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DEPARTMENT OF SUPPLY AND DEVELOPMENT

COMMONWEALTH COPPER AND BAUXITE COMMITTEE

EIGHTH REPORT

Australian Bauxite Resources

AUSTRALIAN BAUXITE RESOURCES

SECOND REPORT

INTRODUCTION:

Bauxite is named after the village of Baux in Southern France, where it was first investigated. For many years it was thought to be a mineral with a fixed chemical composition but it is best described as a rock of colloidal origin consisting mainly of either gibbsite, the trihydrate of aluminium ($Al_2O_3 3H_2O$) or the monohydrate, diaspore ($Al_2O_3 H_2O$) or a mixture of these. The ratio of water (H_2O) to alumina (Al_2O_3) in gibbsite is 1:1.89 and in diaspore 1:5.67, so that it is usually possible to say by examination of the analysis of a bauxite to which type it belongs.

The alumina content of gibbsite is soluble in caustic soda and the production of a chemically pure alumina therefrom is a simpler process than producing a pure alumina by the acid attack to which diaspore must be subjected. Hence the consumption of bauxites containing gibbsite much exceeds that of bauxites containing diaspore.

Most bauxites are earthy looking and are from cream to red in colour, but they vary greatly in appearance. Being more like a rock than the ore of a metal, bauxite deposits have received very little attention from the old style prospector.

It is technically possible to produce aluminium from many aluminous rocks and minerals. The following is a list of minerals from which aluminium is being made or from which it has been shown that it can be made. The name of the country in which it is used follows the mineral name in brackets:-

Alunite (United States and Japan), Clay (Germany and Japan), Leucite (Italy), Andalusite (Sweden), Labradorite (Norway). Alunite and leucite are also ores of potassium. There are special reasons in all these countries why minerals other than bauxite have been resorted to. Aluminium is now such a key mineral that all countries have striven to develop their own raw materials almost without regard to cost. Where bauxite is available, however, it remains unchallenged as the principal ore of aluminium.

In analysing bauxite it is usual to determine the following oxides:-

Alumina, oxide of aluminium (Al_2O_3) usually expressed as total, available (acid soluble) or free (soda-soluble). The great majority of free aluminas quoted herein refer to extraction by a hot 10% solution of caustic soda.

Ferric oxide or red oxide of iron (Fe_2O_3)

Titanium oxide (Ti_2O)

Silica ($SiO2$). In the great majority of Australian bauxites silica is present predominantly in the uncombined state, often as quartz (i.e. broadly speaking as sand grains). More rarely it is present as one of the clay minerals (silicates) such as Kaolinite.

Water (H_2O). There is always some "free" moisture present but in air dried samples the percentage of H_2O given is predominantly that combined with other oxides (chiefly Al_2O_3). In some cases a figure is given as "loss on ignition" which may usually be taken to represent combined water, since alkalis and other oxides which might be driven off on heating are known to be virtually absent.

During its investigation the Committee attempted to get the State Government Analysts to adopt a standard procedure in analysis, so that results obtained in various laboratories would be on a strictly comparable basis. This agreement unfortunately was not reached, but it is believed that the different methods of analysis used, give fairly comparable results.

GENERAL DISTRIBUTION IN AUSTRALIA:

The general distribution of the known bauxite deposits of Australia is shown in Figure "A". It will be seen that bauxite deposits are known to occur in all States except South Australia and the Northern Territory.

The following statement is not merely a compilation based on information supplied by the States. Some members of the Committee have visited all States and Messrs. Martin, Newman and Raggatt have examined all the important deposits. In addition Mr. Martin has been associated with the prospecting of many of the deposits, through Sulphates Pty. Ltd. Dr. Raggatt worked in association with the Broken Hill Pty. Company in surveying many of the deposits in New South Wales.

Information supplied by the State Mines Departments and Broken Hill Pty. Company and Sulphates Pty. Ltd. is gratefully acknowledged. Thanks are also due to Zinc Corporation for making available the services of Mr. A. N. Esdaile, who made analyses of a large number of bauxites, chiefly from New South Wales.

Particulars regarding the deposits in each State are summarised hereunder:-

QUEENSLAND

The only deposits which have been prospected to any extent are those of the Tamborine Plateau, 6 miles from Tamborine Railway Station which is 33 miles southerly from Brisbane. (See Fig. "A" and 1). These deposits have been opened up in Geissmann's quarry (from which several thousand tons of ore have been removed for surfacing roads).

The tonnage probably available adjacent to Geissmann's quarry is about 200,000 tons. The average analysis of a twelve foot face in this quarry is:-

Available.

Al_2O_3	Fe_2O_3	TiO_2	SiO_2	H_2O
42%	26%	4%	1%	27%

Many samples from other localities hereabouts have given comparable results and selected samples have given up to 55% Al_2O_3 and down to 0.3% SiO_2.

There may be considerably larger reserves than 200,000 tons available in the area surrounding Geissmann's quarry, but the subdivision of the locality into numerous small township allotments hampers prospecting.

A considerable amount of prospecting has been done in other areas of the Tamborine Plateau by Sulphates Pty. Ltd., with generally disappointing results.

Bauxite is also reported from the Cairns hinterland.

It may be pointed out that many of the world's developed resources of bauxite occur within the monsoon belt and it is likely therefore that deposits of high grade bauxite will be found in North Queensland.

NEW SOUTH WALES

There is considerable information available concerning the bauxite resources of New South Wales, due chiefly to recent activity by Sulphates Pty. Ltd., Broken Hill Pty. Ltd., and to co-operation of these companies with the New South Wales and Commonwealth Governments.

The principal deposits occur in two groups (1) Emmaville-Inverell, (2) Bundanoon-Marulan-Crookwell. Bauxite has also been found near Trundle. These localities are shown on Fig. "A" and 1.

EMMAVILLE-INVERELL DISTRICT. (See Fig. 2).

In the Emmaville district, as in the Bundanoon-Marulan-Crookwell area, the bauxites form mesa-like deposits and are easily mapped and prospected, but near Inverell there is usually some difficulty in defining the deposits. It is especially difficult to draw the line in the field between "primary" bauxites and redistributed ones, but the latter are invariably found to be high in silica.

There is clear evidence in these districts that the bauxites have been formed by alteration of basalts (and possibly tuffs and breccias). Many of the deposits represent the lateritised capping of the tin-bearing leads which are such a well known feature of the area. Deposits 1 to 5 represent one such series and deposits 9 to 12, another.

All the more important bauxite deposits of the Emmaville-Inverell district are free from overburden and readily accessible from existing means of transportation.

(1) Portions 34, 36, 37, 32, 31, 29 and 30 Parish of Lorne and Portions 10 and 11 Parish of Lockerby, County of Arrawatta, 28 miles by road, W.N.W. from Inverell and 45 miles by road from Deepwater, the nearest railway station.

Prospecting operations by the Broken Hill Pty. Company have proved a total tonnage of 1,700,000 tons of bauxite, much of which is of good quality.

The following table shows the tonnages and chemical composition of higher grade ore available in individual sections of the deposits arranged in order from North to South:-

		Average Thickness	ANALYSIS SiO_2	Fe_2O_3	Al_2O_3 (available)
a.	700,000 tons	22 ft.	3.25	26.30	41.40
b.	350,000 "	26 ft.	2.20	28.86	39.20
c.	160,000 "	See note			
d.	100,000 "	16 ft.	5.06	33.41	42.96
	1,310,000 tons				

Tonnage estimates have been checked by Messrs. Raggatt and Booker. Analyses were made by the Company.

Note:- Section c is joined to Section d. and is separated by three chains from b. A shaft has been sunk on it but results are not yet to hand. Its quality is likely to be at least as good as that of d.

(2) Portions 2, 5, 6 and 11 Parish of Astley, County of Arrawatta, 12 miles by road westerly from Emmaville and 28 miles from Deepwater railway station.

Some sections of this group of deposits have been prospected by the Broken Hill Pty. Co. and the remainder by Sulphates Pty. Ltd. A total tonnage in excess of 2,000,000 has been proved by shaft sinking operations.

