 76.9 per cent. of metallic tin, and to have a specific gravity of 7.15.

Bulk samples from the Cornwall mine of a foliated ore composed of albite, tourmaline, muscovite and quartz gave assays of 1.79, 0.55, 3.46 and 1.09 per cent.; these samples were obtained from above the 150 feet level.

Simpson also (Woodward, 1908, p. 18) makes the following remarks regarding the pegmatites:—

They are probably not dykes in the sense of being fissures filled by sheets of originally molten rock, but are more probably closely related to ordinary "lodes," being the result of hydrothermal action. The tin may have been introduced into them in vapour or solution of tin fluoride, which has been acted upon in the fissures by carbonate of lime, or even felspar, with the production of tin oxide and such minerals as topaz and tourmaline.

Rocks similar to those occurring at the Vulcan cut also occur at the old Fremantle cut (p. 44), and preparations are now being made to commence sluicing from there. Similar rocks are also reported to have been exposed in recent prospecting workings for tantalite in Bunbury Gully.

Earlier writers (e.g., Woodward, 1908, p. 29) make reference to foliated granites, containing small amounts of cassiterite, but little information is given regarding the distribution of these. Woodward (1908, p. 29) records that a foliated granite containing a network of small pegmatite dykes was worked near North Greenbushes.

It would seem likely that the foliated granites of earlier writers, Ellis' replacement gneiss and Miles' injection gneiss are all related.

At the Kapanga workings the ore body consisted (see p. 162) mainly of kaolin, quartz, tourmaline and cassiterite—no mica being noted.

Tourmaline is abundant in all ore bodies, and, as it persists in the laterite, it has been used during prospecting. It has been found that the distribution of tourmaline indicates the extent of the ore body existing below the laterite (p. 46).

The strikes of the ore bodies, where these can be observed, vary considerably from almost north-south to almost east-west. The dip is generally westward or southward, but may be vertical and is occasionally eastward (e.g., at the Kapanga workings). Even the strikes and dips of the principal ore bodies show some variations—Vulcan, strike N 30° W, dip 70° W; Cornwall, strike N 17° W, dip steep west; South Cornwall, probably similar to Cornwall; Kapanga, strike N 5° E, dip 70°-80° E; Dixie, strike N 65° W, dip 80° S. Generally the strikes of the smaller ore bodies cannot be observed from the surface, because they have not been stoped through the laterite. The shafts are very close together and their arrangement gives no indication of the strikes of the ore bodies. In the vicinity of the Cornwall workings and immediately east of there a number of small ore bodies have been stoped to the surface. Their strikes and dips are indicated on plate II.

Some information regarding the grade of the concentrates obtained from the various lodes was given to the writer by the late Mr. H. Barrymore. The information was taken from old assay records, compiled while Mr. Barrymore was buying tin concentrates at Greenbushes. It has reference to a period after 1912, and is given below.

Workings.	Tin, per cent.	Notes.
White lode	70	Occasionally lower, because of tantalites.
Dixie	70	...
Cornwall	68	...
South Cornwall	68	...
Fremantle Cut	60	Some tantalite.
Kapanga	70	...
Lost and Found ...	70	...
Caledonian, N. end ...	55–58	Parcels of tin concentrates from the Vulcan workings sold during 1942–43, assayed from 44·3 to 67·2 per cent. Sn—the majority of the parcels being 60 per cent. Sn or better. Many of the parcels contained a small per cent. Sb (usually sufficient for a small penalty charge) and also a small per cent. S.
S. end ...	68	

Alluvial deposits.

During 1942 and 1943, no work was in progress on any alluvial ground. A small proportion of this may be eluvial (e.g., see p. 78). It has been pointed out in a previous section of this report the principal production of alluvial tin has been from the Old Alluvium, which has been fully described (pp. 39-42). There has been a smaller production from Recent Alluvium.

Some information regarding the grade of the concentrates obtained from various workings has been given to the writer by the late Mr. H. Barrymore (see p. 26). It is taken from old assay results, and has reference to a period after 1912. The information is set out below:—

Area number (See fig. 12.)	Workings or locality.	Tin %
1	New Zealand Gully	70
2	Locations 289, 290	70
3	Spring Gully	70
	Paperbark Swamp	64
4	Three C's	64
	Battler's Gully	60
5	Bunbury Gully—top end	62
	—lower end	66
	Angus' Cut	55–99
	Cole's Cut	63
	Bunbury Cut	66
	Westralian Gully—top end	62
	—lower end	64–65
6	Scandinavian Gully	68
	Salt Water Gully	62
	Kelly's Flat	70
7	Floyd's Gully	66–68
11	Boronia Gully	66
12	Mt. Jones	65

Recent Alluvium.—The principal workings in Recent Alluvium are in Salt Water Gully at its junction with Scandinavian Gully, in Floyd's Gully and in Spring Gully. In all these places the alluvium has been sluiced. Elsewhere the workings in Recent Alluvium are small. It is not possible to give any figures for the production from Recent Alluvium since the amounts have either been lost in "Sundry Claims," or else grouped with the production from areas of Old Alluvium. Although there is quite an extent of Recent Alluvium

shown in Bunbury Gully at its junction with Elliot's Gully it is only quite thin, and production has been almost entirely from Old Alluvium under the laterite.

The greatest production is from Spring Gully, which has been continuously worked over a length of 60 chains, a width of from two to three chains and a depth of from 10 to 12 feet. This ground was worked in the very early days of the Field as Claim 318, later as part of Stanhope United leases, and still later as part of D.C. 56.

Old Alluvium.—As is to be expected workings in the Old Alluvium are not confined to present valleys, but also occur on the higher ground away from the valleys e.g., the Mount Jones workings are on a flat topped hill on the west side of Norlup Brook. The Old Alluvium has a maximum thickness of approximately 100 feet in the vicinity of the Three C's workings, but has not been worked below 50 feet. That depth was reached in shafts on Elliot's old Claim, 219A., now portion of D.C. 90.

In the early days of the Field the alluvial ground was worked by means of shafts—the pay dirt being hauled to the surface during the summer, and puddled during the winter. Much of the ground worked in this way was later worked again by hydraulic sluicing methods, and in the open cuts the remains of old timbers can often be seen e.g., in Cole's Cut on D.C. 90. In many places, numerous closely spaced old shafts can still be seen, e.g., in the vicinity of D.C. 95 and M.C. 48, on D.C. 90, and immediately east of the east boundary of M.C. 34. The alluvial ground at these last localities was generally from 20 to 30 feet in depth, although, as pointed out above, a maximum depth of 50 feet was reached. More will be said regarding these areas in a later section of this bulletin (Chapter IV). Precise information regarding the thickness of the wash and the values has not been recorded.

Between Spring Gully and Westralian Gully, there are extensive areas of white sand underlain at shallow depths by laterite, and at greater depths by sands, clays, pebbles and boulder beds, all being part of the Old Alluvium. In this area, in addition to the more extensive workings such as those in the vicinity of the Three C's area, there are numerous shallow workings in the surface sand or sometimes in the laterite. The sand has frequently been worked down to the laterite. Workings of this type can be seen extending from D.C. 94, through E.A.C. 961 to C. 917. In recent years (1938, 1940?), sand having a maximum thickness of five feet has been worked on E.A.C. 961. A few samples taken by the writer indicated values of about 1 lb. cubic yard, (see p. 145).

Many earlier writers have expressed the view that these areas of sand at Greenbushes have resulted from the weathering of granitic rocks (e.g. Woodward, 1908, p. 31 to 32). The idea being, apparently that the felspar and mica have been removed and that the quartz has been left behind. If the granitic rock originally contained numerous stringers and veins containing cassiterite then the cassiterite would be found in the residual sand. The writer does not agree with this view and is of the opinion that these sandy areas are portion of the Old Alluvium. The quartz grains are always well rounded.

The principal production from the Old Alluvium has been from various areas, such as New Zealand Gully, Spring Gully, Three C's Area, Bunbury Gully etc., which have been worked by hydraulic sluicing methods. Resulting from this work are a series of more or less isolated open cuts. It is reported by old residents of Greenbushes that the payable values were confined to "pools." Most of the open cuts are now full of water and the sides have frequently fallen in. Very little information is available regarding them. The average depth would be from 15 to 20 feet. The most continuous workings in the Old Alluvium are those in Spring Gully, which extend along the valley for a distance of 40 chains. Elsewhere, as can be seen from plate I there are a series of isolated open cuts. Such information, as is available regarding individual areas, is collected together in the following chapter.

The bottoms of such of the cuts as could be examined and the dumps of many of the shafts consist of a white, to yellow to grey clay. It is known that some of the workings in the vicinity of the Three C's area have bottomed on a blue-grey sedimentary clay, which has been shown by boring to have a thickness of from 20 feet to 72 feet. Elsewhere the white, to yellow to grey clay, is believed to be a very weathered greenstone (basement). Various means by which this weathered greenstone can be recognised have already been given (p. 46).

TANTALUM AND NIOBIUM

The total recorded production of tantalite from Greenbushes to the end of 1943 is 9.55 tons (table 6), of which 6.14 is from lode material and 3.41 from alluvial ground. It is probable that the actual production is higher than this, as much of the tantalite produced in the early days of the Field was not reported.

Information regarding tantalite in Western Australia has recently been summarised by K. R. Miles, H. P. Rowledge and Dorothy Carroll (1944), and a section on Greenbushes contributed by the present writer. Reference should be made to this work, for more detailed information regarding the tantalum and niobium minerals occurring at Greenbushes than is given below and also for their uses.

Minerals.

The principal tantalum mineral at Greenbushes is high grade ferrotantalite assaying up to 80% Ta_2O_5 (Simpson, 1908, p. 453). Minor quantities of stibiotantalite (Simpson, *op. cit.* p. 452) occur and more recently small quantities of ferrocolumbite. (Simpson, 1939 and Bowley, 1939), and probably tapiolite (Bowley, 1938, p. 94) have been recorded. During 1943 magnetic concentrates, from the Vulcan workings on M.C. 4, weighing 3.18 tons and containing approximately 38% Ta_2O_5 were sold. A parcel containing 5548 lbs. of magnetic concentrates from the Vulcan workings and 717 lbs. of concentrates (Ta_2O_5 = 37.9 per cent.) from elsewhere in the field gave the following assay figures:—[8]

Moisture = 0.02 per cent., Ta_2O_5 = 35.49 per cent., Cb_2O_5 = 36.49 per cent., TiO_2 = 2.24 per cent. SnO_2 = 1.16 per cent. It appears that the principal mineral present is columbite rather than tantalite. On the other hand parcels of concentrates from M.C. 1 gave assays[8] varying from 55.33 per cent. Ta_2O_5, 12.24 per cent. SnO_2) to 74.32 per cent. Ta_2O_5 (3.32 per cent. Cb_2O_5, 2.47 per cent. SnO_2).

Greenbushes tantalite generally shows no crystalline faces, but one water worn fragment did show radiated structure similar to that seen in some of the Moolyella ore (Simpson, 1910, p. 315).

Tantalum has been detected in clean cassiterite from the Field. A crystal of cassiterite from the South Cornwall Mine was found to contain 1.76 per cent. Ta_2O_5, while a pebble from North Greenbushes contained 1.15 per cent. Ta_2O_5 (Simpson, op. cit. p. 315). Later investigations have shown that while such crystals of cassiterite contain some tantalite in solid solution tantalite also occurs free (Edwards, 1940, pp. 738-741).

Although stibiotantalite is of no commercial importance as a source of tantalum it is of very great interest as it was the first tantalum mineral to be found in Western Australia. In 1893, J. J. East noted an unusual mineral containing antimony in some tin concentrates from Greenbushes (East, 1893 and 1894). It was submitted to G. A. Goyder for analysis and found to be tantalate and niobate of antimony (Goyder, 1893 and 1894). The mineral was named stibiotantalite. Subsequently the mineral and its occurrence have been described on a number of occasions (Simpson, 1899, pp. 52-54. 1902, p. 42; 1908, pp. 442, 452-455; 1936, pp. 14-16: Simpson and Gibson, 1907, pp. 67, 112-114: Miles, Rowledge and Carroll, 1944). Referring to the distribution of this mineral, Simpson (1936) says:—

[8] Analysis from liquidation statement, U.S. Commercial Company. See Geol. Survey file 42/43.

The main source of the Greenbushes mineral has been the Enterprise M.L. 369, on the saddle between Floyds and Bunbury Gullies, about a mile S.E. of the town, and the alluvium in these gullies below this lease. A little has also been found in Boronia Gully near the Boronia M.L. 361, 2 miles N.W. of the town. Some has been found with tantalite and cassiterite in the Enterprise lode, a greisenised pegmatite, but the major quantity in the tin bearing alluvium. In all probably well under one hundredweight of the mineral has been obtained, and most of it shipped away in parcels of tin ore or tantalum ore.

All the specimens obtained from the lode, and many of those from the alluvium, have been in the form of replacements of, or fissure fillings in, comparatively large pieces of the tantalite. It thus appears that the genisis of the tantalite has preceded that of the stibiotantalite, the latter being formed by interaction between antimonial solutions and pre-existing tantalite in the later stages of pegmatite history. Veinlets are rare, and consist of honey-coloured translucent mineral, usually 1 mm. or less in thickness. Replacements are quite common, and usually proceed from one side of the tantalite to an extent ranging from a thin shell only 1 mm. thick to an almost complete replacement of a mass several centimetres across. The advancing face of the antimony replacement is always uneven, and often ragged, whilst completely isolated inclusions of unaltered tantalite have frequently been observed in the stibiotantalite.

This pseudomorphous stibiotantalite is usually very finely granular, dull grey or yellow in colour, and of low translucency.

In addition to the large alluvial pebbles of intergrowths of the iron and antimony compounds, the alluvial ground carried smaller pebbles, usually not over 5mm. in diameter, of pure stibiotantalite. Many of these have the appearance of the replacing mineral just described, others are more of less translucent, and apparently consist of a single crystal individual. Owing to its comparative softness and brittleness, crystal faces are not preserved, only one crystal capable of orientation, and measurement being known. Cleavage faces are more often apparent, and occasionally two adjacent crystal faces with worn boundaries.

Much of the alluvial mineral is translucent in thickness up to 4 or 5 mm. and some of it quite transparent when 1 mm. or rarely 2 mm. thick. The colour is usually some tint of pale yellow, sulphur honey or lemon. Darker fragments grade towards cement grey on the one hand, and dark brown on the other. The mineral is anisotropic. In some pieces a distinct cleavage is to be seen, probably (001).

Stibiotantalite ranges in specific gravity from 6.41 to 7.48 (Simpson, 1936, p. 15), and therefore is not separated from cassiterite (G. 6.8-7.1) during sluicing operations. At one time it threatened to cause quite serious trouble as the antimony found its way into the smelted tin and thereby reduced its value (Simpson, 1908, p. 452). Fortunately its distribution in the alluvium is restricted to that occurring in Bunbury Gully and the upper portion of Floyd's Gully near the head of Bunbury Gully.

Lode deposits.

The main production of high grade tantalite has come from the workings on "Enterprise," late M.L. 369 (now part of M.C. 1), which is close to the Greenbushes-Bridgetown road, and approximately one mile from Greenbushes (plates I and II). Both eluvial and lode tantalite have been obtained from these workings. The principal ore body was 18 inches wide and has been described (Simpson, 1908, p. 453) as being a crushed rock (greisen) composed almost wholly of pale green mica with accessory quartz, tourmaline, cassiterite and tantalite in fragments from the size of sand up to an inch in diameter. According to descriptions given by old residents of Greenbushes, the tantalite occurred in more or less isolated patches, each containing up to 20 lbs. of tantalite. The strike of the ore body is given by Campbell (1906, p. 18) as N 37° W and its dip as 22° S.W. It is probable that the main shoot has been worked to just below water level. Eluvial tantalite was obtained from shallow workings in this same vicinity in the early days of the Field, and recently, 1942 and 1943, from shallow workings under the road, and on the east side of the road (see pp. 141-144). So far (May, 1943) 2.13 tons of high grade tantalite have been obtained from 1942-43 workings.

Campbell (1906, p. 18) records that a little tantalite has been found associated with cassiterite on two leases—"Wills," M.L. 370 and "Dill McKay," Claim 755—in the vicinity of M.L. 369. He also notes that some is reported to have occurred on "Galtemore," M.L. 379. There are two specimens of tantalite—one of lode tantalite and one of alluvial tantalite—in the Geological Survey collection, which are reported to have come from this lease. It is reported that a micaceous lode containing tantalite was found at a depth of 40 feet in a shaft. It is interesting to note that up to approximately 10 per cent. tantalite was recorded recently in some concentrates from this same vicinity.

During 1942, and 1943, the writer was shown a number of other localities from which it was reported there had been a small production or from which specimens of tantalite had been obtained. These localities are shown on figure 10. The tantalite is reported to have occurred in pegmatite.

During July, 1943, approximately 30 cubic yards of ore was broken from an ore body in shaft B (figure 14). Full details of this work are given on page 150. The concentrates obtained were reported to consist principally of cassiterite, but no assay information is available.

At Shaft C (figure 10, M.C. 5) the writer was shown a very micaceous pegmatite in some shallow workings, from which some tantalite was said to have been obtained. The concentrates from a single sample taken by the writer consisted almost entirely of cassiterite.

Another locality, marked shaft D (figure 10, M.C. 9), was inspected by H. A. Ellis (1944) late in 1943. Here a new shaft had been sunk 35 feet and small amount of driving had been done from the bottom of the shaft. There was also a second shaft being sunk 27 feet to the north-west of the above new shaft. The workings are in a schistose granitic lode formation. The material from the 35 feet shaft and drives is reported (Ellis, 1944) to have averaged approximately 1.7 lbs. of clean mixed concentrates per cubic yard. Concentrates taken from the shaft during sinking contained from 25 to 40 per cent. of columbite and from 40 to 55 per cent. of cassiterite. Specific gravity determinations indicated that the columbite contained 49 per cent. Ta_2O_5 and 34 per cent. Nb_2O_5. Later the two shafts were connected by a drive (Foxall, 1944), and the drive was continued northward for 45 feet from the most northerly shaft, from which there was also a west crosscut for 25 feet. Foxall gives the following average assay results:—

		%
Drive (total 90 feet)	SnO_2	.165
	$(TaNb)_2O_5$	.164
Crosscut (25 feet)	SnO_2	.066
	$(TaNb)_2O_5$	.026

It was reported to the writer that concentrates from the Fremantle cut (plate III) and also from portion White Lode contained some tantalite.

The writer was also told that a few specimens of tantalite had been obtained in the vicinity of the Greenbushes railway station—probably close to the north-west corner of M.C. 26—and that these had been sent to the late Dr. Simpson for examination. Subsequent prospecting by a local resident failed to reveal any further tantalite.

Lode tin concentrates from "Amanda," M.L. 56 have been found to contain a small percentage of mixed tantalum and niobium oxides (Simpson, 1908, p. 453). A magnetic product from the Vulcan workings on M.C. 4 tin concentrates has been found to contain approximately 38 per cent. Ta_2O_5. During 1943, the weight of this magnetic product sold was 3.18 tons valued at £1,385.

Tantalite has also been recorded from concentrates from workings on "Haphazard," M.L. 147 (Maitland, 1901, p. 13).

Alluvial deposits.

Alluvial tantalite was associated with the tin ore in the upper portion of Bunbury Gully and also in that portion of Floyd's Gully near the head of Bunbury Gully. It is reported to have occurred in pieces from the size of fine shot to 13 lb. in weight (Simpson and Gibson, 1907, p. 112). The writer was told that the concentrates from the sluicing cut close to the north-east corner of W.R. 289 (the last work done in Bunbury Gully) contained 15 per cent. tantalite.

Recently up to 10 per cent. tantalite has been found in concentrates from some samples from the vicinity of M.C. 48 and D.C. 95 (see pp. 119-123).

IRONSTONE.

The ironstone was produced from a series of shallow quarries situated approximately 30 chains north-east of the railway station. A brief inspection of these was made during 1942. They appeared quite similar to the ironstone quarries in the vicinity of Clackline (Hobson, 1944, p. 51). The ironstone, which was quarried, was a high grade limonite, and was merely the more ferruginous portions of the laterite.

PRODUCTION—GENERAL INFORMATION.

TIN.

It was not until 1899 that any record was kept by the Mines Department of the production of minerals other than gold. Prior to 1899 the only record of tin concentrates produced from Geenbushes is from export figures. Up to 1906 the concentrates from lode material and those from alluvial ground were not recorded separately—only the total being recorded. The values recorded are those reported by the producers.

All concentrates produced prior to 1906 have been regarded in official figures as being alluvial. During the compilation of table 8 this was found to be incorrect and the production figures for the period prior to 1906 were carefully examined. Where possible reference was made to a descripton of the workings on the lease or claim under consideration. If no description was available the situation of the lease or claim was considered. Where it was evident that lode concentrates had been recorded as alluvial, a change was made. The figures given in table 4 are therefore slightly different from those published in Mines Department Annual Reports.

In table 4 the yearly production figures for Greenbushes and for Western Australia, together with the average London price, are set out. The figures for the years prior to 1906 have been estimated from table 8. The same information is given graphically in figure 11.

From table 4 and figure 11 the following points will be readily seen:—

(i) The quantity of alluvial concentrates produced from Greenbushes has far exceeded the quantity of lode concentrates.

(ii) Except in recent years, 1937 onwards, the quantity of lode concentrates from Greenbushes has not greatly affected the total production.

(iii) After 1936, the quantity of lode concentrates produced from Greenbushes exceeded that of the alluvial concentrates.

(iv) The maximum production for Greenbushes was in 1906 and for the whole State in 1907.

(v) Immediately after 1907 there was a rapid drop in Greenbushes production. The price of tin also fell, but although the price of tin recovered and exceeded its price in 1906, yet the production continued to decline, showing that the best of the tin was worked prior to 1908.

(vi) In 1921 there was a big fall in production.

(vii) After 1921 production reached a maximum of 61.41 tons in 1926 and a minimum of zero in 1931.

(viii) The total production from Greenbushes represents 65 per cent. of the total production from the State. The Greenbushes production has exceeded the production for all other fields in the State except in the following years—1901, 1907, 1922, 1930, 1931, 1933, 1934, 1941.

(ix) The greatest production from other fields in the State was during the period 1900 to 1909, which was also the period of maximum activity at Greenbushes.

TABLE 4.

YEARLY PRODUCTION AND VALUE OF TIN CONCENTRATES FROM GREENBUSHES, FROM WESTERN AUSTRALIA AND THE AVERAGE LONDON PRICE.

Year.	Greenbushes.*				W.A.†	Average London price§ of tin (Sn) per ton (2240 lbs.) in £ Sterling.
	Lode. Tons (2240 lbs.)	Alluvial. Tons (2240 lbs.)	Total. Tons (2240 lbs.)	Value. £A.	TOTAL. Tons (2240 lbs.)	£ s. d.
1889	....	....	....	....	5·0	93 0 11
1890	....	....	....	....	67·5	94 4 0
1891	....	....	204·00	10,200	204·00	91 4 0
1892	....	....	265·49	13,843	265·49	93 9 6
1893	....	....	171·50	7,664	227·95	85 7 7
1894	....	....	371·25	14,325	390·25	68 18 1
1895	....	....	277·15	9,703	277·15	63 6 8
1896	....	....	137·25	4,338	137·25	59 9 11
1897	82·40‡	4647·52‡	95·55	3,275	95·55	61 8 0
1898			68·14	2,760	68·14	71 4 1
1899			277·32	21,658	334 82	122 8 7
1900			435·62	29,528	823·49	133 11 6
1901			321·34	18,852	734·32	118 12 8
1902			403·21	24,680	619·56	120 14 5
1903			524·94	34,362	817·05	127 6 5
1904			533·64	34,462	854·50	126 14 8
1905			643·52	52,960	1079·26	143 1 8
1906	26·18	757·10	783·28	79,195	1494·93	180 12 11
1907	40·40	729·60	770·00	73,045	1623·69	172 12 9
1908	13·90	562·43	576·33	41,046	979·36	133 2 6
1909	44·40	414·35	458·75	34,786	754·23	134 15 6
1910	25·06	292·65	317·71	27,974	471·21	155 6 2
1911	27·82	383·30	411·12	44,638	559·77	192 7 0¾
1912	14·90	415·55	430·45	50,166	553·83	209 8 5
1913	29·06	429·42	458·48	50,954	600·93	206 5 7
1914	5·32	239·22	244·54	21,145	331·94	....
1915	7·55	239·78	247·33	21,431	325·98	164 4 0
1916	9·94	271·80	281·74	27,319	434·91	182 3 5
1917	11·18	226·74	237·92	29,928	306·97	237 13 1
1918	50·52	245·28	295·80	57,653	395·30	329 11 2
1919	23·66	220·95	244·61	34,959	281·31	257 9 8
1920	10·25	179·84	190·09	31,249	231·59	296 1 7
1921	7·00	45·87	52·87	5,778	67·37	165 8 2
1922	0·15	15·71	15·86	1,393	41·21	159 10 9
1923	....	28·02	28·02	3,024	52·42	202 5 0
1924	0·32	52·24	52·56	7,469	81·11	248 17 4
1925	1·21	54·06	55·27	8,764	79·23	261 1 6
1926	....	61·41	61·41	10,126	96·83	291 2 0
1927	1·23	57·11	58·34	9,544	95·78	289 1 5
1928	....	54·54	54·54	6,355	90·02	227 4 8
1929	0·91	37·39	38·30	4,099	56·16	203 19 4
1930	....	0·65	0·65	63	13·05	141 19 0
1931	....	....	....	....	6·30	118 8 11
1932	8·25	....	8·25	725	15·25	135 18 7
1933	....	3·04	3·04	407	15·50	194 12 0
1934	1·55	....	1·55	218	13·02	230 7 6
1935	....	17·32	17·32	2,360	17·87	225 14 5
1936	....	21·85	21·85	2,784	26·45	204 12 8
1937	39·44	17·58	57·02	8,068	59·79	242 6 6
1938	41·25	10·65	51·90	6,253	52·50	189 11 9
1939	10·78	....	10·78	1,447	11·93	226 5 11
1940	32·90	0·65	33·55	4,627	36·50	256 12 3
1941	4·13	0·95	5·08	769	10·94	261 9 8
1942	9·26	3·45	12·71	2,369	23·41	259 10 0
1943	3·20	0·18	3·38	615	8·72	259 10 0
Totals	584·12	10738·20	11322·32	995,355	17,318·59	....

* 1889–1898.—From Rept. Dept. of Mines for 1899, Table X, p. 272.
1899–1943.—The amount of tin reported to the Mines Dept. is given. Figures from published Annual Reports or from Statistical Branch. Minor adjustments by R. A. Hobson.

† 1889–1898.—As above. The tin exported in 1889 and 1890 (5.0 tons and 67·5 tons respectively) is recorded as being probably from Greenbushes.
1899–1943.—As above.

§ 1889–1939.—From "The Mineral Industry," New York.
1888–1897 are for Straits Tin per ton of 2240 lbs.
1898–1920 are "Average price of tin in London in pounds sterling per ton of 2240 lbs."
1921–1939 are the price for "cash, standard per ton."
1940 1943 Supplied by Commonwealth Bureau of Census and Statistics, Canberra.
Information originally compiled in 1942 by R. S. Matheson. Additions by R. A. Hobson, 1944.

‡ Lode and alluvial tin were not recorded separately prior to 1906. The figures given are taken from Table 8.

TABLE 5.

PRODUCTION OF INGOT TIN FROM GREENBUSHES.[1]

Year.	Tons. (2240 lbs.)	Value. £A.
1900	142	18,872
1901	97	12,607
1902	141	16,830
1903	235	29,277
1904	129	16,155
1905	...	1
1906	45	8,746
1907	78	14,725
1908	...	1
	867	117,214

[1] From Report Department of Mines for 1925, p.67. There is no record of any subsequent export of ingot tin from W.A.

It is frequently stated at Greenbushes that much of the tin produced was not reported to the Mines Department. There is now no means of checking this statement or making any estimate of the amount not reported. It should be noted, however, that the total production for Western Australia as recorded by the Mines Department to the end of 1939 is within 371 tons of the figure obtained from Part VII of the Statistical Register for Western Australia, after allowance has been made for the fact that the figure from the Statistical Register includes 867 tons of ingot tin. The total given in Part VII of the Statistical Register appears to be obtained from export figures. The total production of any mineral as given in Part VII of the Statistical Register is, however, considered to be open to doubt by the present Acting Government Statistician[10] and its publication ceased after 1937.

During the period 1900 to 1908 tin concentrates were smelted at Greenbushes, by the same company as was pumping water from the Blackwood River. The amount of metallic tin produced and its value is given in table 5.

The latest figures available giving the total value of the tin produced in the various Australian States are those to the end of 1938, which are given below (Carver, 1942).

[10] Personal communication—Mr. Little, Acting Government Statistician, to writer.

	£
Tasmania	18,799,261
New South Wales	16,422,868
Queensland	12,213,702
Western Australia	1,654,389
Victoria	1,084,744
Northern Territory	664,965
South Australia	*Nil*
Australia	50,839,929

These figures show that Western Australia occupies fourth place as a producer of tin and that she had produced to the end of 1938 approximately 3 per cent. of all tin produced in Australia.

TANTALUM.

In table 6 the yearly production of tantalum concentrates from Greenbushes and from Western Australia is set out. This information has recently been collected together by Dr. K. R. Miles for use in a bulletin dealing with the occurrence of tantalite in Western Australia[11]. It is probable that the total production from Greenbushes is greater than is given in table 6 as it is generally considered that much of the tantalite produced in the early days of the Field was not reported to the Mines Department. According to Mines Department records 245.1 tons of tantalite were produced in Western Australia to the end of 1938, while according to the Statistical Register the production was 278 tons—a difference of 33 tons. According to the figures given in table 6, the Greenbushes Field has produced approximately 3 per cent. of the Western Australian production. Simpson (1935, p. 10) gives the "reputed output" of Greenbushes to 1935 as 10 tons. Using this figure and taking the total W. A. production as 295 tons the percentage of the total produced by Greenbushes is increased to approximately 5 per cent.

[11] Miles, Rowledge, and Carroll (1944).

TABLE 6.

PRODUCTION OF TANTALUM CONCENTRATES FROM GREENBUSHES AND FROM WESTERN AUSTRALIA.

Year.	Lease or claim.	Greenbushes.[1] Lode.	Alluvial.	Total.	Value.	Western Australia[1]
		Tons. (2240 lbs.)	Tons. (2240 lbs.)	Tons. (2240 lbs.)	£A.	Tons. (2240 lbs.)
1905	"Enterprise", M.L. 369	2·34	...	2·34	1590	
1909	"Enterprise", M.L. 369	...	0·85	0·85	214	
1929	D.C. 81 (= M.L. 369) and D.C. 83 (= M.L. 370) ...	0·30	...	0·30	70	
1932	Eureka, M.L. 640 (= M.L. 369) ...	...	0·45	0·45	135	260·35 (total to 1943)
1942	M.C. 1	...	0·17	0·17	121	
1943	M.C. 1	...	1·94[2]	1·94[2]	4,111[2]	
	M.C. 4 (Vulcan) ...	3·18	...	3·18	1,385	
	Various	0·32	...	0·32	98	
	Total for 1943...	3·50	3·50 1·94	5·44	5,594	
	TOTALS ...	6·14	3·41	9·55	£7,724	260·35

[1]Information originally compiled by K.R. Miles. Refer Mines Department Mineral Resources Bulletin No. 3.

[2]Complete to November 1943. Details regarding a parcel of 4,966 lbs. of concentrates shipped in December, are not yet available. (May, 1944).

IRONSTONE.

The quantity and value of ironstone produced at Greenbushes between 1899 and 1904 is given in table 7.

TABLE 7.

PRODUCTION AND VALUE OF IRONSTONE FROM GREENBUSHES

Year.	Tons. (2240 lbs.)	Value. £A.
1899	2,000	1,391
1900	...	...
1901	2,725	2,086
1902	1,955	831
1903	220	88
1904	581	233
TOTALS	7,481	£4,629

PRODUCTION—DETAILED INFORMATION FOR TIN.

It has already been explained that prior to 1899, no record was kept by the Mines Department of the quantity of tin produced, and that up to 1906 alluvial tin was not recorded separately from lode tin. In compiling table 8, the writer has made a careful examination of the records now available at the Mines Department, Statistician's Office and also of information published by that Branch in Annual Reports. Some information has also been gathered from Geological Survey bulletins. Unfortunately, production from claims, extended alluvial claims and dredging claims has all been recorded under the heading of "Sundry Claims." The original returns from claim owners and the Mining Registrars' monthly returns have been destroyed, and there is now no means of finding the production from individual claims, grouped under that heading. It is extremely difficult to understand just why this was done as most of the claims, except perhaps in the very early days of the Field, were surveyed. Valuable information has been lost, and of a total recorded production of 11,322 tons of concentrates 5,989 tons are recorded as coming from "Sundry Claims" i.e., it is not known where 53 per cent. out of the production of the Field came from. The figures given in table 8 for "Sundry Claims" are slightly less than that in the records of the Statistician's Branch. From the available records the writer was able to take out of "Sundry Claims" the productions for a few individual claims. Also some information was obtained from Geological Survey bulletins. The productions given in these publications are generally for one year only, and it is not now possible to find out if there was any production in preceding or succeeding years. The figures obtained therefore may not represent the total productions.

The amounts of lode and alluvial tin concentrates given in table 8 also differ slightly from those published in Mines Department Annual Reports. All production prior to 1906 is officially recorded as alluvial. Descriptions of many of the workings are available (e.g. Simpson and Gibson, 1907: Woodward, 1908), and where a lode was being worked the figures have been changed from alluvial to lode. A few similar adjustments have also been made for the period 1906 onwards.

For table 8 and also for use in the following chapter the Field has been divided into a number of areas which have been named and numbered. They are shown in figure 12. The areas are more or less natural subdivisions of the Field, but the boundaries, between them are arbitrary. They serve quite well for the grouping together of the production figures and for Chapter IV.

Within these subdivisions, the production figures have been grouped together under existing leases or claims or groups of these. It has frequently happened in the past that a group of leases or claims have been worked by the one company and only the total production has been reported. Where there are two or more lots of old workings on one existing lease or claim, no attempt has been made to group together production from each lot of workings. To have done this would have made the table more complex. Should this information be desired it will be necessary to re-group some of the figures given—a task which should not be difficult.

TABLE 8.

RECORDED PRODUCTION OF TIN CONCENTRATES FROM THE GREENBUSHES MINERAL FIELD TO DECEMBER, 1943

Existing leases are shown in heavy type. Leases covering approximately the same ground are grouped together and their productions totalled.

AREA NO. 1.—DUMPLING AND NEW ZEALAND GULLIES.

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	£A.
Refer figure 12	M.C.'s 26, 24, 23, 7; D.C. 67; W.R.'s 288, 276, 263; G.A.'s 39, 38; M.H.L. 27; M.A. 25	....	....	....	....	....
Greenbushes Development Co. Ltd	M.L.'s 35, 169, 218, 272, 287, 295, 296, 331, 375, 395, 421, 428, 432, 448, 453	1906–21	0·35	971·91	972·26	87,010
Turn of the Tide	M.L. 565 (= 425)	1913, 14, 17–21	....	20·46	20·46	2,689
Little Wonder	M.L. 470	1908–13	5·00	49·73	54·73	5,455
Nickel Kramer Tin Mining Co. Ltd.	M.L.'s 413, 423, 424, 425, 470, 471	1907–10	....	9·17	9·17	726
Great Boulder	M.L. 419 (= 380 = 292)	1907	0·15	0·25	0·40	40
Mt. Pleasant	M.L. 471	....	....	....	....	....
Nickel Kramer	M.L. 244	1907	2·92	....	2·92	266
Central	M.L. 296	1903–06	....	100·16	100·16	9,728
Glasgow	M.L. 375	1905–06	0·93	0·61	1·54	150
Mt. Pleasant	M.L. 244	1902–06	....	44·30	44·30	3,795

North Junction	M.L. 394 (=338 = 154)	1906	0·10	0·05	0·15	17
	726C[8]	1906	....	5·81	5·81	603
	671C[8]	1906	....	0·54	0·54	49
	652C[3]	1906	....	1·55	1·55	155
Westralian Stanneries, Ltd.	M.L.'s 35, 169, 195, 218, 221, 228, 272, 287, 292, 293, 295, 299, 310, 375	1902–06	....	109·33	109·33	8,171
Lady Esther	M.L. 331 (= 156 = 17)	1903, 1905	....	10·00	10·00	744
Stanrighan	M.L. 294	1902–03	....	0·48	0·48	28
Caledonia Tin Mine, N.L	M.L. 156, also 17 and 24 in 1901 (17 = 331 = part 156)	1901–02	....	12·26	12·26	685
Glasgow	M.L. 234 (and 166 in 1901)	1901–02	....	0·33	0·33	18
North Junction	M.L. 154 (= 338 = 394)	1900–02	....	0·45	0·45	28
W.A. Mt. Bischoff	M.L. 218	1901–02	....	5·38	5·38	342
Greenbushes Tinfields, Ltd.	M.L. 105 (= 221)	1899–1901	....	1·00	1·00	120
Horans No. 1, North	M.L. 169 (= 20)	1900–01	....	9·50	9·50	684
Glasgow	M.L. 166 (55 = 166 = 234 = 353)	1900	.. .	0·47	0·47	33
Horans	M.L. 35	1899[1]–1900	....	188·35	188·35	11,605
Horans No. 1, West	M.L. 21 (= 216 = 376 = 495)	1899	....	0·10	0·10	12
New Zealand Syndicate, N.L.	M.L.'s 17 (=156) and 24 (=330)	1899	....	0·80	0·80	50
Westralian Stanneries	179C	1899[1]	....	94·25	94·25	5,349
	178C (= part 760C)	1899	....	4·27	4·27	376
TOTAL	....	....	9·45	1,641·51	1,650·96	138,928
Scadden	M.L. 531 (= 337)	1913	....	1·41	1·41	176
Gladstone	M.L. 337	1904–10	....	60.96	60·96	5,194
Total	....	....	....	62·37	62·37	5,370
Old Sport	M.L. 400	1906–07	1·45	0·05	1·50	150
AREA TOTAL	....	....	10·90	1,703·93	1,714·83	144,448

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	£A.
	Area No. 2.—Locations 289, 290.					
Tailings worked by McKay and Struthers	Loc. 290	1920–21	....	5·39	5·39	762
Worked by Clarth and others	Locs. 289, 290	1904–09	....	318·04	318·04	28,959
AREA TOTAL	....	....	....	323·43	323·43	29,721
	Area No. 3.—Spring Gully.					
W.R. 291, G.A. 53 and down stream to 489 Refer fig. 12.	....	....	....	....	....	....
	D.C. 56	1932	....	8·25	8·25	725
	D.C.'s 56, 84	1930	....	0·65	0·65	62
Stanhope United (included in D.C. 56 after 1919[2])	M.L.'s 450, 458, 485, 486, 487, 488, 489	1907–19	....	569·80	569·80	71,290
Stanhope	M.L. 387 (= part 450)	1906	....	6·53	6·53	704
Aqua	M.L. 214 (= part D.C. 56)	1901–02	....	4·45	4·45	256
Spring Gully	318C (= 771C = M.L. 484)	1899[1]–1906	.. .	161·97	161·97	11,991
Total	....	....	....	751·65	751·65	85,028
	608C[3], [4]	1906	....	21·90	21·90	2,083
	W.R. 292 (= part 700C)	....	....	....	....	....
	700C[3]	1906	....	58·35	58·35	5,928
Total	....	....	....	80·25	80·25	8,011

North of Spring Gully including D.C. 16 and 714C	....	....	....	....	....	....
Estanto Sluicing Co.	M.L. 528[5] also (D.C.'s 27 and 33)	1911–20	....	....	....	....
	758C[8]	1906	....	0·40	0·40	43
Queen May Consols	M.L. 317 (= 222)	1903–05	....	22·01	22·01	1,454
Homeward Bound Tin Mining Syndicate, N.L.	M.L.'s 19, 222, 225	1902	....	11·40	11·40	811
Homeward Bound	M.L. 222	1901	....	9·41	9·41	597
Redruth	M.L. 19	1900, 1901	....	5·61	5·61	346
Redruth Extended	M.L. 225 (= 39)	1901	....	0·50	0·50	30
Total	....	....	....	49·33	49·33	3,281
Ethel May	M.L. 577	1916–18	....	18·29	18·29	2,267
Morning Star	M.L. 578	1916–17	....	1·55	1·55	147
Substitute	M.L. 569	1914–15	....	8·50	8·50	910
Pat	M.L. 498 (= 819C)	1913	....	0·74	0·74	84
AREA TOTAL	....	....	....	910·31	910·31	99,728

Area No. 4.—Battler's Hope—Three C's—Poverty Flat Area

E.A.C.'s 960, 963 ; D.C.'s 18, 94 ; M.L.'s 555, 571, and vicinity	....	....	....	....	....	....
	E.A.C. 960	1942	....	0·74	0·74	210
	D.C. 94 (= D.C. 97)	1937	....	5·05	5·05	723
	E.A.C. 963	1937	....	0·66	0·66	71
	949C	1933	....	1·05	1·05	149
Scotia leases	M.L.'s 505, 519, 614	1909–29	....	100·32	100·32	11,958
Three C's. leases	M.L.'s 529, 555	1920	....	9·15	9·15	1,513
Phoenix Sluicing Co.	M.L.'s 529, 555, 571	1916–17	....	58·95	58·95	5,553
Three C's.	M.L. 529	1912–15	...	53·33	53·33	4,314
Homeward Bound	M.L. 599	1918	...	1·07	1·07	200
New Moon	M.L. 513 (= 367)	1910–11	...	0·31	0·31	26
Legado and Westralia	M.L.'s 454, 501	1911	...	2·75	2·75	282

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value. £A.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	
Westralia	M.L. 501	1910–11	...	0·90	0·90	64
Westralia and Legado	M.L.'s 454, 501	1909	...	13·99	13·99	944
Westralia and Legado	M.L.'s 391, 454	1907–09	...	20·89	20·89	1,645
Legado	M.L. 454	1907, 1910	...	9·90	9·90	828
Homeward Bound Tin Mining Syndicate, N.L.	M.L.'s 247, 264–68	1901–02	...	2·0	2·0	115
Aurora leases	M.L.'s 357, 359, 360, 367, 408	1907–08	...	19·95	19·95	1,472
Consolidated Tin Sluicing & Mining Co., N.L.	M.L.'s 357, 359, 360, 367, 408	1906–07	...	36·85	36·85	3,429
Greenbushes Sluicing Co.	M.L.'s 357, 359, 360	1905–06	...	25·33	25·33	2,234
	734C[8]	1906	...	1·80	1·80	167
	705C[8]	1906	...	5·80	5·80	571
Total	... ...	...	...	370·79	370·79	36,468
	E.A.C. 961	1938, 1940	...	1·35	1·35	157
	876C	1937	...	0·80	0·80	142
	759C[8] (= part D.C. 39) ...	1906	...	0·30	0·30	26
AREA TOTAL	... ...	...	...	373·24	373·24	36,793

M.C.'s 15, 17, 33, 35	... ...	...	...	...	...	...	...
Vulcan Minerals, Ltd.[6]	M.C.'s 3, 4, 8, 15, 16, 17, 33, 34, 35, 36, 37, 38, 39, 40, 41	1937-43	132·49	..	132·49	17,430
	M.C.'s 2, 4	1936-37	11·50	...	11·50	1,634
Excelsior leases	M.L.'s 472, 497, 510 ...	1912, 1913, 1915, 1917-22	...	119·85	119·85	17,934
Southern Cross	M.L. 580 (= 436 = 574 = 580 = D.C. 77)	1918, 1921	7·95	...	7·95	1,006
Estanto Sluicing Co.	M.L.'s 528; D.C. 27, 33, 12; 608C	1911-20	...	449·35	449·35	48,335
Jellicoe	M.L. 592	1918	...	0·31	0·31	57
Baltory Hill, Caledonian Tin Mining Co., Ltd.	M.L. 436	1910-13	4·49	0·05	4·54	412
Westralian Gully Tin Co., Ltd.	M.L.'s 381, 435, 436, 472, 478 (= 746C)	1907-10	6·38	34·38	40·76	3,235
Aqua	M.L. 472	1910	...	1·50	1·50	128
Aqua, West	M.L. 478 (= 746C)	1910	0·20	...	0·20	16
Excelsior Extended	M.L. 510	1913, 1912	...	0·05	0·05	5
Excelsior Tin Mining Co., Ltd	M.L. 497	1908, 1909	...	4·05	4·05	281
Birthday	M.L. 496	1908-09	...	1·65	1·65	107
Champion	M.L. 484 (= 771C)	1908-09	...	3·05	3·05	248
Excelsior Tin Mining Co., Ltd.	M.L. 491	1908	...	0·45	0·45	36
Westralian, North	M.L. 392	1907	...	1·77	1·77	155
Ironclad	M.L. 456 (= 179)	1907	0·95	...	0·95	82
	771C[8]	1906	...	0·35	0·35	37
	750C[8]	1906	...	13·70	13·70	1,397
	746C[8]	1906	...	11·85	11·85	1,175
	695C[8]	1906	...	0·60	0·60	60
Caledonian	M.L. 76	1899-1900	8·06[9]	...	8·06	542
Ironclad	M.L. 179	1900	0·45[9]	...	0·45	30
Queen's Birthday	M.L. 58 (= 265)	1899	1·20	...	1·20	82
Total	... ...	...	173·67	642·96	816·63	94 500

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	£A.
M.C. 3	... ...	...	...	...	...	...
Lost and Found	M.L. 628 (= 374 and 393 = M.C. 3)	1927	0·33	...	0·33	50
Lost and Found	M.L. 605 (= 543 = 374) ...	1918	0·05	...	0·05	87
Lost and Found, North	M.L. 606 (= 393)	1918, 1919	4·80	...	4·80	975
Lost and Found	M.L. 543 (= 374)	1912, 1913	4·82	...	4·82	580
Bunbury End	M.L. 563 (= 543 = 374) ...	1913	0·56	...	0·56	60
Lost and Found	M.L. 374	1905–11	12·56	1·30	13·86	1,402
Lost and Found, North	M.L. 507 (= 393)	1910–12	8·23	0·25	8·48	919
Lost and Found, North	M.L. 393	1906–09	11·02	...	11·02	915
Amanda leases	M.L.'s 56, 217	1902–04	...	22·83[10]	22·83	1,471
Glencoe	M.L. 217 (= 146)	1900–02	3·66[9]	...	3·66	201
Amanda	M.L. 56	1899–1901	...	0·85	0·85	52
Total	... ...	...	46·48	25·23	71·71	6,712
M.C. 6, M.C. 8 and W.R. 286	... ...	...	...	...	...	...
Greenbushes Tin, Ltd.	**M.C.'s 6, 9[12], 20, 25, 27,32; M.L. 620**	1940–43	1·22	0·95	2·17	495
	M.C. 6	1938, 1940	0·45	...	0·45	50
	D.C. 92	1934–36	...	25·50	25·50	3,263
King Tin leases	M.L.'s 73, 233, 271, 504 ...	1906–21	6·52	119·54	126·06	15,900
Found at Last	M.L. 617	1920	0·57	...	0·57	130
Nil Desperandum	M.L. 596 (= 401)	1918	0·25	...	0·25	48
Old Bunbury	M.L. 504 (= 775C)	1909–12	...	37·62	37·62	3,619

Nil Desperandum	M.L. 401	1906, 1907	1·55	...	1·55	162
Dreamland	M.L. 382	1905–08	1·61	1·92	3·53	368
Nelson leases	M.L.'s 73, 233	1902–07	...	61·01	61·01	4,164
	789C[8]	1906	...	0·77	0·77	79
	779C[8]	1906	...	0·60	0·60	62
	776C[8]	1906	...	0·30	0·30	30
	775C[8]	1906	...	10·65	10·65	991
	774C[8]	1906	...	0·75	0·75	76
	753C[8]	1906	...	7·20	7·20	786
	752C[8]	1906	...	8·50	8·50	821
	748C[8]	1906	...	1·44	1·44	136
	738C[8]	1906	...	4·87	4·87	471
Pioneer (= King Tin, North)... ...	M.L. 271	1902	...	1·84	1·84	117
Nelson	M.L. 73	1899–1901	...	22·40	22·40	1,675
Total	... ...	...	12·17	305·86	318·03	33,443
	D.C. 90	1935–38, 1942	...	6·39	6·39	923
	710C	1906[8]	...	2·10	2·10	199
	683C	1906[8]	...	2·70	2·70	255
	219AC	1906[8]	...	16·60	16·60	1,639
	535C[13]	1899	...	0·40	0·40	24
Total	... ...	...	...	28·19	28·19	3,040
M.C. 34	... ...	...	...	...	...	...
Kapanga	M.L. 515	1910–29	35·96	1·35	37·31	4,803
Two Battlers	M.L. 603	1919	0·10	...	0·10	12
Haphazard	M.L. 147 (= 122)	1900–09	0·28	8·79	9·07	573
Tairua	M.L. 410	1906, 1907	3·88	...	3·88	390
Esperence Hill	M.L. 389	1906	0·15	...	0·15	15
Haphazard Extended	M.L.'s 245, 246	1902, 1903	...	3·22	3·22	196
Hokitica	M.L. 281 (= 219)	1902	0·16	...	0·16	10
Wheal Fortune	M.L. 219	1901	0·20	...	0·20	13
Victoria	M.L. 110 (= 199)	1900–01	0·25	...	0·25	20
Total	... ...	...	40·98	13·36	54·34	6,032

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	£A.
M.C. 32 and W.R. 289[14]	... ...	...	...	...	...	...
Champion	M.L. 511	1910–1924	1·60	215·42	217·02	24,045
	781C[8]	1906	0·35	...	0·35	35
	712C, 762C[8]	1906	...	9·55	9·55	905
Total			1·95	224·97	226·92	24,985
	M.C. 9[13]	1937	...	0·36	0·36	44
Hokitica No. 1	M.L. 308 (=241)	1903	...	1·35	1·35	75
Total			...	1·71	1·71	119
	M.C. 1[13]	1937, 1942	...	2·24	2·24	465
Enterprise[15]	M.L. 369	1906, 1907 1912, 1914 1916, 1918	0·20	7·29	7·49	667
Wills	M.L. 370	1907	2·52	2·10	4·62	378
Total			2·72	11·63	14·35	1,510
Last Chance	M.L. 522	1913–1915	1·55	7·32	8·87	831
You and Me	M.L. 550	1913	...	2·15	2·15	210
Berkshire	M.L. 90	1900, 1901	...	0·34	0·34	17
AREA TOTAL			279·52	1,263·72	1,543·24	171,399

Area No. 6. Salt Water Gully.

