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DEPARTMENT OF SUPPLY AND SHIPPING.

Mineral Resources Survey Branch

BAUXITE DEPOSITS, BOOLARRA-MIRBOO NORTH DISTRICT, SOUTH GIPPSLAND, VICTORIA.

Report No.1943/58. Plans No. 900, 907-909, 912, 915, 965-971A, 972-974.

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PLANS.

BAUXITE DEPOSITS, BOOLARRA-MIRBOO NORTH DISTRICT, SOUTH GIPPSLAND, VICTORIA.

1. INTRODUCTION

This report is written chiefly to present estimates of reserves of bauxite proved to date in Gippsland. Consequently discussions of the geological aspects of the investigation, though essential to an understanding of the subject, are kept to a minimum.

Pages 8 to 10 contain the salient features of this report in summarized form. Brief references to the mode of occurrence of the bauxite and a table of ore reserves are there given.

The existence of bauxite in the neighbourhood of Boolarra and Thorpdale, County Buln Buln, South Gippsland has been known for some years and bauxite from Nahoo, Allot. 8 Ph. Narracan South, has been used for chemical purposes for over 20 years. Eleven additional discoveries were made from time to time up to April, 1942, when an extensive prospecting programme was undertaken. In the short time that has elapsed since then a further twelve deposits have been discovered, making a total of twenty-four deposits in the adjoining parishes of Moe, Allambee East, Narracan South, Mirboo and Budgeree in the county of Buln Buln. Several of these deposits have been systematically tested by shaft sinking and boring. This exploration is still in progress.

The Geological Survey of Victoria has published reports referring to bauxite in Gippsland. These are indicated by the following references.

1921. Whitelaw, O.A.L. and Watson, J.C. "Bauxite Clays at Narracan South". Rec. Geol. Surv. Victoria, Vol.1V, pt. 3, p.277-279.

1936. Ferguson, W.H. "Bauxite near Boolarra, Gippsland", Rec. Geol. Surv. Victoria, Vol. V, pt. 2, p.289-292.

1940. Baragwanath, W. "Kaolin & Bauxite", Vic. Min. & Geol. Journal, Vol. 2, No. 2, p.117.

2. LOCATION.

The bauxite deposits described in this report occur within an area of 150 square miles, the centre of which is 16 miles south-west from Yallourn and 74 miles east-southeast from Melbourne. The area is well served by railways as it is traversed by two branch lines from the Gippsland Railway, one from Moe to Thorpdale, 91½ miles by rail from Melbourne, and the other from Morwell to Mirboo North, 109 miles by rail from Melbourne. None of the deposits is more than 6 miles by road from rail. (see Plate 1).

3. TOPOGRAPHY.

The area lies in the South Gippsland hills and is part of an elevated and dissected plateau, the general level of which is about 1,200 feet above sea level.

The principal drainage is that of the Morwell and Tarwin Rivers. The former flows north to join the Latrobe at Morwell and the latter enters Bass Strait through Anderson Inlet, six miles east from Wonthaggi.

The area was formerly heavily timbered, but the better quality land is now fairly closely settled and the timber cover of these areas has been almost completely destroyed. Much of the poorer country, the greater part of which is underlain by post-basalt sand and grit is still covered with scrub and some timber remains on these areas. As the bauxite occurs under these post-basalt sands it is fortunately within such areas that the prospecting operations have been, and mining operations will be, carried on. Hence the industry can develop with a minimum of disturbance to the local rural community.

4. GEOLOGY.

Stratigraphy - The area has been geologically mapped by the Victorian Mines Department as part of its systematic survey of parishes. Sulphates Pty. Limited have also made extensive reconnaissances in the area, the results of which they have freely made available. The area has been visited several times by the authors and one of us (H.B.O.) supervised most of the drilling done by the Commonwealth. As a result of the foregoing and of recent prospecting operations which have been carried on in the search for bauxite deposits, the stratigraphical succession in the area has been definitely established. Some of this work has proceeded concurrently with Miss Crespin's review of the stratigraphy of Gippsland and as some of the formations in the area dealt with herein are common to that described by Miss Crespin, their geological age may be defined fairly precisely and some long standing controversies regarding the age of the older basalt and of the associated formations disposed of. The stratigraphical succession is as follows:

		Maximum Thickness in Feet.	
Recent Disconformity	Alluvium	----	Clay sand & gravel.
Post Kalimnan Disconformity		----	Sand and gravel.
Anglesean (Lower Middle Miocene) Disconformity	Yallourn formation	760	Lignite, Ligneous Clay, Clay and sand.
Lower Miocene ? Disconformity		34	Bauxite, coarse sand, clay.
Lower Miocene or	Older basalt	237	Basalt.
Oligocene Unconformity		40 +	Sands, clay, brown clay.
Jurassic			Sandstone, mudstone black coal.