The following statement summarises the information available concerning this group of deposits:-

	Tons	Thickness in Feet	ANALYSIS SiO_2	Fe_2O_3	Al_2O_3 (available)
(a) 3 small deposits in Portions 5 & 6	300,000	-	No shafts or samples.		
(b) Portion 11 (N.E. Section).	1,000,000	18	4.30	30.40	34.30
(c) Portion 11 (S.W. Section).	300,000	35	7.0	35.6	29.2
(d) M.L.1	400,000	19	2.16	27.60	39.60
(e) Portion 2.	120,000	34	1.76	26.24	43.15
(f) Portion 1.	58,000	19	4.10	31.14	39.13
Total	1,878,000	excluding (c)			

Tonnage estimates have been checked by Messrs. Raggatt and Booker. Analyses were made by the Company.

(3) Large deposits occur in and adjacent to Portions 512 and 516, Parish of Scone and Portion 39 Parish of Strathbogie, County of Gough, about three miles south-west of the village of Emmaville, which is 16 miles westerly from Deepwater Railway Station. Final results of prospecting are not yet available, but it is apparent that there is a considerable tonnage (exceeding 7,000,000) of ore proved here with the following range in composition:-

Section a. These deposits have been prospected by the Broken Hill Pty. Ltd. and occur on Portions 38, 512 and 516, Parishes of Strathbogie and Scone. Mr. F.W. Booker estimates the reserves at approximately 4,000,000 tons, of the following grade:-

SiO_2	"available" Al_2O_3	Fe_2O_3
5.03	33.0	29.44

Section b. Western deposit on Portions 29, 514, 699 and 700, Parish of Strathbogie. Prospected by the Department of Mines, New South Wales, from funds provided by the Commonwealth. Four shafts sunk and two old shafts sampled. At the present time the deposit is not held under mining title. Mr. F.W. Booker estimates that there are 3,000,000 tons available in this section, of the following grade:-

SiO_2	"Free" Al_2O_3	Fe_2O_3
6.0	35.9	26.5

(4) Emmaville Common. Rather scattered deposits of low grade. Reserves about 350,000 tons.

(5) Graveyard Creek. Low grade. Reserves about 300,000 tons.

(6) Nullamanna. Several scattered deposits of variable grade ore. Reserves about 500,000 tons.

(7) The Nine Mile, nine miles from Inverell on the road to Warialda.

A shaft was sunk on this deposit by the Broken Hill Pty. Co. which proved a thickness of 10 feet 6 inches with the following composition:-

	SiO_2	Available Al_2O_3	Fe_2O_3
5' in quarry	5.96	39.47	26.95
5'6" at top of shaft in floor of quarry.	15.86	33.36	27.41

The deposit is fairly large and there may be higher grade material in the untested portions.

(531) (8)(9) The Four Mile, four miles west of Inverell on the road to Warialda. Portion 358, Parish Byron, County Arrawatta.

Sampling indicates a minimum thickness of 35 feet with the following composition:-

	SiO_2	Free Al_2O_3
Top 15 ft.	15.00	25.0
Bottom 20 ft.	6.30	37.4

Mr. F.W. Booker of the Geological Survey of New South Wales estimates that there are 285,000 tons of the higher grade bauxite in this deposit. Actual reserves about 10,000 tons. A.B. 10/2/48

Nodules of decomposed basalt up to 8 inches diameter occur sporadically throughout the deposit, constituting perhaps 10% of its bulk. Microscopic examination of these by H.F. Whitworth shows that the felspar crystals have been entirely replaced by gibbsite. Analysis shows the following composition:-

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Loss on ignition
2.0	50.5	16.0	2.1	29.1

When this sample was collected it was considered to be worthless, and it is therefore possible that similar high grade material has been overlooked elsewhere.

(40) (9)(10) Bundarra Road, 10 miles southerly from Inverell Railway Station.

The deposits are situated along and adjacent to the Inverell-Bundarra Road, north and north-east of the road junction forming part of the boundary of Portion 406, Parish of Clive, County of Gough.

A large tonnage of ore is available, but most of it is low grade containing under 25% of caustic soda-soluble alumina. The highest soda-soluble alumina percentage noted in an extensive series of samples is 33.5%.

(10)(11) Topper's Mountain lead, 4 miles N.E. of the village of Tingha and 23 miles by road S.E. of Inverell Railway Station.

(41) The highest grade deposits are in Portions 229 and 419, Portions 173 and 434 Parish of Herbert, County of Gough.

In these portions shafts sunk by the Broken Hill Pty. Co. have revealed about 500,000 tons of ore with the following average composition:-

SiO_2	Available Al_2O_3	Fe_2O_3
4.37%	39.37%	30.26%

There is also a very large tonnage of ore containing about 20% soda-soluble alumina, but high in silica. Much of this silica is present in the form of sand grains.

(11) (8) Ten miles from Inverell on south side of the Tingha Road.

Mr. F.W. Booker estimates the available tonnage as 1,250,000 containing:-

SiO_2	Free Al_2O_3	Fe_2O_3	TiO_2
4.9%	35.6%	20.4%	2.3%

The following notes (Deposits 12, 13 and 14) are also based on a progress report by Mr. F.W. Booker:-

(12) (6) Stannifer.

Section a. P.M.L.35, Parish Swinton, Co.Hardinge.

Tonnage	SiO_2	Free Al_2O_3	Fe_2O_3	
60,000	7.0%	28.6%	33.8%	(Figures incomplete)

(7) Section b. West of Portions 19 & 51, Ph.Swinton, Co.Hardinge.

Tonnage	SiO_2	Free Al_2O_3	Fe_2O_3
260,000	6.9%	36.9%	25.2%

(13) (14) Pindari. 22 miles from Inverell on the Emmaville Road.

Tonnage	SiO_2	Free Al_2O_3	Total Al_2O_3	Fe_2O_3	TiO_2	Loss on Ignition
500,000 approx.	2.6%	45.4%	47.5%	18.9%	3.9%	26.9%

Grab samples, no shafts, deposit not surveyed.

(14) (15) Wellingrove. 18 miles west of Glen Innes.

No shafts. Tonnage unknown; not yet surveyed. Analyses of grab samples as follows:-

	SiO_2	Free Al_2O_3	Fe_2O_3	TiO_2	Loss on Ignition
(a)	3.1%	38.3%	26.6%	3.7%	24.8%
(b)	1.7%	43.7%	20.7%	4.1%	28.2%

BUNDANOON-MARULAN-CROOKWELL.

The deposits in this area fall into three groups; Bundanoon-Wingello; Marulan-Bungonia, and Crookwell.

Shaft sinking through the bauxite deposits in this area has shown clearly that at least the more important of them have been formed by the lateritisation of basalt in place. All the deposits form mesa-like outcrops free from overburden and are easily accessible.

The known deposits in the Crookwell district are small, aggregating less than 30,000 tons, generally of about the same grade as the Bundanoon-Wingello group.

A considerable amount of prospecting has been done in the Marulan-Bungonia locality where there is a number of deposits. One of the deposits (known as Jacqua) situated 2 1/4 miles south of Bungonia near Yarralaw Creek (see Fig.3) contains about 1,000,000

tons of bauxite, but the bulk of it contains about 20% silica. Since these deposits are less accessible than the higher grade Bundanoon-Wingello deposits it is considered unnecessary to give further details concerning them.

The Bundanoon-Wingello group being the nearest to industrial centres, easily accessible and cheaply worked, have been extensively prospected by shaft sinking. Detailed surveys were made of the principal deposits in 1940 by H.G.Raggatt, (see Fig.4). The Bungonia-Marulan and Crookwell deposits were later examined by Mr.Mulholland. The foregoing notes on those areas are based on his reports.

The following table summarises the information available concerning the Bundanoon-Wingello group:-

A V E R A G E A N A L Y S I S

No. of Deposit (Fig.4)	Reserves Tons	SiO_2	FeO	Fe_2O_3	Total Al_2O_3	Avail. Al_2O_3	Free Al_2O_3	TiO_2	P_2O_5	Loss on Ignition.
1.	3,500			Not sampled.						
2.	1,625,000	5.37	0.97	31.12	39.28	35.76x		5.17	.104	18.58
3.	50,000	3.87		34.42		31.01				
4.e	170,000	4.17ø	1.74	35.88	36.84	31.71	+ 10000	4.16		18.73
5.	270,000	4.03	1.60	37.39	36.72x	31.59		4.98x		15.88x
6.	1,500,000	6.37	1.66x	32.37	34.99÷	35.34	35.43÷	4.86÷		21.38
7.	Very small.				Not sampled.					
8.	175,000	7.52		30.21		35.18				
9.	10,000	5.47		34.64		34.00				
10.	6,000	7.36		32.64		32.49				
11.	Very small; too low grade to warrant consideration.									
Total	3,809,500									

ø Excluding surface sample. x Three samples only.
÷ Four samples only. e Western end only, see following note:-

Note:- In view of results of recent prospecting on the western end of Deposit 4 by Sulphates Pty. Ltd., special mention is made of it. The deposit has been closely sampled by shafts, 21 of which have been sunk in an area of about 2 acres. This work has not only shown the deposit to be very much thicker than suggested by a study of the surface geology, but has proved a noteworthy tonnage of high grade ore below the ferruginous capping. This work makes possible the following addition to reserves for this deposit:-

Tons	SiO_2	Al_2O_3	Fe_2O_3
24,000	4.5%	53.9%	5.7%
73,000	6.5%	43.2%	12.6%
500,000	4.5%	31.3%	28.8%

Deposit 4 has been worked by {alunite (Aust) Pty. Ltd.} Sulphates Pty.Ltd. for chemical manufacture and Deposits 5 and 6 by Broken Hill Pty. for ~~blast~~ open hearth flux.