W.R. 265, M.L's. 559, 561, Loc. 8752	... ...	...	...	...	...	...	...
Perseverance	M.L. 318 (=224)	1903	...	0·75	0·75	36
Westralian Tinfields, Ltd.	M.L's. 182/5, 224	1901, 1902	...	7·90	7·90	434
Queen Victoria Tin Mining Syndicate	M.L. 93 (=208)	1899	...	0·30	0·30	15
Total			...	8·95	8·95	485
	D.C. 70	1938	...	8·20	8·20	1,279
	648C and 315C[8]	1906	...	0·60	0·60	57
	792C[8] Includes (W.A. 215) ...	1906	...	0·45	0·45	44
	741C[8]	1906	...	0·85	0·85	85
	670C[8]	1906	...	1·10	1·10	113
AREA TOTAL			...	20·15	20·15	2,063

Area No. 7. Floyd's Gully.

Gold Coin[14]	**M.L. 620**	1937	...	0·30	0·30	39
Gold Coin	**M.L. 620**	1928, 1929	...	3·04	3·04	324
Great Wonder	M.L. 383	1900	...	0·15	0·15	12
Total			...	3·49	3·49	375
	M.C. 25[14]	...	...	...	...	...
I.O.U.	M.L. 469	1907, 1908	...	1·55	1·55	119
Total			...	1·55	1·55	119
Battery Reserve	17393	1938	...	0·70	0·70	84
	801C[8]	1906	...	2·40	2·40	260
Total			....	3·10	3·10	344

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value. £A.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	
Last Chance	M.L. 598 (=D.C. 68) ...	1919, 1920	...	0·46	0·46	66
Energetic	M.L. 303 (=629C, includes 704C)	1902, 1903	...	1·86	1·86	109
	770C[8]	1906	...	0·80	0·80	80
	745C[8]	1906	...	4·66	4·66	410
AREA TOTAL			...	15·92	15·92	1,503

AREA NO. 8. SCANDINAVIAN GULLY AREA.

Vicinity 782C: D.C. 53: M.L. 516: G.A's. 22, 42: M.L's. 107, 118	....	...	...	...	...	...
	D.C. 50 (includes part G.A's. 22, 42)	1935	...	0·65	0·65	91
Forget Me Not	M.L. 466	1907	...	0·40	0·40	40
	782C[8]	1906	...	0·17	0·17	17
	744C[8]	1906	...	1·47	1·47	144
Olympia	M.L. 48 (includes part D.C. 53)	1899	...	1·00	1·00	90
AREA TOTAL			...	3·69	3·69	382

Area No. 9. Central Area

M.C. 5	... ...	...	... ...	...	...
Cornwall	M.L. 615 (=583)	1919, 1920	3·35 ...	3·35	580
Satin Bird	M.L. 588	1917–1919	4·56 1·05	5·61	951
Cornwall	M.L. 583	1917–1919	7·93 ...	7·93	1,513
Cornwall leases	M.L's. 356, 514	1904–1911, 1913–1915	70·35 ...	70·35	6,278
Cornwall	M.L. 40	1902–1903	9·07 ...	9·07	599
Total			95·26 1·05	96·31	9,921
M.C. 5	... ...	...	... ...	...	...
North Cornwall	M.L. 564 (=532=399=351)	1913	0·25 ...	0·25	30
North Cornwall	M.L. 399	1907	1·72 ...	1·72	184
Total			1·97 ...	1·97	214
D.C. 5	... ...	...	... ...	...	...
Mixon	M.L. 302	1902	0·25 ...	0·25	18
Cornwall Extended	M.L. 422	1906, 1907	0·50 ...	0·50	55
Cornwall Extended	M.L. 508 (=part 422) ...	1910	0·05 ...	0·05	4
Total			0·80 ...	0·80	77
M.C. 5	... ...	...	... ...	...	...
South Cornwall	M.L. 300	1903–1907, 1909	30·39 0·25	30·64	2,407
South Cornwall	M.L. 300 and 30H	1910–1913	28·49 ...	28·49	3,140
South Cornwall	M.L. 567 (=300)	1914	4·41 ...	4·41	384
South Cornwall	105H	1920	19·06 ...	19·06	2,583
Total			82·35 0·25	82·60	8,514

For footnotes see p. 102.

TABLE 8—*continued.*

Registered name of company or of lease.	Lease number(s).	Period of production.	Tin Concentrates.			Reported value. £A.
			Lode. Tons (2240lbs.).	Alluvial. Tons (2240lbs.).	Total. Tons (2240lbs.).	
M.C. 5	... ...	...	...	...	...	...
Sunday Gift	M.L. 600	1918	1·72	...	1·72	327
Bird's Nest	M.L. 587	1917, 1918	5·02	...	5·02	931
Total for M.C. 5 ...			187·12	1·30	188·42	19,984
M.C. 22	... ...	...	...	...	...	...
Dixie	M.L. 566 (=629=542=527=388)	1913	0·05	...	0·05	6
Dixie	M.L. 527	1911, 1912	0·60	...	0·60	65
Dixie	M.L. 388	1905–1908	8·67	0·72	9·39	959
Dixie leases	M.L's. 257, 273	1901–1903	12·97	...	12·97	818
Dixie	M.L. 297 (=257)	1902	0·05	...	0·05	3
Total			22·34	0·72	23·06	1,851
Returned Soldier	M.L. 616	1919, 1920	7·23	0·60	7·83	1,346
Gang Forward	M.L. 611	1918	0·46	0·28	0·74	125
Grafter	M.L. 589	1918	1·67	...	1·67	319
Hamel	M.L. 608	1918	...	1·43	1·43	280
Imperial leases	M.L.'s. 188/9, 190/9, 200, 202/9, 210/1, 213, 236, 250, 260/1	1901	3·65	...	3·65	209
AREA TOTAL			222·47	4·33	226·80	24,114

AREA NO. 10. NORLUP BROOK.

			No production recorded.			
AREA TOTAL			...	...	...	...

AREA NO. 11. BORONIA GULLY.

D.C. 17	... ...	...	...	...	...	...
	D.C. 20 (=D.C's. 17, 15, 10) ...	1915, 1916	...	13·61	13·61	1,217
Baronia	M.L. 361	1905–1907	...	16·87	16·87	1,588
AREA TOTAL			...	30·48	30·48	2,805

AREA NO. 12. MT. JONES.

W.R. 285	... ...	...	...	...	...	...
Mt. Jones leases	M.L's. 460, 461	1909–1914	...	167·05	167·05	19,788
Norilup Tin Mining and Dredging Co., Ltd.	M.L's. 396[16], 397, 460, 461, 479, 480	1907–1908	...	3·82	3·82	291
AREA TOTAL			...	170·87	170·87	20,079
TOTAL OF ABOVE ...	... ...	1899–1943	512·89	4,820·07	5,332·96	533,035
Sundry Claims	... ...	...	71·23	5,917·91	5,989·14	462,395
Total recorded Production for Field ...	... ...	1889–1943	584·12	10,737·98	11,322·10	995,430

For footnotes see p. 102.

Footnotes:

1. And prior to 1899.
2. Production except that noted lost in "Sundry Claims."
3. Taken from Bulletin 32. Production given for 1906 only. May be some subsequent production lost in "Sundry Claims."
4. See also Estanto Sluicing Co., 1911–20, Area 5.
5. Production from M.L. 528 included with production from D.C's. 27 and 33, Estanto Sluicing Co., Area 5.
6. Work confined to M.C. 4.
7. See also Area No. 3.
8. Information from Bulletin 30. Production given for one year only.
9. Probably includes some alluvial tin concentrates.
10. May include some lode tin concentrates.
11. Extends east of M.C. 3.
12. Production from M.C. 6.
13. From Annual Report of the Mines Department for 1899. Production given for one year only.
14. Refer also Greenbushes Tin, Ltd.—M.L. 620, M.C's. 6, 9, 20, 25, 27, 32. Area No. 5.
15. For tantalite production refer p. 85.
16. M.L's. 396, 397 are in Area No. 10.

MARKETING OF CONCENTRATES.

There are no tin smelters in Western Australia and tin concentrates are usually sold to smelters in the Eastern States. Under normal conditions they could be sold for export abroad, but at the present time the export of tin concentrates is prohibited. The price of both tin and tin concentrates have been fixed by the Commonwealth Government.

All tantalum concentrates produced at the present time are purchased by the United States Commercial Company acting through the Commonwealth Government and the State Mines Department. It is urgently wanted.

There is also a sale for niobium concentrates, but the prices are not very attractive.

It is realised that much of the information supplied in this section of this bulletin will be out of date, perhaps before the bulletin is printed, and almost certainly before many years have passed. Nevertheless, it will act as a guide, and producers will be able to get the latest information by reference to the Mines Department or the ore buyers. Under normal conditions the prices will not be fixed and will, of course, vary from time to time, according to market conditions.

Concentrates should be double bagged in strong jute bags to avoid spilling during shipment and should be clearly labelled. Suitable bags can generally be obtained from the ore buyers.

Tin concentrates.

The following are buyers of tin concentrates:—

O. T. Lempriere & Co. Pty. Ltd., Collins House, 360 Collins Street, MELBOURNE, C. 1. (Western Australian Agents—Sumpton & Sons, Phillimore Street, FREMANTLE.)

T. H. Kelly, 39 Hunter Street, SYDNEY. (No agent in Western Australia.)

Anyone desiring to sell tin concentrates should get in touch with either of these firms, who will supply the terms and conditions under which they purchase tin concentrates. There appear to be minor differences in the terms and conditions of purchase of each firm.

Information regarding the price and conditions of purchase are set out in general terms in the following paragraphs.

The price at the time of writing, (May, 1944) is fixed at 66s. per unit for concentrates containing 70 per cent. Sn. delivered to Sydney. Concentrates containing less than 70 per cent. are subject to the following deductions:—

Less 1½d. per unit or part thereof to 60%
Less 2d. per unit or part thereof to 50%
Less 3d. per unit or part thereof to 40%

Based on this information the price per ton of various grades of concentrates are given below. These prices are taken from a complete table of prices prepared by Mr. J. S. Foxall, the Assistant State Mining Engineer.

Tin %	Price per ton (2240 lbs.) £	s.	d.
40	121	3	4
45	139	2	6
50	157	14	2
55	175	15	5
60	194	5	0
65	212	9	4
70	231	0	0
75	247	10	0

From these figures it will be seen that every endeavour should be made to have the concentrates as clean as possible. A clean concentrate not only means a high price per ton, but also less freight between the point of origin and Sydney.

Penalties are imposed for impurities. The following figures are quoted by O. T. Lempriere and Co. Pty. Ltd., at 17th March, 1944.

Sulphur and Arsenic ... { Up to 0·15%—No charge. / 0·15% to 2%—£1 10s. per ton. / Over 2%—£2 per ton.

Any arsenic in excess of 0·5% to be charged at the rate of 1s. 6d. per ton for each 0·1% As. in addition to the combined charge.

Combined impurities (Cu., Pb., Bi., Sb., etc.) { Up to and including 1·5 per cent.—4s. per ton for each 0·1 per cent. Minimum charge of £1. / 1·5 per cent.–2 per cent —5s. per ton for each 0·1 per cent. or part. / Over 2 per cent.—6s. per ton for each 0·1 per cent. or part.

WO_3 ... ... { Up to 0·5 per cent.—No charge. / 0·5 per cent. to 1·0 per cent—10s. per ton. / Over 1 per cent.—10s. per ton for each 1 per cent or part.

Payment is made on the basis of the weights and assays at the smelter, the seller being represented at the weighing and sampling if desired. Provision is also made for agreement on assays if this is desired. Under normal peacetime conditions, Norman Hill & Co. Pty. Ltd., of Cathcart House, 11C Castlereagh Street, Sydney, will buy tin concentrates for export.

Tantalum concentrates.

At the time of writing (May, 1944), all tantalum concentrates are purchased by the United States Commercial Company acting through the Commonwealth Department of Supply and Shipping and the States Mines Department. Prices which have been fixed by agreement between the Commonwealth Government and the United States Board of Economic Warfare, are $ 1.30 per lb. of Ta_2O_5 contained in 30 per cent. Ta_2O_5 concentrates, increasing by 7 cents per lb. for each 1 per cent. over 30 per cent. to $ 4.80 for 80 per cent. concentrates.

The prices given below are taken from a table prepared by Mr. J. S. Foxall, the Assistant State Mining Engineer,

Ta_2O_5 %	Prices per short ton (2000lbs.) £ s. d.
30	240 2 4
35	355 11 2
40	492 11 0
45	651 1 9
50	831 3 6
55	1,032 16 3
60	1,256 0 0
65	1,500 14 9
70	1,767 0 5
75	2,054 17 1
79	2,300 12 9

Penalties are imposed if the total of Ta_2O_5 plus Nb_2O_5 is less than 60 per cent., if the SnO_2 plus TiO_2 exceeds six per cent., if the SnO_2 exceeds three per cent. and if the TiO_2 exceeds three per cent.

Final payment is made on the basis of American weights and assays.

Tantalite is urgently wanted and it can be seen from the above that concentrates as low as 30 per cent. Ta_2O_5 can be sold. Prior to the present war the concentrates in demand were those containing not less than 60 per cent. Ta_2O_5. The market was very limited and the mines were not worked continuously. More details regarding tantalite concentrates sold in the pre-war period are contained in Mineral Resources Bulletin No. 3. (Miles, Rowledge and Carroll, 1944).

Niobium concentrates.

Although columbite has been recorded from Greenbushes and must exist in appreciable quantities in recent parcels of the magnetic product separated from the Vulcan tin concentrates no parcels of niobium concentrates have been produced.

Norman Hill and Co. Pty. Ltd., quote the following approximate prices for niobium concentrates at 3rd March, 1944:—

Concentrates assaying minimum 60% Nb_2O_5 £227 11s. 2d. per ton.

Concentrates assaying minimum 45% Nb_2O_5 £124 2s. 5d. per ton. Both the above prices are for concentrates delivered c.i.f. New York. No payment is made for the tantalum content of niobium concentrates.

Tin/tantalite/columbite concentrates.

These concentrates are handled by both O. T. Lempriere & Co. Pty. Ltd., and by Norman Hill & Co. Pty. Ltd. Both these firms will separate such concentrates by magnetic separation into two products—a non-magnetic or tin product and a magnetic or tantalite columbite product—at a charge of £10 per ton of mixed concentrates treated. The tin product is then disposed of as tin concentrates, and the tantalite columbite product as tantalite columbite concentrates. O. T. Lempriere & Co. operate their own tin smelter, while Norman Hill & Co. do not and consequently there are some differences of procedure in disposing of the two lots of concentrates. Various charges are made and details would, no doubt, be supplied by either of the above firms to those interested.

At the present time any tantalum concentrates must be sold through the Commonwealth Government at prices, which have already been given.

PROSPECTING AND SAMPLING.

It is intended in this section of the bulletin to deal with the prospecting and sampling of ground, which, as a result of preliminary investigations, appears favourable to further work. The question, which arises, is whether or not the ground can be profitably worked under existing conditions. A full discussion of this question is beyond the scope of the present report, and the writer makes no claim to have the knowledge and experience necessary for such a discussion. It is desired to stress here the need for thorough and systematic sampling of the area under consideration, as the first step in answering the above question. It is not intended to give details, but rather to outline procedure.

The sampling of alluvial ground has been described many times —a good recent description being by A. G. Palmer, (1942), who deals with the methods used in Malaya. The methods described by Palmer are routine practice and have been proved to give reliable results.

Either pitting or boring may be adopted. Pitting is suitable for shallow dry ground, while boring, which is the method more frequently used, can be used in deep wet ground. If the wash is very coarse drilling will not give reliable results, and shaft or pit sinking is to be preferred. Pits or bores should be methodically set out. This is done by setting out a grid having two sets of grid lines at right angles to each other. Palmer recommends that the lines should be three chains apart, but much depends on the size of the area to be examined and the probable size of the payable area. In a field, such as the Greenbushes Field, where the areas which have been worked are comparatively small, closer spacing is necessary. How much closer must be decided for any individual area under consideration. When the grid has been set out boring or pitting is commenced. Bores or pits on lines extending across the area at either end and in the centre are first completed. Subsequently every second line is completed. If favourable results are obtained then the remaining lines are completed. This general scheme may require modification. Thus, if the area is large and consistent results are obtained on the completion of every second line further drilling or pitting is not necessary. On the other hand, when every line is completed, consistent results may not have been obtained. Additional sites will then have to be marked out and more holes put down. Again if, at any time, sufficient holes have been put down to show that the area is of no value then further boring or pitting would not be done.

All holes must be carefully sampled. A channel sample is usually taken down the side of a pit until the wash is reached. The whole of the wash is sluiced, the concentrates cleaned, dried, weighed and submitted for assay. Samples from the overburden are washed and the concentrates treated in the same way as the concentrates from the wash. Drill holes are usually sampled over five feet lengths. Should, however, there be a change in the nature of the ground, samples may be taken over a shorter length. The volume of each sample should be measured and the concentrates obtained by washing carefully weighed. Individual concentrates may be submitted for assay or all concentrates from one hole may be grouped together and assayed.

The average value of each hole (pit or drill hole) can now be calculated and the value of the area as a whole estimated.

All this is done before any plant is considered, and enables a suitable type and size of plant to be selected with confidence, since it is known that the expenditure on the plant is justified.

The Banka drill, which is hand operated, and which is described by Palmer is not suitable for use at Greenbushes because of the laterite, which is frequently very hard. The percussion drill used for boring for water would seem to be quite suitable, provided the driller was impressed with the need of always having the casing ahead of the drilling tools or sand pump and realised that the object of the work was to get samples and not to make rapid progress with the hole. It would not be possible, of course, to have the casing ahead of the tools while going through the laterite.

For lode deposits the same methods of sampling as are used for any lode or reef should be followed. Sampling procedure for ore bodies of these types is standardised and has been described many times (e.g., Jackson, C. F., and Knaebel, J. B., 1934). Details of procedure vary from mine to mine, but in all mines samples are taken in a methodical and careful manner. In development or prospecting work, samples should be taken across the ore body at regular intervals, wherever it is exposed. In drives, samples are taken across the face at right angles, if possible, to the dip of the ore body, or across the roof or floor of the drive at regular intervals. Crosscuts are sampled along the walls, while shafts, winzes and rises are sampled across the walls—all samples being taken, if possible, at right angles to the dip. Care should be taken that an equal volume of material is taken from all portions of the sample cut.

In many tin lodes, the cassiterite is very unevenly distributed and the procedure outlined above will not give reliable results. When this is so, the only reliable method of sampling is to break and treat some of the ore.

Chapter IV.

ORE DEPOSITS—RECENT PROSPECTING AND OTHER WORK UNDERTAKEN BY THE MINES DEPARTMENT.

INTRODUCTION.

During 1942 and 1943 a certain amount of prospecting and development work was done by the Mines Department under the direct supervision of its own officers. In addition considerable assistance was given to two projects—namely proposed sluicing on M.C. 6 and the production of tantalite on M.C. 1. A sluicing plant was erected on M.C. 6 during 1943, but had not commenced operations at the end of the year. Details regarding the work done at other localities are given below.

MINERAL CLAIM 47.

By R. S. MATHESON.

Plates IV, V, VI, VII.

GENERAL INFORMATION.

Mineral Claim 47, which includes parts of old Claim 641 and the "Terminus," M.L. 181, adjoins the south corner of the Greenbushes Townsite.

The occurrence of stanniferous lodes in this area has been known for many years, but it was not until 1942 that any serious attempt was made to determine their commercial importance. Investigations by departmental officers in the early part of 1942, suggested the possible occurrence of a wide north-west—south-east lode formation on M.C. 47, which was likely to contain several shoots of ore. Although the available information was meagre, it was considered that prospecting of the lode information was warranted under existing circumstances, and a scheme to prospect it by means of northeast-southwest crosscuts was therefore proposed. Prospecting operations, consisting of about 119 feet of shaft sinking and about 475 feet of driving and crosscutting, were carried out under the writer's supervision, during the period 6th August to 13th October, 1942.

Immediately prior to the commencement of prospecting, the writer mapped the distribution of tourmaline in the laterite covering the area (plate IV) and this indicated that the original conception of a north-west-southeast lode formation was wrong, and that the stanniferous material was more likely to occur as a number of scattered lenses of variable attitude. This was subsequently borne out in prospecting operations.

PRODUCTION.

The presence of old workings on M.C. 47 suggests that small parcels of lode material have been obtained, but it is impossible to trace production from this area in the official records. The production, however, may possibly be included with that from "Sundry Claims" over the entire Field.

TOPOGRAPHY AND GENERAL GEOLOGY.

Mineral Claim 47 is situated on the north-western slope of a north-west-south-east trending ridge, which occurs on the western side of the Greenbushes townsite. The elevation of the country varies from 1050 feet at the north-west boundary to about 1065 feet at the south-east boundary, and there is a gradual fall both to the north-east and south-west.

With the exception of an outcrop of fine grained greenstone, which occurs on the south-western side of the old reservior, the area is completely covered by ferruginous laterite (see plate IV). From an examination of the workings on M.C. 47 and adjoining holdings, there is good reason, however, to believe that the underlying rocks consist of greenstones, which have been intruded and replaced along shear zones by granitic material. The greenstones are probably decomposed amphibolite schists, and judging from a few observations in the underground workings, they have a general north-north-westerly strike and a steep east-north-easterly dip. All the granitic rocks in the area are tourmaline-bearing and stanniferous, and they constitute the lodes. The lodes occur as lenticular bodies of variable attitude.

The ferruginous laterite occurs as a hard layer over most of the gound included in the mineral claim, and has a maximum thickness of about 20 feet. The laterite overlying the granitic lode material is distinguished from that overlying greenstone country by the presence of muscovite mica or angular grains of quartz and tourmaline.

THE WORKINGS.

Prospecting was carried out by the Mines Department at both the northern and southern ends of M.C. 47, and it is convenient to describe the northern workings and the southern workings separately. The lenses of lode material occurring between these two sets of workings were not prospected.

Northern workings.

The extent of the old workings at this end of the area can be seen on plates nos. IV and VI. Based on the conception of a north-west-southeast lode formation, it was proposed to crosscut between shafts B and I, but the proposed crosscut proved to be a drive. The true mode of occurrence of the stanniferous lodes was evident soon after the commencement of prospecting operations, and this necessitated a revision of the original scheme.

The prospecting work proved the existence of four separate lenses of decomposed lode material, occurring in kaolinised greenstone country.

No. 1 Lens, strikes N 70° E and dips about 20° S.S.E., and has been driven on for about 140 feet at the 32 feet level. The lens has an average width of about five feet, and, judging from the tourmaline-bearing laterite at the surface (see plate IV), a length considerably in excess of that tested by driving. The lode is decomposed, and varies from friable, sugary, material, consisting mainly of tourmaline and quartz, to soft, puggy material consisting of a mixture of kaolin, tourmaline, quartz, and a little mica. Quartz veinlets occur in the lode in a few places.

No. 2 Lens is intersected in the West New Shaft, and is also exposed in the 32 feet level drive. The lens has a thickness of four to five feet in the drive and a flat southerly dip, and the strike is rather irregular. The lode is exposed in the drive over a length of 28 feet, but its total length is unknown. No. 1 and No. 2 lenses are similar in character, and apparently occur in the same shear plane.

In the workings off the East New Shaft, two apparently separate bodies of lode material occur, which are believed to be parts of the same lens, and are consequently described together hereunder as No. 3 lens. The lens is very irregular and shows considerable variations in thickness, but the general strike is apparently in an east-

north-east direction and the general dip to the south south-east. By reference to the transverse section on plate V it will be seen that the footwall dips much more steeply than the hanging wall. In the north-west crosscut and west drive the lode material is highly impregnated with tourmaline, but in the other workings it consists mainly of a mixture of kaolin and muscovite mica, with only a few scattered crystals of tourmaline. No. 3 Lens is very likely in the same shear plane as lenses nos. 1 and 2.

No. 4 Lens was intersected in shaft 1 between the surface and 16 feet 6 inches vertical depth. The base of the lode material is practically horizontal, the dip, if any, being very flat to the south south-east.

The shape of the outcrop of this lens (see plate IV) suggests that this dip is not the true dip of the lode, but the available information is inconclusive. The lode material consists mainly of a friable, sugary, mixture of tourmaline and quartz, but some kaolin is also present. The distribution of tourmaline-bearing laterite at the surface suggests that two shear planes, one striking north-east and the other north-west, intersect at the surface about 120 feet north-west of shaft I.

Another lens of lode material, on which two old shafts, (G and H) have been sunk, occurs at the northern end of M.C. 47. No investigations were carried out in these workings, but the surface examination suggests that there may be some connection between this lens and No. 4 lens (see plate IV).

Southern workings.

One hundred feet of exploratory work, consisting of 16 feet of shaft sinking and 84 feet of crosscutting, was carried out near the south end of M.C. 47. With the exception of six feet of shaft sinking in Congdon's Shaft (see plate IV), all the work was done on a lode situated at the south corner of the Police Yard. The Police Shaft and Shaft X were deepened, and crosscutting was carried out from them in east and west directions. This work proved the existence of a stanniferous lode between 50 and 60 feet wide, with a northerly strike. The hanging wall of the lode varies in dip from 45° in the Police Shaft workings to 80° in the Shaft X workings, while the footwall appears to be vertical. The lode consists of a somewhat puggy mixture of kaolin, tourmaline and quartz.

A small flatly dipping lens of lode material was intersected and passed through in Congdon's shaft.

SAMPLING.

The samples collected from the workings were about 10 lbs. weight, and were obtained, at intervals of 5 feet, from channels 1 to 2 inches wide and 1 to 2 inches deep, cut, as near as possible, perpendicular to the strike and dip of the lodes. The localities of the samples collected, and also the attitude of the sample cuts, are indicated on the accompanying plans (plates VI and VII).

In the northern workings, owing to the flat dip of the lodes, the samples were obtained from vertical channels. Prior to establishing the true mode of occurrence of the lodes, some samples were collected from horizontal channels in the five main shafts, but these samples[12] were later discarded. By examining the assay plan in conjunction with the geological plan it will be seen that only in very few instances do the sample channels extend from the footwall to the hanging wall of the lode. The true thickness was obtained, however, by putting auger holes into the roof of the drive in a few places. The samples obtained from the auger holes give some idea of the values near the hanging wall of the lode. It should be remembered that practically all the samples were obtained from channels which are not at right angles to the dip of the lode, and some adjustment will therefore be necessary to obtain true widths.

Due to the steep dip of the lode in the southern workings, the samples were obtained from horizontal channels. In these workings also, the channels are not at right angles to the dip of the lodes, and consequently adjustments will have to be made to the sample widths to obtain true widths.

The samples collected were forwarded to the Government Mineralogist and Analyst for determination of their metallic tin content. Tests were also made to detect the presence of any tantalum or niobium in the samples.

ASSAY RESULTS.

To avoid possible unnecessary work, it was decided that, firstly, only a carefully selected number of the samples collected should be assayed.

The assay results obtained from the selected samples from the northern workings are contained in table 9. The general low metallic tin content of these samples indicated that assays of the remaining samples from these workings were unwarranted.

[12]Samples Nos. S1 to S8, S13 to S19. S21 and S22, S24 and S26 to S29.

The results obtained from the selected samples from the southern workings, contained in table 10 were sufficiently encouraging to warrant assays of all the samples collected. The complete assay results are contained in table 11 and the weighted average values of the lode in the various parts of the workings are calculated in table 12.

TABLE 9.

ASSAY RESULTS FROM NORTHERN WORKINGS

(Assays made on dry ore).

Tests carried out by writer indicate that 1 c. yd. of lode materialweighs 2,700 lbs. Hence per cent. Sn multiplied by 27 gives lbs. Sn per c. yd.

Field No.	Lab. No.	Sample Width. Inches.	Sn. per cent.	Sn. lbs per c. yd.	Locality.
S 9	5770	42	0·13	3·51	From shaft 1.
S10	5771	78	0·10	2·70	From shaft 1.
S11	5772	60	0·04	1·08	From shaft 1.
S12	5773	60	0·05	1·35	From shaft 1.
S20	5781	60	0·02	0·54	From East New Shaft.
S23	5784	60	0·11	2·97	From West New Shaft.
S25	5786	60	0·02	0·54	From East New Shaft.
S30	5791	42	0·06	1·62	From Shaft B.
S31	5792	18	0·04	1·08	From Shaft B.
S32	5793	48	0·12	3·24	From West New Shaft (Part of S23 section).
S33	5794	60	0·02	0·54	From East New Shaft.
S34	5795	60	0·02	0·54	From East New Shaft.
S35	5796	72	0·02	0·54	From East New Shaft.
S39	5800	69	0·11	2·97	From 32 ft. level drive.
S43	5804	38	0·22	5·94	From 32 ft. level drive.
S47	5808	31	0·07	1·89	From 32 ft. level drive.
S51	5812	61	0·21	5·67	From 32 ft. level drive.
S55	5816	60	0·06	1·62	From 32 ft. level drive.
S59	5820	36	0·20	5·40	Face of X. cut off shaft E.
S60	5821	66	0·09	2·43	Face of X. cut 32 ft. level.
S62	5823	66	0·13	3·51	From 32 ft. level drive.
S78	5839	24	0·35	9·45	From 32 ft. level drive.
S81	5842	42	0·52	14·04	From 32 ft. level drive.
S91	5852	68	0·43	11·61	32 ft. level, near Shaft B.
S92	5853	20	0·37	9·99	Auger hole in roof of drive.
S93	5854	18	0·06	1·62	Auger hole in roof od frive.
S94	5855	26	0·12	3·24	Auger hole in roof of drive
S95	5856	13	0·06	1·62	Auger hole in roof of drive.

No tantalum or niobium was detected in any of these samples

TABLE 10.

ASSAY RESULTS FROM SOUTHERN WORKINGS
(Assays made on dry ore).

Per cent. Sn. multiplied by 27 gives lbs. Sn. per c. yd.

Group.	Samples in group.	Lab. No.	Sn. per cent.	Sn. lbs. per c. yd.	Locality.
A.	(S99, S100, S101, S102, S104)	6285	0·13	3·51	From Police Shaft workings.
B.	(S105, S106, S107, S108, S109, S110)	6286	0·35	9·45	From Police Shaft workings.
C.	(S114, S115, S116, S117)	6287	0·09	2·45	From Shaft X. workings.

No tantalum or niobium was detected in any of these samples.

TABLE 11.

ASSAY RESULTS FROM SOUTHERN WORKINGS.
(Assays made on dry ore).

Per cent. Sn. multiplied by 27 gives lbs. Sn. per c. yd.

Field No.	Lab. No.	Sample Width. Inches.	Sn. per cent.	Sn. lbs per c. yd.	Locality.
S97	5858	58	0·10	2·70	From Police Shaft.
S98	5859	61	0·09	2·43	From Police Shaft.
S99	5860	64	0·10	2·70	From Police Shaft.
S100	5861	60	0·05	1·35	West X. cut off Police Shaft.
S101	5862	60	0·05	1·35	West X. cut off Police Shaft.
S102	5863	60	0·07	1·89	West X. cut off Police Shaft.
S103	5864	36	0·13	3·51	West X. cut off Police Shaft.
S104	5865	60	0·27	7·29	East X. cut off Police Shaft.
S105	5866	60	0·16	4·32	East X. cut off Police Shaft.
S106	5867	60	0·20	5·40	East X. cut off Police Shaft.
S107	5868	60	0·19	5·13	East X. cut off Police Shaft.
S108	5869	60	0·41	11·07	East X. cut off Police Shaft.
S109	5870	60	0·30	8·10	East X. cut off Police Shaft.
S110	5871	60	0·16	4·32	East X. cut off Police Shaft.
S111	5872	40	0·17	4·59	East X. cut off Police Shaft.
S112	5873	73	0·18	4·86	From Shaft X.
S113	5874	74	0·10	2·70	From Shaft X.
S114	5875	74	0·10	2·70	From Shaft X.
S115	5876	60	0·09	2·43	West X. cut off Shaft X.
S116	5877	60	0·07	1·89	West X. cut off Shaft X.
S117	5878	48	0·05	1·35	West X. cut off Shaft X.
S118	5879	34	0·07	1·89	West X. cut off Shaft X.
S119	5880	36	0·18	4·86	East X. cut off Shaft X.

No tantalum or niobium was detected in these samples.

TABLE 12.

SOUTH WORKINGS, M.C. 47, GREENBUSHES.

Field No.	Assay value (.) % Sn.	Sample width. Inches.	Per Cent x inches.	Width Inches.	Av. Value. % Sn.	Av. Value. Lbs. Sn. per c. yd.	Av. Value. Lbs. SnO_2 per c. yd.
S97	0·10	58	5·80	...	...	...	...
S98	0·09	61	5·49	...	...	...	...
S99	0·10	64	6·40	...	...	...	...
Totals	...	183	17·69				
Grade of Lode in Police Shaft ...				61	0·09	2·43	3·06
S99	0·10	64	6·40	...	...	...	...
S100	0·05	60	3·00	...	...	...	...
S101	0·05	60	3·00	...	...	...	...
S102	0·07	60	4·20	...	...	...	...
S103	0·13	36	4·68	...	...	...	...
S104	0·27	60	16·20	...	...	...	...
S105	0·16	60	9·60	...	...	...	...
S106	0·20	60	12·00	...	...	...	...
S107	0·19	60	11·40	...	...	...	...
S108	0·41	60	24·60	...	...	...	...
S109	0·30	60	18·00	...	...	...	...
S110	0·16	60	9·60	...	...	...	...
S111	0·17	40	6·80	...	...	...	...
Totals	...	740	129·48	...	...	...	...
Grade in crosscuts off Police Shaft ...				740	0·17	4·59	5·78
S104	0·27	60	16·20	...	...	...	...
S105	0·16	60	9·60	...	...	...	...
S106	0·20	60	12·00	...	...	...	...
S107	0·19	60	11·40	...	...	...	...
S108	0·41	60	24·60	...	...	...	...
S109	0·30	60	18·00	...	...	...	...
S110	0·16	60	9·60	...	...	...	...
S111	0·17	40	6·80	...	...	...	...
Totals	...	460	108·20	...	...	...	...
Grade in E. crosscut off Police Shaft				460	0·23	6·21	7·82

TABLE 12—*continued.*

SOUTH WORKINGS, M.C. 47, GREENBUSHES—*continued.*

Field No.	Assay value (.) % Sn.	Sample width. Inches.	Per Cent. x inches.	Width Inches.	Av. Value. % Sn.	Av. Value. Lbs. Sn. per c. yd.	Av. Value. Lbs. SnO_2 per c. yd.
S112	0·18	73	12·14	...	...	...	...
S113	0·10	74	7·40	...	...	...	...
S114	0·10	74	7·40	...	...	...	...
Totals	...	221	26·94	...	...	...	...
Grade of Lode in Shaft X.	...			73·7	0·12	3·24	4·08
S114	0·10	74	7·40	...	...	...	...
S115	0·09	60	5·40	...	...	...	...
S116	0·07	60	4·20	...	...	...	...
S117	0·05	48	2·40	...	...	...	...
S118	0·07	34	2·38	...	...	...	...
S119	0·18	36	6·48	...	...	...	...
Totals	...	312	28·06	...	...	...	...
Grade in crosscut off Shaft X.	...			312	0·09	2·43	3·06

The weighted average value for the whole of the workings is 3.78 lbs. Sn per cubic yard, which is equivalent to 4.76 lbs. SnO_2 per cubic yard.

It is not unreasonable to assume that the recovery value for this class of lode material would represent 70 per cent. of the assay value, in which case the average values stated above will be reduced to the following figures.

Police Shaft .. .. .. = 2.1 lbs. SnO_2 per cubic yard.
Crosscuts off Police Shaft .. = 4.04 lbs. SnO_2 per „ „
East crosscut off Police Shaft = 5.47 lbs. SnO_2 per „ „
Shaft X .. .. .. = 2.85 lbs. SnO_2 per „ „
Crosscut off Shaft X .. = 2.1 lbs. SnO_2 per „ „
Workings as a whole .. .. = 2.64 lbs. SnO_2 per „ „

CONCLUSIONS.

Although a few small payable shoots probably occur in the northern workings, the lode material is generally too low grade, and the reserves too small, to warrant large scale development. The flat dip of the lodes is also a disadvantage, as cheap open cut mining methods could not be used.

Large scale development of the lode in the southern workings is also out of the question, but at least a portion of it could probably be worked on a small scale. The average recoverable value for the workings as a whole is only 2.64 lbs. SnO_2 per cubic yard, but the east crosscut off the Police Shaft (see plate VII) has an average recoverable value of 5.47 lbs. SnO_2 per cubic yard over a width of 38 feet four inches. It is possible that appreciable reserves with an average recoverable value of this order may occur along the footwall of the lode formation but further prospecting is necessary before this can be established. Crosscutting eastwards from Shaft X to the footwall of the lode formation is recommended, and in connection with this recommendation it is interesting to note that the highest assay result (S119), obtained in the crosscutting off Shaft X, was from the extreme eastern end.

VICINITY D.C. 95 AND M.C. 48.

Plates VIII, IX.

INTRODUCTION.

The area examined is located approximately one and a half miles south-southwest of Greenbushes, and is in the vicinity of late Three C's workings. Its position is shown on figure 10. Numerous shafts have been sunk in the area in the past, and it is reported that only the best portions of the "wash" were mined. The "wash" was treated at the Bunbury End State Battery.

In examining this area the writer's instructions were:—

(i) To locate and sample the old shafts, taking channel samples where these could be obtained. If the shafts had fallen in or were, for any reason inaccessible, samples were to be taken from the dumps.

(ii) To set out a boring grid.

The field work was done during June, 1943. Later a selected number of concentrates were submitted for mineral examination and also for assay.

PREVIOUS WORK.

In the early days of the Field many shafts were sunk in the area under consideration. These varied in depth from 10 feet to 35 feet, and were sunk until the "wash" was reached. The richest portions of this were mined and carted to the State Battery at Bunbury End. There is now no record of the quantity of tin produced, but the writer was told that the area was worked for from 12 to 15 years.

In 1936 nine bores were put down by the Mines Department in search of deep leads (Forman, 1937, pp. 11 to 15). Six of these bores (Battler's Hope line) were located in the north-west corner of the

area under consideration and the remaining three (Phoenix East line) in the south-east corner (plate VIII). The bores varied in depth from 82 feet to 108 feet. Values rarely exceeded a trace of SnO_2 per cubic yard, the maximum value being 1.35 lbs. in Battler's Hope bore No. 6 at 31 feet to 36 feet.

During 1941, a number of shallow bores were put down by a Mr. Jamieson for a Perth syndicate.

GENERAL GEOLOGY.