The Jurassic rocks consist of alternating beds of sandstone and mudstone with, in places, thin beds of coal. The rocks are very felspathic and weather to a clayey soil. At intermediate stages of weathering they bear a superficial resemblance to decomposed basalt. Over most of the area, basalt lies unconformably upon the Jurassic sediments but in some places considerable thicknesses of Tertiary sediments including gravel, clay and lignite underlie the basalt (Stirling, J. "Report on the Brown Coal and Lignites of Victoria" - Progress Report, Geological Survey of Victoria - Page 73 - 1899).

The upper surface of the basalt has been subjected to erosion, and bauxite has been formed from volcanics which accumulated in depressions in this surface. The bauxite bodies consequently possess an irregular plan, but a more or less symmetrical lenticular cross section.

The bauxite was eroded prior to the deposition of the Yallourn formation which consists of sand and clay, or mixtures of the two, with, in places, lignite and ligneous clay.

The focal point for age determination in this sequence is, of course, the Anglesean age of the post-basaltic lignites and ligneous clays. This is established both by working outwards from the comparatively small area which has been prospected for bauxite and by the foraminiferal content of the Yallourn formation itself. Plate 2 which is based upon the geological parish maps issued by the Victorian Mines Department, shows how the beds assigned to this formation in the Mirboo area may be directly correlated with the type section, and table 1 of Miss Crespin's bulletin shows its wider correlation in Gippsland.

The Anglesean is Lower Middle Miocene in age.

Allowing for the fact that the time required for the formation of 30 or more feet of bauxite is considerable and that the bauxite was eroded before the Yallourn formation was laid down upon it, the most probable age for the bauxite is Lower Miocene and as the bauxite in turn rests upon an erosion surface cut out of the older basalt this basalt is most probably of Oligocene age. It cannot be younger than Lower Miocene.

As stated above, the older basalts are known to be underlain in places by sediments including lignites, but these beds have not been studied so far in this investigation. It is possible they contain foraminifera which would throw further light on the geological age of the lower part of the Tertiary sequence in this area. The condensed but comprehensive discussion by A.B. Edwards (Roy.Soc.Victoria, Volume 51, part 1, pages 75 and 76, 1938) of the age of the older basalts indicates a convergence of several lines evidence which, with the modifications made necessary by Miss Crespin's recent review, still apply. The older view re-expressed by C. A. Sussmilch as late as 1937 (Presidential Address Linnean Society, New South Wales, 1937), that these basalts cannot be older than Lower Pliocene is clearly no longer tenable.

<u>STRUCTURE</u>. We are not concerned here with the pre-Tertiary structure, but it may be noted that the Jurassic rocks were gently folded and extensively block-faulted prior to a period of prolonged erosion which resulted in the formation of the peneplain surface upon which the Tertiary sediments rest.

Subsequent to the deposition of the Yallourn beds, marked faulting again occurred, resulting in the formation of troughs in which are preserved great thicknesses of Tertiary sediments including lignite. The Latrobe River occupies one of these troughs and a minor one extends from Morwell to Boolarra. The dominant trend of these faults is north-northeast and this has given rise to the rough pattern of parallel tongues of Tertiary rocks occupying a large part of South Gippsland as shown in Plate 2.

The significance of this faulting so far as the bauxite is concerned may readily be seen from Plate 3, which shows how the faulting has divided the area into blocks. As a result, bauxite is found over a wide range of elevations - 500 feet above sea level, 2 miles west of Boolarra; 1,000 feet at Budgeree and 1,200 feet at Watkins, 3 miles north from Mirboo North.

5. METHODS USED IN PROSPECTING & PROVING DEPOSITS.

Nearly all the deposits have been discovered by Messrs. Sulphates Pty. Limited, who have kept in close touch with the Victorian Mines Department and ourselves. During this collaboration there has been free discussion which has resulted in establishing a geological background upon which prospecting has gradually come to be based. (See introduction to section 8 of this report).

GEOPHYSICAL PROSPECTING:

Prior to the commencement of the drilling campaign on the Boolarra and Napier's deposits, some geophysical surveys were made by L. A. Richardson, Geophysicist of this Branch, to determine whether prospecting for and investigation of the bauxite deposits could be aided by such surveys. The electrical resistivity method was used and subsurface resistivity conditions were determined at 67 points on the Boolarra Open-cut area, 14 points on Orgill's area and 34 points on Napier's area. A review of the results in the light of the information provided by the recent drilling operations and geological investigations reveals the following features:-

1. The resistivity of the basaltic clay which forms a bedrock for the known bauxite deposits is commonly of the order of 100-500 ohm feet units. A higher resistivity has been noted in some places.