The total reserves of bauxite proved in the Bundanoon-Wingello areas are therefore in excess of 4,400,000 tons.

TRUNDLE.

The following statements are taken from a recent report by Mr. C.St.J. Mulholland:-

The principal occurrences of bauxite so far examined are

situated at a locality known as the Four Corners near the intersection of the Peak Hill-Trundle and Trundle-Numulla Roads, about 10 to 12 miles north-east of Trundle, in the Parishes of Salisbury and Coradgery West, County Kennedy and Parish of Plevna, County of Cunningham.

The deposits mapped (9 in number) occur within an area of about 12 sq. miles, and are believed to have been formed by the alteration in place of Mesozoic tuffs.

Two types of lateritic material occur in the district, viz. (a) Pisolitic laterite consisting of small ferruginous concretions with an aluminous matrix, and (b) Concretionary laterite or bauxite consisting of nodules of aluminous material either loosely cemented together or lying loose in thin beds with the interstices around the concretions filled with red loam.

The pisolitic material in the deposits is invariably low grade but the concretionary (nodular) bauxite contains some high grade material as indicated in the following table:-

Deposit No.	Tonnage	SiO_2	Al_2O_3 (Free)	Al_2O_3 (Total)	Fe_2O_3	TiO_2	Loss on Ignition
1.	2,000	5.14	51.5	55.0	9.7	0.54	25.38
2.	4,000	5.35	43.9	50.0	11.00	1.05	?
5.	3,000	6.86	40.2	43.00	19.6	1.00	29.03
6.	5,000	7.49	40.2	47.44	17.31	1.00	?
7.	1,000	5.22	45.9	49.45	14.85	1.95	?
9.	25,000 ø	7.85	39.7	45.48	18.53	1.50	?

ø Insufficient prospecting to give reasonable estimate of value of this deposit.

Some of the picked large concretions contain up to 57% free Al_2O_3.

Other deposits similar to those examined by Mr. Mulholland have recently been discovered in adjoining areas.

VICTORIA

All the known deposits of bauxite occur in the County of Buln Buln in the Gippsland district of Victoria. The principal deposits are situated in the Boolarra-Thorpdale district to the south-west of Morwell. All these are within six miles of the railway (See Fig. 5).

Other deposits occur at (i) Burgess Creek, Parish of Callignee, (ii) Parish of Devon, 7½ miles north of Gelliondale, (iii) near Gelliondale railway station. The three localities last mentioned lie approximately along a meridian in the order listed from north to south 14 miles east of Maryvale which is shown on Fig. 5.

The Victorian deposits are similar in type being apparently derived from the alteration of volcanic tuffs and breccias of the older volcanic series. Unlike the New South Wales deposits they all have some overburden composed of sands and clays. Considerable faulting and slumping has occurred. All these factors make prospecting difficult and shaft sinking is necessary to enable even approximate estimations of reserves to be made.

The following numbers refer to Fig. 5.

(1) Rodda's, three miles S.W. of Thorpdale.

This bauxite is high in silica and is used chiefly by Ordish Firebrick Pty. Ltd. in the manufacture of aluminous firebrick.

(2) Nahoo, three miles S.E. of Thorpdale.

The bauxite bed is about 7 feet thick and is overlain by an overburden of sand and clay upwards of 15 feet thick. Proved and probable reserves are each about 20,000 tons.

Ore, as mined, from this deposit has the following composition:-

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	H_2O
15.0%	52.0%	3.5%	4.0%	26.0%

It is used by Sulphates Pty. Ltd. for chemical manufacture.

(3) This deposit, 1 3/4 miles westerly from Boolarra has been worked by Sulphates Pty. Ltd. for several years.

The deposit is divided into two sections by a creek. The average thickness of bauxite in one section is 8 feet with an overburden of sand about 7 feet thick. In the other section the bauxite has an average thickness of 10 feet with overburden up to 35 feet, but generally about 16 feet thick.

Mr. W. H. Curteis of Sulphates Pty. Ltd. estimates the tonnage proved by open cut and shaft sinking at about 140,000 tons with a possible reserve of about the same amount. Messrs. Newman and Raggatt consider these estimates are conservative.

The ore has the following composition:-.

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	H_2O
5.0%	53.0%	6.5%	4.5%	31.0%

(4) Half a mile westerly from Boolarra.

This deposit has been worked in a small way for some years, but there are not enough exposures to enable reserves to be estimated.

(5) Four miles south-east of Boolarra (usually known as Greenwood's or Fisher and Lamb's).

This deposit has been exposed by open cut and trenching. The principal face shows a 12 foot face of bauxite with the base not reached, overlain by 24 feet of sands and grits with some clay bands up to two feet thick. Here and there in the bauxite are boulders which appear to represent clayey weathered basalt.

Although proved reserves do not exceed 10,000 tons the impression obtained from field observations by both Messrs. Newman and Raggatt is that considerable reserves are likely to be available.

A sample taken down a 10 foot face by H. G. Raggatt was analysed by A. N. Esdaile with the following result:-

SiO_2	Free Al_2O_3	Total Al_2O_3	Fe_2O_3	TiO_2	Ignition loss
5.6%	53.8%	55.1%	5.3%	4.6%	29.2%

Other deposits. South and south-east of Boolarra in the Parish of Mirboo and north-east of Mirboo North in Parish Allambee East.

Reconnaissance examination of these deposits and preliminary sampling suggest that they are very similar to the developed deposits but insufficient work has been done to allow of estimation of reserves.

These remarks apply also to the deposits situated at Burgess Creek, Gelliondale and in the Parish of Devon.

TASMANIA

Bauxite deposits have only been discovered in Tasmania recently (late 1941) and much work remains to be done before it will be known what this State's resources are.

The only deposits known so far are those near the village of Ouse (See Fig. 6).

The Ouse deposits occur in two groups (a) about two miles N.N.W., (b) about one mile east and south-east of the village of Ouse.

The total reserves have been estimated on an arbitrary basis at 2,000,000 tons, half of which are considered to be in group (a). The results obtained by shaft sinking (which is still in progress) suggest that the estimate for group (a) is likely to be realised.

The results of sampling of the three shafts so far completed on this group indicate uniformity in composition. The average of seven samples each representing a five foot section of the faces exposed in the shafts, is:-

SiO_2	Free Al_2O_3
4.12%	43.46%

Note: Complete analyses not available.

The above statements are based on progress reports by the Director of Mines, who is supervising the prospecting work being done by the State of Tasmania.

The largest deposit referred to above is easily accessible and free from overburden other than small variable amounts of lateritic soil.

WESTERN AUSTRALIA

Large areas of the Darling Range within 30 miles of Perth are capped with lateritic bauxite. The deposits are easily accessible by railway or road and could be worked by open cut. Large tonnages are in fact so mined for surfacing of roads and paths and for garden edgings.

It is evident that there are very large reserves of gibbsitic bauxite available, containing upwards of 10% of silica. However, chemical analysis and examination of hand specimens indicates that in nearly all the deposits this silica is present mainly as quartz. If this quartz could be removed cheaply, a relatively high-grade bauxite would be available, as reference to the following analyses will show:-

Lab.No. Locality	6534/40 Toodyay %	452/38 Sawyers Valley %
Al_2O_3 NaOH soluble	43.48	44.47
Al_2O_3 acid soluble	46.01	45.78
Fe_2O_3 acid soluble	10.14	8.06
SiO_2 free (quartz)	10.39	16.65
SiO_2 combined	2.70	2.46
H_2O above 100°		25.12
H_2O at 100°		.75
TiO_2 acid soluble	2.46	.91

There are many shallow sections of deposits provided by road and rail cuttings and by pits excavated for winning road gravels, but there has been no systematic prospecting by shaft sinking. Until this has been done it will not be known whether the bedrock contour is approximately parallel to the present surface or whether it is relatively flat, giving in some places considerable thicknesses of bauxite. It is possible that shaft sinking might reveal zones of bauxite, free from quartz.