The surface of the area being considered is covered with either sand or laterite. Shaft sinking and boring has shown that the sandy areas are underlain by laterite at varying depths up to a maximum of six feet. The laterite may be either solid, or loose and rubbly so that it can be readily broken with a pick. The average thickness of the laterite or laterite and sand is approximately six feet. Shaft sinking and boring have also shown that the area is underlain by a series of horizontal sands, clays, pebble and boulder beds having a maximum thickness of approximately 100 feet. These beds have been deposited on a basement of greenstones, mica schists and granitic rocks. The sands, clays, pebble and boulder beds are believed to be portion of the Old Alluvium.

The deep bores put down in 1936 (Forman, 1937, pp. 11-15) passed through from 58 feet (?) to 103 feet (?) of Old Alluvium before entering basement. The depths at which the various bores entered basement rocks are given below:—

Battler's Hope line—

No. 1.—88 feet—mica schist.

No. 2.—83 feet—mica schist.

No. 3.—63 feet?—mica schist (?) at 63 feet and granite at 79 feet.

No. 4.—75 feet—granite.

No. 5.—72 feet—granite.

No. 6.—81 feet?—mica schist (?) at 81 feet and granite at 98 feet.

Phoenix East line—

No. 1.—78 feet—greenstone.

No. 2.—103 feet?—granite.

No. 3.—69 feet?—granite.

The logs of the Battler's Hope line of bores show that these after passing through from 4 feet to 9 feet 6 inches of surface sand and laterite entered a clayey zone, which extended to depths of from 43 feet to 78 feet. In the two most southerly bores, numbers 4 and

6, sandy horizons, which appear to correspond with the horizon worked in the vicinity of D.C. 95, were encountered in this zone, at depths given below.

Bore No.	Depth in feet.	Lbs. SnO_2 per cubic yard.	Material.
4	22—27	·02	Fine white sand.
6	21—26	·003	Fine grained sand.
...	26—31	·001	Ferruginous sand.
...	31—36	1·35	Coarse grained sand containing tourmaline to 35 feet and thence into clay.

Thus the sandy horizon is 14 feet thick in bore number 6, 5 feet thick in bore number 4, and has lensed out before the other bores have been reached. Below the clayey zone all bores entered a zone, consisting of sands and pebble and boulder beds, which extended to basement.

The Phoenix East bores passed through from 5 to 18 feet of surface sand and laterite, and then entered a clayey zone, which extended to depths varying from 29 to 51 feet. Below this the bores entered a sand and "wash" zone, which extended to basement. The horizon worked by shafts in the vicinity of D.C. 95 apparently comes to the surface in the shallow workings close to the north-east corner of D.C. 29, and is not found in the Phoenix East bores.

Most of the shafts in the vicinity of D.C. 95 have bottomed on a blue-grey clay, which is apparently portion of the clayey zone found in the deep bores. This is the only place in Field, known to the writer, where there is a false bottom in any workings.

THE PRESENT WORK.

The location of all the shafts is shown on plate VIII. Quite a number of these shafts have completely fallen in, while others have been only slightly filled in by material fallen from close to the surface or by collapse towards the bottom of the shaft. Whenever the present depth appeared to approximate to the original depth it was measured and is recorded on plate VIII. Thus the recorded depth will, for the most part, be on the shallow side. The depths so obtained varied from seven to 31 feet, with an average of about 15 feet.

Those shafts, from which samples were obtained, are shown solid black. The samples were, for the most part, obtained from the dumps with a post hole digger. Channel samples were obtained from some of the shafts and the results are shown on plate IX. The volumes

TABLE 13.

MINERAL CONTENTS (MAINLY THE NON-OPAQUE MINERALS) OF SOME TIN CONCENTRATES FROM D.C. 95 AND M.C. 48.

	Tourmaline.	Rutile.	Zircon.	Staurolite.	Kyanite.	Gahnite.	Quartz.	Magnetite.	Andalusite.	Epidote.	Garnet (Pink).	Garnet (Yellow).	Yellow isotropic mineral.	Yellow rutile or brookite.	Perovskite.	Ilmenite.
18D, 8′—12′	P	P	P	P	P	P	...	...	...	...	...	...	...	...	...	...
20g, 17′—18′	...	P	P	P	P	P	...	P	...	...	P	P?	...	...	...	...
23K, 10′ 6″—11′ 6″	...	P	P	P	P—	P—	...	...	...	...	...	...	...	...	...	...
11′ 6″—16′	...	P	P	P	P?	...	...	P	...	...	...	...	...	...	...	...
24F, 0′—10′	P	P	P	P	P?	...	...	P	P?	...	...	P?	...	...	P—	...
24M, 6′—8′	P	P	P	P	P—	P+	P	...	...	...	...	...	...	...	...	...
36 (wash)	P	P	P	P	P	P	P	...	...	P?	...	...	...	...	...	...
39 (wash)	P	P	P	P+	P+	P	P	P	...	...	...	...	...	...	...	P
40 (wash)	...	P	P	P	P—	P—	...	...	P—	...	...	...	...	...	...	...
1A (wash)	...	P	P	P	P—	P—	...	...	...	...	...	...	P	...	...	...
19Q (wash)	P	P	P	P	P	P+	P	P	...	...	...	P+	...	...	...	...
14P (headings)	P	P	P	P	P	P	P	P—	...	...	...	...	P	...	...	...
17A	P?	P	P+	P	P	P	P	...	...	...	...	...	...	...	...	...
18B	...	P	P	P	P	P	...	P	...	...	...	...	...	...	...	...
18E	...	P	P	P	P	P	...	P	...	...	...	...	...	...	...	...
24C	...	P	P	P	P—	P—	...	P	...	...	...	...	...	...	...	...
25H (wash)	P	P	P	P	...	P	P	P	...	...	...	...	P	...	...	...
10F	P	P	P	P	P	P	P	P+	...	...	...	...	P—	...	...	...
20g, 5′—10′	P	P	P	P	P	P	...	...	...	...	P+	...	...	P	...	...
10′—15′	...	P	P	P	P	...	...	P	...	...	P	...	...	...	...	...
22D (wash)	P	P	P	P	...	P	P	P	...	...	...	...	...	...	...	...

of the samples were measured and the samples panned. The concentrates, so obtained, were dried and weighed. These concentrates, varied from fine to medium grained and contained, in addition to cassiterite, a number of other minerals. Some of the concentrates appeared fairly clean, while others contained appreciable quantities of minerals other than cassiterite. Subsequently 21 selected concentrates were submitted for mineral examination and assay.

The principal non opaque minerals were found by Dr. Miles to be tourmaline, rutile, zircon, staurolite, kyanite, gahnite, while quartz, andalusite, epidote, garnet, brookite (?) and perovskite were also present. Magnetite was noted in most of the concentrates and ilmenite in one. The results are summarised in table 13.

Assay results showed that even those concentrates which appeared clean, contained appreciable quantities of minerals other than cassiterite—probably mainly ilmenite. All sample results are set out in table 14, while the localities are shown on plate VIII.

Immediately below the surface sand and laterite, in most of the shafts examined, there was a fine to medium grained clayey sand, which was generally partly consolidated by ferruginous solutions, presumably during the formation of the laterite. One shaft, 14E, had been sunk in a friable sand, while in two others, 24F and 24M, a clayey grit was encountered. All samples taken from above the "wash" softened in water and could be quite readily washed. Thin pebble beds, from 2 to 6 inches thick, were seen in some of the shafts above the main "wash," while in one shaft. 23K, there was a pebble bed 1 foot thick and containing 20 lbs. of concentrates per yard (6.9 lbs SnO_2).

The wash, where seen, consisted of either pebbles or boulders up to 6 inches in diameter with a clayey matrix. It varied in thickness from 1 foot to something over 4 feet (18D). It was generally unconsolidated, but a sample from one shaft 20G, had to be dollied before washing.

TABLE 14.

RESULTS OF SAMPLING—D.C. 95, M.C. 48.

Sample Number.	Depth.	Laboratory number.	Nearest point on boring grid.	Lbs. concentrates per cubic yard.	Assay Sn. %	Lbs. SnO_2 per cubic yard (calculated).	Notes.
1A (wash) ...	...	9165	I7	10·9	26·66	3·7	
1B	...	...	I7	Tr.	...	...	
1C	...	...	J6	1·6	...	...	
1D	...	...	J6	1·2	...	...	
9A	0′—5′	...	E8	2·3	...	...	
9B	0′—5′	...	E8	1·2	...	...	
9C	0′—2′	...	E9	1·7	...	...	
10A	0′—7′	...	E0	1·3	...	...	
10B	0′—6′	...	D0	2·4	...	...	
10C (wash) ...	...	...	D0	1·1	...	...	
10D	0′—5′	...	D0	1·6	...	...	
10E	0′—2′	...	C6	3·2	...	...	
10F	...	9173	B1	11·3	2·42	0·4	
10G	0′—3′	...	E0	2·0	...	...	
10H	0′—5′	...	E0	1·6	...	...	
10I	0′—2′	...	F0	3·2	...	...	
13A	0′—5′	...	D9	1·2	...	...	
13B	...	...	D9	Tr.	...	...	
14C	...	...	I12	1·2	...	...	
14E	...	...	H11	2·9	...	...	
14G	...	...	H12	2·3	...	...	
14I	...	...	H11	Tr.	...	...	
14J	...	...	H10	1·0	...	...	
14L	...	...	H10	3·6	...	...	
14H	...	...	H10	1·6	...	...	

14P	...	...	H10	0·8	...	...	
14P (wash) ...	...	9167	H10	14·8	40·97	7·7	Small amount of tantalite or columbite in concentrates.
14Q	...	...	H10	2·4	...	...	
14R	0′—5′	...	G11	Tr.	...	...	
	5′—9′	...	G11	Nil	...	...	
	9′—11′	...	G11	Nil	...	...	
15C	...	...	J11	1·9	...	...	
15I	...	...	K10	0·5	...	...	
15K	...	...	K9	0·6	...	...	
15U	...	...	J10	0·5	...	...	
15Z	...	...	J9	Tr.	...	...	
16E	...	...	J13	6·7	...	...	
16H	...	...	I13	2·4	...	...	
17A	...	9168	I11	13·2	7·17	1·2	
17I	...	...	I11	2·5	...	...	
18A (dump) ...	...	...	G13	0·5	...	...	
18A (wash) ...	...	...	G13	6·6 ?	...	...	
18B	...	9169	H13	10·8	2·72	0·4	
18D	5′—8′	...	H13	1·3	...	...	0′—5′ laterite.
18D	8′—12′	9156	H13	37·2 ?	3·34	1·6	Small amount of tantalite or columbite in concentrates.
18E	...	9170	H14	12·1	13·73	2·1	
19A	...	...	I9	1·3	...	...	
19D	...	...	I9	0·8	...	...	
19E (dump) ...	...	...	H9	3·1	...	...	
19E (wash) ...	...	...	H9	6·0	...	...	
19H	...	...	H8	0·9	...	...	
19I	...	...	I8	3·6			
19N	5′—10′	...	I8	1·3	...	...	0′—5′ laterite.
19N	10′—13′	...	I8	0·9	...	...	
19N (dump) ...	...	...	I8	0·9	...	...	
19Q (wash) ...	...	9166	I8	16·1	29·18	6·0	
19V	...	...	J8	1·5	...	...	
19Z	...	...	J9	1·3	...	...	

TABLE 14—*continued.*

Sample Number.	Depth.	Laboratory number.	Nearest point on boring grid.	Lbs. concentrates per cubic yard.	Assay Sn. %	Lbs. SnO_2 per cubic yard (calculated).	Notes.
20D	...	...	K11	1·3	...	...	
20J	...	...	L10	Tr.	...	...	
20Q	...	...	L11	1·0	...	...	
20W	...	...	M11	Tr.	...	...	
20g	5′—10′	9174	L12	7·0 ?	5·17	0·5	
20g	10′—15′	9175	L12	8·9 ?	2·15	0·2	
20g	15′—17′	...	L12	0·7	...	...	
20g	17′—18′	9157	L12	12·4	27·46	4·3	
20J	...	...	K12	3·2 ?	...	...	
20I	...	...	K11	0·8 ?	...	...	
21A	...	...	K8	1·0	...	...	
21B	...	...	K8	1·7 ?	...	...	
21C	...	...	J8	0·8	...	...	
21I	...	...	J9	0·9	...	...	
21J	4′—9′	...	J9	1·5	...	...	
21J	9′—12′ 6″	...	J9	0·9	...	...	
21J (dump) ...	...	...	J9	2·7	...	...	
22D	...	9176	M12	7·4	2·71	0·2	
23D	...	...	J12	4·4	...	...	
23F	...	...	J12	2·7	...	...	
23H	...	...	J12	1·3	...	...	
23K	4′ 6″—10′ 6″	...	K13	1·0	...	...	0′—4′ 6″, laterite.
23K	10′ 6″—11′ 6″	9158	K13	24·9	21·96	6·9	Approximately 10% of concentrates lost in transit between Geological Survey and Chemical Laboratory.
23K	11′ 6″—16′	9159	K13	5·2	3·26	0·2	

24C	...	9171	J14	9·8	16·63	2·1	
24D ...	...	...	K14	2·7	...	...	
24F	0′—10′	9160	J15	2·1	10·35	0·3	
24F (dump) ...	...	...	J15	3·2	...	...	
24G	...	...	J15	1·3	...	...	
24M	0′—6′	...	J15	1·3	...	...	
24M	6′—8′	9161	J15	14·9	42·28	8·0	
24M (dump) ...	...	...	J15	1·7	...	...	
24N (wash) ...	...	...	J15	12·9	...	...	
24P	...	...	J15	1·5	...	...	
25A	...	...	K16	2·4	...	...	
25B	...	...	K15	4·7	...	...	
25H	...	9172	K16	10·9	49·31	6·8	
25I	...	...	K16	1·3	...	...	
25L	...	...	K15	4·6	...	...	
26A	...	...	M10	2·3	...	...	
26B	...	...	M10	2·3	...	...	
26C	...	...	M10	2·8	...	...	
26D	...	...	M11	1·7	...	...	
27	0′—3′	...	N9	2·0	...	...	
28	0′—2′ 6″	...	O9	2·9	...	...	
29	0′—4′ 6″	...	M6	1·8	...	...	
30	0′—5′	...	L0	0·9	...	...	
31	0′—4′	...	L1	1·0	...	...	
32	0′—4′	...	M1	1·3	...	...	
33	...	...	N0	1·5	...	...	Sample taken over 4′, side of open cut.
34	...	...	A17	Tr.	...	...	
35	0′—6′	...	A18	Tr.	...	...	
35	7′—13′	...	A18	Nil	...	...	
36 (wash) ...	...	9162	B17	15·7	50·8	10·0	Approximately 10% tantalite in the concentrates.
37	0′—4′	...	C17	Tr.	...	...	
37	4′—12′	...	C17	Tr.	...	...	
38	...	...	D5	Tr.	...	...	
39 (wash) ...	...	9163	D5	27·3 ?	18·42	6·4	Small amount of tantalite or columbite in concentrates.

TABLE 14—*continued.*

Sample Number.	Depth.	Laboratory number.	Nearest point on boring grid.	Lbs. concentrates per cubic yard.	Assay Sn. %	Lbs. SnO_2 per cubic yard (calculated).	Notes.
40 (wash) ...	...	9164	E4	20·2	19·19	4·9	Approximately 15% of concentrates lost in transit between Geological Survey and Chemical Laboratory.
40 (dump) ...	...	...	E4	Tr.	...	...	
41	0′—4′	...	H0	Tr.	...	...	
41	4′—8′	...	H0	Tr.	...	...	

(i) All samples qualitatively examined for tantalum and niobium. None detected except where noted.
(ii) Tin assays and qualitative examination for Ta and Nb by Government Chemical Laboratory.
(iii) Portions of the concentrates were spilled from their containers in transit from the Geological Survey to the Chemical Laboratory. Although there was a small loss from each of the concentrates a comparison of the weights of concentrates as received at the Laboratory with field weights showed that the loss was negligible except for samples 23K, 10′ 6″—11′ 6″ (loss 10%) and 40 (loss 15%). Assay results for these two samples are therefore only approximate.

TABLE 15.

CONCENTRATES ASSAYED GROUPED ACCORDING TO WORKINGS AND MATERIAL SAMPLED.

Workings.	Material sampled.	Sample number and depth.	Lbs. concentrates per cubic yard.	Assay Sn %	Lbs. SnO_2 per cubic yard (calculated.)
Group 1—Vicinity of the N.E. corner of M.C. 48	"Wash" from remnants in ore paddocks or near shafts	36	15·7	50·18	10
		39	27·3?	18·42	6·4
		40	20·2	19·19	4·9
Group 2—Vicinity D.C. 95 and west side of M.C. 48	Overburden in situ	20g, 5′—10′	7·0?	5·17	0·5
		20g, 10′—15′	8·9?	2·15	0·2
		24F, 0′—10′	2·1	10·35	0·3
		23K, 11′ 6″—16′	5·2	3·26	0·2
	"Wash" in situ	18D, 8′—12′	37·2?	3·34	1·6
		20g, 17′—18′	12·4	27·46	4·3
		23K, 10′ 6″—11′ 6″	24·9	21·96	6·9
		24M, 6′—8′	14·9	42·28	8·0
	"Wash" from remnants in ore paddocks or near shafts	1A	10·9	26·66	3·7
		14P	14·8	40·97	7·7
		19Q	16·1	29·18	6·0
		25H	10·9	49·31	6·8
	Samples from main dumps	10F	11·3	2·42	0·4
		17A	13·2	7·17	1·2
		18A	10·8	2·72	0·4
		18E	12·1	13·73	2·1
		22D	7·4	2·71	0·2
		24C	9·8	16·63	2·1

Even in the shafts now accessible "bottom" could not always be seen. It is reported that most of the shafts bottomed on a clay. A blue-grey clay was seen by the writer on the tops of many of the dumps and it is probable that most of the shafts have bottomed on this blue-grey clay. It was seen *in situ* in two shafts—14R and a shaft between A18 and B18 (refer to boring grid.) Not all the shafts bottomed on blue-grey clay. Immediately under the wash in shaft 24M there is a very weathered granite. Weathered granite was also seen in the dump of the shaft at L12 (boring grid). The shafts in the vicinity of the north-east corner of M.C. 48 went through a blue-grey clay and eventually bottomed on a greenstone. These shafts differ from those on the west side of the road in that the "wash" apparently occurs below a layer of blue grey clay. The depth to this "wash" or to the greenstone is not known as these shafts have all partly or wholly fallen in. Judging by the dumps it seems likely that the depth to the "wash" was 20 to 25 feet. Samples taken from small heaps of "wash" found at the surface (36, 39, 40) gave high values, but all remaining samples taken in this vicinity from dumps or accessible portions of shafts gave values of less than ½ lb. per cubic yard.

The assay results show that all the concentrates submitted for assay contain appreciable quantities of minerals other than cassiterite. Subsequently a number of the concentrates not submitted for assay were examined by the writer using the zinc dish test for cassiterite. It was found that the concentrates from the shallow sand workings contained a high percentage of cassiterite, while those from elsewhere contained a big proportion of minerals, usually fine grained, which were not cassiterite. It was not considered necessary to submit all samples for assay as many of the samples were taken from dumps and the work done was only of a preliminary nature.

In table 15 those concentrates, which have been assayed, are grouped together according to the workings and material sampled. When considering these results it must be remembered that only a few samples were taken *in situ* and that some of the shafts sampled are on the margin of the area worked.

POSSIBILITIES OF AREA.

The workings fall into two groups—those close to the north-east corner of M.C. 48 and those west of the road. Each of these two groups will be considered separately.

Working close to the north-east corner of M.C. 48.

The available information regarding these workings is summarised below:—

(i) The shafts have been sunk through a blue grey clay into a "wash" and have bottomed, at depths of probably 20 to 25 feet, on greenstone.

(ii) The "wash" was not seen *in situ* and no information is available regarding its thickness. Samples from remnants of the wash found near old shafts assayed from 4.9 lbs to 10 lbs. SnO_2 per cubic yard. The concentrates from one of these samples (36) contained approximately 10 per cent. tantalite, while concentrates from a second sample (39) contained a small amount of tantalite or columbite.

(iii) Samples from the dumps and the overburden all contained less than ½ lb. concentrates per cubic yard.

(iv) Only a few shafts have been sunk in this vicinity.

It is evident that the possibilities of the area depend entirely on the thickness of the wash and its values. These could readily be determined by sinking a few shafts.

Workings west of the road.

The principal workings west of the road are those in the vicinity of D.C. 95 and the S.W. corner of M.C. 48. It is to be understood that the sluicing cuts on D.C. 29, D.C. 18, M.L. 529, and D.C. 35 are not being considered.

The available information regarding the old shafts on and near D.C. 95 is summarised below—

(i) Numerous shafts have been sunk to depths varying from a few feet to approximately 30 feet. While most of these shafts have bottomed on a blue sedimentary clay a few have bottomed on granite. The clay has been shown by boring to be portion of a zone varying in thickness from 20 to 70 feet. No values have been found below the clay zone.

(ii) The concentrates submitted for assay contained a big proportion of minerals other than cassiterite. Examination of some of the other concentrates with a zinc dish indicated that they also contain appreciable quantities of minerals other than cassiterite.

(iii) The overburden, where sampled *in situ,* contained up to ½ lb. SnO_2 per cubic yard.

(iv) The "wash," where sampled *in situ* contained 1.6 lbs. to 8 lbs. SnO_2 per cubic yard.

(v) Samples of the "wash" from ore paddocks or small heaps near the old shafts contained 3.7 to 7.7 lbs. SnO_2 per cubic yard.

(vi) Samples from the main dumps contained 0.4 lbs. to 2.1 lbs. SnO_2 per cubic yard.

(vii) The best of the "wash" has been removed in the early days of the Field.

Here again the possibilities of the area can only be assessed by shaft sinking or drilling. A few preliminary shafts would soon indicate the possibilities of the area, which could then be proved by systematic shaft sinking or boring. Present indications are that the possibilities of the area depend upon the thickness and value of the "wash" and how much of it has not been removed.

The concentrates from the shallow sand workings are much cleaner than those from the shafts. None have been assayed, but examination of some of the concentrates in a zinc dish showed that cassiterite was the principal mineral present. It is reported that values up to 3 lbs. per cubic yard have been found by boring below the laterite in the shallow workings close to the centre of the north boundary of M.C. 48.

BORING GRID.

A boring grid has been set out as indicated on plate VIII, with the lines spaced at intervals of two chains. The bore sites have been marked on the ground by posts from two to three feet high and from two to three inches in diameter. The co-ordinates of each post are clearly marked on it in red paint. No boring has been done.

PRELIMINARY SAMPLING AT VARIOUS LOCALITIES.

Plate III and Figure 10.

INTRODUCTION.

At the conclusion of the work on D.C. 95 and M.C. 48 (pp. 119-123) the writer was instructed to carry out preliminary sampling at any locality likely to give favourable results. The localities examined were selected by the writer and Mr. R. S. Matheson. The writer's instructions were to take channel samples in any accessible shafts or workings and samples from the dumps of other shafts. The dump samples were taken with a four inch post hole digger, which was also used to sample shallow sand deposits. It must be clearly understood that neither money nor equipment was available for shaft sinking, pit sinking or drilling.

The following areas were examined:—

Area south of Westralian Gully.

Area at the head of Westralian Gully and extending north-west to D.C. 94.

Dredging Claim 90.

Area of Old Alluvium, east of the main Greenbushes-Bridgetown road and extending from Floyd's Gully to beyond the South Greenbushes Townsite.

Paperbark Swamp.

Area in the vicinity of the south boundary of location 290.

Location 9948, at the head of Boronia Gully.

Other areas.

Each area will be described in turn and full details of the samples taken given. The values referred to in this report are lbs. concentrate per cubic yard. The concentrates were obtained by panning and no assays have been made. No attempt was made to systematically sample any one of these areas, and in all only three weeks was spent on this work.

AREA SOUTH OF WESTRALIAN GULLY.

This area is covered with a sandy soil and the usual Greenbushes vegetation i.e., mainly jarrah and red gum. In part it is swampy and ferns are thick. In the swampy parts big trees are absent.

A number of holes were put down with a post hole digger. Except for G 6 these all bottomed on laterite at depths up to 5 feet. Water level in G 6 was 7 feet, but below this depth to 10 feet there was sufficient clay present to make the hole stand up. Ten chains west of G 7 the laterite contained rounded quartz boulders and the dump of a nearby shaft consisted entirely, so far as could be seen, of weathered mica schist.

Not more than a trace of cassiterite was found in any of these samples. The alluvium could not be tested below the laterite.

Details regarding the samples taken are set out in table 16.

Conclusions.—The sand overlying the laterite in this area contains practically no tin. No information is available regarding the alluvium below the laterite.

TABLE 16.

SAMPLE INFORMATION FOR AN AREA SOUTH OF WESTRALIAN GULLY

Sample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yd.	Notes on concentrate.
G1— 0′ to 5′	A clayey sand, with some gravel boulders. Stopped on laterite at 5 ft.	Nil	...
G2—0′ to 2′	Sand. Stopped on laterite	Tr.	...
G3—0′ to 2′ 6″	Sand. Stopped on laterite	Nil	...
G4—0′ to 4′	Coarse sand with some tourmaline at 3′ to 4′	Tr.	...
3′ to 4′	Separate sample taken	Tr.	...
G5—0′ to 2′	Sand with some boulders	Tr.	...
2′ to 3′	Sand	Nil	...
G6—0′ to 5′	Sand	Tr.	...
5′ to 10′	Sand, but clayey below 5 feet. Water at 7 feet, but the hole stood up reasonably well to 10 feet		
G7—0′ to 2′	Sand, stopped on laterite at 2 feet	Tr.	...

AREA AT THE HEAD OF WESTRALIAN GULLY AND EXTENDING NORTH-WEST TO D.C. 94.

The material at the surface at the head of Westralian Gully is a sand, which going south extends to the area considered above. Going north the sand extends to about the north boundary of E.A.C. 960. It also extends in an east-north-east direction towards Elliot's Gully. The workings about the east end of D.C. 94 and also those immediately north of the north-east corner of E.A.C. 960 are shallow pits in rubbly laterite, which contains "wash" boulders. On D.C. 94, E.A.C. 961, and C 876 there are old sluicing cuts. That on C 876 is full of water, but the bottoms of the other cuts can be seen. Both appeared to have bottomed on a very weathered greenstone.

In about the centre of E.A.C. 960 there is a shallow sand cut, which bottoms on laterite, and which was worked very recently by Prospector Wilkes. Along the north boundary of E.A.C. 960 there are old shallow workings. The sand hereabouts, which is quite coarse, appears to have been worked over, but nevertheless one sample, G. 54, indicated values of 1 lb. per cubic yard. All the samples taken from the vicinity of E.A.C. 960 and also extending north-east and north-west gave values of about 1 lb. per yard over depths varying from 9 inches to 4 feet.

Further south towards Westralian Gully values in the surface sand drop away to a ½ lb. per cubic yard. In addition to shallow sand samples two samples, G. 13 and G. 14, were taken from small heaps of wash close to two shafts, which have now completely fallen in. Both of these wash samples contained only ½ lb. per cubic yard. In 1942 the writer was shown a square pit sunk in Westralian Gully to a depth of about 8 feet. It was full of water, but near the side of the pit was a small heap of wash boulders. A sample taken from this contained only a trace of tin. These results do not encourage further prospecting in Westralian Gully.

Full details regarding the samples taken are given in table 17.

The shallow laterite working north of the north-east corner of E.A.C. 960 (samples G.8, G.9, and G.10) all bottom on a clay, which is, in all probability, a very weathered greenstone.

Conclusions.—There appears to be an area of sand and rubbly laterite, with a depth of up to four feet, in the vicinity of E.A.C 960, which contains one lb. per yard. No systematic sampling of this area was done.

On the western side of the area there are a number of comparatively small sluicing cuts. Prospecting might reveal additional areas, which could be sluiced.

No encouragement was obtained for additional prospecting in Westralian Gully.

TABLE 17.

SAMPLE INFORMATION FOR AN AREA EXTENDING FROM THE HEAD OF WESTRALIAN GULLY NORTHWEST TO D.C. 94.

Sample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yard.	Notes on concentrates.
G8—0′ to 2′	From the side of a shallow cut with a clay bottom. Laterite and rounded quartz boulders	1	...
G9—0′ to 3′	As for G8, but from another cut	1	...
G10—0′ to 3′	Face of shallow cut in rubbly laterite	1½	...
G11—0′ to 4′	North face of Wilkie's sand cut. Bottomed on laterite	1	...
G12—0′ to 3′	East face of Wilke's sand cut. Bottom laterite	1	...
G13—0′ to 5′	Sand, water at 5 feet)	½	...
5′ to 6′	Sand, water at 5 feet)		
Wash	From the dump of a nearby shaft, now fallen in. Three shafts hereabouts, 2 with only sand in main dumps and the third with clay in the main dump.	½?	This concentrate contains a number of medium sized fragments of a black mineral which is not cassiterite
G14—Wash	Wash from small dump	½	...
G15—0′ to 5′	Sand	½	...
G16—0′ to 4′	Head of the old sand workings leading down to Westralian Gully	1	...
G17—0′ to 5′	Sand	Tr.	...
5′ to 7′ 6″ ...	Sand	¼	...
G33—0′ to 2′ 6″ ...	Sand from the side of a shallow cut	¼	...
G34—0′ to 4′	Face of a shallow sand cut	1	...
G53—0′ to 2′ 6″ ...	From a patch of unworked sand	1	...

TABLE 17—*continued.*

SAMPLE INFORMATION FOR AN AREA EXTENDING FROM THE HEAD OF WESTRALIAN GULLY NORTH-WEST TO D.C. 94—*continued.*

Sample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yard.	Notes on concentrates.
G54—0′ to 5′	Coarse sand, from a place which appears to have been worked before	1	...
G55—0″ to 9″	Sand not previously worked	1½	...
G58—0′ to 4′	Wash boulders, sand and laterite rubble	2	Clean medium grained concentrate
G59	Sand and wash boulders from a dump of a shallow pit ...	2½	Some sand in concentrate
G60—0″ to 12″ ...	Clay and rubbly laterite, with some boulders. Face of shallow cut	1	...
G61—0′ to 4′	Clayey sand from side of shallow cut	1)	Fine grained concentrates
4′ to 6′	Wash	6)	

DREDGING CLAIM 90.

This area was examined by Mr. Matheson in 1942 during the course of his plane table mapping. A report has been prepared (p. 176), which not only summarises his own observations, but also includes information from previous reports. The present notes are intended to summarise only the writer's observations, made during a preliminary sampling campaign in 1943.

Most of the work on this claim was done prior to 1908, and very little information regarding the depth of the "wash," the thickness of the "wash," the values in the "wash," or material through which the numerous shafts were sunk, is available. Only a few of the older men now at Greenbushes have any knowledge of work done in this area. One of these, Mr. J. McKay, gave the writer the information which is summarised below.

According to Mr. McKay there were originally four claims in this area—Hard Graft, Elliot's Claim, Nutall's Claim and the Little Wonder.

Hard Graft.—These old workings extended from Keyser's Cut to about the track, which crosses D.C. 90 in north-easterly south-westerly direction. It is reported that the depth to the "wash" was 40 feet and that the "wash" varied in thickness from one foot to three feet. It was sometimes cemented. Values up to one cwt. per yard are reported. The newer shafts, on the east side of the group of workings, were sunk later and values are reported to have been lower. In addition to the main "wash" at the bottom of the shafts it is reported that the shafts passed through an upper "wash." Other than this upper "wash" the material through which the shafts were sunk, is reported to have contained no tin.

Elliot's Claim.—This claim extended westward from the Hard Graft to about the locality of sample G 27. The depth to the "wash" is reported to have been generally 40 to 45 feet, but to have reached 50 feet in one shaft. The thickness of the "wash" varied from one to five feet, although this latter thickness was exceptional and occurred in only one shaft. Values were high and varied from one cwt. per yard to three-and-a-half cwts. per yard. This last value was exceptional and occurred at the east end of the claim.

Nutall's Claim.—This claim extended westward from Elliot's claim to the end of the workings. It is reported that the depth of the "wash" was 20 to 25 feet and that the thickness of the "wash" was 18 inches to 2 feet. Shafts are not so numerous on this claim as on the two claims just referred to.

Mr. McKay is of the opinion that the "wash" has been practically completely removed on the old Hard Graft claim and on Elliot's claim, but that there are still patches of "wash" left on Nutall's claim.

The Little Wonder.—These old workings occupied the area later sluiced by Cole and all signs of the old workings disappeared during sluicing.

Details regarding the samples taken by the writer are set out in table 18 and the localities are shown on plate III.

Nearly all the old shafts have fallen in. Water level in those that have not is from 20 to 30 feet. Most of the dumps of the old shafts consist, so far as can be seen, of a very weathered greenstone. It was customary to drive in the weathered greenstone below the "wash" and to drop the "wash" down. In this way the material from the shaft was quickly covered up. Very few samples could therefore be obtained from the dumps. The writer was able to get down two of the more recent shafts at the east end of the lease (samples G 29, G 30). A band of grit, two feet three inches in thickness in one of these shafts gave a value of three lbs. of concentrate per yard, but all the remaining samples from these shafts gave very low values—½ lb. per yard or less. Samples taken from Keyser's Cut and from Cole's Cut also gave low values—½ lb. or less—for the overburden.

Of the remaining samples, taken from the sandy portions of dumps and presumed to represent at least some of the material through which the shafts were sunk, about half gave values varying from a trace to 1 lb. per yard, while the remaining half gave values of from 1½ lbs to 5 lbs. per yard. It may be that some of the shafts contain gritty bands similar to those in G. 30. It is impossible to draw any very definite conclusions from these results.

Some recent shafts in the vicinity of the plane table station (R.L. 868.5 feet.) between Keyser's Cut and Cole's Cut have been sunk entirely in a very weathered greenstone.

Cole's Cut bottoms on a white clay, which at one place is seen to contain small quartz veins, and is therefore believed to be a weathered greenstone. Similar material is seen in many of the dumps on D.C. 90.

Maitland (1900, pp. 19 to 20) inspected various shafts in Elliot's Gully during 1899, and noted that one of them bottomed at 42 feet on a decomposing clayey rock, which was traversed by a small quartz vein, while another bottomed at 50 feet on a decomposed clay slate with a vertical dip. Another was described as having bottomed on a "decomposing clayey rock probably a clay slate". The clayey rock occurred in all shafts immediately below the "wash."

The writer considers that there is little doubt that basement rock has been reached in the workings on D.C. 90.

Conclusions.—From the above it will be seen that the deepest ground is on Elliot's old claim, where a maximum depth of 50 feet was reached, and where the average depth is reported to have been from

TABLE 18.

SAMPLE INFORMATION FOR D.C. 90.

ample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yard.	Notes on concentrate.
G18—dump	Clayey sand. Small amount of tourmaline showing in dump	½?	Very fine grained concentrate, which may contain some ilmenite
G19—dump	Fine grained clayey sand	¾	Some coarse pieces SnO_2
wash	Sample taken from the ore paddock. "Wash" is a white clayey sand with some small pebbles and some tourmaline	7	Contains some sand and tourmaline
G20—dump	Clayey sand	1	
wash	Sample taken from ore paddock. "Wash" is clayey sand with some small pebbles See also G29	2½	Some pieces SnO_2 up to 0·2″ maximum diameter
G21—dump	Sand—shaft fallen in	1¾	Medium grained
G22—dump	Yellow sand	½	Fine grained
G23—dump	Yellow coarse grained sand	½	Very fine grained
ore paddock ...	From a very small heap of material	7½	Medium grained
G24—dump	Clayey sand	Tr.	...
G25—dump	Sand	3½	A clean concentrate, with a number of medium sized pieces of SnO_2
G26—dump	Sand	2½	Fine grained
G27—dump	Sand	5	A fine grained concentrate, check for ilmenite
G28—dump	Sand	1½	Contains some sand and a number of medium grained pieces SnO_2

TABLE 18—*continued.*

Sample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yard.	Notes on concentrate.
G29—0′ to 5′	Laterite—no sample	...	...
5′ to 10′ ...	Laterite, partly rubbly. At 9 feet into clayey sand ...	Nil	...
10′ to 15′ ...	Clayey sand, 1 foot of clay at 14 feet to 15 feet	Nil	...
15′ to 20′ ...	Sand, with some grit bands	½	...
20′ to 24′ ...	Coarse sand	Tr.	...
	Shaft fallen in below 24 feet. Samples G20 (dump and ore paddock) were taken from this shaft		
G30—0′ to 5′	Four feet of sand and laterite. Shaft boarded. Then 1 foot of sand. No sample	...	...
5′ to 10′ ...	Sand	Tr.	...
10′ to 15′ ...	Sand—less clayey and also coarser grained than in G29	½	Very fine grained concentrate
15′ to 17′ 3″ ...	Grit, with abundant tourmaline	3	...
17′ 3″ to 21′ ...	Coarse grained, current bedded sandstone. No sample. Water at 21 feet. Bottom of shaft at 34 feet	...	...
G31—0′ to 5′	Sand	½	...
5′ to 10′ ...	Sand and clayey grit	½	...
G32—"wash"	From a heap of "wash" in Keyser's Cut	3½	...
G56—0′ to 8′	Sand and rubbly laterite	Tr.	...
8′ to 14′ ...	White clayey sand	Tr.	...
G57—0′ to 7′	Rubbly laterite and sand—no sample	...	...
7′ to 10′ 6″ ...	Clayey sand	Tr.	...
10′ 6″ to 13′ 6″	"Wash," bottoms on a white clay	1	...

40 to 45 feet. The average depth on the Hard Graft claim is reported to have been 40 feet. On both of these claims much of the overburden contains no tin. In addition the "wash" has been very extensively worked by means of shafts, which have been sunk very close together. Mr. McKay, who worked in these shafts many years ago, considers that the "wash" has been almost entirely removed.

On Nutall's claim the ground is shallower and the shafts are not so close together.

Prospecting on Nutall's old claim by drilling might reveal an area which could be sluiced. The information outlined above does not encourage prospecting further to the east on Elliott's claim or on the Hard Craft.

It is considered that basement rocks have been reached in the old workings on D.C. 90.

AN AREA OF OLD ALLUVIUM EAST OF THE MAIN GREENBUSHES-BRIDGETOWN ROAD AND EXTENDING FROM FLOYD'S GULLY TO BEYOND THE SOUTH GREENBUSHES TOWNSITE.

Towards the south end of this area and in the vicinity of the southern end of the South Greenbushes Townsite there are some shallow scattered workings. The country hereabouts is covered with laterite, which frequently contains rounded quartz boulders. There are two small groups of workings, one on the eastern side of the alluvium and the other on the western side.

The eastern group of workings (samples G38 to G42) consists of a series of shallow pits up to two feet deep, some shallow shafts, and a series of prospecting pits. Rounded boulders occur in the laterite and in the dumps of many of the shallow pits. It appears probable that a small amount of material has been worked from the shallow pits, but that the remainder of the work was for prospecting purposes. Samples indicated values varying from a trace to 2½ lbs. per cubic yard.

The western group of workings (samples G43, G44) consists of a group of shallow pits, one of which measures about 1 chain by 1 chain. Some material has been worked from this pit and three samples were taken from it. The pit bottoms at 4 feet on clay. Values obtained vary from 1 lb. to 3 lbs. per cubic yard. Samples G43, 2 to 4 feet, and G44, 2 to 4 feet were both taken from the same bed of "wash" at distance of from 12 to 15 feet apart. The results show that there are rapid variations in the values in the "wash."

The alluvium extends away to the south-east, but appears not to have been worked and no samples were taken by the writer.

Going north-west there is a patch of alluvium in which no work has been done.

TABLE 19.

Sample number and depth.	Description of material sampled.	Lbs. concentrate per cubic yard.	Notes on concentrate
G38—dump	A clayey grit with wash boulders. Water at 6 feet in shaft. Same shaft as G42	Tr.	...
G39—dump	... ...	2	...
G40—dump	... ...	½	...
G41—dump	... ...	2½	...
G42—0′ to 1′	No sample	...	...
1′ to 6′	2 feet 6 inches of rubbly laterite and clay and thence into a clayey wash	Tr.	...
G43—0′ to 2′	Rubbly laterite, with wash boulders	3	...
2′ to 4′	Clayey "wash" Samples taken from east face of a shallow pit about 1 chain by 1 chain	2½	...
G44—0′ to 2′	No sample	...	...
2′ to 4′	Clayey "wash" From same pit as G43	1	...
G45—dump	Sand	3½	...
G46—0′ to 4′	Laterite—no sample	...	...
4′ to 5′ 6″ ...	Clayey "wash"	2½	...
G47—dump	Sand. A few "wash" boulders on dump	½	...
G48—dump	Sand	¾	...
G49—dump	Sand	Tr.	...
G50—dump	Sand. Boulders up to 6 inches to 8 inches thereabouts. Approximately 23 feet to wash	1	...
G51—0′ to 5′	Rubbly laterite, no sample	...	...
5′ to 11′ ...	Clayey sand	Tr.	...
11′ to 17′ ...	Sand	Tr.	...
17′ to 19′ ...	Cemented "wash." Into clay at 19 feet...	3½	...
G52—0′ to 6′ 6″ ...	Rubbly laterite, no sample	...	...
6′ 6″ to 8′ ...	"Wash" and clayey grit. Sample taken from shallow workings	2	...
G76—dump	Lode material in dump	2	Angular SnO_2 from a lode

The principal work has been in the vicinity of the north boundary of M.L. 90 and extending northwards to M.L. 552.

The alluvium is still shallow in the vicinity of the south corner of M.C. 34. Two to three chains east of this lease corner there are a number of shallow pits and workings up to 2 feet deep. At about 5 chains north of this lease corner the alluvium has deepened, and there are pits up to 6 to 8 feet in depth. The laterite hereabouts is 5 feet thick. The pits are all partly fallen in and the bottoms cannot be seen. Rounded boulders are showing in the dumps.

Five chains further north the top of old workings were seen in a partly collapsed shaft at a depth of 6 feet. Sample G45, taken from the dump, gave a value at 3½ lbs. per yard. A sample, G46, from 18 inches of "wash" was obtained from a nearby pit and gave a value of 2½ lbs. per yard.

Further north shafts are abundant and the ground deepens to 15 to 20 feet. The distribution of the shafts and the samples taken are shown on plate III. and figure 10. The writer has been able to get very little information regarding these workings. All workings are very old and, with one or two exeptions, inaccessible. Most of the dumps consist, so far as can be seen, of clayey material. The writer is of the opinion that this clayey material is a very weathered greenstone, indicating that basement has been reached in these workings. The remains of ferromagnesian minerals could be seen in the clayey material on some of the dumps, while at other dumps portions of clayey material were seen to contain thin bands of vein quartz. Evidently a considerable amount of driving has been done in the basement rocks and the material removed from the shafts has been covered.

The average depth of the shafts, where this could be seen was approximately 20 feet, except at the extreme north end of the patch of workings, where the shafts were deeper, and where it is reported that the alluvium was 40 feet deep.

The shafts are very numerous in the vicinity of M.L. 552. The main workings on this lease have a depth of from 20 to 25 feet, but in the vicinity of the east boundary the workings are quite shallow. In addition to the alluvial workings on this lease there are some deep shafts which have been sunk in basement rock.

The writer has no information regarding the thickness of nor the values in the "wash" at this group of workings.

Conclusions.—Because of the number of shafts sunk and the extent of the alluvium this area is worthy of consideration as a possible area for sluicing.

PAPERBARK SWAMP.

The available equipment was insufficient to enable the alluvium to be sampled below water level, which was, in the few holes put down, at from four to nine feet. The few samples obtained contained only a trace of tin.

The old sluicing cuts were, with one exception, full of water. The cut, which could be examined, bottomed on white clay, completely devoid of any suggestion of bedding and containing, in some places, angular quartz and tourmaline. It seems likely that this white clay is very weathered basement rock.

AN AREA IN THE VICINITY OF THE SOUTH BOUNDARY OF LOCATION 290.

Four samples were taken with a post hole digger in this vicinity. All samples consisted of white sand. Sample hole G71 encountered water at five feet, while the remaining three all stopped on laterite. The values obtained did not exceed ¼ lb. per cubic yard.

LOCATION 9948—HEAD OF BORONIA GULLY.

In this vicinity there is quite an appreciable unworked area of sandy soil and laterite with rounded quartz boulders.

Samples G66, G67, and G68 consisted of sand and were taken with a post hole digger. They contained only a trace of cassiterite.

Sample G69 also consisted of sand and was taken from the west face of a shallow cut. The value obtained was ½ lb. per cubic yard.

Sample G70 was taken from a shallow gravel pit, used for getting

OTHER AREAS.

A few additional samples were obtained from widely scattered areas, but the values in all these samples were low and the areas will not be described individually.

Details regarding these samples are set out in table 20.

TABLE 20.

SAMPLE RESULTS FROM VARIOUS LOCALITIES.