2. The resistivity of the overburden and bauxite is variable over a wide range, but is almost invariably higher than that of the basaltic clay.

3. The depth to the basaltic clay may be determined approximately in most places where the resistivity of the overburden and bauxite is appreciably greater than that of the basaltic clay.

Plate 3A. shows resistivity curves illustrating effects due to deepening bedrock. Electrode separation, in feet, is plotted vertically and apparent resistivity, in ohm feet units, is plotted horizontally. The progressive deepening of the high values of resistivity on the curves from point to point going easterly, can be regarded as evidence of increasing bedrock depth in that direction.

In general, therefore, the resistivity method provides a fairly ready means of determining approximately the depth to bedrock and this may be used to facilitate prospecting in areas selected by geological methods as favourable for the occurrence of bauxite.

Probably other geophysical methods could also be used to reduce the cost of prospecting when a search becomes necessary for deposits which almost certainly exist but which do not outcrop.

METHODS OF PROVING:

Three different methods of proving the deposits have been adopted - (a) By Sulphates Pty. Limited, (b) Victorian Mines Department, (c) Department of Supply & Shipping. Each of these is briefly discussed.

(a) Messrs. Sulphates Pty. Limited have developed an effective method of prospecting by hand-boring followed by shaft sinking at selected points. Holes are spaced at 100 feet intervals on a rectangular grid and an auger of 1½ inches diameter is used. The method provides a quick and relatively cheap method of prospecting where depths do not exceed about 30 feet. The holes are not cased so that the bauxite is liable to some contamination from the sides of the hole, but analyses of auger samples provide a useful guide to the quality of the deposit. For purposes of accurate sampling the hand-boring is followed by shaft-sinking where boring has revealed a favourable thickness of bauxite.

(b) The Victorian Mines Department use a power-operated percussion drill which is also equipped with a hand-operated auger. Power is supplied by a small vertical Kelly and Lewis engine operating on fuel oil. The tools used consist of a drive pump and short sinker bar operated by solid rods with screwed joints. Drilling is effected by raising the rods about one or two feet by power and then releasing the load with a clutch, thus permitting the rods and pump to fall under their own weight. When necessary the pump is replaced by an auger which is turned by hand through a wooden capstan head fitted to the topmost rod. A crew of a foreman and two men operate the drill which is capable of sinking holes 5 inches in diameter.

(c) The Department of Supply & Shipping. The method used is the same as that used in testing alluvial (placer) deposits. In this campaign the work was done by Victoria Gold Dredging N.L., for the Minerals Production Directorate of the Department of Supply & Shipping. Two Ruston Bucyrus percussion rigs were used with a string of tools consisting of a drive pump with detachable clack-valve, two sinker bars and swivel. The tool assembly weighed about 15 hundredweight. The most satisfactory length for the barrel of drive pump was found to be 5 feet as with a longer barrel the hydrostatic head caused loss of the sample by splashing when the clack was opened.

While drilling was in progress 5 inch casing in 5 feet lengths was kept close to the bottom of the hole until bauxite was encountered. At this stage the casing was driven a few inches into the bauxite and the hole pumped clean of sand, clay or loose material. Flushing with water and pumping was continued until the mud-pump returned only clean water to the surface and the bottom of the hole was free from sand, etc.

Boring was then continued with the drive-pump to 2 feet into the bauxite, the contents of the pump being collected in a numbered drum. The casing was then driven to the bottom of the hole and loose bauxite broken from the sides of the bore by the casing show was pumped out and added to the sample already collected.

The second and succeeding samples were then taken in a similar manner except that these samples were taken in lengths of 5 feet. The reason for taking the first sample for the shallower depth of 2 feet was to minimise the effect of any accidental contamination of the bauxite with sand or clay. As the drillers became more proficient it was found that there was little or no contamination of the first sample taking place.

The samples were recovered in various degrees of moistness from a thin sludge containing a few hard angular lumps of bauxite to an earthy mass sufficiently damp to cohere when pressed in the fingers.

The samples were dried on iron trays over wood fires being constantly stirred while drying to hasten drying and avoid local over-heating. When dry, the samples were cooled, crushed to ¼" with a Braun "Chipmunk" driven by a petrol engine and divided on a Jones sampler.

Provided experienced and careful men are employed all these methods give comparable results hence as (a) is by far the cheapest, it is considered the most suitable to use provided the depth of drilling does not exceed 30 feet, and the bauxite is not too hard. Probably a self-contained truck-mounted rotary drill would be the best all-round plant, but none of these was available when this campaign was in progress.