It is possible, too, that quartz-free bauxites may be present overlying a suitable bedrock and that higher grade material may be found at the head of, and adjacent to, modern drainage.

The production of a high grade bauxite from the Darling Range areas therefore depends upon:-

(i) A cheap process of beneficiation of high free-silica bauxites.

(ii) The chance that in a thick section high-grade zones may exist.

(iii) The chance that high-grade bauxites may be found overlying a quartz-free bedrock.

The Committee has made recommendations with regard to the foregoing but it is not known whether these have been carried out.

CONSTITUTION OF AUSTRALIAN ORES

It will be seen by reference to the bauxite analyses given in the preceding pages that the percentage of "free" alumina (soda-soluble) and "available" alumina (acid-soluble) in bauxites of adjacent deposits and of obviously similar composition are much the same and that the amount of total alumina present in these ores is not more than a few per cent higher than alumina extracted by acid or alkalis. Further, in many instances the ratio of Al_2O_3 to loss on ignition (H_2O) in the ores approximates to the ratio of these constituents in pure gibbsite, despite the high Fe_2O_3 content. In pure gibbsite the ratio is 1:1.89. The average ratio in 40 analyses from deposit 4 (Bundanoon-Wingello) is 1:1.77, and from deposits (3) and (5) of the Boolarra-Thorpdale district it is 1:1.71 and 1:1.84 respectively.

These facts show that the alumina is present predominantly as gibbsite ($Al_2O_3 3H_2O$). This deduction has been verified by Mr. H. F. Whitworth who has identified gibbsite in thin sections of bauxites from several localities from New South Wales.

In addition to gibbsite, the bauxites examined contain hematite, magnetite, and in some instances, limonite and quartz grains. In some Australian bauxites titanium is present as ilmenite, but in specimens from at least one deposit, it has been shown to be present as Xanthitane (hydrated aluminium titanate). Clay minerals such as kaolinite are present in some ores, but usually in very small amounts.

The foregoing remarks are intended to stress the fact that the Australian ores are chemically and mineralogically closely similar to the gibbsite ores used in other countries for the manufacture of aluminium by the Bayer process.

The rather remarkable uniformity in type of the great bulk of Australian bauxites despite their wide geographical distribution deserves special comment, as it means that a process worked out to treat any one of them is likely to be applicable to all.

COMMERCIAL BAUXITES

"The specifications for commercial bauxite vary according to the purposes for which the bauxite is to be used. As bauxite is used for a variety of purposes, the range of specifications is wide. Bauxite is used mainly as an ore of aluminium and as raw material for the manufacture of aluminium chemicals, aluminium abrasives, and high-alumina cement. Small quantities have also been used for the manufacture of refractories and in processes for the purification of petroleum products". (U.S.Bureau of Mines, Bull.312, p.16).

In Australia small quantities of bauxite are being used for chemical manufacture. High iron bauxite is being used by the Broken Hill Pty.Co. in place of fluorspar in the open hearth furnace charge. Relatively large tonnages of pisolitic bauxite are also used for surfacing roads and paths.

The following notes refer to analyses of bauxite for use in the manufacture of aluminium.

A recent statement (Mining & Metallurgy Vol.22, No.419, p.531, 1941) gives the following classification of UNITED STATES ores:-

	Al_2O_3	SiO_2	
Metallurgical or "A" grade	55% or more	8% or less	
"B" grade	50%-55%	9%-15%	
"C" grade	45%-50%	15%-30%	
"D" grade	30%-45%	30%-45%	SiO_2 plus Fe_2O_3

This report states:- "Some authorities believe that with modern Bayer process equipment, bauxite containing down to 48 percent alumina and 9 percent silica can be utilised. By beneficiation it is hoped to reduce the silica content of ore averaging 13 to 14 percent silica to 9 per cent".

In the U.S.S.R. (Minerals Yearbook 1937, pp.681-682; 1938, 595) ores worked in the Urals have the following composition:-

	Al_2O_3	Fe_2O_3	SiO_2
(a) Kamensk	36.0%	35.0%	5.3%
(b) Vagran	50.0%	26.0%	3.7%

The Kamensk plant uses the Bayer process and the electric current used at the plant is steam generated.

Deposits worked in HUNGARY (Mineral Trade Notes, U.S.Bureau of Mines, Vol.13,No.3,Sept.1941) in the last few years have the following composition:-

Al_2O_3	Fe_2O_3	SiO_2	TiO_2	H_2O
50%-63%	15%-30%	2%-4%	2.5%-4%	16%-20%

These deposits have 15 to 65 feet of overburden.

The bauxites of GUIANA and the NETHERLANDS EAST INDIES are usually referred to as high grade. According to Minerals Yearbook, 1937, pp.680-681, the Bintang (N.E.I.) and Surinam (Dutch Guiana) bauxites have the following composition:-

	Al_2O_3	SiO_2	Fe_2O_3	TiO_2
Bintang	53%	2.5%	13.5%	1.2%
Surinam	59%	2.0%	6.0%	-

The deposits at Bintang are 12 feet thick and at Surinam 10 to 18 feet thick.

It is not known for certain whether the foregoing analyses relate to crude ore, since it is believed that all ores from these countries are at least washed before shipment. They do, however, give some idea of the requirements expected in a high grade ore.

It will be seen that bauxites with a great range in chemical composition are being used for the manufacture of aluminium and that the most objectionable single impurity is silica. The American classification relates to the special conditions existing in the United States, namely, a shortage of low silica bauxite, and cannot be applied rigidly to Australian deposits from which millions of tons could be won containing well below 8 per cent silica.

Points to be noted in this American grouping are the low alumina-silica ratio permitted even in group A, namely 7:1 and the belief expressed by some authorities that a ratio as low as 5.3 : 1 would not preclude the treatment of bauxite by the Bayer process with alumina as low as 48%.

In general, it is believed that for the manufacture of aluminium by the Bayer process, bauxite containing not more than 6% silica is preferred, and that ore containing not less than 50% alumina and not more than 6% silica can safely be classed as high grade.

As regards their alumina: silica ratio, Australian bauxites are quite satisfactory, but most of them are relatively low in alumina, and consequently high in iron and titanium.

One question to be decided when the economics of the establishment of an aluminium industry is being considered is, whether it is cheaper and better to beneficiate the raw material or to use a greater quantity of chemical reagents in the processing of alumina. Another question is whether it would be cheaper and better practice to use a bauxite with alumina 50% and silica 5% or ore containing say 40% alumina and 4% silica, having regard to other factors which may decide the location of the alumina and/or the reduction works.

This general discussion is intended to point out some of the unknowns which preclude a drawing up of grades for Australian bauxite on present information.

TREATMENT.

The principal impurities in bauxite are iron minerals, titanium minerals, free silica (quartz) and clay minerals.

As already stated, some form of beneficiation, usually washing, is commonly applied to bauxites mined in other countries.

A simple washing experiment carried out on ore from deposit No.3 Boolarra, shows that this ore responds readily to such treatment:

	"Free" Al_2O_3 %	Al_2O_3 %	Fe_2O_3 %	SiO_2 %	TiO_2 %	Ignition loss. %
Crude ore	50.3	56.0	4.2	5.3	4.2	29.0
Washed ore	56.6	58.8	3.4	3.1	3.3	30.1

These samples were re-ground to pass through a standard Tyler Screen of 100 meshes to the inch.

However, this ore could be used as mined, and the experiment is chiefly of value as indicating how some of the higher silica deposits of Gippsland might respond to beneficiation.

Gandrud and De Vaney (Bull.U.S.Bureau of Mines No.312,1929) recommend tabling and jigging as a means of improving the grade of high iron bauxites.

Some experiments carried out by J.T.Hardman in the laboratory of the New South Wales Mines Department suggest that jigging may be effective in producing high-iron and high alumina fractions from the Wingello type of bauxite. (See Appendix "A"). Most of these ores are low enough in silica to permit considerable concentration without raising the silica percentage above commercial limits.