Locality.	Sample number.	Lbs. concentrate per cubic yard.	Notes.
South boundary of Location 9947	G62	Trace	Rubbly laterite and soil with rounded quartz boulders.
Location 10632, close to cemetery	G63—0′—5′ 6′—7′ ...	Trace	Sandy clay, becoming quite hard at 7 ft.
North side of Westralian Gully	G35—0′—5′ 5′—7′ ...	½ ¼	Sand. Water at 6 ft.
	G36—0′—3′ 6″ ...	1	Laterite at 3 ft. 6 in.
	G37—0′—6′ ...	½	Sand.
	6′—9′ 6″ ...	Trace	Sandy laterite, with a few wash boulders at 9 ft. to 9 ft. 6 in. Into blue clay at 9 ft. 6 in. Blue clay is probably a weathered greenstone.
M.L. 529 (Three C's area)	G64—0′—5′ ...	½	Sand.
	5′—10′ ...	¼	Sand.
	10′—11′ ...	¼	Sand. Water at 11 ft.
	G65—0′—5′ ...	½	Sand.
	5′—10′ ...	Trace	Sand. Water at 10 ft.
Location 10954, in north-east corner of mineral field	G75—0′—3′ 6″ ...	Nil	Fine grained sand.

CONCLUSIONS.

(1) Further prospecting by drilling or pit sinking in the two localities listed below might reveal areas suitable for sluicing.

The north-western portion of D.C. 90.

The area of Old Alluvium east of the main Greenbushes-Bridgetown road, which is referred to in the report.

(2) There is an area of shallow ground, up to four feet in depth in the vicinity of E.A.C. 960, which offers some scope for prospecting and working on a small scale. Samples taken by the writer indicate values of about one lb. per cubic yard. No attempt was made to sample this area systematically.

(3) Prospects at Paperbark Swamp do not appear to be very encouraging, but if a drill were operating in the vicinity it would be desirable to put down a few test holes in Paperbark Swamp.

(4) No encouragement was obtained for further prospecting in Westralian Gully. Values in the surface sand south of Westralian Gully are extremely low. No test was made of the full depth of the alluvium in this vicinity.

(5) Such other samples as were taken offered no encouragement for further work. Samples of soil and laterite containing "wash" boulders taken from location 9947 and from location 9948 contained only a trace of cassiterite.

(6) The writer was impressed with the impossibility of obtaining reliable information regarding many of the old workings. These have often been abandoned for many years, and most of the men, who worked in them are now dead. Long periods have been allowed to elapse without any official examination being made of this area. Thus there are very many shafts, which have now wholly or partly fallen in and about which no information is available.

MINERAL CLAIM 6.

Introduction.—Late in 1942 it was reported that there was some alluvium in Bunbury Gully and also some nearby lode material which could be worked. Boring was undertaken to test the values and the extent of the ore bodies. The locality tested is shown on the accompanying plan (fig. 13).

Boring.—A boring grid was set out as shown and boring was commenced with 3 inch and 4 inch tools. As the holes were all expected to be shallow it was thought that hand boring would be suitable. It was soon found, however, that the area was underlain by a layer of hard laterite, which, in some of the holes, could be penetrated only with extreme difficulty and in others could not be penetrated at all. At sites numbers 1 and 39 the laterite was penetrated with 4-inch tools and casing driven as far as possible. Below the casing samples were taken with 1¾ inch auger. At sites 2, 4 and 11 the bores were abandoned, while at sites 8, 12, 17 and 21 shafts were sunk through the laterite and samples taken with a 1¾ inch auger (bores 12, 17 and 21) or with a 1¼ inch auger (bore 8). In this way fairly good samples were obtained, and contamination from the upper portions of the holes was kept to a minimum by scraping off the outside material from the auger each time it was withdrawn from the hole. The alluvium contained sufficient clay to make it stick reasonably well to the auger. The volumes of the samples obtained were measured and the samples panned. The concentrate was dried, tested with a magnet for magnetite and weighed.

In all six holes were drilled and the results are set out in table 21. The results obtained in these six holes did not warrant further drilling and the area was abandoned.

Bores 1 and 39 show that there is from 11 to 12 feet of tailings and laterite overlaying the alluvium, and that this alluvium is only from 5 feet 6 inches to 9 feet in thickness. Values vary from 3½ to 8 lbs. concentrate per cubic yard. The length of the strip of unworked alluvium is approximately 200 feet.

There is from five to seven feet of laterite on the east side of the creek (sites 8, 12, 17 and 21). The country is mainly a weathered greenstone, but does contain some small shoots of tin ore—e.g., 15 to 18 feet, bore 17. Some of these shoots have been worked by means of shafts in the past. The workings are now full of water and the only information available is that values are reported to have been good.

TABLE 21.

RESULTS OF DRILLING ON M.C. 6—1942.

Bore No.	Depth in Feet.	Value by panning lbs. Conc. per cubic yard.	Geology.	Notes.
1	0′ 0″— 6′ 6″	...	... ...	Tailings.
	6′ 6″—11′ 0″	...	Laterite	
	11′ 0″—12′ 0″	...	... ...	No sample.
	12′ 0″—16′ 6″	3½	Alluvium, fairly clayey	4 in. casing jammed at 13 ft. 6 in. and boring continued with 1¾ in. auger in an uncased hole.
	16′ 6″—20′ 0″	½	Weathered pegmatite	Two samples washed (16 ft. 6 in. to 17 ft. 3 in. and 17 ft. 3 in. to 20 ft. 0 in.). Concentrates from both samples included some alluvial tin.
39	0′ 0″—10′ 0″	...	... ...	Tailings.
	10′ 0″—12′ 0″	...	Laterite	
	12′ 0″—13′ 4″	...	... ...	No sample.
	13′ 4″—15′ 2″	8	Sandy alluvium	4 in. casing down to 15 ft. Continue drilling below 15 ft. with a 1¾ in. auger in an uncased hole.
	15′ 2″—21′ 0″	7	Sandy alluvium	
	21′ 0″—22′ 0″	5?	Pegmatite	Concentrate included a big proportion of alluvial tin.
	22′ 0″—31′ 0″	1	Pegmatite. Very little tourmaline until 29 ft.—31 ft. At 31 ft. tourmaline quite abundant	Only a small amount of alluvial tin in concentrates.
8	0′ 0″— 4′ 0″	...	Laterite rubble	Shaft sunk through laterite.
	4′ 0″— 7′ 0″	...	Laterite	Sample taken with 1¼ in. auger.
	7′ 0″—13′ 0″	...	Weathered greenstone. No tourmaline ...	There are a number of hard layers or lumps in the greenstone. Sample taken, but not washed.
	13′ 0″—20′ 0″	...	Weathered greenstone. No tourmaline	

12	0′ 0″— 3′ 0″	...	Laterite rubble	Shaft sunk through laterite.
	3′ 0″— 5′ 0″	...	Laterite	Sample taken with $1\frac{3}{4}$ in. auger. Hard layer or lump at 11 ft. 7 in. which could not be penetrated.
	5′ 0″— 8′ 0″	...	No sample	
	8′ 0″—11′ 7″	$\frac{1}{2}$	Weathered greenstone	
17	0′ 0″— 4′ 6″	...	Laterite rubble	Shaft sunk through laterite and sample with $1\frac{3}{4}$ in. auger.
	4′ 6″— 7′ 0″	...	Laterite	
	7′ 0″—12′ 0″	...	... ...	No sample.
	12′ 0″—17′ 0″	2	Weathered greenstone with some tourmaline. Amount of tourmaline increasing below 15 ft. and quite abundant at 17 ft. Also some quartz below 15 ft.	Value obtained probably low. because some laterite rubble included in sample, thus increasing its volume.
	17′ 0″—21′ 10″	5	Weathered greenstone with abundant tourmaline to 18 ft. Below 18 ft. amount of tourmaline decreased until it was practically absent at 21 ft. 10 in.	
21	0′ 0″— 3′ 0″	...	Laterite rubble	
	3′ 0″— 9′ 0″	...	... ...	No sample.
	9′ 0″—14′ 0″	$\frac{1}{2}$	Weathered greenstone	Hard layer or lump at 11 ft.
	14′ 0″—18′ 0″	1	Weathered greenstone	Both samples from this bore are poor samples, as only small proportion of the material drilled was recovered. This was due to material being scraped off the auger by hard layers as it was withdrawn from the hole.

MINERAL CLAIM 1.

Mineral Claim 1 includes late "Enterprise," M.L. 369, from which most of the tantalite produced at Greenbushes has come. Eluvial tantalite was obtained in this vicinity in the early days of the Field from the west side of the Greenbushes-Bridgetown road and later from a number of shallow pits on the east side of the road. During 1942, there was some production from a shallow pit just east of the road. During June and July of 1943, the workings were extended across the road—special permission being given for this. The maximum depth of these workings was approximately 12 feet. Most of the tantalite occurred in pieces having a diameter of ½ inch or more, but some fine grained concentrates were obtained by sluicing. Some large pieces of tantalite up to 52 lbs. in weight were found at the north end of the pit. The distribution of these suggests that they have not come from the lode on the west side of the road, but have been shed from a lode occurring under the road. Later a strip of country extending from the road in a south-easterly direction towards the creek was worked by means of scoops and the material carted away and sluiced. The total production from all these workings from November, 1942, to November, 1943, is 2.11 tons of tantalum concentrates. These concentrates contained from 55.33 to 74.32 per cent. Ta_2O_5. Additional details have already been given on page 85. In addition there is a parcel of 4,966 lbs. of tin tantalum concentrates awaiting further separation. At the time of writing (June, 1944) work is still in progress in this area. The scoops have been replaced by a mechanical shovel.

During July, 1943, approximately 30 yards of ore was broken from a lode in shaft B, which was reported to contain tantalite (fig. 14). The shoot, which strikes N 40° W and dips 40°-50° southwest, has been stoped over a length of 15 feet, over a width of from two to three feet and over a depth of 12 feet. It is still to be seen in the floor of the drive, which is approximately seven feet above water level. A preliminary examination of the concentrates obtained as a result of sluicing showed that these consisted mainly of cassiterite. (Government Chemical Laboratory 7414). No assay information is available. The shoot contains abundant tourmaline, but otherwise appears similar to the country, which is a very weathered granitic rock.

Chapter V.

ORE DEPOSITS—THE OLD WORKINGS

INTRODUCTION.

Except in the area covered by plates II and III the old workings were not mapped in detail. During the course of the 10 chain mapping the old workings were briefly inspected, and are indicated on plate I. All the old shafts were inaccessible, and many of the open cuts were filled with water. Very little information regarding the alluvial workings is available from old reports. Much the same applies to the lode workings. For these, however, some information has been gathered from Mines Department files. The writer has not seen a complete plan of any of the workings on the Field. For the purpose of this chapter and also for use in table 8 the Field has been divided into a number of convenient areas (fig. 12). A general description of the workings in each of these areas will be given, while for those areas—numbers 5 and 9—mapped in detail additional information regarding some of the workings will be given. Insufficient information is available to attempt a description of all the individual workings. Very rarely will it be possible to give the depth of, thickness of, and values in the "wash" for the alluvial workings, or the dimensions and values of the lodes, which have been worked.

DUMPLING AND NEW ZEALAND GULLIES—AREA NO. 1.

References—Montgomery, 1904, p. 82: Simpson and Gibson, 1907, pp. 62 to 64: Woodward, 1908, pp. 39 to 44.

The principal workings in this area are in New Zealand Gully and in the vicinity of the main road. There are also smaller sluicing cuts at the north end of M.C. 7 and on M.C. 24. The principal production has been from the Old Alluvium. In New Zealand Gully there are two main lots of workings, those on W.R. 288 ("Lady Ester," M.L. 331)[18], and those on M.C. 7, south of the creek ("Little Wonder," M.L. 470; "W.A. Mt. Bischoff No. 2 Ltd.," M.L. 295; "Horans," M.L. 35). On W.R. 288 the open cut extends over a length of 15 chains and has a depth of from 20 to 30 feet. The material worked consists of rounded quartz pebbles in a matrix of smaller pebbles and clay. The cut has bottomed on a very weathered greenstone, and is now partly filled with water. The principal workings close to the main road are immediately north of D.C. 67. The alluvium here is seen to have bottomed, at a maximum depth of 15 feet, on a very weathered greenstone. In addition to the production from the Old Alluvium there has been a small production from lode material. The lode workings are all small and very little information is available regarding them. Portion of the head of Spring Gully has been included in this area since "Mt. Pleasant," M.L. 471 (D.C. 40) was held between 1907 and 1910 by the Nickel Kramer Tin Mining Company together with other leases in the vicinity of Dumpling Gully (see table 8). In the vicinity of D. C. 40 there are a number of shallow sluicing cuts, from three to 10 feet deep, which have bottomed on a very weathered greenstone. According to Simpson and Gibson (1907, p. 65) the maximum depth of the alluvium in this vicinity was 30 feet.

Despite the fact that work in this area continued until 1921 the latest report available is that by Woodward in 1908. Referring to the area as a whole Woodward (1908, p. 44) says:—

> The whole of the Dumpling Gully area is situated at the extreme north end of the main stanniferous belt, the bed rock is in many places simply riddled by small tin-bearing veins, quantities of which have been removed bodily when in a weathered state and treated as alluvium. The tin is of a brilliant black in most perfect octahedral crystals, assorted with small quantities of tourmaline and contained in a kaolinised granite showing a little mica in places; so far, however, no veins of sufficient value and size have been discovered to be profitably worked into the solid country.

[18]It should be noted that W.R. 288 is not identical with M.L. 331, but occupies approximately the same ground.

Both Woodward (1908, p. 42) and Montgomery (1904, p. 82) record the existence of stockworks near the railway station. No information is recorded regarding the thickness and values in the wash and very little regarding its nature. Referring to "W.A. Mt. Bischoff," M.L. 218 (M.C. 24, plate I) Simpson and Gibson (1907, p. 62) say:—

> Specimens of ore (688,689) from this lease consist of a hard ferruginous conglomerate carrying a considerable amount of fine and coarse sub-angular tin stone. A third specimen (690) appears to be a much weathered granitic rock carrying a little coarse angular tin ore.

The same writers (p. 63) note that the stanniferous material on "Little Wonder", M.L. 470 consists of wash and hard ironstone conglomerate. Referring to "Glasgow," M.L. 375 (S.E. corner M.C. 23 and G.A. 39, plate I) they say (p. 63):

> A lode said to be 5 feet wide has been sunk on to a little depth. Of two specimens of lode stuff presented by Warden Geary to the Museum in 1905, one (6517) from near the surface is a pegmatite composed mainly of albite with tourmaline, quartz, muscovite, garnet and a considerable percentage of tin ore; the other (6518) from a depth of 30 feet is a quartz-tourmaline rock with but little tin.

On M.L. 400 it is reported (Simpson and Gibson, 1907, pp. 63-64) that stanniferous granite was encountered at 12 feet.

The total recorded production from this area is 1714.83 tons of tin concentrates, of which 1703.93 is recorded as alluvial and 10.90 as lode.

LOCATIONS 289 AND 290—AREA No. 2.

References.—Simpson and Gibson 1907, p. 64: Woodward, 1908, p. 45.

Between 1904 and 1909 and from 1920 to 1921 workings on these locations produced 323.43 tons of alluvial tin concentrates. It is known that work on these locations was in progress in 1890 (Simpson and Gibson, 1907, p. 64), but production has been lost in "Sundry Claims" or else not reported.

The country hereabouts consists of white sand, with patches of laterite containing rounded quartz pebbles and grains. It is believed to be portion of the Old Alluvium.

The principal workings are a series of sluicing cuts, the largest of which is on location 290. These are completely filled with water. The smaller cuts on location 289 have a depth of from 10 to 12 feet.

No information is available about the thickness of or values in the wash.

SPRING GULLY—AREA No. 3.

References.—Simpson and Gibson, 1907, pp. 65-66: Woodward, 1908, pp. 46-51.

Although Spring Gully has been worked practically continuously over a length of 1½ miles and has produced 910.31 tons of concentrates very little information is available about it. The principal work has been in the Gully itself, although there are quite a number of shallow open cuts and also some shafts on its north side. In the vicinity of G.A. 53 work has been extended into Paperbark Swamp. Further south-east in Paperbark Swamp there are four smaller cuts. These cuts are reported to have had a maximum depth of 14 feet. One of them, close to the south-west corner of location 8755, is much shallower, and is reported to have had an average depth of 6 to 7 feet. When inspected in 1942 all contained some water and some were completely filled with water. It is reported that prospecting away from these cuts yielded disappointing results—the values being ½ to 1 lb. per cubic yard. Shallow samples taken by the writer in 1943 yielded from a trace to ½ lb. concentrates per cubic yard. It is probable that all workings in Area No. 3 have bottomed on basement rocks although some of the cuts could not be inspected because of water.

For reasons already given (p. 153) Area No. 1 has been extended to include the Mt. Pleasant workings at the head of Spring Gully. These workings more properly belong to Area No. 3, the production of which would be increased by about 50 tons if these workings were included.

Referring to Claim 318, which extend from about G.A. 53 to C. 798, Simpson and Gibson (1907, p. 65) say:—

> This is one of the oldest and most productive alluvial claims on the field. It occupies a narrow strip of the main gully for a length of ¾ mile. The deposit in this claim consists of two distinct portions, an upper or "free dirt," and a lower or "stiff clayey dirt." The former was loose and gravelly, being composed of fine and coarse quartz (694, 695) of a somewhat violet tinge, and granular structure very typical of Greenbushes. It was from one to three feet thick, about 18 to 20 yards wide, and proved exceptionally rich in tin. The latter consisted largely of a stiff white clay (1633) containing irregular bands of fine cassiterite associated with garnet, zircon, tourmaline, and gahnite (zinc spinel) in irregular grains and well-formed crystals of all shades of green (697). Occasional small pieces of metallic tin are found in the wash. These have probably been reduced from surface ore during bush fires.

BATTLER'S HOPE, THREE C'S, POVERTY FLAT—AREA No. 4.

References.—Simpson and Gibson, 1907, p. 67: Woodward, 1908, pp. 65-67: Forman, 1934, 1937.

The principal old workings in this area are those at the head of Moulton Brook (D.Cs. 35 and 39), the Three C's and other workings in the same vicinity (D.Cs. 95, 29, 18, M.L.s. 571, 520, 555), various old sluicing cuts south-west from the Three C's workings (C. 876, E.A.C. 961, D.C. 94, E.A.C. 963), and numerous shallow workings extending from D.C. 94, through E.A.C. 960 to C. 917. The total recorded production from the area is 373.24 tons of concentrates, all of which are alluvial.

It has already been noted that bores put down during 1936, in the vicinity of the Battler's Hope and Three C's workings passed through a maximum of approximately 100 feet of Old Alluvium. The information obtained from these bores has been summarised on page 120, while full details are given by Forman (1937) in an earlier report. The thickness of the wash in the vicinity of the Battler's Hope workings was first demonstrated about 1902, when two shafts were sunk to over 100 feet (Forman, 1934, pp. 13-14).

Reference has already been made (Chapter IV) to the workings in the vicinity of D.C. 95. It has been pointed out that here and possibly also at the Three C's the workings have bottomed on a false bottom. Although tin has been found (Woodward, 1908, p. 67) below the horizon, which has been extensively worked, the low values obtained by boring and existence of a thick clayey zone offer no encouragement to the possibility of working a deep horizon.

At the old Three C's workings there are extensive open cuts, now mostly filled with water, about which no information is available.

South-west from the Three C's there are a number of shallow sluicing cuts (C. 876, E.A.C. 961, D.C. 94), some of which can be seen to have bottomed on a very weathered greenstone. Others were full of water.

Extending from D.C. 94, through E.A.C. 961 to C 917 there are numerous shallow workings, some of which are quite extensive. In some places the laterite has been worked, while at others the material worked is the sand occurring above the laterite. Samples taken from the sides of various old cuts gave values of about one lb. concentrates per cubic yard (p. 145).

BUNBURY GULLY, ELLIOT'S GULLY, WESTRALIAN GULLY AREA NO. 5.

References.—Campbell, 1906, pp. 18 to 19: Simpson and Gibson, 1907, pp. 67 to 71: Woodward, 1908, pp. 51 to 64: Feldtman, 1914: Wilson, 1929, p. 44: Larcombe, 1929, p. 15: Simpson, 1929, p. 105; Bowley, 1929, p. 107: Howe, 1929 p. 40; 1930, p. 42: Ellis, 1939.

GENERAL INFORMATION.

Area No. 5 includes Bunbury Gully with its two subsidiary gullies, Elliot's and Westralian Gullies, and also portion of the divide between the Bunbury Gully and Salt Water Gully. It was in the vicinity of the junction of Bunbury Gully and Elliot's Gully that cassiterite was first found in the Field by D. W. Stinton in 1888. Later, this area was worked by a Bunbury Syndicate, and hence the name Bunbury Gully. This portion of the Field is also often known as Bunbury End for the same reason. The total recorded production is 1543.24 tons of tin concentrates, of which 1263.72 tons are from alluvial ground and 279.52 are from lode material. In addition the entire recorded production of tantalite concentrates (9.55 tons) has come from this area. From M.C. 1 at the head of the gully high grade tantalite assaying up to 80 per cent. Ta_2O_5 has been produced at various times between 1905 and the present. In recent years tantalum concentrates, assaying from 35 to 38 per cent. Ta_2O_5 have been separated from the tin concentrates produced at the Vulcan workings on M.C. 4. The tin concentrates from Bunbury Gully down about as far as W.R. 289 (Greenbushes Well) are reported to have contained alluvial tantalite. Information regarding tantalite has already been given in chapters II and III, and reference will be made to M.C's 1 and 4 in a later section of this chapter. Stibiotantalite, which was the first tantalum mineral to be found in Western Australia, occurs in the Old Alluvium in Bunbury Gully, and also at the late "Enterprise" workings (M.C. 1), near the head of the gully (see p. 77). Near the head of Bunbury Gully a little water worn gold has been found in the tin concentrates (Simpson and Gibson, 1907, p. 67).

Tin concentrates have been obtained in Area No. 5 from both Recent and Old Alluvium and also from lode material. The principal production has been from the Old Alluvium, with in all probability, only a very small amount from the Recent Alluvium. The Vulcan workings on M.C. 4 have been the largest producers of lode tin concentrates on the Field.

The principal workings in Old Alluvium are those in Bunbury Gully itself, John's Cut, Bunbury Cut, Allen's Cut, Angus' Cut and various un-named cuts extending from M.C. 6 almost to the head of the gully, those in the vicinity of D. C. 90, Cole's Cut, Keyser's Cut, workings on Hard Graft, Elliot's and Nutall's old claims, those in Westralian Gully, and finally those old workings extending from the South Greenbushes townsite in a general north-easterly direction. Reference has already been made to some of these old workings in chapter IV. An embankment has been built across Westralian Gully at its junction with Bunbury Gully, and the old working in Westralian Gully are under water. No information is available about these workings.

The principal lode workings are, as pointed out above, the Vulcan workings on M.C. 4. Appreciable quantities of tin concentrates have also been produced from the old Kapanga workings on M.C. 34, and from the Lost and Found workings on M.C. 3. There are also a series of smaller old workings on both sides of the Gully e.g. the Fremantle cut and the Nil Desperandum workings. A small amount of lode tantalite has been produced at one place on M.C. 9.

MINERAL CLAIM 1.

Plates I and II.

Although the greater portoin of M.C. 1 is in Area No. 9 yet the most important workings—the old Enterprise workings—are in Area No. 5. Tantalite was first found in this vicinity about 1900, and parcels have been produced at various times right up to the present. Some work is now in progress (June, 1944). Lode, eluvial and alluvial tantalite have been produced. Information about these workings has already been summarised and reference should be made to page 150.

MINERAL CLAIM 34.

By R. S. Matheson.

Plate III.

General information.

Mineral Claim 34 is situated on the eastern side of the Greenbushes-Bridgetown main road, about one-and-a-half miles south-east of the Greenbushes townsite. The mineral claim occupies an area of about 108 acres, and includes the workings of the old "Kapanga," "Esperance Hill" and "Two Battler's" leases. Portions of the old "Haphazard" M.L. 147 and "Victoria" M.L. 110, are also included in this area.

The principal workings are those of the "Kapanga" mine, which was in operation during the period 1910 to 1929, but prior to 1910, the old "Tairua," "Hokitika" and "Wheal Fortune" leases occupied the same ground. It will be seen from table 22 that these leases have produced 41.55 long tons of tin concentrates valued at £5,216, which is about 76 per cent. of the total production from M.C. 34. With the exception of about 9 long tons of alluvial tin from the old "Haphazard" workings, which are situated in old alluvial ground near the south corner of the area, the production has been from lode workings. The stream tin recorded from leases other than the "Haphazard" is believed to be eluvial, not alluvial, tin.

There was no activity on M.C. 34 at the time of inspection (September, 1942) and all the workings were inaccessible. Some information concerning the workings is contained in previous departmental reports however, and the writer has made free use of these in compiling this report.

Production.

Production information for M.C. 34 is given in table 22.

TABLE 22.

PRODUCTION FROM M.C. 34 TO 31ST DECEMBER, 1943.

Registered name of company or lease.	Lease numbers.	Period of production.	Tin Concentrates.			Reported value.
			Lode.	Alluvial.	Total.	
			Long tons.	Long tons.	Long tons.	£A.
Victoria	M.L. 110	1900–01	0·25	....	0·25	20
Haphazard	M.L. 147	1900–09	0·28	8·79	9·07	573
Wheal Fortune	M.L. 219	1901	0·20	....	0·20	13
Hokitika	M.L. 281	1902	0·16	....	0·16	10
Haphazard Extd.	M.Ls. 245 and 246	1902, 03	....	3·22	3·22	196
Esperance Hill	M.L. 389	1906	0·15	....	0·15	15
Tairua	M.L. 410	1906, 07	3·88	....	3·88	390
Kapanga	M.L. 515	1910–29	35·96	1·35	37·31	4,803
Two Battlers	M.L. 603	1919	0·10	....	0·10	12
Total Production	....	....	40·98	13·36	54·34	6,032

Topography and geology.

The mineral claim occupies the eastern and southern slopes of a rather prominent hill, which is part of the divide between the Bunbury Gully and Salt Water Gully stream systems. The country varies in elevation from about 850 feet at the south corner of the mineral claim to about 1050 feet near the north-west corner. The mineral claim is devoid of rock outcrops, being covered by ferruginous laterite, but the composition of the laterite suggests that, with the exception of a small area of Old Alluvium at the southern corner of the mineral claim, the

underlying rocks are part of the basement complex. This is confirmed by an examination of mine workings and of previous literature. The available information indicates that the basement complex in this locality consists of greenstones, mainly amphibolite schists, which are intruded and replaced along shear zones by stanniferous lodes of granitic composition. Although the strike of the schistosity of the greenstones has not been definitely stated, it is apparently in a north to north-west direction, and the dip is 60 to 70 degrees westward. There has also been no definite statement made concerning the origin of the amphibolite schists, and some doubt exists as to whether or not they have been intruded by greenstone dykes.

The greenstones were, at one time, well exposed in Elias' Tunnel, which is situated a short distance north of the "Kapanga" workings, and after an examination of it in 1908, Woodward (Geol. Survey 263/1900, also 1908, p. 27) made the following notes.

Whilst at Greenbushes I made an inspection of this tunnel and was surprised at the quantity of work done, viz.: driving 1,000 ft. and three shafts sunk for ventilation to depths of from 50 ft. to 100 ft., the last and deepest being close to the face at the end of the tunnel, requiring about 10 ft. to connect.

This tunnel has been driven in decomposed rock of a basic character with occasional veins of diorite and pegmatite dykes (called lodes) to within some 100 ft. of the face when a hard bar of bronzite diabase was encountered, this was risen upon thus altering the grade of the drive.

This work is of considerable interest in as much as it has demonstrated conclusively that the country rock of the tin lodes is not granite, as previously supposed, but a rock of basic character, the actual nature of which cannot yet be determined in this weathered zone, but it will in all probability prove to be an igneous character similar to the belts of the auriferous regions of this State.

Another feature of interest is the character of the pegmatite dykes, which may be counted as nine according to Mr. Elias, but which I reduce to four since if these veins do not in every instance actually unite at the level floor, they give every indication of doing so at no great depth below, thus pointing to the conclusion that many of the small stanniferous veins, now being prospected in other points upon this field in the zone of weathering, may do likewise in the solid country, thus increasing in volume and possible value.

Feldtmann's examination (1914) of the "Kapanga" mine substantiates the belief that the basement complex consists mainly of greenstones. Several of the specimens of greenstone collected by Feldtmann were petrologically examined by Farquharson (1914), and found to be biotitic hornblende schists.

The stanniferous lodes have been described by Feldtmann (1914, p. 158) as follows:—

> The primary tin-bearing rocks are evidently, with the exception of such secondary formations as the alluvial and eluvial deposits and the laterites, the youngest rocks of the district, being intrusive into the greenstone. They occur for the most part as dyke-like bodies of varying width, consisting of quartz, felspar (albite) and muscovite mica; the relative proportions of these minerals vary considerably, the rocks in some instances consisting chiefly of albite with a little quartz and a fair amount of tourmaline; in some quartz is the predominating mineral, whilst in others muscovite mica is in much evidence; tourmaline is seldom absent, and is usually present in large proportions; among the minerals occurring as accessories are cassiterite, ilmenite, arsenical pyrites, stibio-tantalite, tantalite, garnet, gahnite, topaz, zircon and gold. So far as the writer knows wolfram has not been discovered in the primary tin-bearing rocks, but Krusch mentions its occurrence in alluvial deposits.

The ferruginous laterite is pisolitic, and where it overlies the stanniferous lodes it contains angular quartz and tourmaline, and occasionally mica. Waterworn grains of quartz and tourmaline occur in the laterite overlying the Old Alluvium.

The workings.

An examination of the dumps suggests that lode material was mined everywhere on M.C. 34, except at the old "Haphazard" workings, where both alluvial ground and lode material were mined. The only information available from previous literature concerns the "Kapanga" and "Haphazard" workings.

"Kapanga" workings.—At this mine a stanniferous lode (Fox's Lode) of granitic composition, which strikes in a northerly direction and dips 70° to 80° east, has been mined at intervals over a length of about 10 chains. The old main shaft, which was sunk to a vertical depth of 96 feet is the deepest point in the workings, but little if any driving has been done below the 88 ft. level. According to Feldtmann (1914, pp. 162-166) 90 feet of driving was done at the 47 ft. level, 220 feet at the 75 ft. level, and about 20 feet at the 88 ft. level. The average thickness of the lode is not known, but it is reported to vary in width from 3 feet 6 inches to 15 feet at the 47 ft. level, and it pinches out to a stringer in several places between the 75 ft. and 88 ft. levels. Taken as a whole the lode proper is fairly lenticular. The lode appears to have a considerable width at the surface, but this is due to the accumulation of a large amount of detrital material on its down hill side. The so-called alluvial cassiterite reported from these workings has very likely been recovered from this detrital material.

Although the lode formation has an average easterly dip of from 70° to 80°, its foliation planes, and also the schistosity of the enclosing greenstone country, are said to dip to the west at 65°.

The lode formation consists principally of a mixture of kaolin, quartz, tourmaline and cassiterite. A specimen of lode material (Reg. No. 13624) from the bottom of the main shaft has been described by Feldtmann (1914, p. 166) as "a fine grained gritty white rock, with slightly foliated structure, consisting largely of albite felspar and quartz, with numerous crystals of blackish tourmaline, showing a roughly parallel orientation; a few pinkish-red garnets occur in the vicinity of a small quartz stringer, and some pale green zinc spinel (gahnite) was visible in hand specimen."

The best values throughout the mine are reported to have occurred on the walls of the lode formation, particularly the west wall. Tourmaline was very abundant on the walls in places, and it is thought that some of the cassiterite actually occurred within the tourmaline. The concentrates from this mine were high grade averageing about 70 per cent. metallic tin.

Ground water was not encountered in the workings, but fresh greenstone was met with in the deeper parts of the mine.

More detailed information concerning the "Kapanga" mine, and also a plan of the workings, are contained in Feldtmann's report in Bulletin 59.

During the year 1929, the Mines Department put down three diamond drill holes to test this line of lode at depth, but no lode material was encountered. Details concerning the bores are given in a later section of this report.

"Haphazard" workings.—As has been pointed out previously (see p. 158) only portion of the old "Haphazard" lease is included in the ground now occupied by M.C. 34. The principal workings on this lease were situated in alluvial ground, but lode material was also mined. By reference to the table 22 it will be seen that the total production from the "Haphazard" workings to 31st December, 1943 is 12.29 long tons of tin concentrates, of which only 0.28 long tons came from lode workings.

In his report on the Greenbushes Field in 1900 A. Gibb Maitland (1901 p. 13) made the following notes concerning these workings.

Haphazard M.L. 147.—Two shafts connected by a crosscut at 50 feet from the surface have been put down upon what has been regarded as "lode matter." Shaft No. 2 having been timbered to within a short distance of the bottom, prevents the section of rock piereed being examined. The foot of the shafts shows a decomposing tourmaline bearing gneiss, dipping west, and trending north 30 degrees east. The tourmaline is often of large size, and some very highly ferruginous ore is associated with it. From the foot of No. 2 shaft a crosscut 50 feet in length connects with No. 1 shaft. The first 30 feet of the crosscut from

No. 2 shaft has been carried through a decomposing granite rock, succeeded by about 20 feet of tourmaline gneiss dipping to the west. No "lode" has yet been discovered in the workings. In other portions of the property the residuary sands and gravels have been worked with fair results. Some material assaying (in the official laboratory) low in tin, viz., 11 per cent., was found to be associated with quartz, garnets, limonite, magnetite, tantalite, zircon and ilmenite.

This lease has yielded 9.07 tons of concentrates valued at £550. No information is available concerning the workings in alluvial ground on the old "Haphazard" lease.

Boring.

While the Mines Department was carrying out a boring campaign at Greenbushes during the period 1928 to 1929, three diamond drill holes (Nos. 9, 10 and 11) were put down to test the "Kapanga" line of lode at depth. The sites of these bores are shown on the accompanying plan (plate III), while other details including the results of boring are well stated in a report by A. M. Howe (1930), which is quoted hereunder.

During 1928 eight bores were drilled at Greenbushes, representing a total of 2,433 feet of drilling. The programme was completed early in 1929, when three bore holes had been drilled at the Kapanga Mine.

No. 9 Bore was commenced on 16th January at a point 575 feet northwest from the southwest peg of the lease. It was depressed at an angle of 45 degrees bearing east. It was completed on the 1st February at a depth of 300 feet, but the lode was not intersected, although the depth of the bore was a good deal in excess of that required to do so had the lode continued down.

No. 10 Bore was commenced on 8th February at a point 660 feet north of the southeast boundary peg. It was depressed at an angle of 45 degrees bearing west, and was therefore bored from the eastern side of the lode. It was completed at a depth of 300 feet on 28th February, but the lode was not intersected.

No. 11 Bore, started at a point 200 feet north from No. 10 Bore and depressed at an angle of 45 degrees, was drilled at the request of the mine owner and with the concurrence of this Department on a bearing of 225 degrees instead of 270 degrees as originally intended. The object of drilling this hole in a south-west direction was to intersect a lode stated to have a strike N.W.—S.E. in addition to the main lode striking north. It was commenced on the 8th March and completed on 27th March at a depth of 350 feet, but neither lode was intersected.

In view of the fact that Bores Nos. 9, 10 and 11 failed to intersect the lode, it was decided not to drill No. 12 borehole.

Decomposed greenstone occurred in the upper part of all the bores, but fresh amphibolite was encountered at bore depths of 132 feet, 110 feet and 135 feet in Bores Nos. 9, 10 and 11 respectively.

Conclusions.

There is no great incentive for further prospecting on M.C. 34, but with the present high price of tin (66s. per unit), it may be possible to recover small parcels of ore from the old workings.

Good values are reported to have been obtained in places beyond the south end of the "Kapanga" line of workings, and consequently some prospecting appears to be warranted in this direction.

In his report in Bulletin 59, Feldtmann (1914, p. 167) draws attention to the probable existence of two parallel lode formations on the western side of the "Kapanga" lode. The outcrops of these lode formations have no doubt been prospected without success since the time of Feldtmann's inspection (Feb. 1914), but little, if any, attempt has been made to prospect them at depth.

MINERAL CLAIM 6.

By R. S. Matheson.

Plate III.

General information.

Mineral Claim 6, which lies across the main Greenbushes-Bridgetown road, is situated 1½ miles south-east of Greenbushes townsite. The mineral claim includes a half mile section of Bunbury Gully, extending from Angus' Cut at the north-west to John's Cut at the south-east, and also a large section of Elliot's Gully.

The area is held by Greenbushes Tin Ltd., but no work has been done since 1940. The main activity on the mineral claim was during the period 1937 to 1940, during which time, as a result of a successful boring campaign on the ground lying to the west of the main road, the Company erected a bucket dredge in the old Bunbury Cut. Due to the failure of the dredge to prove its capability for handling the ground however, operations were abandoned before the areas, where the best values had been indicated by boring, were reached.

At the time of inspection (September, 1942) the only activity on the mineral claim was on the eastern side of the main road in the vicinity of the old "Nil Desperandum" workings, where Prospector Coleman, was opening up a few small shoots of stanniferous lode material. At the time of writing this report (November, 1942) an unworked section of Bunbury Gully east of the South Greenbushes hall, is being tested by boring (see p. 148).

The writer was only able to make a surface examination of the area, but has obtained additional information by reference to previous departmental reports.

Production.

The production of tin concentrates, which can be established as coming from the ground now held as M.C. 6, is shown in table 23. The total production may be more than these figures indicate however, as the production from numerous claims scattered over the entire field has been grouped under the heading "Sundry Claims" in the official

production statistics. The production from "Sundry Claims" to the 31st December, 1943, is 5,917.91 tons of alluvial tin and 71.23 tons of lode tin, valued at £462,395. It has only been possible, in a few instances to trace the production from individual claims.

TABLE 23.

PRODUCTION FROM M.C. 6 TO 31ST DECEMBER, 1943. [1]

Registered name of company or lease.	Lease numbers.	Period of production.	Tin Concentrates.			Reported value.
			Lode.	Alluvial.	Total.	
			Long tons.	Long tons.	Long tons.	£A.
Nelson	M.L. 73	1899-01	....	22·40	22·40	1,675
Pioneer	M.L. 271	1902	....	1·84	1·84	117
Nelson Leases	M.L's. 73,233	1902-07	....	61·01	61·01	4,164
Dreamland	M.L. 382	1905-08	1·61	1·92	3·53	368
	738 C.	1906	....	4·87	4·87	471
	748 C.	1906	....	1·44	1·44	136
	775 C.	1906	....	10·65	10·65	991
	779 C.	1906	....	0·60	0·60	62
	789 C.	1906	....	0·77	0·77	79
Nil Desperandum	M.L. 401	1906-07	1·55	....	1·55	162
King Tin Leases	M.L's. 73,233	1906-21	6·52	119·54	126·06	15,900
Old Bunbury	M.L. 504	1909-12, 18	....	37·62	37·62	3,619
Nil Desperandum	M.L. 596	1918	0·25	....	0·25	48
	D.C. 92	1934-36	....	25·50	25·50	3,263
	M.C. 6	1938-40	0·45	....	0·45	50
Greenbushes Tin, Ltd.	M.C. 6, etc.	1940-43	1·22	0·95	2·17	495
Total production	....	....	11·60	289·11	300·71	31,600

[1]It is important to note that during the period 1899 to 1905 only the total quantity of tin concentrates produced was recorded, but from 1906 alluvial concentrates and lode concentrates were recorded separately. All the production prior to 1906 was recorded as alluvial concentrates in later statistics.

Topography and geology.

As will be seen from the accompanying geological map (plate III), Bunbury Gully trends in a northwest-southwest direction through the centre of M.C. 6, and is joined near the south-east boundary by Elliot's Gully, which comes in from the west. There is a drop in elevation along Bunbury Gully from about 910 feet near the north-west boundary to about 820 feet near the south-east boundary. The country rises both east and west from Bunbury Gully, and the highest point in the area is the north peg of M.C. 6, which has an elevation of 1010 feet.

The area is completely covered by laterite and alluvium, but from an examination of the shafts and open cuts on M.C. 6 and adjoining mineral claims the basement rocks in this area appear to consist mainly of amphibolite schists, which have been intruded and replaced along shear zones by granitic material. By reference to chapter II it will be seen that the amphibolite schists very likely have a north to north-west strike and a steep variable dip. The

granitic rocks exposed in workings are all tourmaline-bearing and stanniferous, and constitute the lodes mined in this area. With the exception of the lode formation exposed in Fremantle Cut, which has been proved by boring to extend for several chains in a north to north-westerly direction, the lodes appear to consist of small shoots with variable attitudes.

Both Recent and Old Alluvium occur in the area, and the main distinguishing feature between the two types is the occurrence of a solid laterite capping over the Old Alluvium. In places, however, the laterite capping appears to have been removed by erosion, and it is difficult to distinguish between the two types of alluvium.

The Old Alluvium occurs as terraces along the sides of Bunbury Gully, and its limits can be fixed fairly accurately from the distribution of waterworn quartz grains, waterworn tourmaline and, occasionally, waterworn cassiterite, in the overlying laterite, The alluvial terrace on the western side of Bunbury Gully is well preserved, but the one occurring on the eastern side has been removed, to a large extent, by erosion. The distribution of the Old Alluvium examined in conjunction with the contours, suggests that its original thickness was between 30 and 50 feet. The Old Alluvium is believed to have originally formed a continuous sheet across Bunbury Gully, but has since been extensively eroded, leaving terraces on the hills flanking the gully. As seen in Angus' and Allen's Cuts the Old Alluvium consists mainly of a mixture of quartz, tourmaline and kaolinitic material, which contains a little tin throughout. The best values are reported to have occurred in the Old Alluvium however, in a basal seam of coarse wash, a few feet thick. The coarse wash is cemented together in places, and contains waterworn boulders up to six inches in diameter.

A belt of Recent Alluvium, consisting of cassiterite-bearing sands and gravels, occurs in Bunbury Gully and Elliot's Gully, but most of the workings pass into Old Alluvium at shallow depths. In these areas much difficulty was experienced in distinguishing between the two types of alluvium, and the geological boundaries between them must therefore be regarded as only approximate.

A hard laterite capping occurs over most of the area and covers both the Old Alluvium and the basement rocks. The laterite overlying basement rocks is generally more ferruginous than the laterite overlying the Old Alluvium and contains no waterworn quartz and tourmaline grains. Angular grains of quartz and tourmaline occur however, in the laterite capping of the stanniferous lodes.

It is important to note that although laterite is only shown overlying basement rocks on the accompanying geological plans, it also overlies the Old Alluvium.

The workings.

The workings on M.C. 6 are fairly extensive and can be conveniently separated for description into the lode workings and the alluvial workings. The underground workings were inaccessible and the surface workings could only be partly examined due to the presence of water.

Lode workings.—Stanniferous lodes have been mined on both sides of Bunbury Gully, but most of the work has been done on the eastern side. On this side of the gully numerous small shoots of lode material with very variable attitudes, which are overlain in places by thin remnants of Old Alluvium, appear to have been mined. Judging from the size of the dumps it is unlikely that the workings anywhere exceed 50 feet in depth. The overlying alluvial ground is lateritised, and a considerable amount has been stripped from the surface and treated. The alluvial ground is said to have geen very rich in places, and numerous pieces of waterworn cassiterite weighing up to 12 ounces, which were recovered from this ground by Prospector Coleman, were seen by the writer. The old "Dreamland", M.L. 382 and the old "Nil Desperandum", M. L. 401 (596), previously included parts of the ground now occupied by these lode workings. A few notes on the old "Dreamland" lease, which are contained in Bulletin 32 (Woodward, 1908, p. 58) are quoted below.

> Dreamland M.L. 382 (10 acres), includes part of old M.L. 61, Yarana. A tin lode running in a north-west direction has been described as occurring under a cover of 3 feet of cement. This lease has yielded 3.18 tons of ore, worth £340.

It was impossible to make a detailed examination of the lode worked in Fremantle Cut at the time of inspection, due to the presence of water. and no information concerning it is contained in departmental reports. The lode formation occurs under 3 ft. laterite capping, and its walls do not appear to have been exposed. It consists of a soft, kaolinised, tourmaline-bearing rock of granitic composition, very similar in general appearance to the Vulcan lode (Ellis, 1939, pp. 9-13), and may possibly be its north-westerly continuation along the strike.

The boring done by Greenbushes Tin Ltd. indicates that the lode formation extends for about 20 chains north-north-westerly of Fremantle Cut, but it is overlain by Old Alluvium except in the immediate vicinity of the cut.