Experience shows that owing to the irregular shape of the deposits, a 100 foot square spacing is the widest which will give satisfactory results. Geological supervision is also advisable to avoid wasteful drilling. The progressive plotting of a structural plan as drilling proceeded showing contours on the basalt surface and isopachous lines for the bauxite deposits proved useful in locating further drilling sites to maximum advantage and minimized drilling beyond the margins of the deposits. It was found that reasonably accurate forecasts of the thickness and depth of bauxite could be made for points 100 feet or so in advance of the drill.

6. COMMERCIAL GRADES OF BAUXITE.

"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 fluorite 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.

In 1941 (Mining & Metallurgy Vol. 22, No. 419, p.531, 1941) the following classification of UNITED STATES ores was put forward:-

	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

At that time also the following comment was made:- "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 percent".

The most recent American information on grades of ore accepted as suitable for treatment by the Bayer process is given in Mining & Metallurgy, August, 1943, pp.356-361 (two articles). "The ore for the Bayer process has until recently carried only as high as 7 percent silica, but slightly higher silica content is now being tolerated." It is further stated in the articles quoted that ore containing 15% or less of silica is now classed as "Metallurgical grade."

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 less than 8 percent silica.

Points to be noted in the American grading given above 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%.

It is concluded that ore containing approximately 50 per cent alumina and 7 per cent silica may safely be regarded as satisfactory for the manufacture of metallic aluminium. A normal bauxite (gibbsite type) of the above composition would contain not less than 26 per cent moisture leaving not more than 17 per cent as ferric oxide (Fe_2O_3) plus titanium dioxide (TiO_2).

The limits taken for the calculation of reserves in the Gippsland deposits are based on this conclusion.

7. METHODS OF ANALYSIS.

The determination of alumina for the commercial valuation of bauxite is somewhat empirical and consequently it is necessary for a standardised procedure to be followed closely if uniform results are to be obtained in different laboratories.

There are two methods of evaluation in use:-

(1) Available alumina. (Total Alumina).
(2) Free alumina.

Available Alumina (Total Alumina)

This is an acid extraction method and, with some modifications by different analysts, appears to be the one most commonly used. The method is quicker than the alkaline digestion method and is used in essentially similar form by both B.H.P. and S.P.L. The procedure used by the latter company is set out below.

Procedure.

The sample is ground to pass 60 mesh, dried at 105°C for 1 hour and cooled in a desiccator. Weigh 5 grams of the dried sample into a crucible and heat at about 600°C for 1 hour. Cool in desiccator and weigh. Difference in weight is loss on ignition.

To a weighed portion of dry sample (Note: probably that which has already been ignited) add 20-25 ml. of sulphuric acid of S.G.1.60 in a suitable vessel (Note: probably casserole) and digest for some time. Evaporate until white fumes of SO_3 are evolved. Cool, take up in water and again evaporate to fumes. Again take up in water, filter, and wash residue with hot water. If the residue is white, dry, ignite and weigh as SiO_2. If grey or coloured fuse the residue with $NaHSO_4$, cool, dissolve, melt in water, filter and wash. Add filtrate and washings to first filtrate obtained from acid extraction and dry, ignite and weigh residue as SiO_2.

Make filtrate up to some convenient volume, say 500 ml., measure off a portion of this and divide into three aliquot portions:

(a) 50 ml. (=.5 gram). Precipitate with ammonia, filter, wash, ignite and weigh as Al_2O_3 - Fe_2O_3 - TiO_2.

(b) 50 ml. Determine iron volumetrically and calculate to Fe_2O_3.

(c) 10 ml. or more (depending on TiO_2 content). Estimate TiO_2 colourimetrically.

% Available Alumina = % (a) - (% (b) - (c))

Free Alumina.

This is an alkaline extraction method. It is considered that the term "free alumina" is misleading and results by this method of extraction should be as "alumina extracted by hot 10% caustic soda solution".

Procedure.

The method used in the Mines Section of the Victorian State Laboratories is:-

Weigh 2 grams of finely ground sample and transfer to 300 ml. conical flask. Add 100 ml. of 10% NaOH solution and boil gently for 3 hours on a hot plate, keeping the flask covered with a small funnel or crucible to act as a reflux condenser.

Transfer contents of flask to a 200 ml. measuring flask, cool and dilute to the mark. Mix well and allow to settle.

Pipette off 50 or 100 ml. of solution, according to the grade, run into porcelain evaporating dish, acidify with HCl and evaporate to dryness over a water bath. Take up residue with hot dilute HCl, filter and wash with water.