It is believed that flotation might be successfully applied to the beneficiation of Australian ores.

SUMMARY AND CONCLUSIONS

Commonwealth Copper + Bauxite Com.

The Committee was charged with making a survey of the bauxite resources of Australia. This work is now almost completed and it is not expected that any results obtained in the next three months will materially alter the position.

This does not mean that discoveries of other deposits may not be made from time to time (this is in fact very probable) but that the results to hand give a clear picture of the position as it is to-day.

A statement of bauxite resources has little meaning if divorced from a survey of their bearing on the possible establishment of the aluminium industry in Australia.

If Australia's requirements of aluminium metal are 5,000 per annum, the yearly requirement of alumina is about 10,000 tons and of bauxite ore between 20,000 and 30,000 tons according to grade.

In establishing the alumina works the principal factors to be considered are:-

(i) An adequate supply of water for process purposes;

(ii) The relative cost of delivery of bauxite and fuel to the site (it should be noted that the fuel requirement per ton of alumina is 1 ton of black coal or its equivalent).

(iii) The availability of chemicals for the manufacture of alumina;

(iv) The cost of transport of alumina to the reduction works.

In establishing an aluminium reduction works the principal factors to be considered are:-

(i) Availability and cost of electric power, and

(ii) Cost of delivery of ingot aluminium to rolling mills and fabricating plants.

With these factors in mind the following are the salient points established by the survey of bauxite resources:-

(1) Bauxite occurs in all States except South Australia and the Northern Territory.

(2) The only proved deposits in Queensland are those of Tamborine Mountain. Known reserves are 200,000 tons, of the following approximate grade - Alumina 42%, silica 1%.

(3) In Eastern New South Wales there are 15,000,000 tons of proved reserves of bauxite containing from 34 to 45% alumina and from 1.76 to 5.47% silica. Small reserves of high grade ore also occur at Bundanoon and Trundle. Proved reserves at these localities are only equal to one year's requirements, but prospecting is likely to reveal further deposits.

(4) High grade bauxite occurs in the Boolarra-Thorpdale district of Victoria. The largest worked deposit has proved and possible reserves each of about 140,000 tons. Run of mine ore contains 53% alumina and 5% silica. Other deposits of comparable grade appear likely to contain noteworthy tonnages but have not been sufficiently prospected to enable reserves to be estimated. (450000 tons ?)

NOTE:

(5) In central Tasmania newly discovered deposits are being prospected. It seems likely that there will be at least 1,000,000 tons available in one deposit containing 43.46% alumina and 4.12% silica.

(6) The bauxite deposits of Western Australia are of about the same grade as those of New South Wales, Queensland and Tasmania as regards alumina, but are more siliceous. It is probable they could be improved by cheap ore-dressing processes. The reserves are very large.

(7) The great bulk of the Australian bauxite reserves are of similar type (being gibbsitic, with high iron) and any process developed to use ore from one deposit could probably be used without much modification to treat any other.

(8) All deposits are easily accessible from existing means of transportation.

(9) Most of the New South Wales and Western Australian deposits have little or no overburden. This also applies to the largest deposit in Tasmania. The Victorian deposits have a sandy overburden ranging in thickness from seven to thirty-five feet. The higher grade ore in S.E.Queensland is overlain by 8 to 10 feet of red soil and vermicular laterite which might have to be stripped in mining.

(10) Assuming Australian bauxite is used as the source of alumina for the production of aluminium, the location of the reduction works (i.e. the aluminium smeltery) will obviously, in addition to

factors of quantity and grade, be a very important if not a determining factor in assessing the relative values of the bauxite deposits mentioned as occurring in the several States.

(11) If the Lake Campion alunite deposit is worked for the production of potash, further investigational work may show that alumina suitable for the production of aluminium can be produced as a by-product. If this should prove to be so and such by-product alumina could be freighted to the aluminium smeltery at a cost comparable with that of alumina available from bauxite, this would be a factor to be taken into account when smeltery capacity was being expanded.

(SGD.)	COLIN FRASER	Chairman
	H. G. RAGGATT	Deputy Chairman
	J. MALCOLM NEWMAN)	
	A. J. KEAST)	Members
	J. HORSBURGH)	
	M. J. MARTIN)	

APPENDIX "A".

Papers:
N.S.W.
Ms.41/8694

ORE DRESSING AND METALLURGICAL REPORT NO.139
BAUXITE FROM SUTTON FOREST.

Consignment: A consignment consisting of nine bags weighing approximately 18 cwt. was received from Sulphates Pty. Ltd. on 14th October, 1941. As this consignment was not selected by or under the supervision of a Departmental Officer, no responsibility in respect thereto is accepted by this Department.

DESCRIPTION OF THE BAUXITE. Ferruginous Bauxite.

SAMPLING AND ASSAYING. The ore was sampled by standard methods and analysed with the following results:-

Loss on ignition	22.1%
Al_2O_3	38.5%
Fe_2O_3	31.6%
SiO_2	2.4%
TiO_2	4.1%

EXPERIMENTAL TESTS. Preliminary tests were carried out in a hand worked jig fitted with a 30 mesh screen, the screen area being sixteen inches by nine inches. The ore was prepared for jigging by hand crushing to 20 mesh and removing the fines by sieving this product on a 20 mesh screen. Batches weighing 18 lbs. were fed to the jig and jigged for seven or eight minutes.

As there are no outstanding physical characteristics by which the highest or lowest grade bauxite could be distinguished the jigged product was removed in layers and each layer was separately assayed.

No.1 Top Layer represented about 35% by volume of the total charge fed to the jig.
No.2 Second layer represented about 25% of the total volume fed to jig.
No.3 Ore on the jig screen represented about 20% fed to jig.
No.4 Material that passed through the jig screen representing 20%.
These products were assayed with the following result:-

	Al_2O_3%	Fe_2O_3%	SiO_2%	TiO_2%	Loss on ignition, %
No.1	43.15	30.25	3.03	4.15	19.24
No.2	39.11	35.50	1.41	3.77	18.50
No.3	29.70	48.70	1.50	4.30	15.20
No.4	29.80	45.40	4.60	4.30	15.60

COMMENTS.

These results prove that simple jigging partially separates the Al_2O_3 and Fe_2O_3 and substantially improves the percentage of Al_2O_3 and Fe_2O_3 respectively.

A mechanically driven jig would of course, considerably improve the results obtained by hand jigging. Further, it is reasonable to assume that this method of concentration would produce respective grades of Al_2O_3 and Fe_2O_3 which would conform to the specification demanded by the buyers of these minerals. In jig concentration the Fe_2O_3 would, of course, be collected in the hutches and the Al_2O_3 as tailings.

Table concentration on fine grades would also be effective.

A test has also been carried out on ore ground to 20 mesh, but the assays are not completed.

(Sgd.) J. T. HARDMAN.

31/12/41.