Alluvial Workings.—In Elliot's Gully and the lower part of Bunbury Gully the workings appear to be situated in Recent Alluvium, but pass into Old Alluvium at shallow depths. The Old Alluvium also occurs as a terrace between Angus' and Allen's Cuts, and this ground has been extensively mined. Tantalite and stibiotantalite are associated with the cassiterite in both the Old and Recent Alluviums.

The old reports reproduced hereunder contain some general information about the alluvial ground on M.C. 6, but no distinction is made between the Old and Recent Alluvium.

Hamel and Smith's Claim.—(Maitland, 1900. pp. 18-19: Simpson and Gibson, 1907, pp. 68-69.) Some distance lower down Bunbury Gully, and on the southern wall of the valley, a series of shafts have been put down to varying depths. These shafts disclose the underground structure of the country. Two vertical shafts of about 30 feet in depth are connected underground.

In the workings a well marked "tin floor" underlies at a comparatively low angle to the West. The material forming the "floor," locally spoken of as "wash," is about 2 ft. 6 in. in thickness, and consists of mica, quartz, a little tourmaline and tin. The deposit in all probability represents the decomposed portion of one of those tin-bearing veins by which the granite is reticulated. The most southerly shaft on the claim, at a slightly lower altitude, has a depth of about 20 feet, and the "wash" only about one foot in thickness.

Some little distance to the south seven other shafts have worked a similar deposit.

On Krammer's Claim a vertical shaft, 34 feet in depth, intersected a decomposed "tin floor" of from three to four feet in thickness. The floor has a gradual dip to the South-West. The deposit ("wash") is very rich in tin, the ore being often rounded or sub-angular (1823). In that portion of the property which lies close to the bank of the gully very sharp, bright, angular tin (1284) occurs at a very short distance below the surface. The ore must have been released from its parent source not far from where it is at present found.

On the western bank of Bunbury Gully, and opposite Bench Mark XXIII, is a water shaft some 30 or 40 feet in depth. The shaft was inaccessible to me, but, judging from the material lying at grass, the sinking was through a very decomposed micaceous granite.

Further to the south-west, and on the western bank of the gully, three shallow shafts have been put down. The most northerly of the three shafts, about 10 feet in vertical depth, show a few feet of cement rubble, partially consolidated, succeeded by about three feet of "wash" containing a high percentage of tourmaline. The most westerly of the group was about 20 feet in depth, and passed through no wash, but merely pierced a clayey decomposition product of a granite . . . An important tributary, Elliot's Gully, enters the main channel of the Bunbury to the south of the bore hole just alluded to. A good deal of prospecting has been carried out along the course of the gully.

The walls of the watercourse are hemmed in by the ferruginous conglomerate which forms the bulk of the watershed.

The ground held by Messrs. Portwood and Burnet, near the mouth of the valley, has been exploited by two shafts about 40 feet in vertical depth. The northernmost shaft exposed a series of cemented gravels, forming a true conglomerate in places, resting upon an uneven floor, which dips at an angle of about five degrees to the south-east. The bottom upon which the deposit rests is very clayey, and is derived from the disintegration of a very argillaceous rock. A very ferruginous sandstone or conglomerate rests directly upon the clay, and is covered with a whitish tourmaline-bearing wash, which at the bottom is about six inches in thickness. The most southerly shaft, 40 feet in vertical depth, exposes a somewhat similar section. The floor upon which the deposit rests dips at a low angle to the north-east and evidently forms the southern bank of the watercourse. Above the conglomerate, at the bottom of the shaft, is a few feet of very white gritty sand covered by about five or six feet of ironstone rubble, derived from the denudation and subsequent partial consolidation of the ironstone conglomerate which forms the bulk of the surface of the ground.

N.B.—Salmon—Claim 617 (Maitland, 1901, p. 13).—This claim is situated on Bunbury Gully, to the eastward (probably westward is meant here—R.S.M.) of the Yarana Lease. Two shafts have been put down to reputed depths of 15 and 27 feet respectively. Being full of water, both were inaccessible to me. The owner, Mr. Salmon, informed me—and I have no reason for doubting the authenticity of his information—that in the deeper shaft the "wash" (residuary gravels, etc.) extends down to about 16 feet from the surface, and that the rest of the sinking had been through a decomposing granite. I satisfied myself from sampling the dump that the material was stanniferous, and that the tinstone was coarse and angular and could not have travelled very far from its parent source.

Further information concerning the nature of the alluvial ground is contained in the section of this report dealing with the general geology.

Boring.

Information concerning the bores put down by Greenbushes Tin Ltd. during 1939 is shown in a condensed form in table 24, and a plan (figure 15) showing the bore sites accompanies this report. More complete information concerning the bores is contained in Geological Survey file 36/1939. Although the writer is not prepared to vouch for the values obtained in the bores, it is reported (Mines Dept. file 714/41, p. 71) that they were sampled carefully, and every effort was made to be conservative about the values. It is said that the borings were washed separately for each 14 inches of bore and the resultant concentrate weighed for each six feet approximately (probably 70 inches). Unfortunately this detailed information was not kept, and little information is now available concerning the distribution of the tin concentrates in the bores. Judging from the depth to which values persisted in some of the bores put down between Fremantle Cut and Angus's Cut, lode material must have been encountered at depth.

TABLE 24.

RESULTS OF BORING OPERATIONS BY GREENBUSHES TIN LTD. ON M.C. 6.

A 6 inch Keystone drilling plant was used and holes were cased. Boring was done during 1939.

Bore No.	Total Bore Depth.	Depth of Values.	Distribution of Values.	Average Value.	Remarks.
	Feet.	Feet.			
1	84	84	... ...	2 lbs./cub. yd. to 84′ ...	Bore probably passed into lode.
2	84	84	0′—20′, 6 lbs./cub. yd. ... 20′—50′, 6 lbs./cub. yd. 50′—70′, 6½ lbs./cub. yd. 70′—84′, 8 lbs./cub. yd.	7 lbs./cub. yd. to 84′ ...	Bore probably passed into lode. Hole omitted from calculations.
3	50	50	20′—20′, 1½ lbs./cub. yd. ... 20′—50′, 2 lbs./cub. yd.	1·8 lbs./cub. yd. to 50′ ...	
4	30	30	... ...	2 lbs./cub. yd. to 30′	
5	84	84	0′—6′, ½ lb./cub. yd. ... 6′—24′, trace 24′—60′, 6 lbs./cub. yd. 24′—84′, 6 lbs./cub. yd.	5 lbs./cub. yd. to 84′ ...	Probably mainly in lode. Not bottom at 84′.
6	80	80	0′—12′, 1 lb./cub. yd. ... 12′—50′, trace 50′—80′, 5 lbs./cub. yd.	3 lbs./cub. yd. to 80′ ...	Probably passed in to lode.
7	54	54	... ...	½ lb./cub. yd. to 54′	
8	...	...	... ...	Nil	Only trace of tin.
9	...	...	... ...	Nil	Only trace of tin.
10	40	14	... ...	2 lbs./cub. yd. to 14′ ...	Good coarse tin.
11	60	40	... ...	3 lbs./cub. yd. to 40′ ...	0′—14′ coarse tin, 14′—40′ fine tin.
12	48	38	... ...	3 lbs./cub. yd. to 38′ ...	Apparently no tin from 16′—28′. Passed into lode formation at 16′.
13	50	36	0′—16′, 1½ lbs./cub. yd. ... 16′—36′, traces	½ lb./cub. yd. to 36′	

14	40	...	... ...	Nil	A little coarse tin to 14′.
15	50	40	10′—14′, trace	1½ lbs./cub. yd. to 40′ ...	40′—50′ white pegmatite.
16	40	30	... ...	¾ lb./cub. yd. to 30′ ...	
17	50	50	... ...	¾ lb./cub. yd. to 50′	8′—50′ white pegmatite.
18	50	50	... ...	½ lb./cub. yd. to 50′ ...	Similar to No. 17.
19	50	50	4′—12′, trace	1½ lbs./cub. yd. to 50′ ...	
20	50	50	... ...	3 lbs./cub. yd. to 50′ ...	
21	50	12	... ...	3 oz./cub. yd. to 12′ ...	Struck underground workings.
22	60	60	... ...	¼ lb./cub. yd. to 60′ ...	Light tin to 48′. Best tin 48′—54′.
23	64	60	14′—24′, trace	1 lb./cub. yd. to 60′	
24	60	60	4′—8′, trace	1½ lbs./cub. yd. to 60′	
25	50	30	8′—30′, trace	¼ lb./cub. yd. to 30′	
26	50	50	6′—10′, trace	½ lb./cub. yd. to 50′	
27	50	50	46′—50′, trace	¾ lb./cub. yd. to 50′	
28	51	...	... ...	Nil	0′—12′ tailings with some fine tin.
29	50	30	18′—24′, no tin	1 lb./cub. yd. to 30′	
			26′—30′, trace		
30	50	41	... ...	1½ lbs./cub. yd. to 41′	
31	50	20	8′—12′, trace	¼ lb./cub. yd. to 20′	
32	50	...	0′—6′, trace	Nil	Last 20′ contains 2 lbs. iron/cub. yd.
33	40	...	0′—5′, trace	Nil	Hole averages 3 lbs. iron/cub. yd.
34	60	20	... ...	¾ lb./cub. yd. to 20′ ...	¼ lb./cub. yd. to 60′.
35	60	9	7′—9′, trace	7 oz./cub. yd. to 9′	
36	60	24	... ...	1¼ lbs./cub. yd. to 24′	
37	60	16	... ...	1 lb./cub. yd. to 16′	
38	60	17	10′—14′, nil	½ lb./cub. yd. to 17′	
			14′—17′, trace		
39	67	60	6′—8′, nil	1 lb./cub. yd. to 60′	
			14′—20′, trace		
			26′—28′, nil		
40	67	60	20′—23′, trace	1½ lbs./cub. yd. to 60′	
			58′—60′, trace		
41	60	16	6′—10′, nil	½ lb./cub. yd. to 16′	
42	65	30	9′—12′, nil	¼ lb./cub. yd. to 30′	
			14′—20′, nil		

TABLE 24—*continued*.

Bore No.	Total Bore Depth.	Depth of Values.	Distribution of Values.	Average Value.	Remarks.
	Feet.	Feet.			
43	60	16	... ...	¼ lb./cub. yd. to 16′ ...	Tailings to 5′.
44	60	24	0′—8′, trace	5 oz./cub. yd. to 24′	
45	60	42	12′—15′, nil	½ lb./cub. yd. to 60′	
			36′—40′, trace		
			42′—60′, nil		
46	60	40	40′—60′, nil	½ lb./cub. yd. to 60′	
47	60	...	... ...	Nil	Traces only.
48	60	60	22′—26′, trace	1¼ lbs./cub. yd. to 60′ ...	Not bottom at 60′.
49	60	...	4′—16′, fine tin	Nil	Tailings to 4′.
50	55	...	0′—16′, fine tin	Nil	
51	50	18	15′—18′, trace	1¼ lbs./cub. yd. to 18′.	
52	60	30	3′—6′, trace	1 lb./cub. yd. to 30′	
			12′—16′, nil		
53	60	...	... ...	Nil	
54	60	...	0′—4′, fine tin	Nil	
55	60	10	... ...	3 oz./cub. yd. to 10′	
				⅓ oz./cub. yd. to 60′	
56	60	20	... ...	¾ lb./cub. yd. to 20′	
57	60	20	... ...	2½ lbs./cub. yd. to 20′	
58	21	18	0′—3′, trace	½ lb./cub. yd. to 18′	
59	58	25	0′—4′, trace	½ lb./cub. yd. to 25′	
			8′—10′, trace		
60	60	...	0′—8′, trace	Nil	
61	58	15	0′—6′, trace	½ oz./cub. yd. to 15′	
62	58	20	... ...	¾ lb./cub. yd. to 20′	
63	55	25	... ...	1 lb./cub. yd. to 25′	

64	60	60	0′—10′, trace	1½ lbs./cub. yd. to 30′	
			25′—30′, trace	1 lb./cub. yd. to 60′	
			50′—60′, trace		
65	60	40	0′—3′, trace	¼ lb./cub. yd. to 40′ ...	30′—40′ lode material.
			25′—30′, trace		
66	46	15	... ...	4·7 oz./cub. yd. to 15′	
67	30	...	0′—5′, trace	Nil	
68	22	10	... ...	17 oz./cub. yd. to 10′	
69	30	20	20′—25′, trace	5·7 oz./cub. yd. to 25′ ...	0′—10′ tailings.
70	45	15	15′—20′, trace	5 oz./cub. yd. to 20′ ...	0′—5′ tailings.
71	40	30	10′—15′, trace	4·1 oz./cub. yd. to 30′	
			15′—20′, nil		
72	30	25	... ...	58·9 oz/cub. yd. to 25′	
73	35	10	5′—10′, trace	2 oz./cub. yd. to 10′	
74	20	5	0′—5′, trace	4·3 oz./cub. yd. to 5′ ...	10′—15′ traces in lode formation.
75	50	10	0′—5′, nil	3·9 oz./cub. yd. to 10′ ...	0′—5′ tailings nil. Traces of tin 20′—40′.
76	50	40	40′—45′, values low ...	31·5 oz./cub. yd. to 45′	
77	25	15	... ...	17·9 oz./cub. yd. to 15′	
78	35	15	15′—25′, trace	5·8 oz./cub. yd. to 15′ ...	0′—5′, tailings nil.
79	25	20	... ...	22·2 oz/cub. yd. to 20′	
80	18	10	... ...	2·3 oz./cub. yd. to 30′ ...	0′—5′. tailings nil.
81	19	5	... ...	7·6 oz./cub. yd. to 5′	
82	20	10	... ...	5·99 oz./cub. yd. to 10′ ...	0′—3′, tailings.
A.	10	5	0′—5′, trace	Nil	
B.	10	5	0′—5′, trace	Nil	

The sites of bores Nos. 1 to 79 are shown on the accompanying plan fig. 15).

Bores A and B are scout bores reported to have been put down along the south margin of D.C. 90, but their actual sites are not known.

Bores 80, 81, and 82 are said to "prove conclusively—that tin in bore 72 and surrounding it—must be a continuation of Bunbury Cut run, of alluvial wash." Their actual sites are not known.

Estimates of reserves.

Mr. J. S. Foxall, Assistant State Mining Engineer has made an estimate of the reserves (Mines Department File 714/41) in the ground bored by Greenbushes Tin Ltd. Mr. Foxall first of all assumes that the values are correct, and that mining would be limited to a depth of 40 feet, and then describes his method of computation as follows:—

> The estimate was made by contouring the boring plan according to the value per cubic yard, and also according to the depth of the ground indicated. Everything outside the ¾ lb. contour was neglected. Sections were taken every 100 feet and approximate values and depths, according to contours, interpolated at 50 feet intervals along the section lines. The areas of the sections and weighted average values were then worked out, totalled and multiplied by the distance between sections, giving the total yardage and average value of the ground available.

The outline of the ground included in Mr. Foxall's estimate is shown on the accompanying plan of the bore sites (fig. 15).

It is the portions of the reserves, occurring between the east-west lines A to H and M to P on this plan, that are shown in the table 25.

TABLE 25.

Portion of reserves between E.—W. Lines	Volume. Cubic yards.	Average value. Lbs. concentrates per cubic yard.	Average depth. Feet.
P. and O.	23,000	2·02	19
O. and N.	56,000	1·85	27
N. and M.	27,000	0·82	24
M. and A.	99,000	0·92	34
A. and B.	96,000	1·53	38
B. and C.	128,000	1·46	36·5
C. and D.	68,000	1·54	32
D. and E.	48,000	1·08	33
E. and F.	41,000	0·97	37
F. and G.	89,000	1·08	36
G. and H.	65,000	1·28	37
Total reserves ...	740,000	1·31	...

Summary and conclusions.

Mineral Claim 6 is covered by alluvial deposits and laterite but the basement complex very likely consists of greenstones, which have been intruded and replaced along shear zones by stanniferous

material of granitic composition. The schistosity of the greenstones probably strikes in a north to north-west direction, and dips steeply either to the south-west or north-east.

Both the Old Alluvium and the Recent Alluvium occur in the area. The Old Alluvium is distinguished from the Recent Alluvium by being pre-laterite in age, and it occurs as terraces on the slopes of the hills flanking Bunbury Gully. Recent Alluvium, which has resulted from the denudation of the Old Alluvium, occurs in Bunbury Gully and in Elliot's Gully. In this area the Old Alluvial ground is composed mainly of a mixture of waterworn quartz, waterworn tourmaline and kaolin, and the recent alluvial ground of sands and gravels.

By reference to the table 23 it will be seen that most of the production from M.C. 6 has been obtained from alluvial deposits, and, judging from the distribution of the workings, principally from the Old Alluvium. About 289 long tons of tin concentrates have been recovered from the alluvial deposits, and only about 12 long tons of concentrates from the lodes.

Except for Fremantle Cut, the lode workings are confined to a small area near the eastern corner of the mineral claim. In this locality, the lodes have apparently been small shoots with variable strikes and dips, but boring has indicated that the lode exposed in Fremantle Cut is a large, well defined, formation.

If the values in the bores put down by Greenbushes Tin Ltd. are accepted as correct, there is a large quantity of cassiterite yet to be recovered from this area, provided proper mining methods are adopted. The following areas are the most important:—

(1) In particular, the portion of the terrace of Old Alluvium between Angus's Cut and Allen's Cut, together with the Fremantle lode formation which occurs underneath it, warrants development. According to the estimate of the reserves, there are 471,000 cubic yards with an average value of 1.29 lbs. of tin concentrates per cubic yard and an average depth of about 35 feet, in this belt of country. The laterite capping, which attains a thickness of about four feet, presents some difficulty to mining, but with this quantity of reserves its economic removal should be possible. Some difficulty may also be experienced in the treatment of the coarse "wash" at the base of the Old Alluvium as it is sometimes cemented together, but judging from the material seen in the walls of Angus's and Allen's Cuts most of the alluvium should be good sluicing ground. The lode material should also be amenable to sluicing, as it is highly decomposed near the surface.

(2) Development also appears to be warranted in Elliot's Gully where boring has indicated that 269,000 cubic yards of alluvial ground with an average value of 1.34 lbs. of tin concentrates per cubic yard and an average depth of about 28 feet, exist.

(3) Prospecting is warranted in the upper part of Bunbury Gully as small rich, unworked patches of alluvial ground may exist.

DREDGING CLAIM 90.

By R. S. Matheson.

Plate III.

General information.

Dredging Claim 90 is situated on the south-western side of the Greenbushes-Bridgetown main road, about 1½ miles south-south-east of the Greenbushes townsite.

The workings on Elliot's old claim 219A, and also those on old claims 535, 639, 649, 651, 662, 663, 682, 683, 701, 702, 710, 858, 875 and 880 are included in this area. There is unfortunately little information available concerning these old workings, but the information, such as it is, is reproduced in a later section of this report. Most of the work in this area was carried out prior to 1908.

At the time of inspection (August 1942) a few prospecting shafts were being put down on D.C. 90, but they were abandoned soon afterwards due to excessive ground water.

Production.

A considerable amount of cassiterite is believed to have been obtained from the ground now occupied by D.C. 90, but only a small part of the production can be traced in the official records. This is due to the fact that the ground was originally taken up by numerous claims, the production from which is now bulked with that from other claims in the official records. To 31st December, 1943, "sundry claims" in the Greenbushes district have produced 5,917.91 long tons of alluvial tin and 71.23 long tons of lode tin valued at £462,395.

The production, to 31st December, 1943, that can be traced as having come from the ground now occupied by D.C. 90 is given in table 26.

TABLE 26.

PRODUCTION FROM D.C. 90 TO 31ST DECEMBER, 1943.

Registered name of company or lease.	Lease numbers.	Period of production.	Tin Concentrates.			Reported value.
			Lode.	Alluvial.	Total.	
			Long tons.	Long tons.	Long tons.	£A.
	535 C.	1899	....	0·40	0·40	24
	219 AC.	1906	....	16·60	16·60	1,639
	683 C.	1906	....	2·70	2·70	255
	710 C.	1906	....	2·10	2·10	199
	D.C. 90	1935-38, 42	....	6·39	6·39	923
Total production	....	....	....	28·19	28·19	3,040

Topography and geology.

As will be seen from the accompanying map (plate III), D.C. 90 occupies part of the divide between Bunbury Gully and Cowan Brook stream systems, and includes the upper part of Elliot's Gully. The country varies in elevation from about 900 feet at the northern boundary of the area to about 850 feet at the southern boundary. The country is falling from the centre of the claim, to the east, west, and south.

The area is completely covered by laterite and/or Old Alluvium, but the underlying basement rocks very likely consist of, north-westerly striking and steeply dipping, amphibolite schists, which are intruded and/or replaced along shear zones by stanniferous, tourmaline-bearing granitic material. Where seen in shaft dumps, and in Cole's Cut, the basement rocks are highly kaolinised. The laterite directly overlies small areas of basement rocks near the north-east and north-west corners of D.C. 90, but Old Alluvium occurs between the laterite and the basement rocks over the remainder of the area. In places the laterite has been removed by erosion, revealing the sandy upper part of the Old Alluvium. The Old Alluvium consists mainly of a mixture of waterworn, tourmaline-bearing, sands and gravels, which attain a thickness of 50 feet in some places. A bed of very coarse conglomerate (or wash), about two feet thick, which is frequently cemented together by iron oxide, is reported to have occurred at the base of the alluvium. Considerable amounts of cassiterite are reported to have been obtained from this bed of conglomerate. Another bed of stanniferous conglomerate, which occurs at a depth of about six feet from the surface, has been mined in several places in this area. There is insufficient information available to determine the distribution of these two horizons of conglomerate.

The workings.

The workings on D.C. 90 consists of two open cuts, namely Cole's Cut and Keyser's Cut, and numerous shafts and potholes. At the time of inspection (August 1942) only a partial examination of the two opencuts was possible, due to the presence of water, and the other workings were inaccessible.

Cole's Cut.—The situation and extent of this open cut can be seen on plate III. A seam of stanniferous "wash", one to two feet thick and consisting of coarse, waterworn, quartz boulders set in ferruginous grit, has been mined. The "wash" is overlain by white tourmaline-bearing sand, which varies in thickness from six feet along the northern side of the open cut to 15 feet at the eastern end. White, puggy, kaolin occurs immediately below the "wash", and this is apparently true bottom as quartz veinlets were noted in the kaolin in a few places. The laterite capping, which usually occurs over the Old Alluvium, has apparently been partly removed by erosion in the vicinity of these workings. The concentrates obtained from this cut are reported to have averaged about 65 per cent. metallic tin.

Keyser's Cut.—A small open cut, which is known as Keyser's Cut is situated near the south-east corner of D.C. 90. The open cut is 12 to 15 feet deep, and a seam of coarse "wash" has been mined. The alluvial ground is lateritised to about 10 feet from the surface. The concentrates recovered from this cut are reported to have averaged 65 per cent. metallic tin.

Other workings.—Some information concerning the workings on the ground now occupied by D.C. 90 is contained in previous departmental reports, and as these are now out of print the information is reproduced hereunder.

In the year 1899, A. Gibb Maitland (1900, pp. 19-20) reported on this area as follows:—

> An important tributary, Elliott's Gully, enters the main channel of the Bunbury to the south of the bore hole just alluded to. A good deal of prospecting has been carried out along the course of the gully.
>
> The walls of the watercourse are hemmed in by the ferruginous conglomerate which forms the bulk of the watershed.
>
> The ground held by Messrs. Portwood and Burnet, near the mouth of the valley, has been exploited by two shafts about 40 feet in vertical depth. The northernmost shaft exposed a series of cemented gravels, forming a true conglomerate in places, resting upon an uneven floor, which dips at an angle of about five degrees to the south-east. The bottom upon which the deposit rests is very clayey, and is derived from the disintegration of a very argillaceous rock. A very ferruginous sandstone or conglomerate rests directly upon the clay, and is covered with a whitish tourmaline-bearing wash, which at the bottom is about six inches in thickness. The most southerly shaft, 40 feet in vertical depth, exposes a somewhat similar section. The floor upon which the deposit rests dips at a

low angle to the north-east and evidently forms the southern bank of the watercourse. Above the conglomerate at the bottom of the shaft is a few feet of very white gritty sand, covered by about five or six feet of ironstone rubble, derived from the denudation and subsequent partial consolidation of the ironstone conglomerate which forms the bulk of the surface of the ground.

The adjoining ground higher up the gully is held by Mr. Elliot. A great deal of work has apparently been carried out upon the property at different times. The main working shaft is situated near the northern bank of the gully and has been carried down to a vertical depth of slightly over 50 feet. To the top of the "wash" is 50 feet. The "wash" is a very coarse conglomerate with a very large proportion of flat-sided boulders cemented together in part with oxide of iron (1240). Tin shows freely in the different portions of the conglomerate. The average thickness of the deposit is about two feet. The conglomerate rests upon the upturned edges of a decomposed clay slate, which is vertical and which strikes south-east. The floor upon which the deposit rests dips at a low angle to the south-east. Directly overlying the conglomerate is, in places, a fairly extensive deposit of white gritty sand which contains detrital tourmaline. The main shaft is connected with a series of old workings, which expose a somewhat similar section.

To the south of Elliott's an open cast, just on the edge of the flat, six feet in depth, discloses the following section:—

	ft.	in.
Yellow Surface Sand	2	0
Ferruginous Cement	3	0
Coarse "Wash"	1	0 to 1ft. 6in.

Some little distance to the west of Elliott's a bore has been put down to a depth of 65 feet; the bore was sunk with the object of prospecting for what may be called Elliott's Lead, but the location of the bore site proved to be too far to the north, and out of the track of the old watercourse. After passing through about six feet of ferruginous rubble, derived from the disintegration of the conglomerate which forms the northern edge of the gully, the boring tool entered a clay, almost identical in character with that underlying the wash in Elliott's main shaft. The bore was evidently carried through decomposing clay slate. The material at grass at a disused shaft to the west of Elliott's, and in the trend of the old watercourse, showed that the deposit was of a similar nature to that to the east.

North-west of this, on Smith's Claim, two shafts have been sunk. The easternmost of the two had a vertical depth of 42 feet. The bottom of the shaft exposed a conglomerate wash, 18 inches in thickness, resting upon a floor of a decomposing clayey rock, which dips generally to the east at an angle of about 10 degrees. The clayey rock is traversed by a small quartz vein. The wash, which had been followed up on the rise for a distance of about 43 feet from the shaft, showed tin freely. The second shaft, some little distance to the west, had been carried down for a vertical distance of 33 feet with the apparent object of intersecting the wash in the adjacent working. The shaft passed through a very clayey deposit, in all probability resulting from the disintegration *in situ* of a very argillaceous rock. At a depth of about 23 feet, a "tin floor" made its appearance, but no steps had been taken at the date of my visit to exploit it.

Upon the ground lying at the head of the gully, a good deal of desultory work had been carried out. Upon Nuttal's Claim the most northerly of the shafts disclosed a tin-bearing wash of 12 inches in thickness, covered by a gritty sand, carrying a fair proportion of tourmaline. This sandy bed occurred about 18 inches above the bottom wash, but only reached a thickness of six inches. From the mouth of the shaft the first eight or nine feet consisted of detrital ironstone conglomerate. The floor or bottom upon which these deposits rest is a decomposing clayey rock, probably a clay slate. The adjoining shaft to the south had been carried down to a vertical depth of 15 feet. The sinking showed detrital conglomerate five feet; sharp gritty sand, nine feet; tin-bearing wash, one foot. The bottom has a slight underlie to the north-east. Five others shafts in close proximity show a practically identical section.

The following description of Elliott's old claim 219A is contained in Bulletin 30 (Simpson and Gibson, 1907, p. 70).

Claim 219A (8 acres). A great deal of work has apparently been carried out upon the property at different times. The main working shaft is situated near the northern bank of the gully, and has been carried down to a vertical depth of slightly over 50 feet. To the top of the wash is 50 feet. The "wash" is a very coarse conglomerate with a very large proportion of the flat-sided boulders, cemented together in part with oxide of iron (1239, 1240). Tin shows freely in the different portions of the conglomerate. The average thickness of the deposit is about two feet. The floor upon which the deposit rests dips at a low angle to the south-east. Directly overlying the conglomerate is in places a fairly extensive deposit of white gritty sand, which contains detrital tourmaline. Just to the south of Elliott's Shaft an open cut showed 12 in. to 18 in. of coarse wash at a depth of six feet under yellow surface sand and ferruginous conglomerate. The output of this claim during 1906 was:—16.60 tons, £1,639.

Conclusions.

The available information is too meagre for any definite conclusions to be formed concerning the future prospects of the area, but some prospecting appears to be warranted, as unworked sections of rich "wash" may occur between the old workings.

As two horizons of "wash" occur in parts of the area, it is also possible that some of the old workings have been discontinued at a false bottom.

MINERAL CLAIM 45.

By R. S. MATHESON.

Plate III.

General information.

Mineral Claim 45, which is identical with late Mineral Claim 3, is situated on the north-eastern side of the main Greenbushes-Bridgetown road, about 1¾ miles south-east of Greenbushes townsite.

This area has been mined spasmodically since the year 1899, but the main activity was prior to 1914. Mineral Claim 45 includes the workings of the old "Amanda", "Glencoe", "Lost and Found", "Lost and Found North", and "Bunbury End" leases.

At the time of inspection (August, 1942) there was no activity on M.C. 45, and the underground workings were inaccessible. A surface examination of the area was made however, and additional information was obtained by reference to previous departmental reports.

Production.

The production of tin concentrates, which can be definitely established as coming from the ground now occupied by M.C. 45, is shown in the table 27.

It is important to note that during the period 1899-1905 only the total quantity of tin concentrates produced was recorded by the Mines Department, but from 1906 alluvial concentrates and lode concentrates were recorded separately. All production prior to 1906 has been recorded as alluvial concentrates in later official records.

In the case of M.C. 45, it is believed that the 28.89 long tons of alluvial tin recorded, were actually produced, as the Old Alluvium extends over the lodes in this area.

TABLE 27.

PRODUCTION FROM M.C. 45 TO 31ST DECEMBER, 1943.

Registered Name of company or lease.	Lease numbers.	Period of production.	Tin Concentrates.			Reported value.
			Lode.	Alluvial.	Total.	
			Long tons.	Long tons.	Long tons.	£A.
Amanda	M.L. 56	1899–01	....	0·85	0·85	52
Glencoe	M.L. 217	1900–02	....	3·66	3·66	201
Amanda Leases	M.Ls. 56 and 217	1902–04	....	22·83	22·83	1,471
Lost and Found	M.L. 374	1905–11	12·56	1·30	13·86	1,402
Lost and Found North	M.L. 393	1906–09	11·02	....	11·02	915
Lost and Found North	M.L. 507	1910–12	8·23	0·25	8·48	919
Lost and Found	M.L. 543	1912, 13	4·82	....	4·82	580
Bunbury End	M.L. 563	1913	0·56	....	0·56	60
Lost and Found	M.L. 605	1918	0·50	....	0·50	87
Lost and Found North	M.L 606	1918, 19	4·80	....	4·80	975
Lost and Found	M.L 628	1927	0·33	....	0·33	50
Total production	....	...	42·82	28·89	71·71	6,712

Topography and geology.

As will be seen from the accompanying geological plan (plate III) M.C. 45 is situated on the north-eastern side of Bunbury Gully opposite its junction with Elliot's Gully. There is a rise in elevation from about 800 feet at the south corner of the mineral claim to about 890 feet at the north corner. The country rises quickly for a few chains from the south-west boundary, after which there is only a gently rising slope to the north peg of the mineral claim.

The area is completely covered by laterite, but from an examination of shaft dumps and by reference to previous reports, there is good reason to believe that the basement rocks consist of greenstones, which have been intruded, and probably also replaced, along shear zones by granitic material.

The greenstones, which are believed to be comprised mainly of amphibolite schists, very likely strike in a north to north-westerly direction and dip steeply. The greenstone country is kaolinised and decomposed to about 70 feet from the surface.

The granitic rocks are tourmaline-bearing and stanniferous and they constitute the lodes which have been mined in this area. In the main workings the lodes consist of narrow, irregular, pegmatitic veins, and there is no indication of a wide, well defined, lode formation such as was mined on the "Vulcan," M.C. 4 (Ellis, 1939, pp. 9-13). A specimen (2/2517) of a stanniferous, tourmaline-bearing lode material, obtained from the dump of the old main shaft on M.C. 45, is contained in the Geological Survey rock collection. There is some suggestion that the lodes change from the intrusive to the replacement type of deposit near the north-west boundary of M.C. 45, but they are still narrow and irregular.

Old Alluvium, as well as laterite, overlies the basement rocks on the north-eastern half of the mineral claim. Where the laterite overlies the alluvial ground it contains waterworn quartz grains, waterworn tourmaline and occasionally waterworn cassiterite. The Old Alluvium is part of a terrace, which occurs along the north-eastern side of Bunbury Gully, and it is believed to have originally extended over the whole of the area included in M.C. 45.

In the vicinity of the "Lost and Found" workings, the Old Alluvium has been almost completely lateritised, but judging from fresh sections of the Old Alluvium seen elsewhere, it originally consisted of a mixture of quartz, tourmaline and kaolinitic material with a seam of coarse wash at its base. Waterworn quartz boulders, which have probably come from the seam of coarse wash, can be picked up in some of the shallow open cuts on M.C. 45.

The significance of the occurrence of Old Alluvium over the lodes has not been properly understood by local inhabitants. They consider that the cassiterite recovered in the surface workings was shed from the lodes occurring below, while actually it has more likely been derived from other lodes and transported to its present situation. An exaggerated opinion of the value of the "Lost and Found" lodes has resulted from this misunderstanding.

The workings.

The alluvial workings consist of numerous, shallow opencuts, up to about 10 feet deep, which are scattered in a north-west direction through the centre of the mineral claim. The workings extend over a width of two to three chains, and are distributed along the lower boundary of the Old Alluvium. Pieces of waterworn cassiterite weighing up to ½ lb. are reported to have been obtained from these workings.

The underground workings were inaccessible at the time of inspection (August, 1942). The information available from previous reports is meagre, and conflicting in some respects, but two, if not three, lines of lode, which strike in a general north-westerly direction, appear to have been mined. The lodes consist of narrow, lenticular tourmaline-bearing, granitic veins, which are variable in strike and dip. Mining has been carried out mainly between the surface and about 40 feet vertical depth, but one shaft, which is known locally as the main shaft, has been sunk to about 100 feet vertical depth. A plan prepared by R. C. Wilson (1929, p. 44) in 1928, shows the following work off this shaft. At the 75 ft. level there is a south-east drive for 12 feet 6 inches on an easterly dipping lode. At the 90 ft. level there is a north-west drive for 17 feet off the end of which 40 feet of crosscutting has been done; about 12 feet south-west and about 28 feet north-east. In a letter from J. C. Kerr (see Mines Department file 1567/26) who apparently supervised this work, it is stated that the lode at the 75 ft. (? 85 ft.) level was 18 inches wide, and that two lodes, which were respectively 12 inches and 24 inches wide, were encountered in the drive and west crosscut at the 90 ft. level. All the lodes are said to have carried "good tin." The main shaft was sunk with the intention of intersecting a westerly dipping lode, which had been mined near the surface, but it is doubtful whether or not this was actually done. Information obtained from local inhabitants suggests that the main shaft was eventually sunk to a vertical depth of 105 feet. At the time of the writer's inspection ground water level in the main shaft was about 20 feet from the surface.

Other information concerning the workings on the ground now occupied by M.C. 45 is contained in previous departmental reports. As most of these reports are now out of print it is considered advisable to reproduce the information hereunder.

In his report on the Greenbushes Tinfield in 1899, A. Gibb Maitland (1900, p. 19) has made the following notes on this area.

> On the eastern side of the main road to Bridgetown on what was originally M.L. 82/76, a shaft has been put down to a shallow depth upon a tourmaline dyke, which was met with beneath the conglomerate at a depth of about five feet below the surface. The overlying conglomerate

contains detrital tourmaline, which led to the discovery of the dyke. As exposed in the workings the width of the dyke is about 2 feet 6 inches. The strike of the dyke is generally north-west, with an underlie to the south-west at an angle of about 70 degrees. The tourmaline is enclosed in a ferruginous clayey matrix, which contains occasional patches of quartzose material. Evidently the dyke will prove to be one of the felsitic family. The dyke yielded a small quantity of very angular tin, associated with large quantities of titanium. An assay of a sample (1376) yielded in the official laboratory 1.97 parts per hundred of metallic tin. The tourmaline carries a small portion of tin. The dyke is known as the Amanda lode.

What is apparently a parallel lode is exposed some little distance to the north, on what is known as Messrs. Parish and Armstrong's Claim, beneath a cover of about three feet of cement.

In 1903, A. Montgomery (1904, p. 82) commented on this area as follows.—

In the lower part of Bunbury Gully in the Amanda workings, there are veins carrying crystalline tin ore traversing the soft weathered granitic bed rock. These do not appear to be large enough to be called lodes, but are apparently fissure deposits rather than impregnations of a mass of country, and came therefore nearer to the lode type than to that of stockworks. Some of these veins contain nice bunches of tin ore, but none have been large enough for systematic work, and they have only been followed downwards a few feet into the weathered bed rock.

W. D. Campbell (1906, p. 19) reported on the area as follows:—

Another lease No. 374, the Lost and Found, which comprises portion of the extinct M.L. 56, Amanda, is now held by Messrs. Andrew, Winter, and McGowan, and is situated 1½ miles (?) south of the Post Office at Bunbury end; here a shaft 54 feet deep in kaolinised granite has been sunk on a lode composed of four veins or bands of about five inches each, in a total width of four feet, having an underlay of about 25 degrees to the east and a strike of 40 degrees. The formation is gneissic and slightly ferruginous in places; no lode mining has previously been done here. See Mineral Specimen (6516). This formation carries crystals of tin and tourmaline, and resembles the lode on the Cornwall lease. I was informed by Mr. Andrew that, in the lead of tin-wash near here, a solitary specimen of gold was found, weighing 1½ grains, at 24 feet depth.

While engaged on an examination of the "Vulcan," M.C. 4, in 1938, H. A. Ellis (Ellis, 1939, pp. 10-11) also made a brief examination of this area and compiled the following notes:—

The old workings on M.C. 3 (known as the "Lost and Found" lease) suggest that the bulk of the tin oxide was obtained in the past from alluvial deposits associated with laterite, and from narrow decomposed pegmatite dykes, forming a stockwork in phyllites and amphibolite schist. There is no indication in these old workings of the existence of a wide mineralised and granitised zone similar to that exposed in the open cut on M.C. 4, and the deposits on M.C. 3 can be best regarded as forming a band of narrow pegmatite dykes parallel in strike to the main belt to the west.

Boring.

While the Mines Department was carrying out a boring campaign at Greenbushes during the period 1928 to 1929, two diamond drill holes (Nos. 7 and 8) were put down to test the "Lost and Found" line of lode. The sites and directions of these bores are shown on plate III), while the other available information (Larcombe, 1929, pp. 87-88) concerning them is given below.

Bore No. 7, which was depressed at an angle of 50 degrees, was bored in an easterly direction to a linear depth of 250 feet. Kaolinised and decomposed greenstone occurred in the upper part of the bore, but it appears to have passed into fairly fresh unaltered greenstone at a bore depth of between 80 and 100 feet. A stanniferous, tourmaline-bearing, granitic vein, which assayed 0.90 per cent. SnO_2, was encountered in this bore between 124 feet and 125 feet 6 inches linear depth from the surface.

Bore No. 8, which was depressed at an angle of 70 degrees, was bored in an easterly direction to a linear depth of 191 feet. In this bore also, the greenstone country appears to have been kaolinised and decomposed to a bore depth of between 80 and 100 feet. A stanniferous tourmaline-bearing granitic vein, which assayed 0.39 per cent. SnO_2, was encountered in this bore between 122 feet two inches and 122 feet six inches linear depth from the surface.

After an examination of the bore cores, C. O. G. Larcombe described the country rocks as follows:—

> In the Lost and Found mine the rocks are fine grained hornblende schists. At 113 feet in the No. 8 bore the hand specimen is a dense, dark green, semi-schisted greenstone. Microscopically it is a mass of small prisms of green hornblende with minute interstitial grains of felspar and quartz. The whole rock is studded with clear grains of sphene and occasional colourless pieces of epidote.

Conclusions.

As only meagre information concerning the lodes on M.C. 45 is available, it is difficult to form conclusions as to their future prospects.

It is unlikely that the lodes could be successfully exploited at depth, as they are narrow and lenticular, and difficulties in mining would be experienced due to the presence of ground water and hard country. With the present high price of tin (66s. per unit), it may be possible, however, to successfully mine unworked sections of the lodes in the oxidised zone.

Prospecting of the unworked parts of the Old Alluvium (see plate III) is also warranted.

MINERAL CLAIM 4.

By R. S. MATHESON.

Plate III.

General Information.—Mineral Claim 4 is situated on the south-western side of the Greenbushes-Bridgetown main road, about 2 miles south-south-east of the Greenbushes townsite.

A detailed examination of the area was made by H. A. Ellis in 1938 (Ellis, 1939, pp. 9-13), but some additional information was obtained by the writer, during his investigations in the Greenbushes district, in 1942.

Mineral Claim 4, which is known locally as the Vulcan Tin Mine, includes the main workings of the old "Caledonian", "Ironclad", "Battery Hill" and "Southern Cross" leases. A large section of Westralian Gully, which has been extensively worked in the past for alluvial tin, is also included in the mineral claim.

At the time of inspection (September, 1942) sluicing operations were in progress near the north-west end of the Vulcan Cut (see plate III), but the work was discontinued early in 1943.

Production.—The production of tin concentrates, so far as can be established as coming from the Vulcan line of lode, is shown in table 28. The production from old alluvial workings in Westralian Gully, and in Bunbury Gully has been excluded from this table, but is included in table 8.

TABLE 28.

PRODUCTION FROM VULCAN LINE OF LODE TO 31ST DECEMBER, 1943

Registered name of company or lease.	Lease numbers.	Period of production.	Tin Concentrates.			Reported value.
			Lode.	Alluvial.	Total.	
			Long tons.	Long tons.	Long tons.	£A
Queen's Birthday	M.L. 58	1899	1·20	....	1·20	82
Caledonian	M.L. 76	1899–1900	....	8·06	8·06	542
Ironclad	M.L. 179	1900	....	0·45	0·45	30
Ironclad	M.L. 456	1907	0·95	....	0·95	82
Westralian Gully Tin Co., Ltd.	M.Ls. 381, 435. 436 472, 478	1907–10	6·38	34·38[1].	40·76	3,235
Aqua West	M.L 478	1910	0·20	....	0·20	16
Battery Hill	M.L. 436	1910–13	4·49	0·05	4·54	412
Southern Cross	M.L. 580	1918, 21	7·95	....	7·95	1,086
	M.Cs. 2, 4	1936–37	11·50[2]	....	11·50	1,634
Vulcan Minerals, Ltd.	M.C. 4, etc	1937–43	132·49	....	132·49	17,430
Total production	....	...	165·16	42·94	208·10	24,549

[1]This production is probably from Old Alluvial workings in Westralian Gully, not from the Vulcan line of lode.

[2]This parcel may include both alluvial and lode concentrates.

Topography and geology.

As will be seen from the accompanying geological map (plate III) M.C. 4 is situated on a low rise on the south-western side of Bunbury Gully, near its junction with Westralian Gully. Westralian Gully trends in an east-northeast—west-southwest direction through the centre of the area. The country varies in elevation from about 780 feet in Westralian Gully, to about 850 feet near both the north-west and south-east boundaries of the mineral claim.

The area is completely covered by laterite and alluvial deposits, but from an examination of the workings on M.C. 4 and adjoining holdings, there is good reason to believe that the underlying rocks consist of greenstones, which have been intruded and replaced along shear zones by granitic material.

The greenstones are kaolinised near the surface, but in their fresh state are believed to be comprised mainly of amphibolite schists. The schistosity of the greenstones probably strikes in a north to north-west direction and has a westerly dip.

The granitic rocks are exposed in the Vulcan Cut and in the old "Ironclad" workings, and Ellis's description of their origin, with which the writer is in agreement, is given below (Ellis, 1939, p. 10).

> The main workings on M.C. 4 are considered to be in a zone or belt of replacement gneiss and schist of unknown width, the economic importance of which is due to an accompanying introduction of tin oxide into the schistose rock, with associated tin-oxide and tourmaline-bearing pegmatite masses.

Near the north end of the Vulcan cut the schistosity of the lode formation strikes N 30° W and dips about 35° to 60° S.W., but at the south end the schistosity appears to strike in a north-south direction. Reference to the accompanying plan (plate III) and the geological map in Bulletin 32, shows that the "Ironclad" workings are very likely situated on a southern extension of the Vulcan lode formation.