Precipitate alumina with NH_4OH, boil, filter and wash, precipitate twice with hot water. Transfer filter to original beaker and add 50 ml. of hot water. Stir well to pulp filter paper and add 10 ml. HNO_3 and 5 ml. HCl. Warm until precipitate dissolves. Add NH_4OH to reprecipitate alumina, boil, filter and wash precipitate until free from chlorides. Dry, ignite and weigh as Al_2O_3.

8. BAUXITE DEPOSITS.

Introduction: The earlier sections of this report give the geological background upon which a prospecting campaign can be based. Much of the evidence has, of course, been obtained during prospecting operations. The principal points to be noted are:-

1. Bauxite is known to occur on only one horizon.
2. The bauxite deposits fill irregularly shaped erosion hollows in the surface of the older basalt. (One bore on Napier's deposit proved 8 feet of very coarse sand between the basalt and the bauxite, and clay, which is thought to be of sedimentary origin and not weathered basalt, has been found beneath the bauxite in some bores).
3. The bauxite has itself been eroded.
4. The deposits are overlain by a very variable thickness of Tertiary and younger sediments.
5. Extensive faulting has occurred subsequent to the deposition of the bauxite, so that bauxite is found at many different topographic levels.
6. Most of the bauxite deposits occur in unimproved areas and can thus be developed with a minimum of disturbance to the local rural community.

Now that the horizon and typical mode of occurrence of the bauxite has been established, a careful watch should be kept for it in future geological exploration or boring campaigns. Cuttings of bauxite obtained from bores are not particularly distinctive and may easily be wrongly identified by inexperienced persons. The fact that all the known deposits occur on the older basalt may mean that the volcanic centres remained much the same throughout Oligo-Miocene time, but it is possible that bauxite was formed beyond the area occupied by the older basalt and may be found in bores which penetrate the Yallourn formation.

Summary of Reserves: Twenty-four individual deposits of bauxite are now known to occur in the Boolarra-Mirboo North area. Of these, eight have been tested by boring and shaft sinking (Group 1), but little is known concerning the extent of the remainder (Group 2).

The table hereunder summarises the data available concerning reserves and chemical composition of the foregoing deposits. In this table the deposits are arranged in alphabetical order in the two groups mentioned in the preceding paragraphs:-

GROUP 1.

	RESERVES	PROVED RESERVES	GRADE			
	Name of Deposit & Parish in which situated	(Tons 2240 lb.)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %
	Greenwood's Budgeree	49,400	50.0	7.3	8.8	6.0
	Napier's No.1, Mirboo	182,850	52.1	5.5	7.4	5.3
		or 215,000	50.0	6.0	10.0	6.0
	Napier's No.2, Allambee East.	19,000	50.8	10.0	7.6	4.8
	Orgill's, Narracan South	53,600	52.5	5.0	6.5	4.5
	Payne's, Allambee East	61,600	52.75	8.03	5.5	6.1
		and 50,000	-	-	-	-
	Sulphates Pty. Ltd. Narracan South	53,000	53.0	5.0	6.5	4.5
X	Watkins, Allambee East	235,000	51.6	10.1	5.4	5.3
	Total -	704,350				
	(X Data incomplete)	or 736,500				

GROUP 2.

OTHER DEPOSITS Name of Deposit and Parish in Which Situated	POSSIBLE RESERVES	GRADE Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %
Bond's, Budgeree	Unknown, probably small.	-	-	-	-
Crutchfield's, irboo.	" " "	-	-	-	-
De Hay's, Mirboo.	" " "	-	-	-	-
Foy's, Mirboo	100,000 or more	56	4	4.8	-
Fox's, Mirboo.	Unknown	-	-	-	-
Harrison's, Allambee East	Unknown	-	-	-	-
King's Allambee East (North & South deposits)	Unknown	-	-	-	-
Lovell's, Mirboo.	Unknown	-	-	-	-
Martin's, Mirboo	Very small.	-	-	-	-
Nahoo, Narracan South	50,000	52	15	3.5	4.0
Polley's, Allambee East	Unknown	-	-	-	-
Rodda's, Moe	Small	-	-	-	-
Roy's Budgeree	Unknown probably small	-	-	-	-
Sargent's, Mirboo	Unknown	-	-	-	-
Smith's Mill	? 20,000				
Tierney's, Mirboo	Unknown	-	-	-	-
Wanke's, Allambee East.	6,000				

Description of Individual Deposits.

NAPIER'S NO.1 LEASE.

Location: The lease embraces parts of Allotments 120B, 120C and 120E, Parish of Mirboo and is about 1½ miles north-northeast from the township of Mirboo North, which is the terminus of a branch railway from Morwell. The main road from Trafalgar to Mirboo North traverses the lease from north to South.