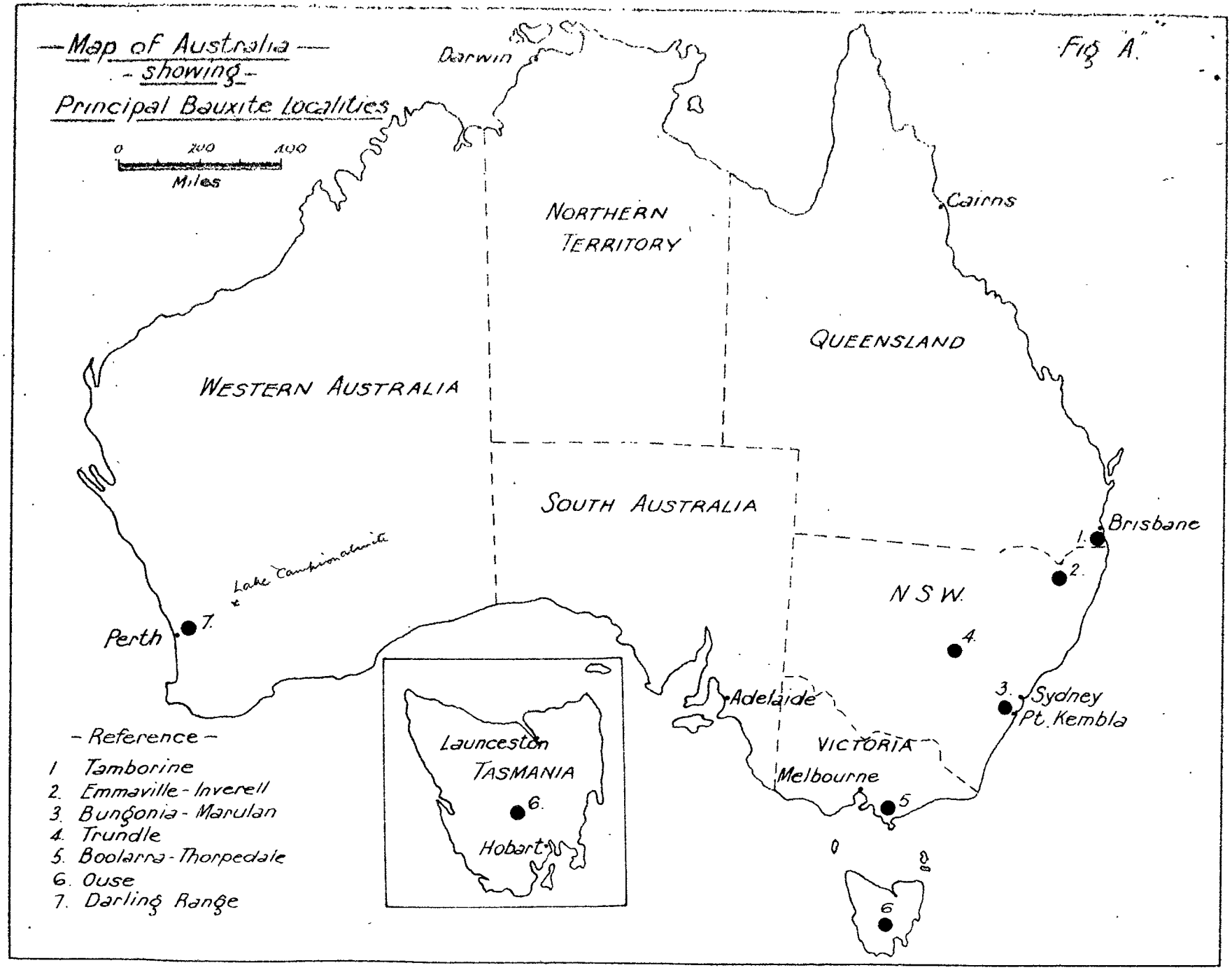

Map of Australia
- showing -
Principal Bauxite Localities
Fig A.
0 200 400
Miles
Darwin
Cairns
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
Lake Campion
Perth
7.
Brisbane
1.
2.
N S W.
4.
3.
Sydney
Pt. Kembla
Adelaide
VICTORIA
Melbourne
5
Launceston
TASMANIA
6.
Hobart
6
- Reference -
1 Tamborine
2. Emmaville - Inverell
3. Bungonia - Marulan
4. Trundle
5. Boolarra - Thorpedale
6. Ouse
7. Darling Range

FIG.1.

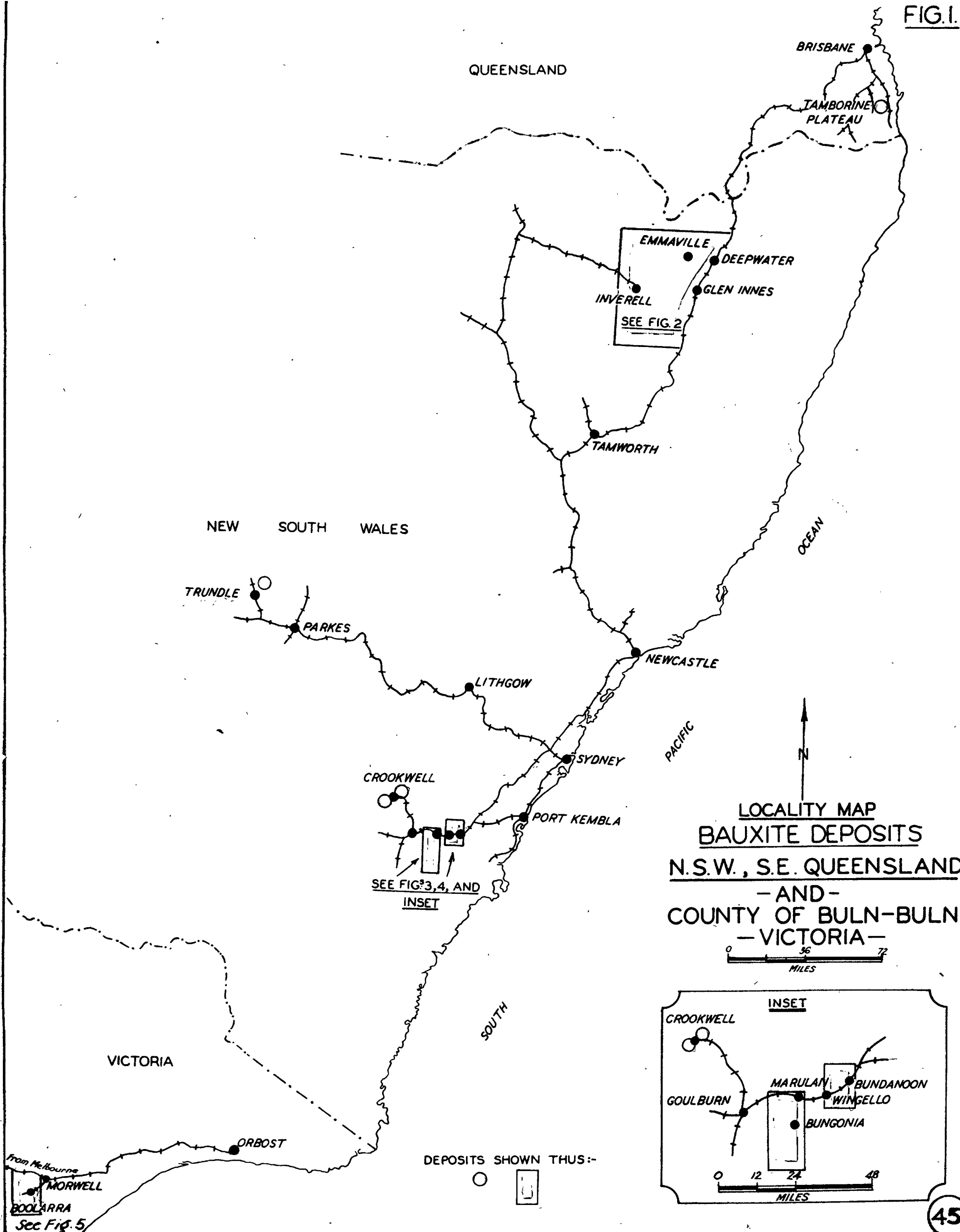
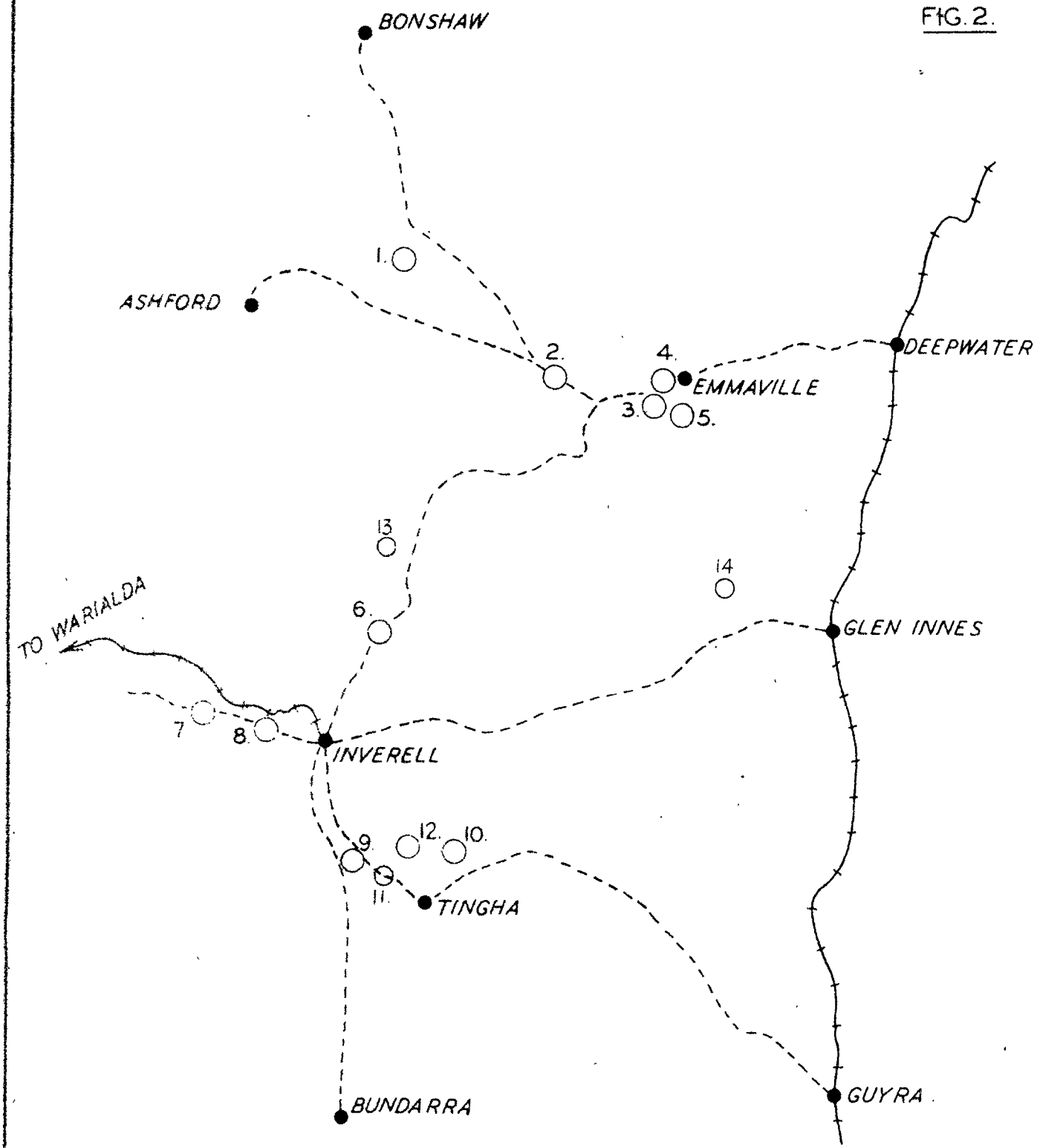