Patches of both Old and Recent Alluvium occur on M.C. 4. The Old Alluvium occurs in the western corner of the mineral claim, but is believed to have originally extended over the Vulcan lode. It is lateritised at the surface, but can be distinguished from the laterite overlying the basement rocks by the presence of waterworn quartz grains and waterworn tourmaline. An unworked strip of Recent Alluvium 18 chains long and about three chains wide, which probably passes into Old Alluvium at depth, occurs along the northern side of Westralian Gully. The Recent Alluvium has no laterite cover and at the surface appears to consist mainly of sand. The alluvial deposits mined in Westralian and Bunbury Gullies are thought to have consisted of both Recent and Old Alluvium.

Laterite, overlying the basement rocks, occurs as a narrow belt on the southern side of Bunbury Gully, and as a rather extensive belt on the southern side of Westralian Gully. Where it overlies granitic lode material, the laterite contains angular fragments of quartz and tourmaline, and occasionally cassiterite. The laterite capping of the Vulcan lode is up to four feet in thickness.

The workings.

The workings on M.C. 4 can be conveniently separated for description into the Vulcan Cut, the "Ironclad" workings and the alluvial workings.

Vulcan Cut.—At the time of inspection the open cut was 880 feet long, about 100 feet average width, and had a maximum depth of about 40 feet. Sluicing operations were in progress at the northern end of the open cut on a lenticular shoot of ore occurring in the lode formation, which dipped flatly to the south-west and was reported to be about 80 feet long and 50 feet maximum width. It was anticipated that work would have to be discontinued on this shoot[14] when it dipped into the south-western wall of the open cut, as the cover would be too thick to be removed economically.

Other rich shoots of ore are reported to have occurred erratically in the lode formation towards the southern end of the open cut. The lode formation as a whole is said to contain small amounts of cassiterite, but its successful exploitation has been due to the presence of the rich shoots.

The lode formation consists of a schistose mixture of kaolin, quartz and muscovite mica, which has been impregnated with tourmaline. The tourmaline is frequently arranged parallel to the schistosity. Beryl is occasionally met with in the lode formation, while an examination of the concentrates has shown that, besides cassiterite, small amounts of tantalite (see p. 70), ilmenite and magnetite are also present.

The average value of the lode material mined from the Vulcan Cut is not known, but H. A. Ellis estimated that the ore treated during the period February, 1937 to January, 1938 averaged 5.39 lbs. of tin concentrates per cubic yard, containing 57 per cent. metallic tin. Parcels of concentrates obtained since then have contained up to 64 per cent. metallic tin, so that it is not unreasonable to assume that the average metallic tin content of the concentrates is in the vicinity of 60 per cent.

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[14]Work was actually discontinued early in 1943.

Judging from the occurrence of tourmaline and quartz in the laterite, the Vulcan lode extends for at least five chains beyond the northern face of the open cut, but the lessees report that boring has indicated that low values occur in the lode formation in this direction. Detailed information concerning the boring was not available, and it is not known how far it extended north-west from the open cut.

The limits of the Vulcan lode formation are not known, but its horizontal width is at least 100 feet. The north-eastern wall, which appears to be the footwall, was encountered in a tunnel, but the south-western wall has not yet been exposed.

Good values are reported to have occurred in the laterite overlying the Vulcan lode, and this is probably due to the fact that the Old Alluvium originally extended over the outcrop of the lode. It is probable that both alluvial and eluvial cassiterite occurred in the laterite.

"Ironclad" Workings.—The old "Ironclad" workings are situated on the southern side of Westralian Gully, south of the Vulcan Cut. The country rocks are covered with laterite in this vicinity, but an examination of the shaft dumps indicates that stanniferous, tourmaline-bearing lode material occurring in greenstone country has been mined. Reference to the geological plan accompanying Bulletin 32, shows that the lode formation was traced almost across Westralian Gully, so that there is little doubt in the assumption that the "Ironclad", workings are on an extension of the Vulcan lode formation. There is a possibility that the Vulcan lode formation may extend as far south as the "Last Chance" workings (see plate I, also Woodward, 1908, p. 64).

No information is available concerning the underground workings on the old "Ironclad" M.L. 456. The official records show that only 0.45 long tons of alluvial tin and 0.95 long tons of lode tin valued at £112, were recovered from the "Ironclad" lease, but it is believed that the 7.78 long tons of lode tin recorded from the "Queen's Birthday" and "Aqua West" leases, and from the property of the Westralian Gully Tin Co. Ltd., were probably obtained from this line of lode.

Alluvial workings.—The Old Alluvium has been worked in a few shafts and potholes south-west of the Vulcan Cut, and, as has been previously explained, cassiterite from the Old Alluvium was probably contained in the laterite overlying the Vulcan lode. The total quantity of alluvial concentrates recorded from M.C. 4, exclusive of that obtained from workings in Westralian and Bunbury Gullies, is 8.56 long tons. Some eluvial concentrates may possibly be included in this production.

Nothing can be added to the descriptions of the alluvial workings in Westralian Gully contained in previous departmental reports.

Conclusions.

There is scope for further prospecting on M.C. 4 in the following places.

A. On the strike of the Vulcan Lode north-west of the open cut.

B. In the vicinity of the "Ironclad" workings.

C. On the unworked patch of Recent and Old Alluvium along the northern side of Westralian Gully.

D. On the area of Old Alluvium.

E. In the event of an increase in the price of tin (present price 66/- per unit), or an improvement in mining methods, it may be possible to mine the Vulcan lode to a greater depth.

SALT WATER GULLY—AREA No. 6.

References.—Simpson and Gibson, 1907 pp. 71, 74: Woodward, 1908, pp. 67-68.

Salt Water Gully heads at the Show Grounds—reserve 8361. It is joined by three west flowing creeks, Scandinavian Gully, Floyd's Gully and Kelly's Flat. Area number 6 includes that portion of Salt Water Gully from which tin concentrates have been produced, the whole of Kelly's Flat, and the lower portions of Scandinavian and Floyd's Gullies.

The principal workings are on D.C. 69 at the junction of Scandinavian Gully and Salt Water Gully. The main production appears to have been from a sluicing cut, now filled with water, in Salt Water Gully, but sluicing has been extended for a short distance up Scandinavian Gully. The material exposed in the walls of that portion of the cut in Scandinavian Gully is a sandy clay, with some quartz boulders. No other information is available regarding these workings. There are small workings nearly all the way down Salt Water Gully to its junction with Kelly's Flat. Here there are some more extensive sluicing cuts. It is reported that ilmenite was very abundant in the alluvium hereabouts. In the lower portion of Floyd's Gully there are two small sluicing cuts, one on Claim 850 and the other at the west end of D.C. 64. The material worked in both these cuts was an unconsolidated sand. It is interesting to note here that a number of shallow shafts sunk immediately west of the west end of D.C. 64 have bottomed on a very weathered granitic gneiss.

The total recorded production from this area is 20.15 tons of tin concentrates, all of which is from alluvial ground.

FLOYD'S GULLY—AREA No. 7.

Reference.—Maitland, 1901, pp. 13-14 (M.L. 80, see below) Area number 7 includes the upper portion of Floyd's Gully. The recorded production from this area is 15.92 tons of concentrates, all of which is from alluvial ground.

The most extensive workings are on "Lost Chance," M.L. 598. The sluicing cut in this vicinity is only about two feet deep at its east end, but deepens to 15 to 20 feet at its west end. At the east end the material in the walls of the cut is an unconsolidated sand, while at the west end the material exposed consists of quartz pebbles in a white clayey matrix. The cut has bottomed at the west end on a granitic gneiss. On plate I this cut is shown as being entirely in Recent Alluvium, but the material exposed in western portion of the cut resembles the Old Alluvium seen in Bunbury Gully. It seems likely that at least some of the production has been from Old Alluvium. The recorded production from M.L. 598 is only 0.46 tons of concentrates, but it should be noted that the same ground was previously held as D.C. 68, the production from which would be recorded under the heading "Sundry Claims."

West of the workings on M.L. 598 there are fairly extensive shallow cuts, two to five feet deep, on T.A. 12 and C. 704. Laterite containing rounded and semi-rounded quartz boulders has been worked in these cuts, which have bottomed on what is probably a very weathered greenstone. Further west still there are a number of smaller sluicing cuts and other shallow workings about which no information is available. Near the head of the gully the creek branches—one branch heads on M.L. 620, while the other heads near the Enterprise workings. It is reported that some tantalite was found in the workings in that branch of the gully heading near the Enterprise workings, but that the main gully did not contain any tantalite in the alluvium.

The only workings in this area to which any reference is made in previous reports are those on "Queen of Greenbushes," M.L. 80. M.L. 80 joined M.L. 107 (see plate I) at its (M.L. 107) south-east side. Maitland (1901, pp. 13-14) describes these workings as follows:—

Queen of Greenbushes (M.L. 80).—Three vertical shafts have been put down in close proximity to each other upon the property. The most Northerly, No. 2 shaft, had been carried down to a vertical depth of 60 feet, through a white granitic rock, carrying small quantities of tourmaline. From the foot of the shaft a drive had been put in to the north for a distance of 15 feet through a whitish granitic rock identical in character with that passed through in the shaft. At nine feet from the face the granite gives place to a clay, which may represent the decomposition product of a porphyry. The junction between the two deposits dips to the south at an angle of from 40 to 50 degrees. This drive has been

continued southwards from the shaft, through a similar granitic rock, for some distance until it intersects another drive trending east and west, connecting with No. 1 shaft. Where the two drives intersect, a winze has been sunk for a vertical distance of 18 feet to what is known as the 80 feet level. A few feet below the floor of the level in the winze a fairly large quartzose portion of the granite which carries tourmaline is said to have yielded fair prospects of tin. None, however, was visible to me. No. 1 shaft, 60 feet in depth, has been sunk through a rock carrying a little mica and decomposing in the direction of kaolin, in all probability a granite of the type prevailing on the field. A drive has been put in a few feet south from the shaft through clayey country, intersected by a quartz leader. No. 3, or the Main Shaft (five feet by three feet) has been carried down to a depth of 100 feet, through a decomposing granitic rock. From the bottom of the shaft a drive has been put in to the westward for a distance of 20 feet. The face of the drive exposes a hard foliated quartzose granitic rock with tourmaline, inclined at a steep angle to the westward, and trending approximately north and south. What may be called the hanging wall of the foliated granite is a highly micaceous schist which has been penetrated a few inches. The thickness of the foliated granite—the so-called lode—is about 10 feet. A carefully selected sample of the "lode" yielded, on assay in the official laboratory, an appreciable quantity of tin, viz., .09 per cent. On the arrival of my specimens in Perth, it was found that certain fragments of metallic tin—not obtained from the "lode"—were included in the sample. These were, of course, extracted before assaying. A small sample of the dressed ore from the property yielded on assay 47.6 per cent. of metallic tin. A great deal of genuine labour has been done upon the property, which the owners inform me represents about £600 in cash. There is no true fissure lode opened up anywhere in the mine, the appearance of a hanging and foot wall being due to the jointing of the country rock, and a deceptive indication from a miner's point of view.

SCANDINAVIAN GULLY—AREA No. 8.

Reference.—Maitland, 1901, pp. 14-15 (The Ruby Tin Mining Co., M.L. 158). The principal workings are on D.C. 49, at the head of Scandinavian Gully. Here there are two small sluicing cuts, both of which were full of water at the time of inspection (October, 1942). No information is available about these cuts.

The only reference to any workings in this area in previous reports is that by Maitland (1901, pp. 14-15) to the Ruby Tin Mining Company's workings on M.L. 158, which extended in a general northerly direction from M.L. 107 (see plate I) and included portion of the headwaters of the creek in Scandinavian Gully. There are a number of old shafts close to the north-east corner of M.L. 107, the dumps of which show rounded quartz boulders. Maitland notes that on M.L. 158, two shafts had been sunk, each to 80 feet, in mica schist. These shafts exposed some quartz leaders and two "barren-looking" quartz reefs. He concludes that "no semblance of lode has been opened up anywhere in that portion of the workings accessible to me." Maitland does not indicate the position of the shafts on M.L. 158.

CENTRAL AREA—AREA No. 9.

References.—References are given under individual leases.

Area number 9 includes the late Cornwall, South Cornwall and Dixie workings together with numerous smaller lode workings and some alluvial workings. It also includes M.C. 47, on which some prospecting was done by the Mines Department in 1942 (see chapter IV).

As elsewhere in the Field the area is covered with laterite. The underlying rocks over most of the area are basement rocks, but there are a few small areas of Old Alluvium. The recorded production of tin concentrates from this area is 226.80 tons, of which 222.47 tons are from lode material and 4.33 tons from alluvium.

MINERAL CLAIM 22.

Plate II.

References.—Files—Campbell, W. D., Mines Dept. file 3736/05, p. 22. Reports (see bibliography)—Simpson and Gibson, 1907, p. 72: Woodward, 1908, p. 72: Wilson, 1929, p. 44: Howe, 1929, p. 39: Larcombe, 1929, pp. 87-88: Bowley, 1929, p. 107: Simpson, 1929, p. 101.

General information.

M.C 22 is situated on the top of a ridge immediately east of Greenbushes. No work was in progress during 1942, and all that could be seen was a series of shafts, either fallen in or full of water, and one open cut. The various shafts are shown on plate II.

Description of workings.

Very little information is available about the workings on this lease. The principal workings appear to be those in the vicinity of the open cut, which is in about the centre of the lease.

The workings were inspected by W. D. Campbell in 1906 (Mines Department file 3736/05, p. 22) who says:—

> The greatest depth reached is in the workings of the new main shaft about 125 feet, the last 25 feet shows the lode to be solid granite with walls in the partly decomposed hornblende schist (see M. Specimen 6998 and 6999). The hanging wall of the lode has a red clay casing with slickenside surface. The tin occurs in the granite lode in crystals up to half an inch broad associated with tourmaline. The quartzose portion is very white. The trend of this lode is 122 to 128 degrees underlaying 65 degrees to the west. There are two cross lodes bearing 182 and 187 degrees whicl would traverse the ground of the suggested residence areas. There is another cross lode towards the western side of the lease, bearing 102 degrees.

Simpson & Gibson (1907) note that in 1906 two hundred and thirty-nine (239) tons of ore were crushed and yielded 1.92 tons of tin concentrates.

In the following year the workings were inspected by Woodward (1908, p. 72) who in Bulletin 32 states:

> On the laterite ridge immediately east of the town is situated this lease, which includes part of old M.L.'s 71, Jeffery, 156, New Zealand Syndicate, and 104, New Guinea. A lode is being worked in this property, of which specimens from a depth of 120 feet are in the Departmental Museum (6998). These show that the lode is a pegmatite vein, composed largely of albite, with lesser quantities of quartz, tourmaline, muscovite, garnet and cassiterite.
>
> The lode in this property has a north-westerly course, dipping to the south-east, and can be traced for a distance of 14 chains. It has been prospected by a number of shafts, sunk to depths varying from 50 to 120 feet, in which it has varied considerably in size, but reaching as much as 12 feet in places, some of the stone being of exceptionally high quality.
>
> There are also a series of north and south veins which strike off from the main lode in a southerly direction; these are five in number and average about three chains in length, and have been prospected by a number of shafts sunk to depths which vary from 30 to 70 feet.
>
> This property has so far yielded 22.16 tons of tin oxide worth £1,763.

Woodward's report is accompanied by a plan reproduced as figure 16, which shows the shafts and also the ore bodies. Woodward states that the main ore body "can be traced for a distance of 14 chains", and indicates a more or less continuous ore body of about that length on his plan. What can be seen from a surface inspection at the present time suggests that a series of comparatively small shoots have been worked on the lease. The pegmatite dyke may or may not be continuous over a length of 14 chains—there is little at the surface to suggest that it was. The main shoot worked, as seen in the open cut, appears to have been not more than 100 feet in length. It is reported by Wilson (1929, p. 44) to have been only 50 feet in length. The other shoots have not been worked right to the surface and hence their length cannot be seen. The distribution of the shafts suggests that they too were short.

Diamond drilling.

Diamond drill hole number 6, put down in 1928, was set out to intersect the ore body worked in the open cut at 200 feet below the surface of the ground (Wilson, 1929, p. 44). Its position is shown on plate II. A number of granitic dykes were intersected in this bore, but none contained more than a trace of tin. Details are set out in table 29. The description of the rocks given in table 29 are those by Larcombe (1929, p. 88), but it should be noted that recent work by Miles (chapt. II) has shown that many of Larcombe's rock names

require to be amended. Unfortunately complete cores are not now available, only a few specimens having been kept in the Geological Survey rock collection. These have been examined by Miles and his descriptions are given below:—

Registered number.	Depth. (feet)	Description.
2/2671	253	Albite rich aplite
2/2671	264	Albite rich aplite
1/4563	273	Biotite schist
1/4569	287	Granulated pegmatite
1/4879	400	Fine grained aplitic biotite granite
1/4569	402	Fine grained aplitic biotite granite

The mineral content of these dykes is of some interest as two of them were found (Simpson, 1929, p. 101) to contain appreciable quantities of glaucophane, a mineral not previously recorded from Western Australia. One of these two dykes contained also some siderite and corundum. Referring to the dyke from 242 feet to 266 feet Simpson says:—

Throughout the 24 feet of core granular albite and quartz were the most abundant minerals. Amongst the minor minerals schorl, ilmenite, garnet and apatite were the most common, with traces of cassiterite, zircon, sphene, biotite, pyrite and rutile. Glaucophane was detected in the upper 14 feet of core, and was most abundant in the first six feet. The concentrate from the first four feet carried about 70 per cent. of siderite in dull yellow to brown granular masses. This is the first time the author (E.S.S.) has seen or heard of this mineral in a pegmatite. Apatite was common throughout, occurring in stout prisms about 0.2mm. in length, presenting characteristic optical properties and readily soluble in cold dilute nitric acid. Finally the concentrate from the middle three feet of the vein included some small corundum crystals.

Glaucophane was also found in the upper portion of the dyke from 273 feet to 291 feet.

TABLE 29.

DIAMOND DRILLING ON "DIXIE," M.L. 632 (1928).

Bore number.	Depression angle.	Depth in bore.	Rock type*	Assay results. % Sn.	
5	45°	153′—153′ 6″....	Tourmalinised white quartz felspar rock	153′—153′ 6″	Nil
		169′—169′ 4″....	Tourmalinised alaskite	169′—169′ 4″	Trace
		220′—223′ 9″....	White aplitic rock	220′—223′ 9″	Nil
		242′—266′	Pegmatite	242′—245′ 6″	Nil
				245′ 6″—258′ 4″	Trace
				258′ 4″—266′	Nil
		273′—291′ 2″....	Quartz felspar rock	273′—291′ 2″	Nil
		397′—403′	Granular saccharoidal quartz rock	397′—403′	Trace

*The rock names are those given by Larcombe (1929, p. 88). Some of these names have been amended. Reference p. 49.

MINERAL CLAIM 5.

General information.

Mineral claim 5 is situated immediately to the south-east of Greenbushes Townsite, and extends across the Greenbushes-Bridgetown road. It includes the late Cornwall and South Cornwall workings together with many smaller workings, about which no information is available. The total recorded production from M.C. 5 is 188.42 tons of concentrates, of which 187.12 are from lode material, while 1.30 are from alluvium. Of the total production of 188.42 tons the late Cornwall main workings produced 96.31 tons and the South Cornwall 82.60 tons i.e. a total of 178.91 tons from these two workings. Production details are set out in table 8. Available information about the Cornwall and South Cornwall workings is summarised below.

Cornwall workings.

References.—Mines Department files—2585/99, 1005/04, 2211/04, 603/14, 2034/17, 1553/19, 755/23, 1557/25, 227/27, 2211/34.

Reports—Maitland 1901, p. 14: Feldtman, 1901, Campbell, 1906, pp. 18, 19: Simpson and Gibson, 1907, pp. 72, 73: Woodward, 1908, pp. 68, 70: Cleland, 1910, p. 56: Wilson, 1926, pp. 80, 81; 1928, pp. 59, 60; 1929, pp. 43, 44. Rockett, 1928, p. 40: Larcombe, 1929, pp. 87, 88: Bowley, 1929, p. 107: Howe, 1929, p. 39.

General information.—These old workings are situated about eight chains east of the Greenbushes-Bridgetown road and immediately south-east of the Greenbushes townsite.

All that can be seen at present (1942) is a series of open cuts along the line of the main ore body, and a great number of shafts elsewhere. No work is in progress and all workings are inaccessible. The main ore body has been worked over a length of at least 450 feet. It strikes approximately N 17° W and dips west at a steep angle. The remaining ore bodies have for the most part, not been worked right to the surface, and it is therefore impossible to get any idea of their sizes, strikes and dips from a surface inspection. The arrangement of the shafts suggests that the ore bodies have been small and discontinuous and that the strike has been erratic.

The ore bodies are reported to have been pegmatite or greisen dykes (Simpson and Gibson, 1907), consisting essentially of quartz, albite, muscovite and tourmaline. They may be foliated.

No complete plan of the workings appears to have been made. The only plan seen by the writer is that published by Wilson (1928). It shows the open cuts, the main shaft and the 90 feet cross cut off the main shaft. The extent of the main workings under the open cuts

is not shown, nor are any of the smaller workings shown. The main workings were evidently all completely inaccessible at the time Wilson's inspection was made, and the published plan shows only the workings inspected by himself.

The Mines Department has in its possession a section, which shows a shaft 100 feet deep, with levels at 60 feet and 90 feet. The 60 foot level is 190 feet long and the 90 foot level is 130 feet long. The section is described as "Longitudinal Section, Western lode," but it is not accompanied by any plan to indicate the locality of the shaft.

It would seem probable that the known ore bodies or at least the richer portions thereof—have been worked out to water level at about 50 feet. As can be seen from plate II a great number of shafts have been sunk.

History of workings.—The ground on which these workings occur appears to have been first taken up as M.L. 40 in 1899. The first official inspection was that by Maitland in 1900. It was reported to Maitland (1901) that the main shaft had been sunk to 120 feet—100 feet by the previous owners and 20 feet by the then owners. Maitland notes that at a depth of 100 feet in the shaft there was a crosscut for about 49 feet east. He says "The rock exposed in the crosscut is a dark highly micaceous schist, dipping at a high angle to the west. The workings in the old shaft show that the place of the mica schist has been taken by a granitic rock, the 'lode' (greisen) consisting essentially of quartz, a greenish mica and a little felspar." He reports that a sample taken by himself in the previous year from an old dump, east of the main shaft, assayed 1.79 per cent. tin, while three bulk samples of greisen subsequently forwarded to the Geological Survey assayed 0.55 per cent. tin, 3.46 per cent. tin and 1.09 per cent. tin. The Government had offered to subsidise deep sinking at Greenbushes and Maitland recommended the Cornwall lease as being the most suitable place at which to test the ore bodies at depth. The lessees were unable to accept the offer, and subsequently the mine was worked by tribute parties. The lease was declared forfeit in 1904, and almost immediately taken up as M.L. 356.

In December, 1905 the workings were inspected by Campbell (1906), who says:—

"The old workings comprised several shafts from 60 feet to 120 feet depth on the various lines of lode, of which there appear to be four in number (see mineral specimens 6510, 6511, 6512), striking about 161 degrees with a westerly underlay of 84 degrees. The two western lodes at least are in decomposed granite, and either one or two of the eastern lodes are probably in the dark mica schist (6514) showing in the dump

of the 120 feet shaft. Very little stoping appears to have been done by this company, their chief endeavour being to go deeper . . . The present owners, Messrs. Woodgate and Meagher, have been stoping and driving from the old workings at 60 feet to the surface of the decomposed rock, which is overlaid by about 7 feet of tin wash and gravel. They state that they found rich patches of ore. They have also sunk several minor shafts with drives and stopings, and have been very well satisfied with the mine. The Statist's returns for the year 1904 give the output as 2.33 tons value £163. This is the total value for that date. I inspected part of the workings down to 50 feet depth; the next level at 65 feet was partly flooded, so that I could not see that part. The lodes are somewhat sinuous, and vary from 18 inches to 5 feet in width, and are approximately parallel, though probably not all continuous through the lease.

Unfortunately Campbell's report is not accompanied by a map, and there are no means of knowing the positions of the shafts to which he refers.

Simpson and Gibson (1907) note that 495 tons of lode stuff were crushed during 1906 for 5.38 tons of tin concentrates, which is equal to 0.76 per cent. tin in the original ore.

Woodward inspected the workings on this lease during 1907 and in Bulletin 32 (1908, p. 70) he says:—

There are three distinct lodes upon this lease, the first one worked being situated at about its centre. This lode has a course a little east of north with a dip to the north-west, it was first opened at its cap by two underlay shafts, which followed down a fairly rich pipe of ore. Later on a small vertical shaft was sunk to a depth of 100 feet, and later still a three-compartment main shaft with a cross cut to the other workings. This lode is a good deal broken and cannot be traced for more than 50 feet at the surface. The next lode lies about two chains north-west of the main shaft, and has been traced for a distance of three chains, following the normal course of a little west of north with a dip to the south-west. It is of good size, attaining as much as 14 feet in width in places, and had been worked to a depth of 30 feet for a length of about 120 feet, yielding very good returns; whilst the lodestuff like that from the upper workings in the first mentioned is very highly micaceous.

The next lode lies about two chains to the westward, and follows a parallel course to the last mentioned; it has been worked for a length of 7½ chains to depths varying from 30 to 50 feet. The size was apparently very variable, being as much as 10 feet in places, whilst at others it was small. The official records show that this mine has produced up to the end of 1907, 37.78 tons of black tin, which realised £3,236.

Woodward's report is accompanied by a plan (reproduced as fig. 17), showing the location of the shafts and also the ore bodies. The three compartment main shaft referred to in Woodward's text, and shown on his plan, is also shown on the writer's five chain geological map.

In 1909 the lease was taken over by F. Cammilleri, who continued to work it until 1914. This appears to have been the period of major production on this lease. Unfortunately there is very little information regarding the work which was done.

Cleland (1910) refers to what he calls the "Eastern Lode," in practically new ground. When inspected in 1909 the ore body had been worked to a depth of 50 feet over a length of from 70 to 80 feet and a width of from 5 to 12 feet. It is reported that walls had not been exposed. The lease was forfeited in 1916.

In the following year it was again taken up, this time as M.L. 583. In 1919, it became M.L. 615 and five years later, 1923, it became M.L. 623. The writer has no information regarding the work done during this period. M.L. 623 was forfeited in 1924.

The lease was again taken up in 1925, as M.L. 627 by a company called the Greenbushes Tin Mining Company. The Government was asked for assistance and Wilson was sent down to inspect. Of the various proposals put forward, Wilson (1926 and Mines file 1557/25) favoured the idea of sinking the old main shaft to 160 feet and crosscutting east and west at 150 feet. It was thought that it would be necessary to crosscut west for 170 feet to intersect the main ore body and east for 50 feet to intersect the east ore body. Referring to the grade of ore Wilson says:—

> Mr. Uphill, who was present, informed me that he worked the East Lode 30 years ago, and that down to the 60 ft. level it averaged from three to four ounces to the dish (i.e. 21 lbs. to 28 lbs. per cubic yard). From 60 to 80 feet he followed a white streak only. At 80 ft. a granity quartz came in carrying tin, which he sunk on for 20 ft. Its width was about 8 ft., and the portion taken out by him averaged ½ lb. of tin oxide to the dish (i.e. 56 lbs. to the cubic yard). He gave me to understand that since then Hunter had crosscut to this lode from the main shaft, and had worked out some of the lode. I was informed by Mr. Gibney that he had spent some money in driving south at the 100 ft. level with indifferent results.
>
> The main lode on the Cornwall has been worked for over 500 feet in length, and is said to have averaged at least 3 ozs. to the dish (21 lbs. per cubic yard) down to a depth of 70 feet.

Work was commenced about May, 1926, (Mines file 1557/25, p. 64). When the shaft was cleaned out it was found to be only 110 feet deep and not 130 feet as had been supposed. By March, of the following year the shaft had been deepened to 131 feet. The cost of this work was much higher than had been anticipated, and it was soon evident that the company would not be able to complete its programme of work. It was then proposed to crosscut at 125 feet instead of at 150 as originally proposed. In this connection

the workings were inspected by Wilson (1928), who agreed to the proposal. In addition to inspecting the main shaft, he was also able to examine the workings at 90 foot level. He says:—

This level, which is usually called the 100 foot level, could be inspected and was in fairly good order considering the long period that it has been under water. The following is a brief description of what could be seen:—Three lodes are met with in the main east cross-cut. A lode, which I have called No. 1 east lode, is met with at a distance of 6 feet from the shaft. On the north side of the crosscut this is about 18 inches in width; on the south side it has nearly pinched out. This lode dips towards, and is said to enter the shaft 10 feet below the 90 feet level and, to be 2 feet in width.

The second lode, which I have called No. 2 east lode, is met with 50 feet from the shaft. A certain amount of driving and stoping had been done north of the crosscut. A few feet of driving only appeared to have been done south of the crosscut, and no stoping, neither faces could be reached.

A third lode, which I have called No. 3 east lode, is met with 105 feet from the shaft. A north drive has been driven on this lode 15 feet and the ore above the timber has apparently been stoped out. In the face the lode is about 15 inches. The south drive is full of dirt, but is thought to connect with a shaft some 25 or 30 feet from the crosscut.

Wilson's report is accompanied by a plan of the accessible portion of the workings. Later, because of the hardness of the rock and the shortage of funds, the idea of crosscutting at the 125 ft. level was given up and some work was done at the 90 ft. level. A crushing of 100 tons appears to have been taken from this level. No information is available regarding the results of this crushing. Work finally ceased about November, 1927.

Diamond drilling.—In 1928 it was decided to put down a number of diamond drill holes at Greenbushes to test the ore bodies below water level. In all twelve sites were selected (Wilson, 1929). Four of these were in the vicinity of the old Cornwall workings, and bores were designed to intersect the continuation of the main ore body at a depth of 200 feet below the surface of the ground. The results of this boring are set out in table 30 (Larcombe, 1929. Bowley, 1929. Howe, 1929).

The main ore body appears to have been intersected in all bores—in number 1 at 243 feet to 246 feet, in number 2 at 263 feet to 271 feet 3 ins., in number 3 at 252 ft. to 253 ft. 6ins. and in number 4 at 256 ft. to 258 ft. 6 ins. It is considerably narrower than it appears to have been in the open cuts—the maximum horizontal width being 5 ft. 10 ins. in number 2 bore. As the ore body is dipping steeply the horizontal width is approximately the true width. The ore body was intersected in all bores at from 160 ft. to 190 ft. below the surface.

TABLE 30.

Diamond Drilling at Cornwall Workings—Greenbushes, 1928.

Bore number.	Depression angle.	Depth in bore.	Rock type.	Width in bore	Horz. width	Assay % SnO_2	Lbs. SnO_2 per cubic yd.–approx.	Mean % SnO_2	Mean lbs. per cubic yd.–approx.	Total horz. width.
1	45°	56′—56′ 6″	Pegmatite : Glassy quartz, felspar, and white mica	0′ 6″	0′ 4″	0·002	0·1	0·002	0·1	0′ 4″
		171′—172′ 4″....	Alaskite	1′ 4″	0′ 11″	0·004	0·2	0·004	0·2	0′ 11″
		243′—246′	Garnetiferous, tourmalinised quartz muscovite pegmatite	3′	2′ 1″	0·22	9·9	0·22	9·9	2′ 1″
2	45°	263′—265′ 6″	Heavily tourmalinised quartz felspar pegmatite	2′ 6″	1′ 9″	tr.	tr.	0·38	17·1	5′ 10″
		265′ 6″—268′		2′ 6″	1′ 9″	0·38	17·1			
		268′—270′ 1″		2′ 1″	1′ 6″	0·91	40·9			
		270′ 1″—271′ 3″		1′ 2″	10″	0·19	8·6			
3	45°	105′—107′	Medium grained saccharoidal quartz felspar rock with tourmaline	2′	1′ 5″	0·16	7·2	0·32	14·4	5′ 8″
		107′—109′		2′	1′ 5″	0·12	5·4			
		109′—111′		2′	1′ 5″	0·83	37·3			
		111′—113′		2	1′ 5″	0·17	7·6			
		120′—122′	Medium grained tourmalinised saccharoidal quartz felspar rock with white mica and in places patches of pure white felspar (albite?) rock	2′	1′ 5″	0·09	4·0	0·12	5·4	2′ 10″
		122′—124′		2′	1′ 5″	0·16	7·2			
		124′—125′		1′	0′ 8″	tr.	tr.			
		252′—253′ 6″....	Mainly white albite (?) rock with some quartz and a little tourmaline	1′ 6″	1′ 1″	tr.	tr.	tr.	tr.	1′ 1″
4	45°	115′—116′	Coarse greisen with some tourmaline	1′	0′ 8″	0·13	5·8	0·13	5·8	0′ 8″
		198′ 3″—200′ 1″	Tourmalinised pegmatite with coarse white mica	1′ 10″	1′ 4″	0·57	25·6	0·57	25·6	1′ 4″
		212′—214′ 6″....	Tourmalinised greisen	2′ 6″	1′ 9″	0·20	9·0	0·17	7·6	2′ 1″
		214′ 6″—215′....		0′ 6″	0′ 4″	tr.	tr.			
		256′—258′ 6″....	Tourmalinised quartz felspar rock	2′ 6″	1′ 10″	tr.	tr.	tr.	tr.	1′ 10″

[1]The rock names are those given by Larcombe (1929, p.88). Some of these have been amended.

The best values are in bore number 2, where 0.38 per cent SnO_2 occurs over 5 ft. 10 ins. If that section of the bore from 263 ft. to 265 ft. 6 ins. which contains only a trace of tin, is neglected the value is increased to 0.54 per cent SnO_2 over a width of 4 ft. 1 in. In bore number one 0.22 per cent. is recorded over 2 ft. 1 in. Only a trace of tin is recorded in bores numbers 3 and 4.

In addition to the probable continuation of the main ore body a number of other ore bodies were intersected in the bores. Bore number 3, from 105 ft. to 113 ft., contained 0.32 per cent. SnO_2 while bore number 4, from 198 ft. 3 ins. to 200 ft. 1 in., contained 0.57 per cent. SnO_2 The dyke in number 3 bore at 105 ft. to 113 ft. was intersected at approximately 80 feet below ground level. As there are a number of shafts immediately east of number 3 bore site this same ore body may have been worked in some of these shafts.

The rock names given in table 30 are those originally given by Larcombe (1929, p. 88). Various rocks from Greenbushes have recently been examined by K. R. Miles (refer chapter II), and it has been found necessary to revise many of Larcombe's names. As has been previously explained complete cores are not now available, and it was possible only to examine such specimens as were originally put in the Geological Survey collection. The specimens examined by Miles are listed in table 31.

TABLE 31.

Bore number.	Depth in bore.	Registered number.	Rock type.
1.	172′	1/4569	Vein quartz
	225′	1/4569	Tourmaline tremolite chlorite schist
	246′	1/4569	Greisen
	247′	1/4563	Amphibolite schist
	272′	1/4878	Biotite amphibolite
2.	252′	1/4569	Glaucophane cholorite biotite schist
	254′	2/2671	Biotite chlorite schist
	265′	1/4569	Tourmaline bearing pegmatite
	267′	2/2671	Tourmaline pegmatite
	279′	1/4563	Fine grained amphibolite
3.	145′	1/4569	Biotite amphibolite
4.	186′	1/4563	Biotite chlorite schist
	189′	2/2671	Glaucophane biotite schist
	200′	2/2671	Garnetiferous tourmaline pegmatite

South Cornwall workings.

References.—Mines Department files—4487/99, 5139/99, 3687/02, 3487/07, 1095/08, 1932/10, 977/12, 244/14, 1421/16, 2067/20.

Reports—Montgomery, 1904, p. 82: Campbell, 1906, p. 19: Simpson and Gibson, 1907, p. 73: Woodward, 1908, pp. 70, 72: Cleland, 1910, p. 56: Wilson, 1929, p. 44: Larcombe, 1929, pp. 87, 88: Bowley, 1929, p. 107: Howe, 1929, pp. 39, 40.

General information.—These workings are located in the south-west corner of M.C. 5, and are 4 chains west of the main Greenbushes-Bridgetown road at a point 15 chains beyond the Greenbushes townsite. At the time of inspection (1942) no work was being done, nor were any of the workings accessible. All that could be seen was a shallow open cut and a series of shafts, either fallen in or full of water. Two sketch plans, one merely showing the approximate distribution of the shafts at the surface and the other the 130 feet level, are all the plans the writer has seen. Not a great deal of information, especially regarding the work in the early days of the field, is available.

The principal work was in the vicinity of the shallow open cut. The writer was told by an old resident of Greenbushes that in the very early days of the field a rich shoot was worked in about the centre of the open cut. It was followed down and rich patches taken out at various times. The shoot is reported to have dipped steeply west and to have pitched north.

History of workings.—The first application for the ground on which these workings were situated appears to have been in 1899. An inspection was made by Maitland in 1900 (Montgomery, A., Mines Department file, 3687/02, p. 14), but no work was in progress, and the two shafts, which had been sunk, were inaccessible.

In 1903, an application was made for assistance to sink a deep shaft. It was proposed to commence a shaft, which could be taken to 500 feet if required. A visit of inspection was made by Montgomery (1900, and Mines Department file 3687/02, p. 14) who found all shafts on the property full of water. He records being told that the deepest shaft was 65 feet deep, and that 600 cubic yards of ore had been washed for a yield of 10 tons of tin concentrates i.e., approximately 37 lbs. of concentrates per cubic yard of ore. The tin bearing formation was reported to be "some 100 feet in width," and Montgomery recommended a series of shafts, 50 feet in depth and with cross cuts east and west to test this formation—the work to be subsidised by the Mines Department.

Subsequently the lessee found himself unable to accept the subsidy, and in 1905, a tribute was let. Work under tribute was continued during most of 1905. In December, of that year the workings were inspected by Campbell (1906, p. 19) who states:—

> At M.L. 300, the South Cornwall, adjoining a portion of the west boundary of the previously described lease, another parallel lode is being worked. The main shaft is 80 feet deep, and the lode adjacent is stoped from 63 feet to the surface, for a width of eight feet from the western side where the schist is more decomposed there is a crosscut east for 78 feet which the owners state is tin-bearing all the way. This shaft is to be deepened 50 feet more, the country rock is mica schist.
>
> About 100 feet further north the lode has been opened up by a 50 feet shaft and is stoped from 50 feet to surface for about 250 feet in length.
>
> The Statist's return for the year 1904 gives for South Cornwall Leases, M.L. 300 (315) 4.50 tons value £330; total to date, 13.10 tons value £931.

In June, 1906, a company known as the Greenbushes Prospecting Company was formed, and the Government agreed to subsidise its activities, subject to certain conditions, to the extent of £1,000 (Mines Department file, 3687/02). An option was secured over the South Cornwall workings. A sketch plan and report submitted by the provisional directors of the company, showed that there were 13 shafts on this lease, and that the main shaft was 130 feet deep. (This is the 80 foot shaft in Campbell's report.) A small amount of driving and crosscutting had been done at the 130 foot level. This shaft is shown on plate II and is 80 feet north of the three compartment main shaft sunk later.

Referring to these workings, Simpson and Gibson (1907, p. 73) say:—

> Some of the richest ore from this mine (4660) was very micaceous, being composed of pale green muscovite, quartz, topaz, and very coarse tinstone. A large specimen (7198) from a depth of 130 ft. recently received from this mine shows a compact somewhat banded lode composed mainly of albite, with quartz, tourmaline, topaz, and cassiterite; 540 tons of lode stuff from this mine were crushed during 1906 for a yield of 4.25 tons of tinstone.

The Greenbushes Prospecting Company, with the approval of the Government, decided to sink a new main shaft to a depth of 200 feet and to test the ore body at that depth. Work was commenced about July 1907. The shaft was sunk to 205 feet, timbered to 200 feet and a crosscut put out in an easterly direction for 52 feet at a depth of 190 feet. At 39 feet the crosscut was reported to be "in the lode channel," but no values were found.

It appears, from a later report (Cleland, 1910, p. 56) that the pegmatite dyke at the 130 foot level should have been intersected in the crosscut at the 190 feet level at about 35 feet from the shaft if it continued down on the same dip. No pegmatite lumps were seen by the writer lying around on the surface, nor is there any record of pegmatite having been intersected in the crosscut. Work was stopped on the crosscut about June, 1908.

Early in 1909 a tribute was let to King, Tully and Bailey, who continued to work on this lease until June of the same year.

In June the workings were inspected by Inspector of Mines Cleland (1910 and Mines Department file 1095/08), who in his report says:—

I find that the lode has been traced, and worked to shallow depths by shafts for a considerable length along the surface.

Of this series of shafts, the most important at the present time is one marked "Prospecting Shaft" on the accompanying sketch. To the south-east of it is a larger shaft sunk—with Government assistance—to a depth of 200 feet vertical. This is at present idle but may be of importance later on.

In the prospecting shaft I went to the bottom, or 130 foot level, where mining is now in progress. At this level a crosscut has been driven in a westerly direction through the lode for about 17 ft. At this point the lode is bounded by a hard black rock. This rock does not come to the surface, but is reported to round off at about 50 ft. below. Along this wall a drive has been extended for a distance of 31 ft. in a nor-westerly direction. No mining has been done here so far, and the values were low. South-westerly from the end of the crosscut a drive has at some time been made, but as it was filled up Mr. Cleland could not follow its course. It connects with the main south drive at a point about 18 ft. from the shaft. The main south drive opens directly off the end of the shaft. For a short distance it has an easterly trend and then turns more to the south partly to follow shoots of good ore and partly to take advantage of the wall of black rock. The drive has a length of 45 feet from the shaft and has been in lode all the way. The present face is being worked to a width of 12 feet. The eastern side of the drive shows no sign of a footwall and the full width of the lode at this level has not been ascertained. Good values are said to be obtained on that side, and I advised Mr. Astles to put out a crosscut at some favourable point in order to try and ascertain the full width of the ore channel. As long as the crosscut continues in good ore it is just as well to open in that direction as to continue driving on the course of the lode. It would, in fact, be advantageous to work a cross-cut and drive alternately. In the face of the drive is a "horse" of soft foliated micaceous rock. This "horse" has continued in the lode for the whole way opened and, in the north end it is seen tapering to a point and cutting out. It dips approximately 60° W. and meets the black rock, which appears to dip about 70° W. In the back of the drive the "horse" has a width of about 18 inches and tapers downwards to about a width of 6 inches. It is said to be diminishing in size going south. I am informed that the ore values are rather higher along the wall and close to each side of the "horse." From results obtained in higher levels it is anticipated

that a shoot of very good ore will shortly be met with in going south. The lode is easily worked and required little explosive. When broken it is wheeled to the shaft, hoisted by bucket and steam winch, dumped on surface, loaded into drays, carted to the north State Mill and treated. This is obviously a costly method, and could be greatly improved upon, as I pointed out to Mr. Astles.

From the centre of the prospecting shaft at the surface the Main vertical shaft is met with at about 80 feet, on a bearing of about 193. This shaft is 10 feet x 4 feet, and divided into three compartments. Being under water below I was unable to make any inspection. From information given by men who worked in it, the shaft continued in hard rock for the full depth of 200 ft. At about 141 ft. a vein of quartz was passed through having a width of 36 inches and carrying little tin.

At 190 feet a crosscut was extended in an easterly direction for about 52 feet. It was designed to cut the lode, but, from what could be learned this was not reached. The evidence of workers is that the face is still in diorite—as it is locally termed and an examination of the waste dump supports the assertion. It is evident that the crosscut must be further extended if the lode is to be tested at this depth.

In a later section of the report and referring to the work of the tribute party, Cleland says "it would appear that from January to May of this year the tributers had treated at different reduction plants three parcels of ore aggregating 279 cubic yards and yielding a total of three tons 10 cwt. 21 lbs. of dressed ore, or an average of 28 lbs. 2.81 ozs. per cubic yard." It is not clear just where this ore came from, but some came from the 80 feet level, and some may have come from 130 feet level (Mines Department file 1095/08, p. 165). The prospecting venture was not a success and was abandoned about June 1909.

Subsequently another tribute party (Astles, Huitson and Teedge) took over and continued working at the 130 feet level (Mines Department file, 1095/08, p. 214). It is reported that the south drive was extended for 45 feet making a total of 90 feet from the shaft and that the ore was mined over a width of 8 feet. The average contents are reported to have been 19.5 lbs. of concentrates per cubic yard. The venture was not successful and work was stopped.