Topography. The area is hilly and the immediate vicinity of the lease is drained by the Little Morwell River which occupies a deep gully within the western lease boundary and parallel to the road mentioned above. A bauxite outcrop near the centre of the lease lies at about 600 feet above sea level and about 60 feet above the level of the river. Details of the surface relief are shown in Plate 4 by contours at a vertical interval of 10 feet.

The bauxite deposit has been divided into two sections by a gully near the centre of the lease. This gully has cut a gap nearly 500 feet wide through the bauxite and about 10 feet into the basalt. It is now partially filled with clay.

Workings. Two quarries have been opened on bauxite outcrops adjoining the road on the eastern side and a number of prospecting shafts had been sunk at various points on the lease prior to the start of the drilling campaign, the results of which forms the subject of this report.

With the exception of two shafts mentioned below, all operations have been confined to that part of the lease which lies to the east of the road and river.

Geology. The area has been mapped by the Geological Survey of Victoria as occupied by Post Volcanic (Lower Middle Miocene ?) sediments with some older basalt exposed in the river channel. Since this survey was carried out new road works have revealed a greater area of basalt marked by a soil cover only a few inches thick. Boulders of comparatively fresh basalt embedded in basaltic clay are visible in the road cuttings both north and south of the southern quarry and near the northern quarry.

Bauxite outcrops about 10 feet north from the southern quarry and 20 feet east from the edge of the road and can be traced for about 150 feet to where it is obscured by soil.

At a point 800 feet west from the northern quarry and on the opposite side of the river valley, ferruginous bauxite outcrops on the slopes at an elevation of about 55 feet above the river. Shallow pits have indicated the extension of the bauxite as a thin bed to 160 feet southwest from the outcrop, but shafts at 200 feet and 300 feet respectively west-southwest are stated to have entered decomposed basalt at a depth of 20 feet without encountering any bauxite.

Sections across the deposit are given in Plates 5 and 6. Following are detailed logs of a few representative bores.

Bore No.9.

Depth Feet From	To	
0	2	Soil
2	6	Clay
6	28	Sand
28	29	Clay
29	31	Sand
31	35	Clay
35	59	Bauxite
59	-	Decomposed basalt.

Bore No.48

0	1	Soil
1	19	Sand
19	25	Grey
25	28	Yellow sandy clay
28	34	Yellow sand
34	45	Grey sandy clay
45	60	Grey sand
60	78	Brown clay and lignite.
78	90	Grey sand
90	95	Yellow sand
95	101	Lignite
101	-	Decomposed basalt

Bore No.93

0	4	Yellow sand
4	8	Mottled clay
8	38	Sand
38	42	Sandy clay
42	65	Sand
65	66	Clay with bauxite
66	-	Decomposed basalt

Bore No.19

Depth Feet From	To	
0	3	Soil
3	8	White clay
8	24	Lignitic clay
24	30	Lignite and clay
30	46	Lignite
46	47	Grey clay
47	49	Lignite
49	68	Bauxite
68	-	Decomposed basalt.

Bore No.66

0	2	Soil
2	7	Grey and mottled. clay
7	30	Brown, yellow and grey sand.
30	33	Grey clay
33	38	Lignite
38	45	White sand
45	51	Bauxite
51	-	Decomposed basalt.

Bore No.88

0	2	Soil
2	12	Sand
12	19	Grey clay
19	41	Grey sand
41	49	White sand
49	52	Grey clay
52	61	Lignitic clay
61	68	Alternating bands of sand & clay
68	77	Fine grey sand with clay
77	83	Coarse grey sand
83	95	Lignitic clay
95	98	Clay with traces bauxite
98	100	Bauxite
100	108	Coarse quartz sand & fragments of bauxite
108	-	Decomposed basalt.

The sections and bore logs show that, while the bauxite generally rests directly upon basalt, there are places where an appreciable thickness of sediments, generally coarse sand may be interposed.

The basalt which forms the bedrock of the bauxite deposits is decomposed to a smooth clay which retains the original basaltic texture presenting a finely mottled appearance, and contains small specks (0.2 mm.) of ilmenite.

In colour the basaltic clay is generally bluish but may be yellow, red, brown or nearly white.

The bauxite also possesses a wide range of colours but is commonly buff, pink, brown, red or, particularly if recovered from below the level of the water table, grey or bluish-grey. The grey bauxite is of poorer quality than the reddish or lighter shades and has a higher iron content due largely to the presence of siderite and pyrite (marcasite ?). However, the colour cannot be regarded as a reliable guide to the quality except for very limited areas. Some very pale pink bauxite has a high silica content.