QUEENSLAND
BRISBANE
TAMBORINE PLATEAU
EMMAVILLE
DEEPWATER
GLEN INNES
INVERELL
SEE FIG. 2
TAMWORTH
NEW SOUTH WALES
OCEAN
TRUNDLE
PARKES
LITHGOW
NEWCASTLE
PACIFIC
SYDNEY
CROOKWELL
PORT KEMBLA
SEE FIGS 3,4, AND INSET
SOUTH
VICTORIA
ORBOST
from Melbourne
MORWELL
BOOLARRA
See Fig. 5
DEPOSITS SHOWN THUS:-
N
LOCALITY MAP
BAUXITE DEPOSITS
N.S.W., S.E. QUEENSLAND
-AND-
COUNTY OF BULN-BULN
-VICTORIA-
0 36 72
MILES
INSET
CROOKWELL
GOULBURN
MARULAN
BUNDANOON
WINGELLO
BUNGONIA
0 12 24 48
MILES

FIG. 2.



LOCALITY MAP

PRINCIPAL BAUXITE DEPOSITS
EMMAVILLE-INVERELL DISTRICT

10 0 10 20

MILES

46

REFERENCE TO NUMBERS USED IN TEXT ○3.

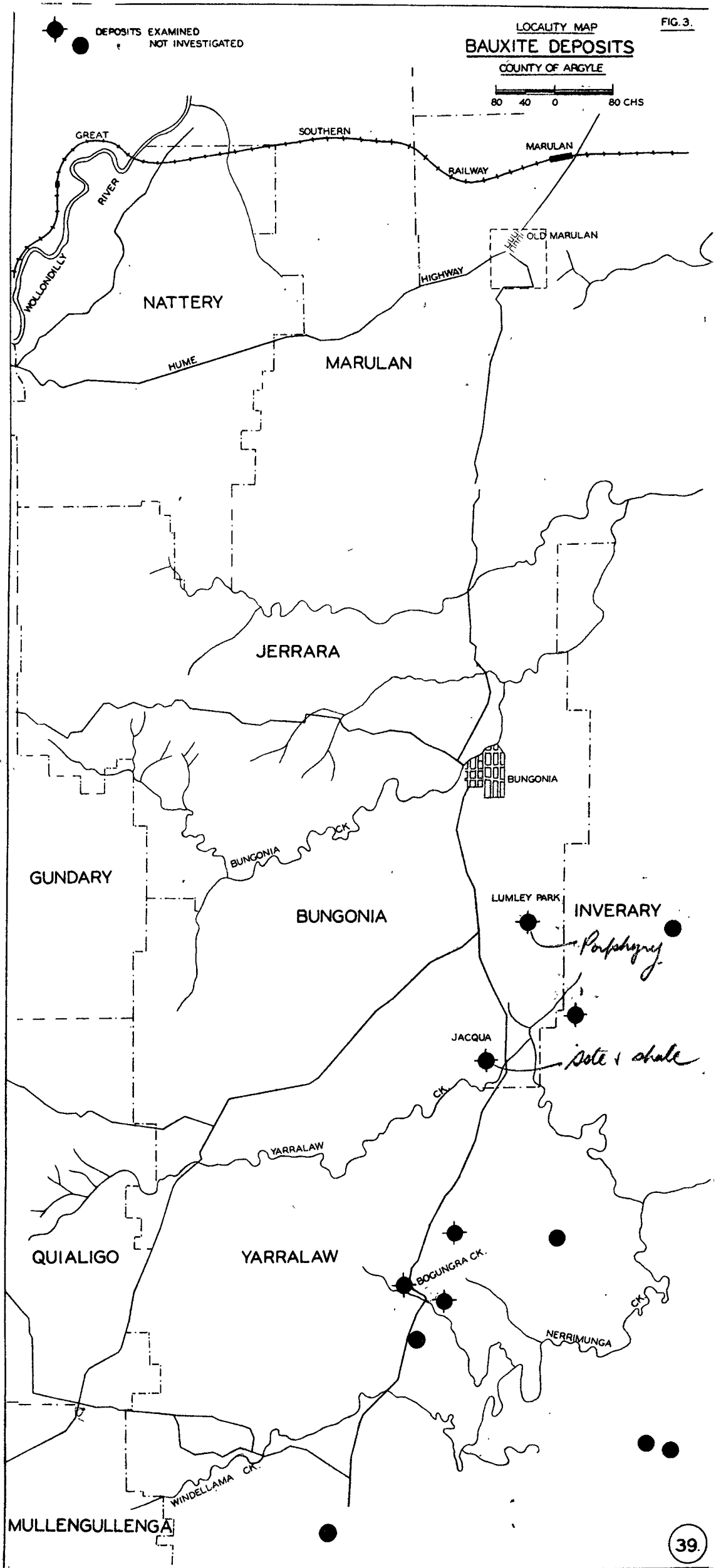
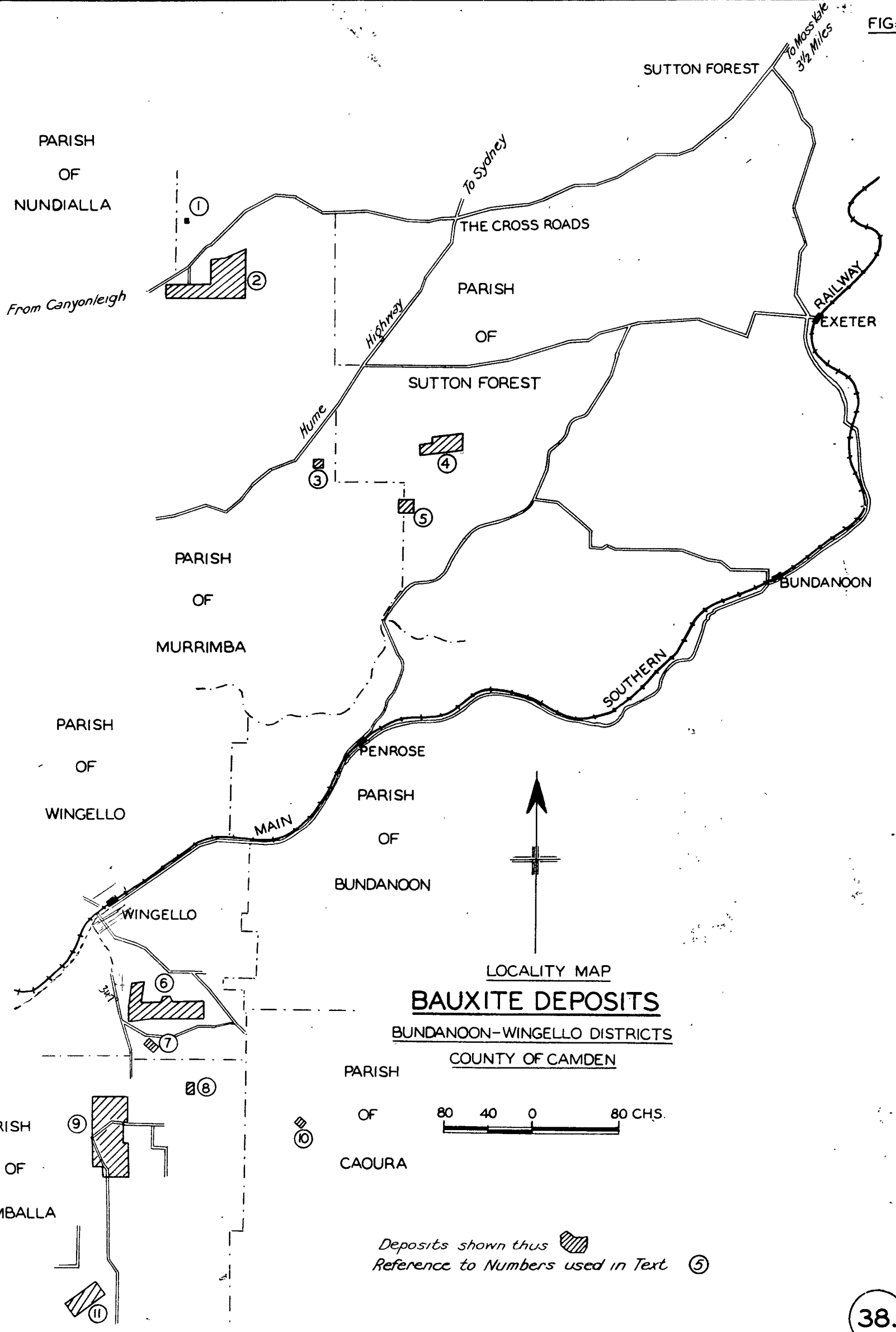
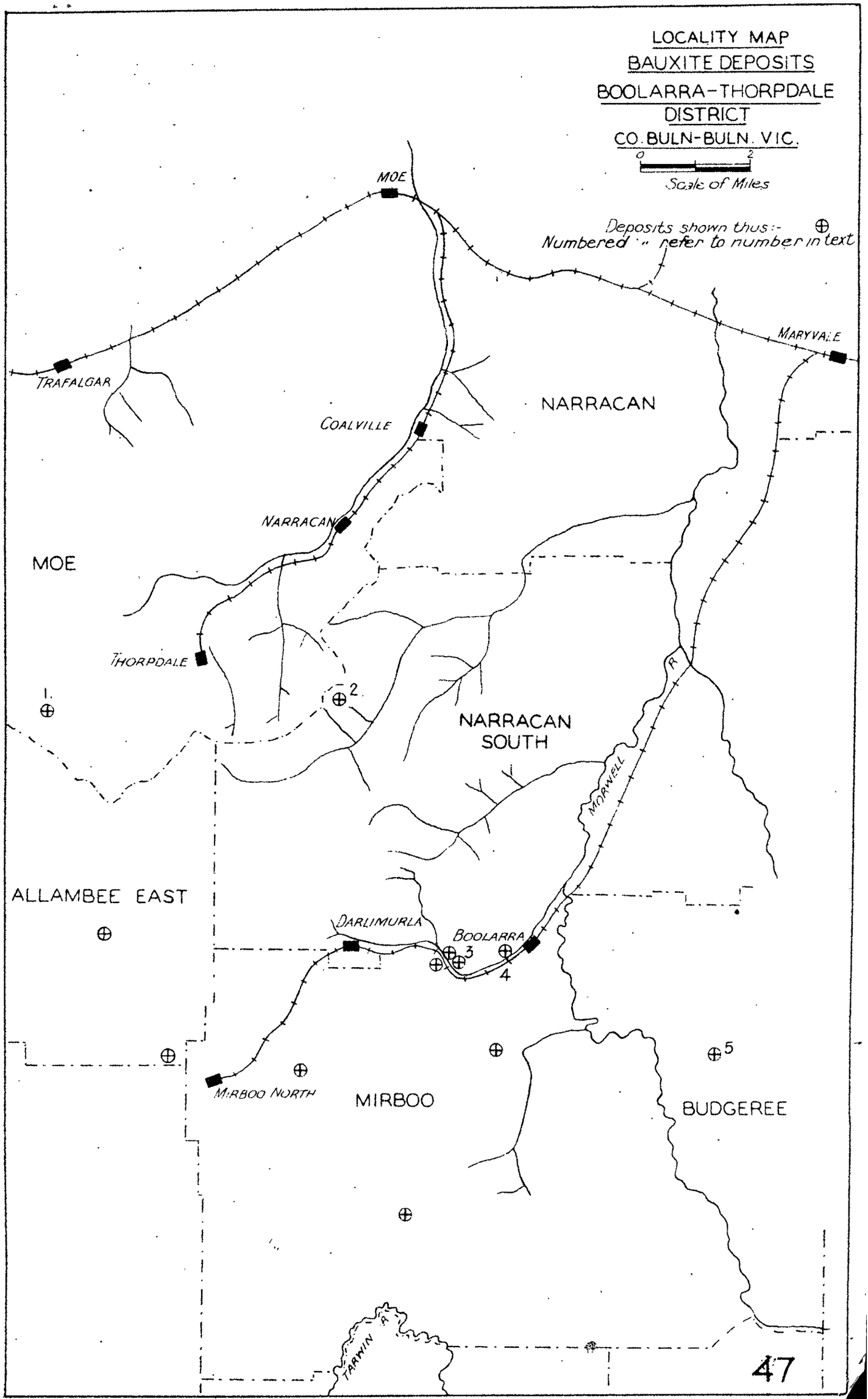

DEPOSITS EXAMINED
NOT INVESTIGATED
LOCALITY MAP
BAUXITE DEPOSITS
COUNTY OF ARGYLE
80 40 0 80 CHS
FIG. 3.
GREAT
SOUTHERN
RAILWAY
MARULAN
RIVER
WOLLONDILLY
OLD MARULAN
HIGHWAY
NATTERY
HUME
MARULAN
JERRARA