In 1910 the lease was declared forfeited and the ground converted into a reserve. Tenders were called for the right to work on this ground, and a three years' tribute was granted to Phillips, Sherwood and Pears. Except for one break, when the mine was under option to the Birthday Gift Gold Mining Co., the ground was worked by the tribute party until November, 1913. During this time tin concentrates to value of £3,469 10s. 0d. are reported to have been obtained (Mines Department file 977/12, p. 190). The only information about the work done is that given by the Mining Registrar, Greenbushes, who states (Mines Department file, 977/12, p. 51):—

With regard to work done as result of options, I am requested to inform you, that the Government shaft has been connected by a drive at the 126 ft. level with the tributers' 126 feet shaft, thus giving access from all parts of the mine to the big Government shaft. All levels have been made thoroughly workable and the lode has been crosscut in various places to the footwall and a level put in along the footwall at 80 feet, 160 feet long. In addition, proper boilers, concentrating tables, tailings and other centrifugal pumps, horizontal engine, etc., have been installed on the mine, also other property of tributers.

It is presumed that 126 foot level referred to is the 130 foot level of earlier reports.

Early in 1914 the lease (as M.L. 567), was applied for by Barrymore and Phillips, who later found themselves unable to work the lease due to the outbreak of war, and their application was withdrawn in September.

In October of the following year the right to work the ground was granted to Phillips, who continued to work it until September 1916. During this time he sold tin concentrates to the value of £967 5s. 7d.

Phillips again applied for and was granted the right to work the ground in May, 1917. From December of the same year to December of 1918 he obtained tin concentrates to the value of £1,112 14s. 8d.

There is no record of the nature of the work done after 1914, but it was evidently all at a shallow depth.

Subsequent to this the ground was held again from September, 1919, to November, 1920, but only a very small amount of work, mainly of prospecting nature, was done. Apparently only 1 cwt. of tin concentrates was obtained and sold. Since November, 1920, no work appears to have been done on this ground. It is held at the present time as portion of M.C. 5.

Diamond Drilling.—In 1928 the Government decided upon a diamond drilling campaign at Greenbushes to test the ore bodies below any of the existing workings. One of the sites selected was in the vicinity of the South Cornwall workings. The bore was set out to intersect the ore body 200 feet below the surface of the ground and immediately north of the shaft 130 feet deep. The position of this bore is indicated on plate II. The total length of the bore was 295 feet and three granitic dykes were intersected, but none of these contained more than a trace of tin. Details regarding this bore are set out in table 32 (Larcombe, 1929). The rock names given in table 32 are those originally given by Larcombe. More recent work by Miles has shown that many of Larcombe's names require to be modified (see chapter III.). Only three specimens from bore No. 6 were examined by Miles (table 33).

TABLE 32.

DIAMOND DRILLING AT SOUTH CORNWALL WORKINGS (1928), GREENBUSHES.

Bore No.	Depression Angle.	Depth in bore.	Rock Type.*	Assay Results.
6	45°	133′—147′	Tourmalinised greisen with white to creamy coarse grained quartz felspar rock	133′—147′, no tin.
		199′—200′	Tourmalinised quartz felspar rock with garnet	199′—200′, trace tin.
		231′—235′ 6″	Tourmalinised medium grained pegmatite with white mica	231′—233′, no tin, 233′—235′ 6″, trace tin.

* The rock names are those given by Larcombe (1929, p. 88). Some of these have been amended, refer page 49.

TABLE 33.

Bore Number.	Depth in Bore.	Registered Number.	Rock Type.
	Feet.		
6	226	2/2671	Quartz vein.
	234	2/2671	Aplitic tourmaline pegmatite.
	245	1/4569	Amphibolite schist.

NORLUP BROOK—AREA No. 10

Although there are a number of old leases extending along Norlup Brook very little work has been done, and there are no references to any of these leases in previous reports. The valley contains a small amount of Recent Alluvium, and is very steep-sided. Small weirs have been constructed on W.R. 242 and also on the reservoir reserve at the junction of Norlup and Cowan Brooks, but both these weirs are now broken. No production is recorded from this area.

BORONIA GULLY—AREA No. 11.

References.—Simpson and Gibson, 1907, p. 64: Woodward, 1908, p. 38.

There is quite an extent of Old Alluvium in the vicinity of the headwaters of Boronia Gully, but this has been worked in only one place. An old sluicing cut extends from D.C. 17 to about the south boundary of location 9948 and is indicated on plate I. The recorded production from this vicinity is 30.48 tons of concentrates, all of which is from alluvial ground. No other information is available about these workings.

MOUNT JONES—AREA No. 12.

Reference.—Maitland, 1919, p. 15.

The principal workings in this area are on W.R. 285, where there is quite an extensive sluicing cut—the old Mt. Jones sluicing cut. The workings are in a white sand, which is partly cemented near the surface. The "wash" was not seen *in situ,* but there were a number of not very well rounded pebbles and boulders scattered about in the old cut, which is seen to have bottomed on a very weathered granitic gneiss, with epidiorite dykes. There is also a shallow cut, two to four feet deep, in sand at the south end of M.L. 534.

The total recorded production from this area is 170.87 tons, all of which is from alluvial ground.

Referring to the Mt. Jones workings, Maitland (1910, p. 15) says:—

> On M.L. 460, Mount Jones, was a patch of residual sands, about 170 feet above the junction of Jones's Creek and the main watercourse which was being hydraulic sluiced. There was very little "over-burden," which was only about 3 or 4 feet thick, the tin-bearing material was "Free," being practically pure sand. This tin was very fine and angular, and obviously could not have travelled very far from its parent source: it very likely owes its origin to the decomposition of a granite *in situ.* The sand patch is hemmed in by granite.

The writer agrees with Maitland that it is probable that the cassiterite has not travelled very far from its source, but considers that the sand is portion of the Old Alluvium. Rounded boulders were seen, away from the workings, at two places close to the south-east corner of location 991. The probable distribution of the Old Alluvium is shown on plate I. The granitic gneiss, exposed on the floor of the cut, may have contained some cassiterite.

Chapter VI.

SUMMARY AND CONCLUSIONS.

(1) At various places in this bulletin information has been summarised and recommendations have been made for additional work. It is not proposed in this chapter to summarise all the information available, but only to draw attention once more to the more significant features already described and to those areas worthy of additional prospecting. No attempt will be made to collect together detailed recommendations for any individual area, already fully described.

(2) The principal source of tin concentrates at Greenbushes has been the Old Alluvium, which consists of a series of horizontal sands, clays, pebble and boulder beds, believed to have been deposited in a shallow sea or lake in middle or late Tertiary times. The Old Alluvium has a maximum known thickness of approximately 100 feet, and a minimum of only a few feet. Its average thickness, where it has been worked, would be about 15-20 feet. It is believed that the tin deposits are beach deposits and that the high ground in the central portion of the Field was an island at the time of their deposition. The Old Alluvium has been mapped within the Field, but is also known to extend beyond the Field. Cassiterite is the only tin material occurring on the Field. The principal production has been from the pebble and boulder beds ("wash"), and values were sometimes exceptionally high—3½ cwts per cubic yard being reported from portion of Elliot's Gully. The principal old workings are in New Zealand Gully, near the head of Spring Gully, in the vicinity of the Three C's area, in Westralian Gully, in Elliot's Gully, in Bunbury Gully, and in Floyd's Gully.

(3) There has been a small production from Recent Alluvium. Except in portion of Spring Gully and at the junction of Scandinavian Gully and Salt Water Gully, the workings are quite small. It is probable that 5 to 10 per cent. of the production from alluvial ground has come from Recent Alluvium.

(4) Basement rocks consist of metamorphosed greenstones and sediments together with replacement and/or injection gneisses, granitic dykes of varying types, and also epidiorite and dolerite dykes. The whole are believed to be of Pre-Cambrian age. The principal rock types are amphibolites and amphibolite schists, biotite and cholorite schists, granulite gneisses, injection gneisses, pegmatites, aplites, greisens, quartz veins, epidiorites and dolerites. Information regarding the various rock types is to be found in the petrographic section of this bulletin, which has been contributed by Dr. K. R. Miles.

Almost the entire Field is covered with laterite, and outcrops of basement rocks occur only at a few localities in the deeper gullies. Additional information has been gained from mining operations and from diamond drilling done during 1928 and 1929. Except at the late Cornwall, South Cornwall, Kapanga, and Lost and Found mines the workings are confined to the oxidized zone. Even at these mines there has been no production from below the oxidized zone. No granite was seen within the boundary of the Field.

The lodes, which have been worked, consisted for the most part of small rich shoots in granitic rocks. All old workings are now inaccessible and very little information is available regarding most of them. Most of the ore bodies have been stoped only to the base of the laterite, and hence very little information about their size, strike and dip can be obtained from a surface inspection. At the Vulcan workings on M.C. 4, however. there is an extensive open cut, and, in addition to rich shoots, cassiterite was also found disseminated through what has been described as probably a replacement gneiss (p. 43). It is not unlikely that the foliated granites of earlier writers (p. 43) are related to Ellis's replacement gneiss (p. 43) and to Miles's injection gneiss (p. 57). Unfortunately earlier writers record very little information regarding the distribution of the foliated granites. Rocks similar to those at the Vulcan workings have been noted at the Fremantle Cut (p. 44), and recent prospecting operations for tantalite[15] have disclosed similar rocks elsewhere in Bunbury Gully. Granitic gneisses have been noted at two places in Floyd's Gully (p. 191). The principal lode workings are the following:—the Vulcan workings on M.C. 4, the late Dixie, Cornwall, South Cornwall, Kapanga and Lost and Found workings. Approximately 5 per cent. of the total production has come from lode material.

(5) Almost the entire Field is covered with laterite. This capping occurs either at the present surface or, quite frequently, a few feet below the surface. It overlies both the Old Alluvium and also basement rocks. The laterite over the basement rocks is sometimes pisolitic, but generally massive, and varies in composition from ferruginous to aluminous. Laterite overlaying the Old Alluvium can be readily distinguished from that occurring over basement rocks as it contains boulders, pebbles or rounded grains of quartz, and such laterite was mapped as Old Alluvium. The laterite shown on plate I is believed to overlie basement rocks.

[15]Personal Communication—Government Geologist to writer.

(6) A scheme has been outlined for prospecting beyond the boundary of the Mineral Field. Cassiterite has been known to occur in an area south-west of Bridgetown since 1907, but although quite a lot of prospecting has been done no development has followed. Cassiterite has also been recorded from Nannup. It seems likely that, except as noted above, very little attempt has been made to prospect for tin away from the Greenbushes Mineral Field. The lodes at Greenbushes appear to occur in an area consisting largely of greenstones, flanked by metamporphosed sediments. It is thought that if this belt of greenstones could be mapped beyond the boundary of the Field and if the distribution of the granite were also mapped additional areas likely to be tin bearing could be selected. Outcrops are likely to be very poor, and it is likely that only very approximate geological boundaries could be obtained. Other greenstone belts may be found. It is evident that the geology of the south-western portion of Western Australia is much more complex than shown on existing geological maps.

(7) The need for careful and complete prospecting by shafting, sinking, or boring on any area under consideration as a possible producer has been stressed (pp. 106-8). It is likely that the richest and most easily accessible deposits have long since been worked out. There may still be a few quite rich patches remaining. It is probable, however, that any remaining areas will be lower in grade and more difficult to work, than those already worked. Areas worthy of further prospecting are listed below. Adequate prospecting should be completed before any consideration is given to a plant, so that a suitable plant can be selected.

(8) Information regarding the old workings has been collected together in chapter V. Full use has been made of previous reports, and information regarding some of the workings has been obtained from old residents of Greenbushes. Complete plans and descriptions of any of the old workings do not exist, and for many workings no information at all is available. Much of the work was done in the very early days of the Field, and the men who did it are dead, or no longer resident on the Field. For the purposes of description the Field has been divided into a number of areas, each of which is a more or less natural sub-division. A general description of each of these areas has been given. For the areas shown on plates II and III more detailed information regarding some of the old workings is given.

(9) During 1942, and 1943, various prospecting operations were undertaken by the Mines Department, and the results of this work are summarised in chapter IV. Shaft sinking and driving were done on M.C. 47, and a small amount of drilling on M.C. 6. Other-

wise the prospecting work was restricted to the examination of old dumps, shafts and open cuts, and neither the money or equipment was available for any drilling or shaft sinking to be done. The conclusions arrived at for each area are given in chapter IV, and any areas considered to be worthy of further examination are listed below.

(10) During 1942 and 1943, work was in progress at the Vulcan workings on M.C. 4 and also on M.C. 1. The work on M.C. 4 was stopped during 1943, but that on M.C. 1 has continued intermittently and is still in progress at the time of writing (July, 1944). Tantalum concentrates, weighing 2.11 tons, have been sold from these workings to the end of November, 1943, and 2.2 tons of tin-tantalum concentrates are now awaiting separation. At present preparations are being made to commence sluicing operations on M.C. 6, which was extensively drilled by Greenbushes Tin Ltd. during 1939 (p. 170).

(11) High grade tantalite has been produced at various times since 1905, from the vicinity of the Enterprise workings near the head of Bunbury Gully. It is from this locality, now portion of M.C. 1, that the production noted above, has come. Tantalite is known to have occurred in the tin concentrates from portion of Bunbury Gully and from portion of Floyd's Gully, but no production is recorded. Recently 3.18 tons of tantalum concentrates, assaying approximately 38 per cent. Ta_2O_5, were separated from the tin concentrates from the Vulcan workings on M.C. 4 and sold. Other localities from which specimens of tantalite have been obtained, or from which there has been a small production are noted. It is also noted that some tin concentrates from samples taken from M.C. 48 contained small amounts of tantalite or columbite (p. 124). During any future operations any tin samples taken should also be examined for Ta_2O_5 and Nb_2O_5.

(12) Figure 11 shows that the maximum production of tin concentrates was in 1906, and that from 1906, to 1920, there was a gradual falling off in production. After 1920, there was a rapid drop in production. Since 1920, the production of alluvial concentrates has continued to decline. Inspection of the Field shows that the alluvial deposits have been extensively worked. It can be assumed then that the richest deposits, and those easily accessible were worked in the early days of the Field and that by 1920, such deposits had been worked out. Unfortunately very little information is now available regarding most of these workings. No doubt there are still some rich patches to be found, but, as already pointed out, any remaining areas are likely to be lower in grade and more difficult to work than those worked in the early days of the Field. Work done during 1942, and 1943, has indicated that the following areas are worthy of further prospecting. All these places have been

extensively worked in the past by means of shafts and the richer patches of wash removed. It remains to be proved whether sufficient cassiterite still exists in the ground to enable the area to be again worked.

(i) A strip of Old Alluvium on the east side of the Greenbushes-Bridgetown road, extending from the South Greenbushes Townsite north-eastward to M.L. 552.

(ii) The north-western portion of D.C. 90.

(iii) An area in the vicinity of D.C. 95 and M.C. 48.

(iv) An area extending from D.C. 94, through E.A.C. 960 to C. 917.

(v) The strip of Old Alluvium between Angus' and Allen's cuts.

(vi) The alluvial ground in Elliot's Gully.

(13) A very large number of shafts have been sunk in the lode country, and, in all probability, an almost equal number of small shoots have been worked. It is not improbable that a few small rich shoots still remain, and may continue to be found for some time.

At the Vulcan workings there were not only the rich shoots, but values were also disseminated through the replacement gneiss. It appears likely that similar conditions exist on M.C. 6. Preparations are now being made on this lease to commence sluicing operations from the old Fremantle Cut and to continue northward. Some consideration should be given to the possibility of similar ore bodies occurring elsewhere. Early writers frequently made reference to foliated granites containing low values, but little information is given regarding their distribution. It is reported that some work was done in an area of these rocks near North Greenbushes. At the old South Cornwall workings values are reported to have extended eastward for 78 feet (p. 204), and there is an open cut having a width of from 100 to 150 feet and a length of approximately 200 feet. It is stated, in a later report, that crosscuts were extended to the foot wall of the ore body, and that some driving was done along the foot wall. Unfortunately no information is available regarding the results obtained from this work. Matheson records 2½ lbs. SnO_2 per cubic yard from some workings in the vicinity of the south-west corner of the police reserve (7019). The ore body, where intersected in crosscuts off one shaft, had a width of approximately 60 feet. Granitic gneiss has been noted at two places in Floyd's Gully (M.L. 598 and immediately west of D.C. 64), and also at various places in Bunbury Gully, during recent prospecting operations for tantalite.

INDEX.

The principal references are indicated in heavy type

INDEX—*continued.*

INDEX—*continued.*

INDEX—*continued.*

INDEX—*continued.*

By Authority: WILLIAM H. WYATT, Government Printer, Perth.

FIG. 1

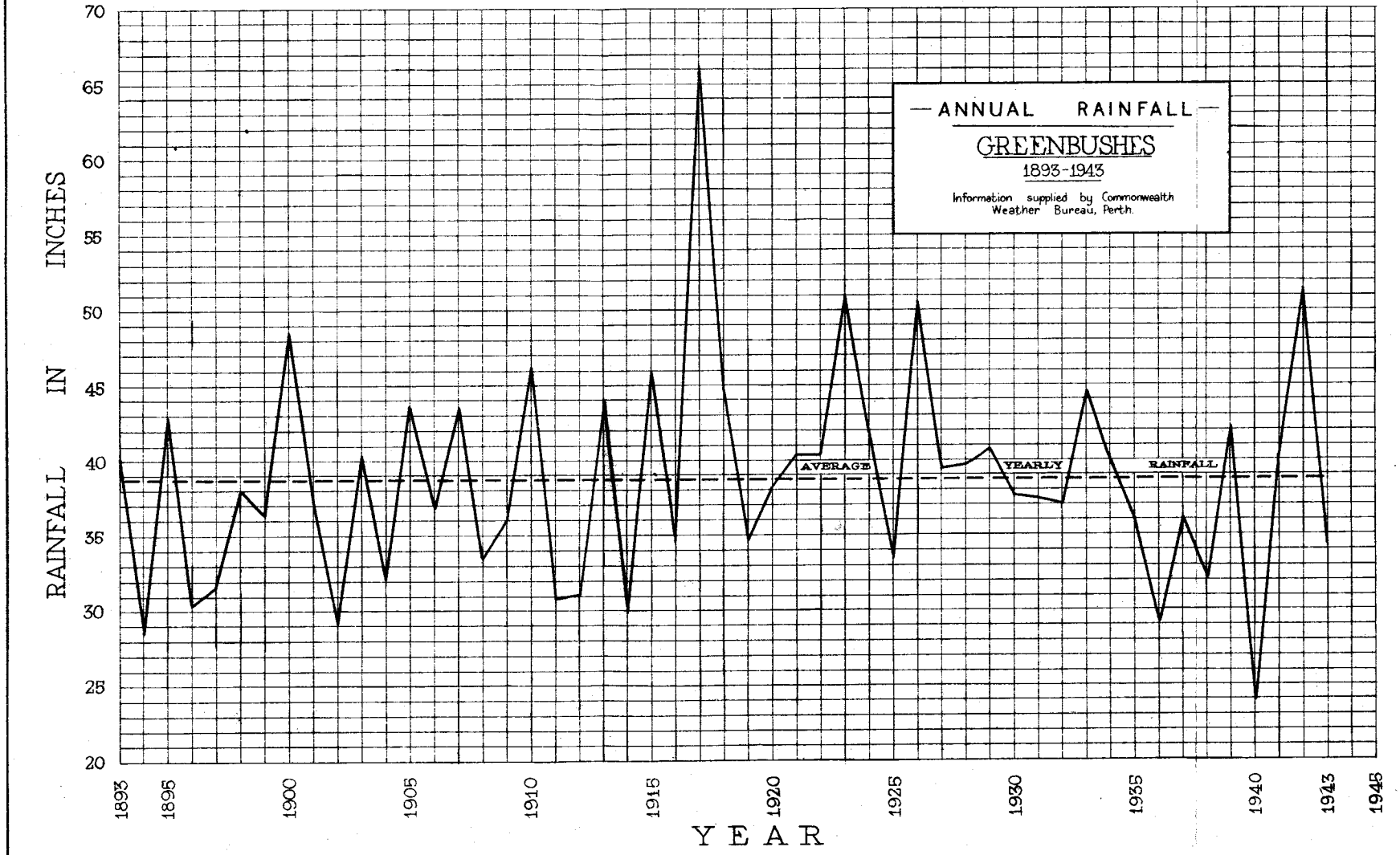

ANNUAL RAINFALL
GREENBUSHES
1893-1943
Information supplied by Commonwealth Weather Bureau, Perth.
AVERAGE YEARLY RAINFALL
RAINFALL IN INCHES
70
65
60
55
50
45
40
35
30
25
20
1893
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1943
1945
YEAR

Figure 10

MINERAL FIELD BOUNDARY

BOUNDARY

FIELD

MINERAL

PADBURY'S HILL

NORTH GREENBUSHES TOWNSITE

GREENBUSHES TOWNSITE

SOUTH GREENBUSHES

ANGUS CUT

ALLENS CUT

KEYSERS CUT

JOHNS CUT

VULCAN CUT

MANTLE CUT

PLATE VII

SHAFT C

SHAFT D

Formed Road

Bromma Gully

Dumping Gully

Spring Brook

Norlup Brook

Cowan Gully

Floyds Gully

Burbury Gully

Kelly's Flat

Salt Water Gully

New Zealand Gully

Westralian Gully

Soil above laterite

Laterite at 4'

Numerous shafts hereabouts

Laterite with wash boulders x
Old shaft, dump is mica schist

G11 and G12 from Wilkes' sand cut

G8, G9, G10 from shallow cuts in Johns' cut

G1 0'-5" Nil
G2 0'-2" Tr
G3 0'-2'6" Nil
G4 {0'-4" Tr / 3'-4" Tr
G5 {0'-2" Tr / 2'-3" Nil
G6 {0'-5" / 5'-10" Tr · Water at 7'
G7 0'-2" Tr
G8 0'-2" 1lb
G9 0'-3" 1lb
G10 0'-3" 1½lbs
G11 0'-4" 1lb
G12 0'-3" 1lb
G13 {0'-5" / 5'-6" / ½lb / Wash from dump ½lb
G14 Wash from dump ½lb
G15 0'-5" ½lb
G16 0'-4" 1lb
G17 {0'-5" / 5'-7'6" ½lb
G33 0'-2'6" ¾lb
G53 0'-2'6" 1lb
G54 0'-3" 1lb
G55 0'-4" 1½lbs
G58 0'-4" 2lbs
G59 Nil lbs
G60 0'-2" 1lb
G61 {0'-8" 1lb / Wash 6lbs 2'
G64 {0'-5" / 5'-10" / 10'-11" / ¼lb
G65 {0'-5" / 5'-10" Tr / ½lb
G66 0'-18" Tr
G67 0'-2" Tr
G68 6"-12" Tr
G69 0'-6" ½lb
G70 Tr
G71 0'-5" ¼lb
G72 0'-18" ¼lb
G73 0'-2'6" Tr
G74 0'-2" ¼lb
G75 Nil
G62 Tr

Sampling by R.A Hobson, July 1943

J.M.L del 5/12/44

REFERENCE

Mining holdings – symbols as for Plate I

Open cuts formed as a result of sluicing

Alluvial workings – May be shallow workings in creeks or deep workings by shafts. Individual shafts too numerous to be shown

Boundary of Old Alluvium

Reported or known production of tantalite or columbite

Reported or known occurrence of tantalite or columbite

Locality, number and lbs. concentrate, per cubic yard, for sample taken from a dump. G59 2½lbs

Locality, number, depth and lbs. concentrate, per cubic yard, for sample taken with a post hole digger or for channel sample G9 0'-3" 1lb

The values shown are all lbs. concentrate, per cubic yard, and no assays have been made.
The principal mineral in all concentrates is cassiterite, but all contain other minerals as well.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SAMPLE MAP

OF

GREENBUSHES MINERAL FIELD

SHOWING ALSO, THE DISTRIBUTION OF TANTALITE OR COLUMBITE

Scale · 40 chains to an inch

40 20 0 40 80

FIG. 11.

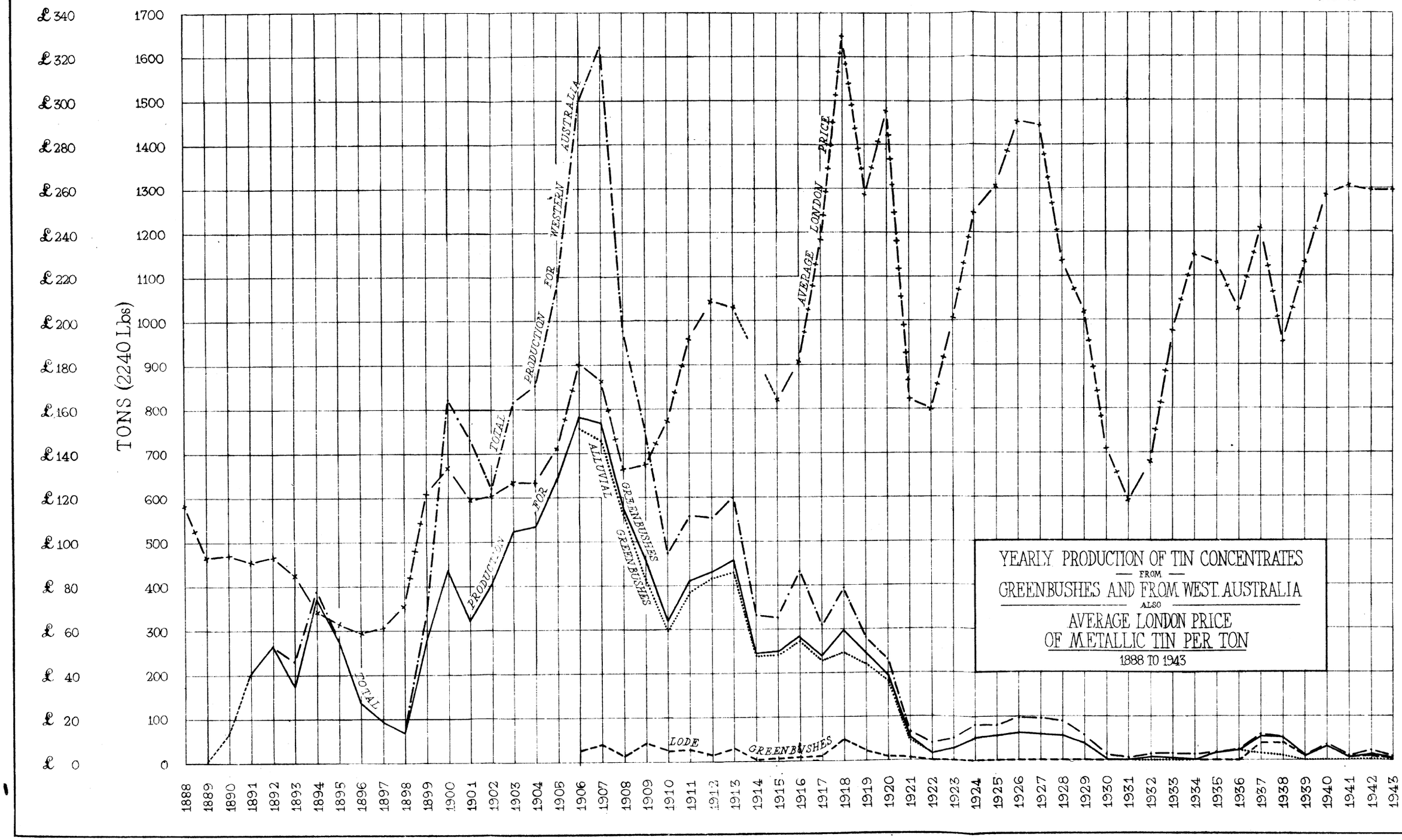

£340
£320
£300
£280
£260
£240
£220
£200
£180
£160
£140
£120
£100
£80
£60
£40
£20
£0
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
TONS (2240 Lbs)
TOTAL PRODUCTION FOR WESTERN AUSTRALIA
AVERAGE LONDON PRICE
TOTAL PRODUCTION FOR ALLUVIAL GREENBUSHES
TOTAL
PRODUCTION
LODE GREENBUSHES
1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943
YEARLY PRODUCTION OF TIN CONCENTRATES
FROM
GREENBUSHES AND FROM WEST AUSTRALIA
ALSO
AVERAGE LONDON PRICE
OF METALLIC TIN PER TON
1888 TO 1943

Figure 12

MINERAL FIELD BOUNDARY

BOUNDARY

MINERAL

FIELD

MINERAL FIELD BOUNDARY

PADBURY'S HILL

NORTH GREENBUSHES TOWNSITE

GREENBUSHES TOWNSITE

SOUTH GREENBUSHES

1 LODE NIL ALLUVIAL 1,703·93 TONS TOTAL 1,714·83 TONS

2 LODE NIL ALLUVIAL 323·43 TONS TOTAL 323·43 TONS

3 LODE NIL ALLUVIAL 310·31 TONS TOTAL 310·31 TONS

4 LODE NIL ALLUVIAL 373·84 TONS TOTAL 373·84 TONS

5 LODE NIL ALLUVIAL 1,263·72 TONS TOTAL 1,263·72 TONS

6 LODE NIL ALLUVIAL 15·92 TONS TOTAL 15·92 TONS

7 LODE NIL ALLUVIAL 20·35 TONS TOTAL 20·35 TONS

8 LODE NIL ALLUVIAL 3·69 TONS TOTAL 3·69 TONS

9 LODE 222·47 TONS ALLUVIAL 4·33 TONS TOTAL 226·80 TONS

10 LODE NIL ALLUVIAL 1,230·87 TONS TOTAL 1,230·87 TONS

11 LODE NIL ALLUVIAL 1,230·48 TONS TOTAL 1,230·48 TONS

12 PRODUCTION NIL

TOTAL PRODUCTION AREAS 1 — 12 5,332·96 TONS
" " SUNDRY CLAIMS 5,989·14 TONS
" " MINERAL FIELD 11,322·10 TONS

— REFERENCE —

Mining holdings symbols as for Plate 1

Open cuts formed as a result of sluicing

Alluvial workings May be shallow workings in creeks, or deep workings by shafts. Individual shafts too numerous to be shown

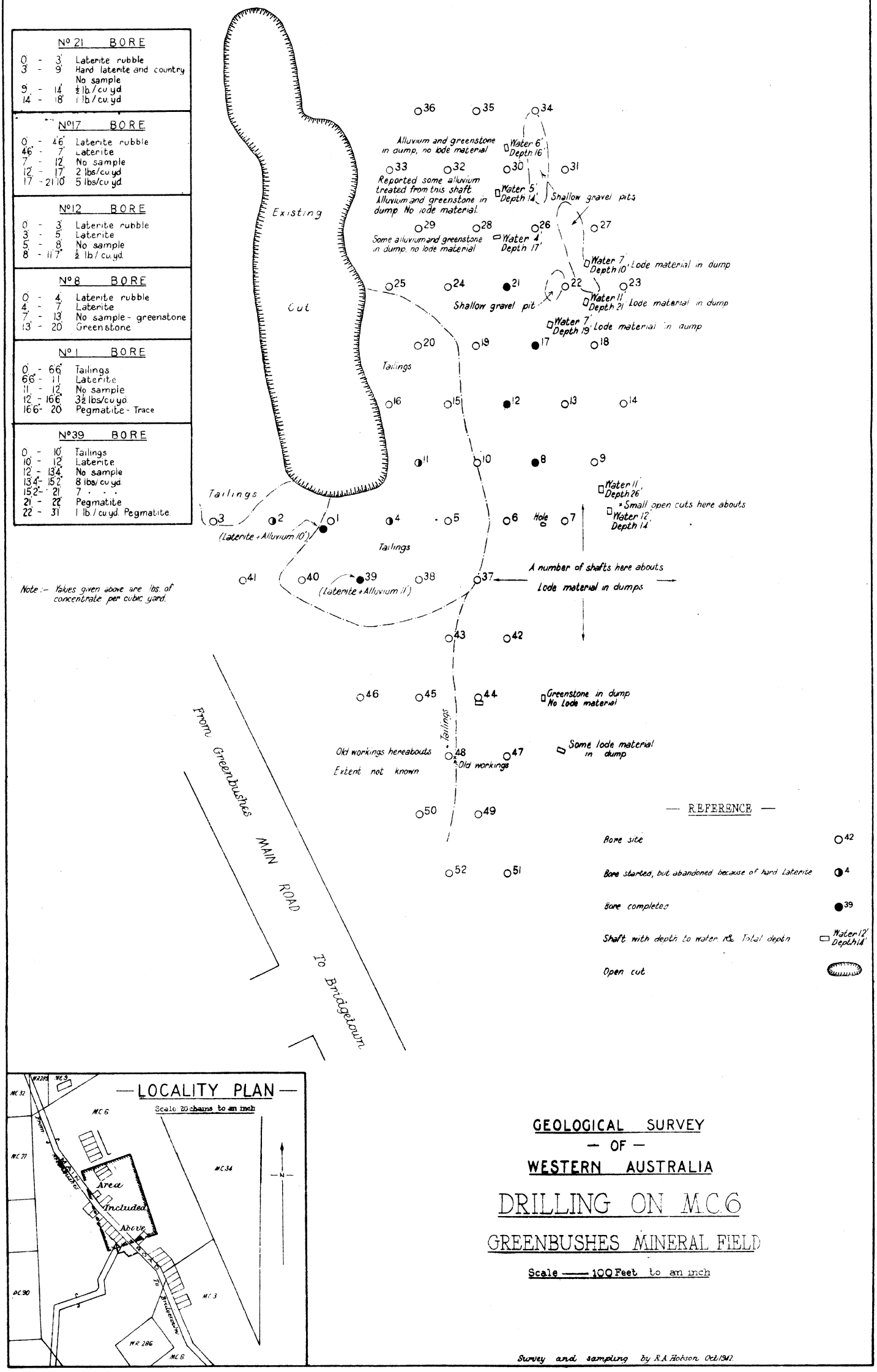
Boundary of Old Alluvium

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

AREAS 1 TO 12
GREENBUSHES MINERAL FIELD

Scale 40 chains to an inch

40 20 0 40 80



GEOLOGICAL SURVEY
— OF —
WESTERN AUSTRALIA

DRILLING ON M.C.6

GREENBUSHES MINERAL FIELD

Scale —— 100 Feet to an inch

Survey and sampling by R.A. Hobson. Oct/1942.

Figure 14.

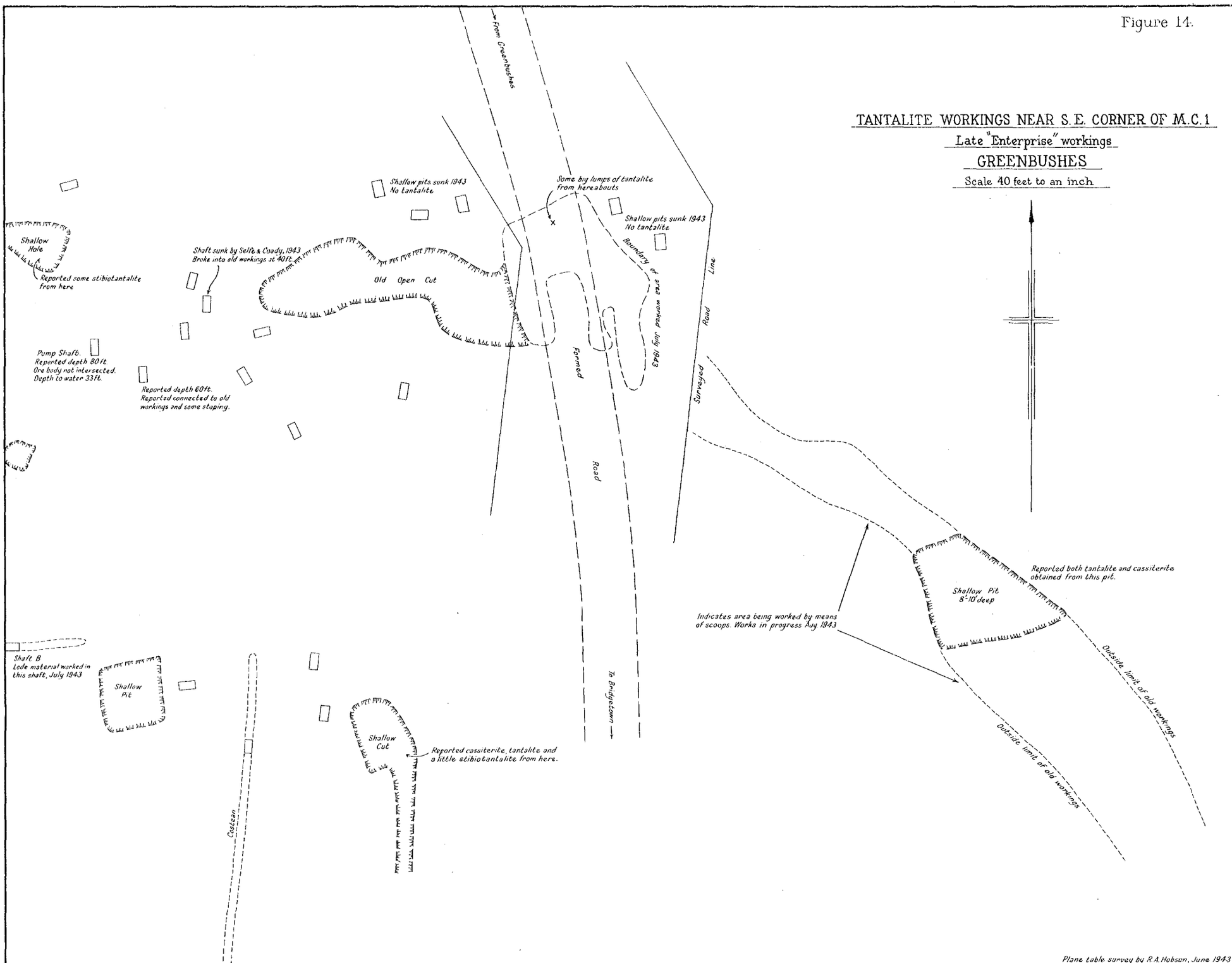
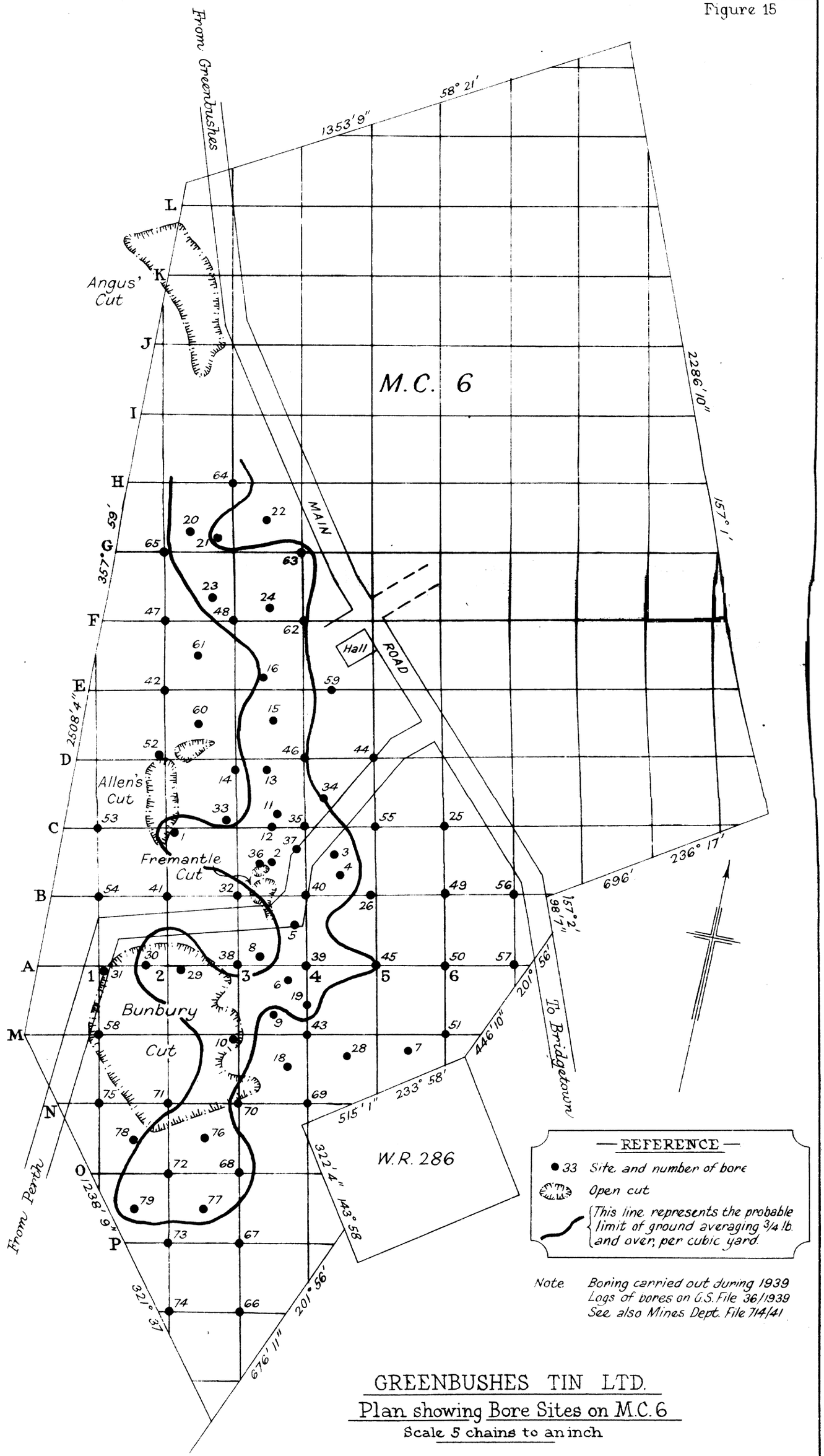

TANTALITE WORKINGS NEAR S.E. CORNER OF M.C.1
Late "Enterprise" workings
GREENBUSHES
Scale 40 feet to an inch
From Greenbushes
Shallow pits sunk 1943
No tantalite.
Some big lumps of tantalite
from hereabouts
Shallow pits sunk 1943
No tantalite
Boundary of area worked July 1943
Shallow
Hole
Reported some stibiotantalite
from here
Shaft sunk by Selfe & Coady, 1943
Broke into old workings at 40ft.
Old Open Cut
Formed Road
Surveyed Road Line
Pump Shaft.
Reported depth 80ft.
Ore body not intersected.
Depth to water 33ft.
Reported depth 60ft.
Reported connected to old
workings and some stoping.
Reported both tantalite and cassiterite
obtained from this pit.
Shallow Pit
8'-10' deep
Indicates area being worked by means
of scoops. Works in progress Aug. 1943
Outside limit of old workings
Outside limit of old workings
Shaft B
Lode material worked in
this shaft, July 1943
Shallow
Pit
Shallow
Cut
Reported cassiterite, tantalite and
a little stibiotantalite from here.
To Bridgetown
Costean
Plane table survey by R.A. Hobson, June 1943

Figure 15



— REFERENCE —

● 33 Site and number of bore

Open cut

This line represents the probable limit of ground averaging 3/4 lb. and over, per cubic yard.

Note. Boring carried out during 1939
Logs of bores on G.S. File 36/1939
See also Mines Dept. File 714/41

GREENBUSHES TIN LTD.

Plan showing Bore Sites on M.C. 6

Scale 5 chains to an inch

Reduced from original plan (100 ++ [illegible] inch) by R.S. Matheson, Oct, 1942

The Hon. H. Gregory M.L.A.
Minister for Mines.