The appearance of the bauxite in the hand specimen varies fairly widely. Much of it is earthy and apparently devoid of any characteristic texture while some is hard and granular. The higher grade material may be distinguished by its low density, finely cellular texture, and the presence of minute crystals of gibbsite which glitter in strong light. The grey varieties have a superficial resemblance to decomposed basalt, but are harsh to the touch in contrast to the smooth soapy feel of the basaltic clay.

Analyses of the bauxite show the composition of the aluminous constituent to be that of the mineral gibbsite - $Al_2O_3.3H_2O$, the presence of which has also been demonstrated by Dr. F.L. Stillwell (Mineragraphic Report No.290,"Bauxite and Clay from Mirboo North", August, 1943). The titanium content varies between 3.0 and 7.5 per cent. TiO_2 with two exceptional samples containing 9 and 15 per cent. TiO_2 respectively. Bauxite which contains 50 per cent. or more of Al_2O_3 generally contains less than 7 per cent. TiO_2. In all the analyses of bore samples that have been made, the iron content has been expressed as Fe_2O_3, but at least some of the iron present is in the ferrous state. The iron content (expressed as Fe_2O_3) of bauxite containing more than 50 per cent. Al_2O_3 varies between 11.5 and 1.4 per cent. and averages 7.4 per cent. For bauxite of similar grade, the average titanium content is 5.3 per cent. The table shows some typical analyses on a moisture-free basis.

A. High-Grade - Included in Reserves.

Bore No.	Thickness	SiO_2	Ign.Loss	Al_2O_3	Fe_2O_3	TiO_2
	Feet	%	%	%	%	%
4	9	8.0	27.9	50.5	6.7	6.9
12	13	5.7	28.5	53.5	5.8	6.5
38	10	7.6	28.2	53.4	4.0	6.8
43	21	2.4	27.4	53.2	12.5	4.5
65	7	5.2	28.9	53.7	7.7	4.5
74	24	4.9	28.9	52.0	8.9	5.3
81	7	7.7	29.6	54.3	3.5	4.9
92	7	4.4	27.9	53.5	7.7	6.5
94	11	4.8	29.1	55.6	5.6	4.9

B. Low-Grade - Not Included in Reserves.

Bore No.	Thickness Feet	SiO_2 %	Ign.Loss %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %
11	20	4.7	28.0	40.9	20.7	5.7
16	15	10.3	26.6	43.3	13.7	6.1
19	19	9.1	28.5	32.1	24.7	5.6
27	33	7.3	27.2	36.3	22.3	6.9
34	34					
Top 2 feet -		13.5	34.5	40.4	5.1	6.5
Bottom 6 feet-		26.5	19.1	22.7	28.5	3.2
50	9.5	10.0	23.5	40.3	21.6	4.6
76	23	7.3	27.7	33.0	28.0	4.0
85	2	10.3	25.8	40.9	15.5	7.5
89	3	29.0	21.3	38.5	4.7	6.5

The Post-Volcanic sediments overlying the bauxite consist of sand, clay and lignite and ligneous clay. Towards the southeastern part of the southern section of the deposit, the lignite attains a thickness of 44 feet. Much of the lignite lies directly upon the bauxite occupying concavities in its surface, and is practically restricted to the area occupied by bauxite. The surface soil is black in colour and contains much coarse angular white quartz sand. This forms a sharp contrast with the chocolate soil formed by weathering of the basalt and provides a useful guide for prospecting operations. The soil is poor in quality and is of little use for agriculture or grazing.

Much of the sand, particularly that near the surface, is clean, coarse and angular. It is much used locally for surfacing roads and for building purposes. The clays vary widely in colour; some appear to be suitable for industrial application. The arenaceous clays contain varying proportions of fine yellow sand.

STRUCTURE. The basalt surface is undulating with a gentle dip to the southeast. The shape of this surface is shown by structure contours in Plate 7. The bauxite tends to lie in troughs in the basalt and it is apparent that it has been laid down on an erosion surface.

Broadly the upper surface of the bauxite does not display the irregular character of that of the basalt, but where exposed in the quarries the surface bears pot-holes and narrow gutters in clear evidence that it has been exposed to erosion.

From the western edge of the deposit the superior surface of the bauxite dips to the east and southeast at from 7 to 10 degrees. The central and eastern portions lie nearly horizontal,but from some places on the eastern margin the dip is gently towards the centre. These features are shown in the sections in Plates 5 and 6.