BUNGONIA
BUNGONIA CK.
GUNDARY
BUNGONIA
LUMLEY PARK
INVERARY
Porphyry
JACQUA
Piste + shale
CK.
YARRALAW
QUIALIGO
YARRALAW
BOGUNGRA CK.
CK.
NERRIMUNGA
WINDELLAMA CK.
MULLENGULLENGA

FIG. 4.


SUTTON FOREST
To Mossvale 3½ Miles
PARISH OF NUNDIALLA
To Sydney
THE CROSS ROADS
From Canyonleigh
Highway
PARISH OF SUTTON FOREST
RAILWAY
EXETER
Hume
PARISH OF MURRIMBA
BUNDANOON
SOUTHERN
PARISH OF WINGELLO
PENROSE
PARISH OF BUNDANOON
MAIN
WINGELLO
PARISH OF CAOURA
PARISH OF BUMBALLA
LOCALITY MAP
BAUXITE DEPOSITS
BUNDANOON-WINGELLO DISTRICTS
COUNTY OF CAMDEN
80 40 0 80 CHS.
Deposits shown thus
Reference to Numbers used in Text (5)


LOCALITY MAP
BAUXITE DEPOSITS
BOOLARRA-THORPDALE
DISTRICT
CO. BULN-BULN. VIC.
0
2
Scale of Miles
Deposits shown thus:- ⊕
Numbered " refer to number in text
MOE
MARYVALE
TRAFALGAR
COALVILLE
NARRACAN
NARRACAN
MOE
THORPDALE
1.
2
NARRACAN SOUTH
MORWELL R.
ALLAMBEE EAST
DARLIMURLA
BOOLARRA
3
4
5
MIRBOO NORTH
MIRBOO
BUDGEREE
TARWIN R.
47