PLAN

SHEWING THE LODES
ON THE

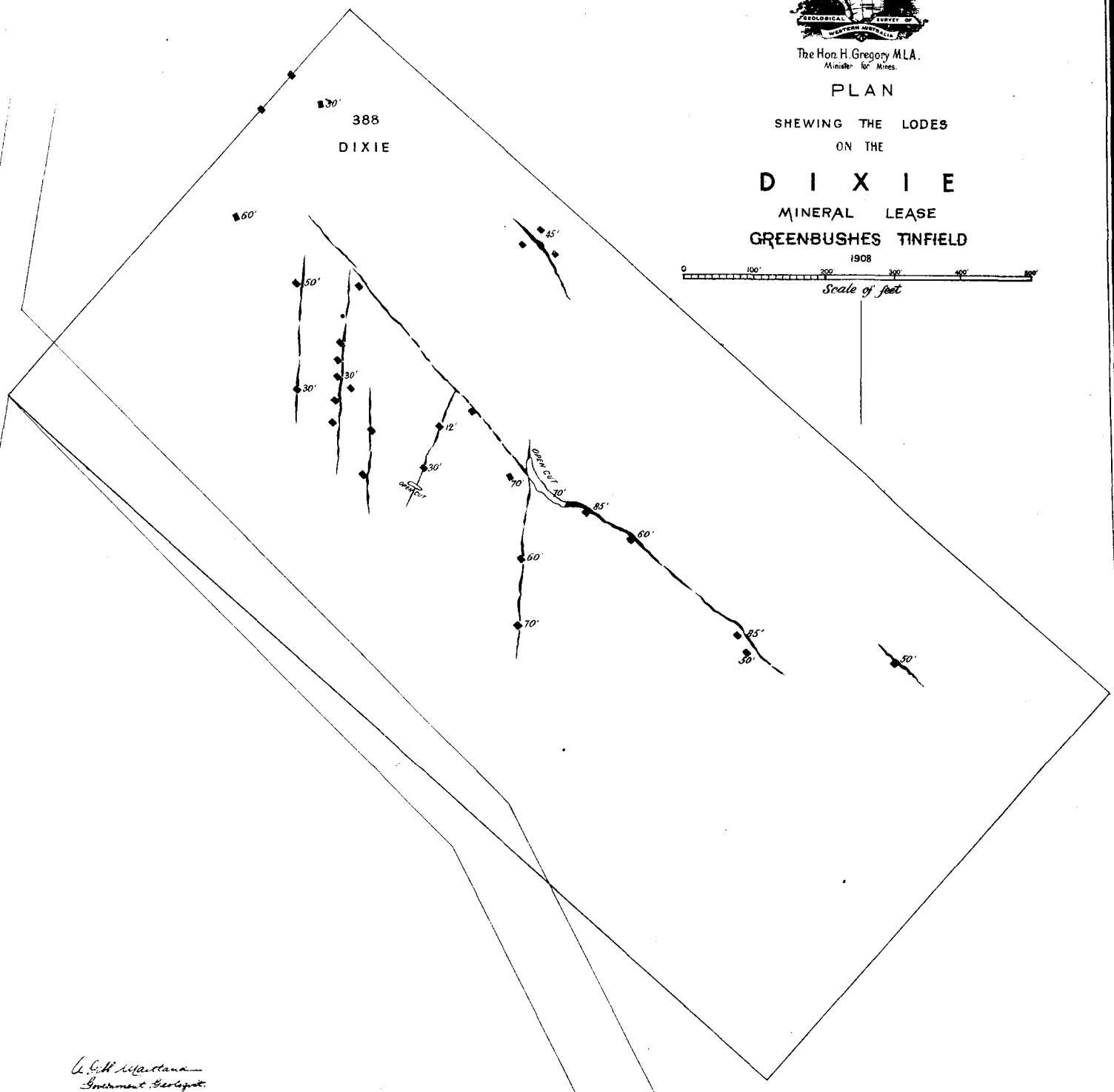
D I X I E

MINERAL LEASE

GREENBUSHES TINFIELD

1908

0 100' 200' 300' 400' 500'
Scale of feet



A. Gibb Maitland
Government Geologist.

R. H. Irwin del. 10.6.08.

H.J. Pether, Government Lithographer, Perth, W.A.

The Hon. H. Gregory M.L.A.
Minister for Mines.

PLAN

SHEWING THE LODES
ON THE

CORNWALL & STH CORNWALL

MINERAL LEASES

GREENBUSHES TINFIELD

1908

0 100' 200' 300' 400' 500'
Scale of feet

40
CORNWALL

300
STH CORNWALL

OPEN CUT
45'
30'
30'
30'
40'
OPEN CUT
MAIN SHAFT
100'
70'
OPEN CUT
50'

OLD MAIN SHAFT 40'
OPEN CUT
40'
50'
50'
130'
MAIN SHAFT 200' 50'

A. Gibb Maitland
Government Geologist.

R.H. Irwin del. 22. 5. 09.

H.J. Pether, Government Lithographer, Perth, W.A.

FIG 3

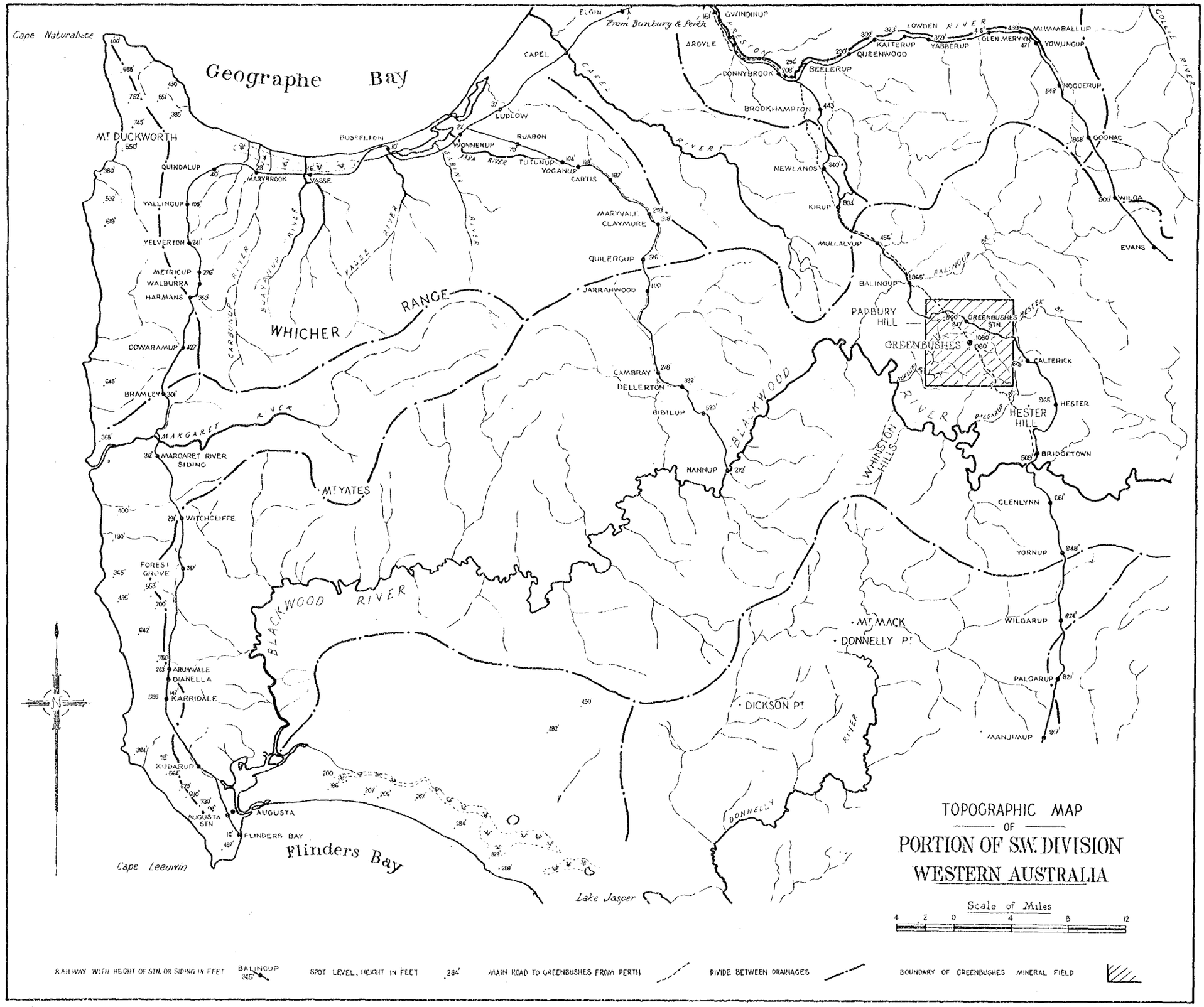

Cape Naturaliste
Geographe Bay
Cape Leeuwin
Flinders Bay
Lake Jasper
From Bunbury & Perth
ELGIN
GWINDINUP
ARGYLE
CAPEL
CAPEL RIVER
LUDLOW
BUSSELTON
WONNERUP
RUABON
FUTUNUP
YOGANUP
CARTIS
MARYBROOK
VASSE
QUINDALUP
MT DUCKWORTH
YALLINGUP
YELVERTON
METRICUP
WALBURRA
HARMANS
COWARAMUP
BRAMLEY
MARGARET RIVER
MARGARET RIVER SIDING
MT YATES
WITCHCLIFFE
FOREST GROVE
ARUMVALE
DIANELLA
KARRIDALE
KUDARUP
AUGUSTA
AUGUSTA STN
FLINDERS BAY
CARBANUP RIVER
SUAYANUP RIVER
VASSE RIVER
SABINA RIVER
WHICHER RANGE
MARYVALE
CLAYMORE
QUILERGUP
JARRAHWOOD
CAMBRAY
DELLERTON
BIBILUP
NANNUP
BLACKWOOD RIVER
BROOKHAMPTON
DONNYBROOK
BEELERUP
QUEENWOOD
KAITERUP
YABBERUP
LOWDEN RIVER
GLEN MERVYN
MUMMABALLUP
YOWUNGUP
NOGGERUP
GOONAC
WILGA
EVANS
NEWLANDS
KIRUP
MULLALYUP
BALINGUP
PADBURY HILL
GREENBUSHES
GREENBUSHES STN
CALTERICK
HESTER
HESTER HILL
BRIDGETOWN
WHINSTON HILLS
GLENLYNN
YORNUP
WILGARUP
PALGARUP
MANJIMUP
MT MACK
DONNELLY PT
DICKSON PT
DONNELLY RIVER
COLLIE RIVER
N
TOPOGRAPHIC MAP
OF
PORTION OF S.W. DIVISION
WESTERN AUSTRALIA
Scale of Miles
4 2 0 4 8 12
RAILWAY WITH HEIGHT OF STN. OR SIDING IN FEET
BALINGUP 365
SPOT LEVEL, HEIGHT IN FEET
284'
MAIN ROAD TO GREENBUSHES FROM PERTH
DIVIDE BETWEEN DRAINAGES
BOUNDARY OF GREENBUSHES MINERAL FIELD

Figure 4

MINERAL FIELD BOUNDARY

NORTH GREENBUSHES TOWNSITE

PADBURYS HILL

GREENBUSHES TOWNSITE

SOUTH GREENBUSHES

ANGUS CUT

ALLENS CUT

KEYSERS CUT

JOHNS CUT

VULCAN CUT

CASTLE CUT

Dumpling Gully

Gibbets Gully

Spring Brook

Cowan Brook

Floyds Gully

Still Water Gully

Kelly's Flat

Burbury Gully

New Zealand Gully

Westralian Gully

Formed Road

— REFERENCE —

1000 FEET	ABOVE SEA LEVEL
900 "	
800 "	
700 "	
600 "	
500 "	
400 "	

Mining holdings – symbols as for Plate I

Open cuts formed as a result of sluicing

Alluvial workings – May be shallow workings in creeks or deep workings by shafts. Individual shafts too numerous to be shown

Boundary of Old Alluvium

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

OROGRAPHICAL MAP

— OF —

GREENBUSHES MINERAL FIELD

SHOWING ALSO, THE DISTRIBUTION OF OLD ALLUVIUM

Scale: 40 chains to an inch

40 20 0 40 80

Compiled from Plate I

J.M.F. del 5-12-44

Plate I

GREENBUSHES MINERAL FIELD

LEGEND

RECENT

Recent Alluvium – Sands, gravels and clays

Areas covered with clayey soil and laterite rubble. Underlying rocks unknown — S

TERTIARY (?)

Laterite – Ferruginous or Aluminous. Believed to overlie basement rocks. — L

Old Alluvium – Horizontal, clay, sand, grit, pebble and boulder beds, capped by laterite — A

PRE-CAMBIAN

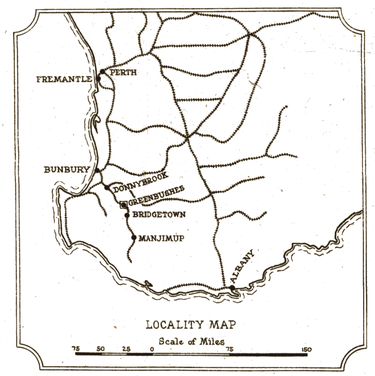
Greenstone — GS

Greenstone (?) – Clayey soil with laterite rubble. Fairly frequent shafts, with very weathered greenstone in dumps. No outcrops — G

Gneiss – Granulitic and injection gneiss — Q

REFERENCE TO SIGNS

Mining holding existing	M.C.9
Mining holding void	M.C.33
Mineral Lease	194
Mineral Claim	M.C.5
Claim	C.648
Dredging Claim	D.C.90
Extended Alluvial Claim	E.A.C.963
Garden Area	G.A.12
Tailings Area	T.A.12
Machine Area	M.A.15
Water Area	W.A.207
Water Right	W.R.288
Dam Site	D.S.84
Miners Homestead Lease	M.H.L.8
Open cuts formed as a result of sluicing	
Alluvial workings – May be shallow workings in creeks or deep workings by shafts. Individual shafts too numerous to be shown.	
Geological boundaries approximate	
Swamps	
Lode workings – Only the principal lode workings are shown. Strike and dip are indicated.	
Deep bores (1936)	
Strike of vertical schistosity	N10°W
Rock outcrop	
Locality and registered number of specimen	X 2/2665



LOCALITY MAP
Scale of Miles
75 50 25 0 75 150

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGICAL SKETCH MAP

OF

GREENBUSHES MINERAL FIELD

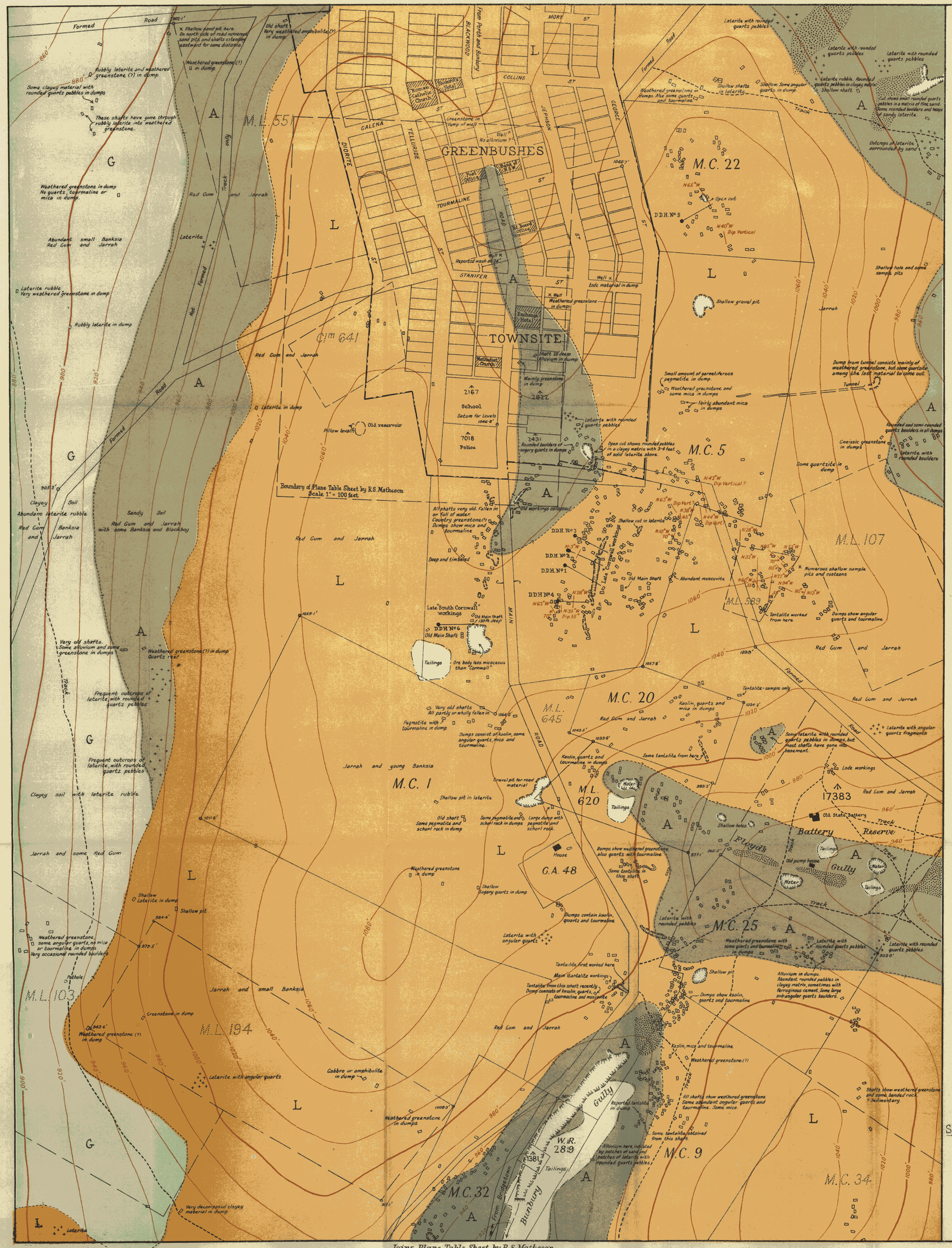
Scale: 20 chains to an inch

20 15 10 5 0 20 40 60 80

Base map from Mines Department, Photograph L.107.
Contours from "Geological Map of Greenbushes," Geological Survey Bulletin 92
Original topographic survey by H.W.B. Talbot.
Geology by R.A. Hobson. Reduced from field maps on a scale of 10 chains to an inch
An area south-east of Greenbushes Townsite, and including all the principal "lode" workings, was mapped by R.A. Hobson and R.S. Matheson, on a scale of 5 chains to an inch, using a plane table and telescopic alidade.
Geological boundaries elsewhere were fixed by pacing, topographic features or by air photos. Sept. to Oct. 1942.

J.McL. del. 5/12/44

Plate II



LEGEND

TERTIARY (?)

Laterite — Ferruginous or Aluminous. Believed to overlie basement rocks — L

Old Alluvium — Horizontal, clay, sand, grit, pebble and boulder beds, capped by laterite. — A

PRE-CAMBRIAN

Greenstone (?) — Clayey soil, with laterite rubble. Fairly frequent shafts, with very weathered greenstone in dumps. No outcrops. — G

REFERENCE TO SIGNS

Mining holding existing	M.C.5
Mining holding void	M.L.107
Mineral Claim	M.C.
Mineral Lease	M.L.
Garden Area	G.A.
Water Right	W.R.
Shafts - inaccessible	▭
Alluvial workings, individual shafts not shown.	
Open cuts	
Tailings	
Strike and dip of ore body, where visible	N62°W 70°S
Diamond drill hole	DDH Nº3
Geological boundaries (approximate)	
Outcrops with no observable strike or dip	
Reduced level at corner of mining holding	1057.8'

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGICAL MAP OF PORTION OF GREENBUSHES MINERAL FIELD

Showing the Central Portion of Belt of Lode Country

Scale 5 chains to an inch

5 0 5 10 15 20

Survey information for base map from Lands and Mines Departments. Geology, topography, workings, tracks etc. from plane table and telescopic alidade survey by R.A. Hobson, June-August, 1942. Datum for levels is a point close to southeast corner of ✝2167 (school), which is taken to be 1046·8 feet.

Plate III

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGICAL MAP OF PORTION OF GREENBUSHES MINERAL FIELD

Showing the Southeastern End of Belt of Lode Country

Scale 5 chains to an inch

5 0 5 10 15 20

Survey information for base map from Lands and Mines Departments.
Geology, topography, workings, tracks etc from plane table and telescopic alidade survey by R.S. Matheson, July–Sept. 1942.
Sample information and other notes inbrown by R.A. Hobson, July, 1943.

LEGEND

RECENT

Recent Alluvium — *Sands, gravels and clays*

TERTIARY (?)

Laterite — *Ferruginous or Aluminous. Believed to overlie basement rocks* (L)

Old Alluvium — *Horizontal, clay, sand, grit, pebble and boulder beds, capped by laterite.* (A)

PRE-CAMBRIAN

Lode Material — *Kaolinised tourmaline-bearing stanniferous rock of granitic composition. Believed to occur as intrusions and replacements in greenstone country.* (T)

REFERENCE to SIGNS

- Mining holding existing — M.C. 6
- Mining holding void — M.L. 90
- Mineral Claim — M.C.
- Mineral Lease — M.L.
- Dredging Claim — D.C.
- Water Right — W.R.
- Geological boundaries (approximate only)
- Diagrammatic representation of lodes showing strike & dip — 70°-80°
- Outcrops with no observable strike or dip
- Shafts
- Tailings
- Open cuts
- Alluvial workings
- Tracks
- Fences
- Dam embankment
- Swampy ground
- Diamond drill holes (put down by Mines Dept., 1928-1929) — DDH No 8
- Locality, number and lbs. concentrate per cubic yard for sample taken from a dump. — G25. 3½ lbs.
- Locality, number, depth and lbs. concentrate per cubic yard for sample taken with a post hole digger or for channel sample. — G31 0-5' / 5-10' ½ lb.

Note — The values shown are all lbs. concentrate per cubic yard. No assays have been made.

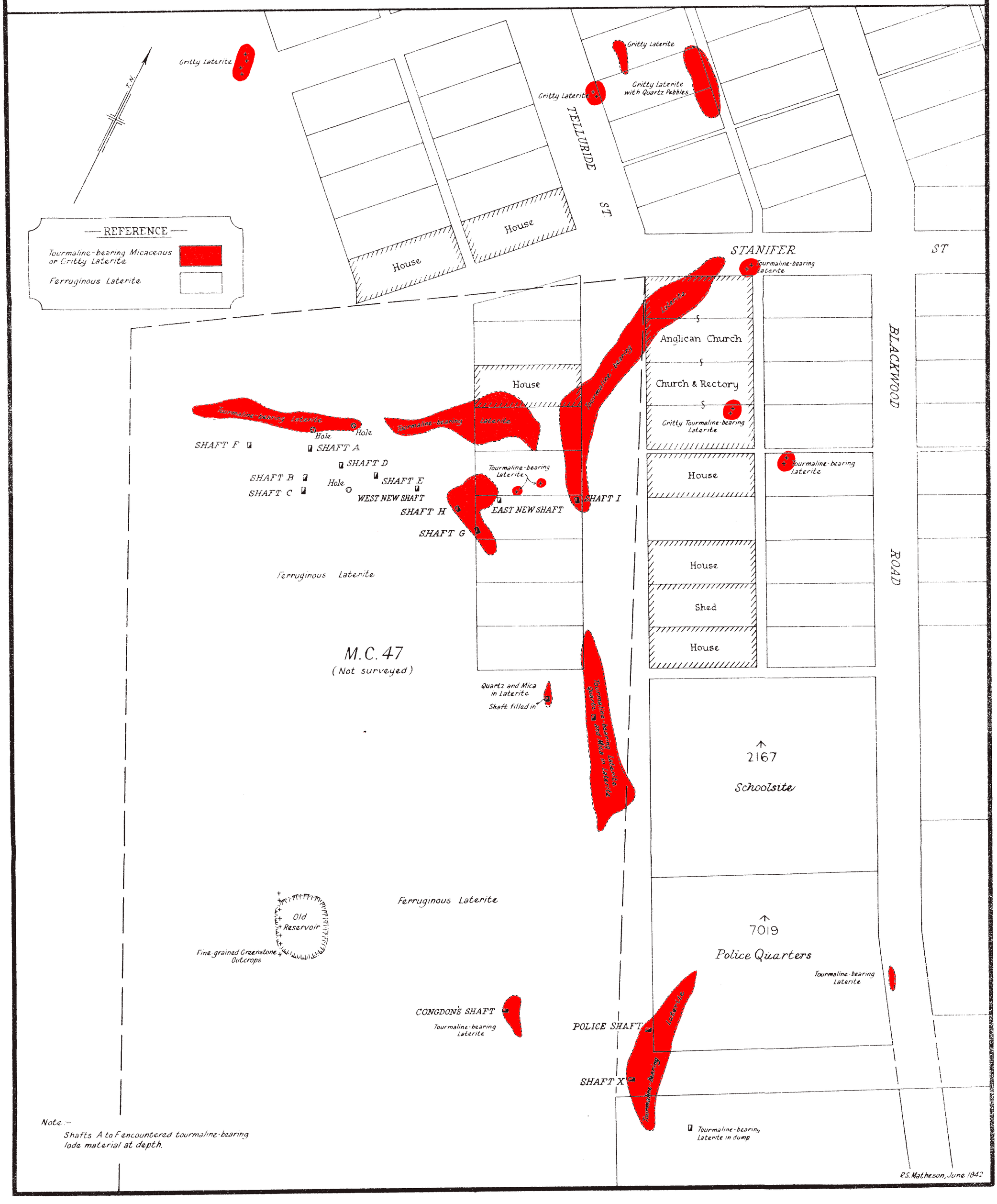
PLATE IV

PLAN OF M.C. 47

GREENBUSHES

SHOWING THE DISTRIBUTION OF TOURMALINE-BEARING, MICACEOUS AND GRITTY LATERITE

Scale: 100 feet to an inch



Note:-

Shafts A to F encountered tourmaline-bearing loda material at depth.

R.S. Matheson, June 1942

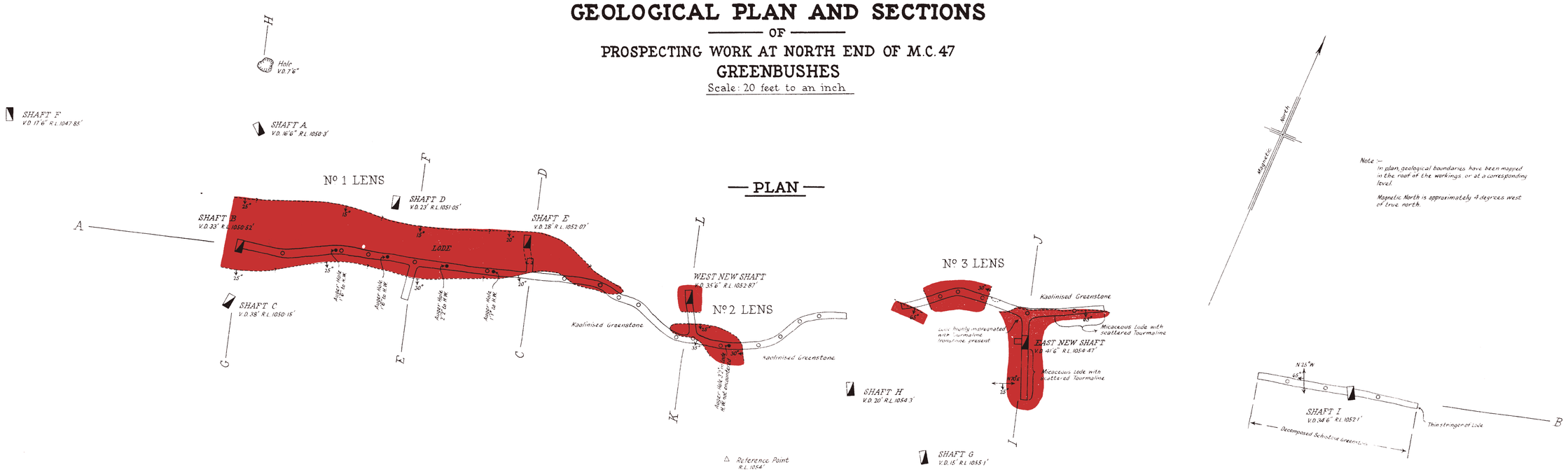
GEOLOGICAL PLAN AND SECTIONS

OF

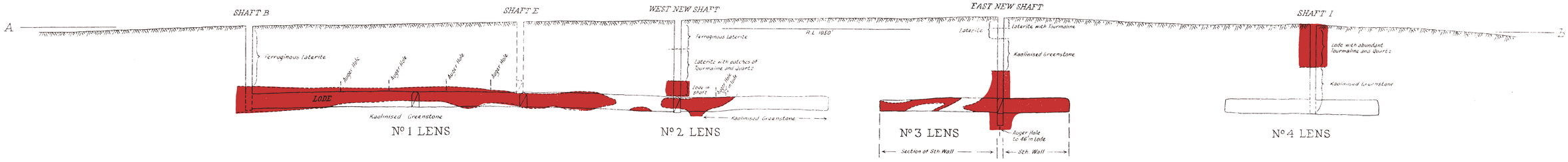
PROSPECTING WORK AT NORTH END OF M.C. 47
GREENBUSHES

Scale: 20 feet to an inch

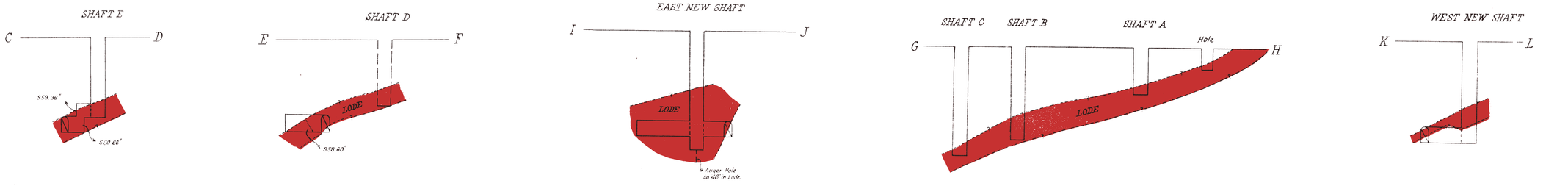
— PLAN —



— LONGITUDINAL SECTION —



— TRANSVERSE SECTIONS —



Compass, tape survey, geology and sampling by R.C. Matheson, Aug.–Sept. 1942.

ASSAY PLAN AND SECTION

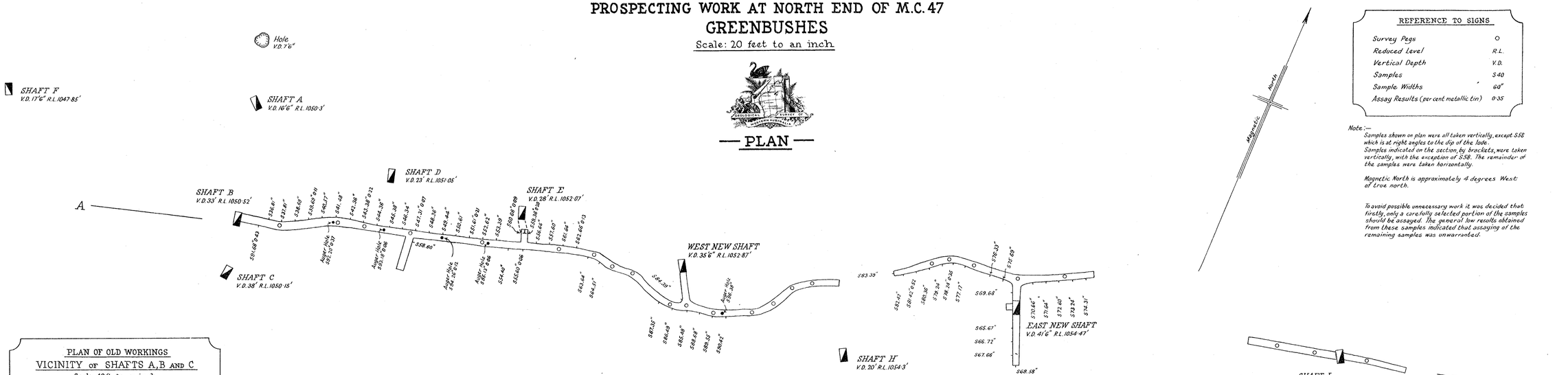
OF

PROSPECTING WORK AT NORTH END OF M.C. 47

GREENBUSHES

Scale: 20 feet to an inch.

— PLAN —



REFERENCE TO SIGNS

Survey Pegs	○
Reduced Level	R.L.
Vertical Depth	V.D.
Samples	S 40
Sample Widths	60"
Assay Results (per cent metallic tin)	0·35

Note:—

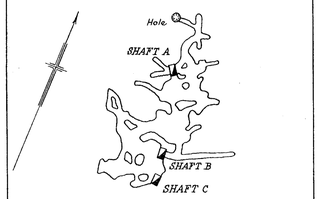
Samples shown on plan were all taken vertically, except S58 which is at right angles to the dip of the lode.
Samples indicated on the section, by brackets, were taken vertically, with the exception of S58. The remainder of the samples were taken horizontally.

Magnetic North is approximately 4 degrees West of true north.

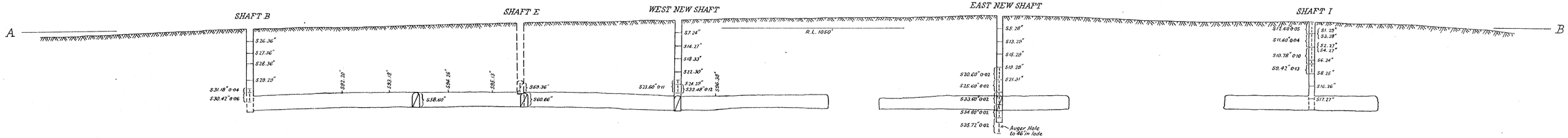
To avoid possible unnecessary work it was decided that firstly, only a carefully selected portion of the samples should be assayed. The general low results obtained from these samples indicated that assaying of the remaining samples was unwarranted.

PLAN OF OLD WORKINGS
VICINITY OF SHAFTS A, B AND C

Scale 40ft. to an inch.



— LONGITUDINAL SECTION —



Compass, tape survey and sampling by R.S. Matheson
Aug.- Sept. 1942

PLAN AND SECTIONS
OF
PROSPECTING WORK AT SOUTH END OF M.C.47
GREENBUSHES

Scale: 20 feet to an inch

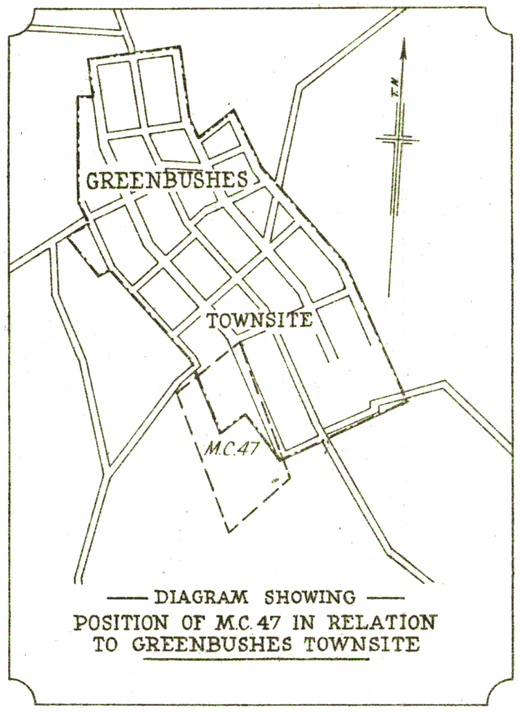
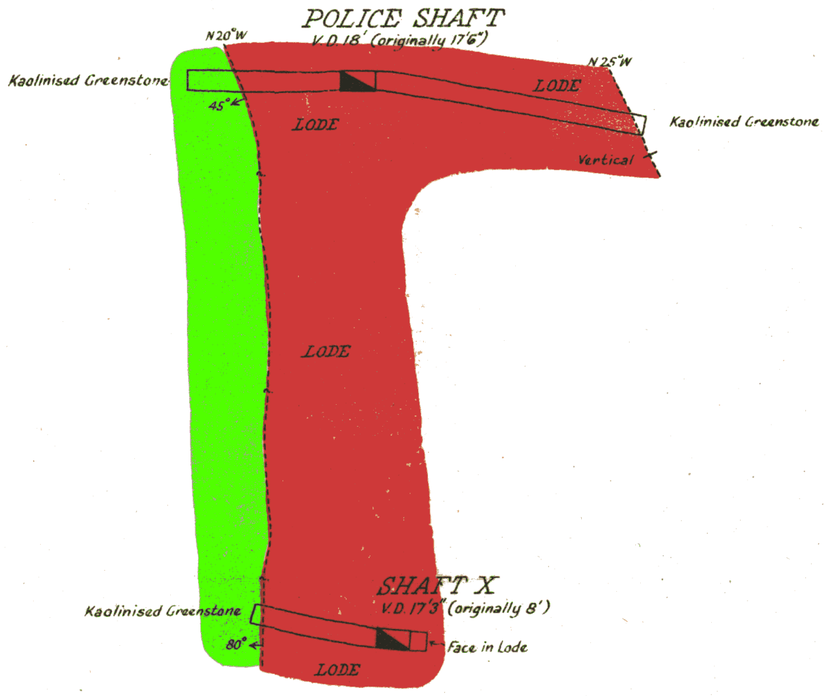


DIAGRAM SHOWING
POSITION OF M.C.47 IN RELATION TO GREENBUSHES TOWNSITE

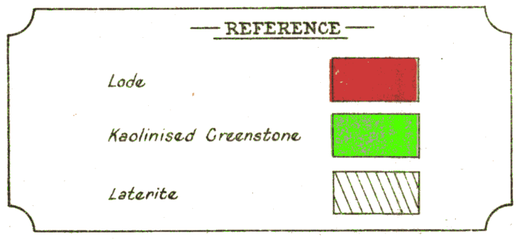
Note:–
Magnetic North is approximately 4 degrees West of true north

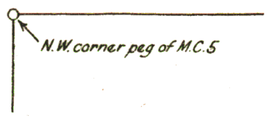
PLAN



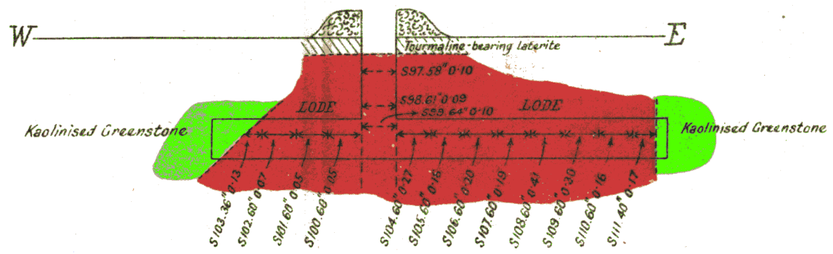
CONGDON'S SHAFT
V.D. 13' (originally 7')

Tourmaline-bearing laterite to 8' V.D., then Ferruginous Laterite. Kaolinitic material in floor.

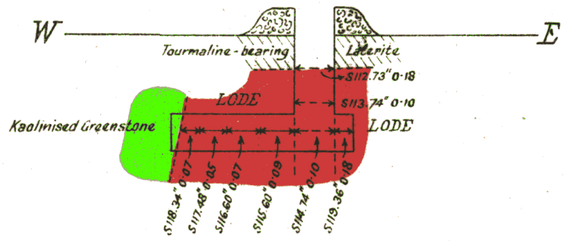




SECTION THROUGH POLICE SHAFT



SECTION THROUGH SHAFT X



Compass, tape survey, geology and sampling by R.S. Matheson, Sept-Oct. 1942

PLATE VIII

D.C.37

From Greenbushes

D.C.35

Main Battler's Gully workings hereabouts

BATTLER'S

Bore No III (1936)

Bore No II (1936)

Bore No I (1936)

Bore No V (1936)

Bore No IV (1936)

Bore No VI (1936)

Extensive shallow workings

Track

HOPE BORES (1936)

Deep shaft

Deep shaft

Shallow workings

Shallow sand workings

Reported 11' ground and 3 lbs/yd in bore hereabouts

M.C. 48
(Not Surveyed)

Track

Shallow workings in sand

Group of shafts hereabouts
Very weathered greenstone in dumps.

Thick Ti-tree

Small group of shafts hereabouts

Very weathered greenstone in dump

Sand in dump

Shallow hole

Thick Ti-tree

3' of sand and rubbly laterite, tinence into clay.

Clay at 3'6"

Shallow workings in laterite up to 4' deep
Laterite contains rounded quartz boulders.

Wash boulders in laterite

Blue grey clay at 9'

Granite at 8'

Very weathered granite material in dump

Laterite with wash boulders.

Gritty laterite with some wash boulders

Laterite with rounded quartz pebbles.

D.C.95

Bore No I (1936)

BORES (1936)

Bore No II (1936)

Shallow workings 2'-3' deep in sand

EAST PHOENIX

Approximate edge of dredged ground

Bore No III (1936)

Shallow workings

Track

M.L.571

D.C.29

Shallow workings

Tailings

Solid ground

Tailings

Shallow workings 3'-4' deep

Shallow workings (2'-3')

M.L.529

Shallow cut filled with tailings

Solid ground

Tailings

D.C.18

M.L.555

— REFERENCE —

Existing mining holding	
Mining holding void	
Mining holding applied for, but not surveyed	
Mineral claim	M.C.
Mineral lease	M.L.
Dredging claim	D.C.
Position and number of deep bore put down by Mines Department in 1936	Bore No V (1936)
Shaft	
Shaft sampled and reference number	23 K
Depth to present bottom of shaft - for shafts not completely fallen in.	17'
Boring sites marked by numbered posts	
Boring grid	

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SAMPLE MAP AND BORING GRID

IN VICINITY OF

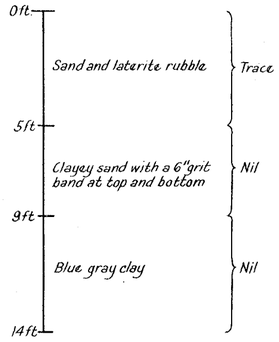
D.C.95 AND M.C.48

GREENBUSHES MINERAL FIELD

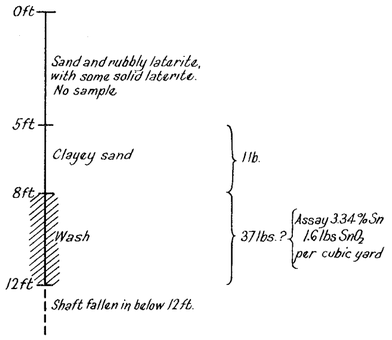
Scale 2 chains to an inch

Plane table, & telescopic alidade survey and sampling by R.A. Hobson, June 1943.

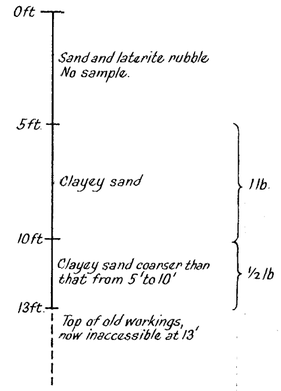
14R



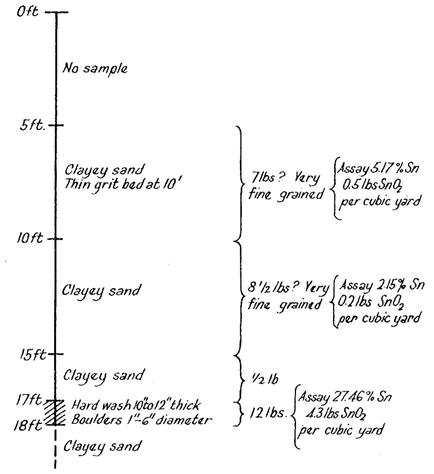
18D



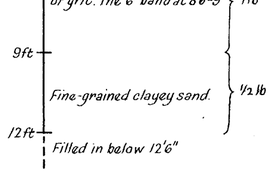
19N



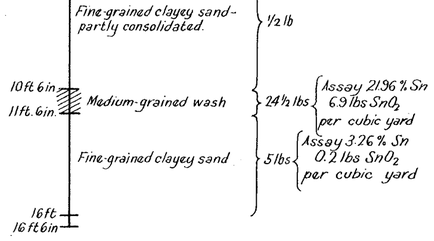
20g



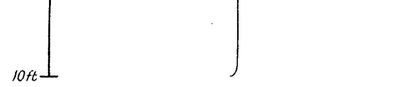
21J



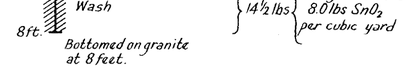
23K



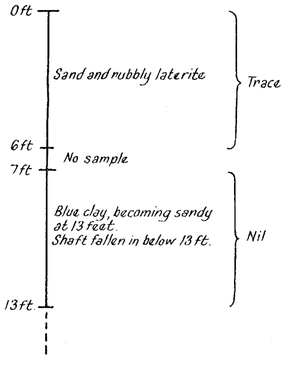
24F



24M

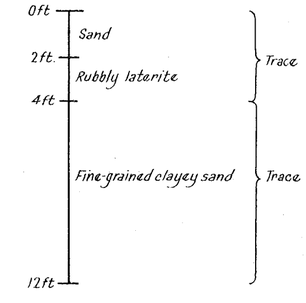


SHAFT BETWEEN A18 AND B18

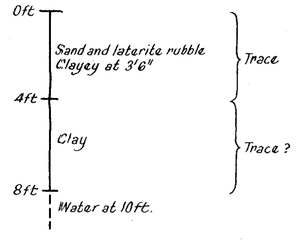


Note :-
Some very weathered greenstone in the dump

C17 42'W. AND 30'N.



H0 30'W. AND 25'S.



Note :-
The values shown (e.g. 5lbs) are lbs. of concentrate per cubic yard, unless otherwise shown.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

CHANNEL SAMPLES TAKEN FROM SHAFTS

IN VICINITY OF

D.C. 95 AND M.C. 48

GREENBUSHES MINERAL FIELD

Scale 5 feet to an inch

Sampling by R.A. Hobson, June 1943