The marked differences in level of the bauxite penetrated by bores near the western margin of the deposit gave rise to the suggestion that several faults with a northerly trend and downthrow to the east had displaced the bauxite. Alternatively it was thought that the differences in level might be accounted for by slumping of the bauxite towards the centre of the basin and by erosion of the surface. Two hand-bores were sunk between Bores 31 and 32 and they revealed a regularly dipping upper surface of the bauxite, thus demonstrating the absence of faulting. It is also noteworthy that no faulting has been disclosed in the quarries on this lease.

There is some evidence of stratification showing in the northern quarry, where horizontal bands of greyish, intercalated with the brown, bauxite which forms the quarry face are discernible.

RESERVES. The following table, shows that reserves of high-grade bauxite proved by drilling amount to 182,850 tons. Of this total, 37,950 tons lie in the northern body and 144,900 tons in the central and southern body.

The average composition of this bauxite, on a dry basis, is:-

Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	Ignition Loss %
52.1	5.5	7.4	5.3	28.5

Examination of the sections in Plates 5 and 6 and of the analyses given in the table on page 13 shown that the bauxite falls into two groups; one with the Al_2O_3 exceeding 50 per cent. and the other with Al_2O_3 below 42 per cent. Very few samples with an intermediate alumina content were found. For this reason very minor amounts of bauxite containing less than 50 per cent. alumina have been included in the calculated reserves. In these circumstances, although the aim was to demonstrate the tonnage of bauxite containing not less than 50 per cent. alumina, the virtual absence of bauxite of a composition between 50 and 42 per cent. alumina raised the average figure to 52.1.

It would be possible in the course of quarrying operations to strip about 32,000 tons of lower grade bauxite, mainly from below the high grade material without removal of additional overburden. The inclusion of this quantity of low grade bauxite would increase the total tonnage to about 215,000 and low the average composition to:-

Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %
50	6	10	6

In calculating the tonnages given in the table some quantities of ore containing in excess of 50 per cent. alumina have been disregarded on account of thickness of overburden or isolation from the main bodies. A small tonnage of bauxite easily available under thin overburden and situated near the southern quarry has also been omitted owing to its high silica content.

A density of 2.2, equivalent to 16 cubic feet to the long ton has been allowed in converting the volume of bauxite in situ to long tons. For computing the tonnage of overburden the factor that has been used is 15 cubic feet to the ton or 1.8 tons per cubic yard.

It should be pointed out that the overburden figures refer to the volume standing vertically above the proved reserves of bauxite and no allowance has been made for batter. Where quarrying has been, or is being, carried out it has been found that a face cut in the overburden may be left standing nearly vertical for very long periods.

NAPIER'S NO. 1.

North Body.

LINE	BAUXITE Tons (2240 lb.)	Composition Al_2O_3 %	SiO_2 %	OVERBURDEN Cu.yd.	Tons (2240 lb.)	RATIO Overburden / Bauxite
1300N	9,500	51.5x	5.0x	19,100	34,300	3.61
1200N	16,650	53.6	2.9	28,800	51,900	3.12
1100N	10,100	53.4	7.4	25,700	46,300	5.29
1000N	1,700	57.0	7.9	5,800	10,400	6.00
Total:	37,950	53.2	4.3	79,400	142,900	3.77

NAPIERS NO. 1.

Southern Body.

LINE	BAUXITE Tons (2240 lb.)	Composition Al_2O_3%	SiO_2 %	OVERBURDEN Cu.Yd.	Tons (2240 lb.)	RATIO Overburden / Bauxite
B/f.	37,950	53.2	4.3	79,400	142,900	3.77
400N	15,000	52.0	4.9	12,390	22,300	1.5
300N	8,500	55.7	4.0	15,560	28,000	3.3
200N	3,750	56.2	6.8	26,800	48,300	12.9
100N	3,380	54.3	7.7	19,160	34,500	10.1
00	22,750	52.8	4.9	92,800	167,000	7.3
100S	12,450	51.9	5.3	8,760	15,800	1.3
200S	25,000	51.7	8.4	43,600	78,600	3.1
300S	3,600	50.0	7.8	3,670	6,600	1.8
400S ≁	-	-	-	-	-	-
500S	6,060	53.8	4.2	11,200	20,200	3.3
600S.	8,900	50.7	7.0	17,200	31,000	3.4
700S	32,030	52.1	6.0	36,900	66,200	2.1
800S	3,480	50.5	8.0	4,560	8,200	2.4
GRAND: TOTAL:	182,850	52.1	5.5	372,000	669,600	3.66

x Estimated..

≁ Less than 1,000 tons under shallow overburden and containing 51.7 per cent. Al_2O_3, 13.7 per cent. SiO_2. Excluded from reserves on account of high silica.

GREENWOOD'S LEASE.

This lease with an area of approximately 8 acres is the westernmost of the group of three leases held in the Parish of Budgeree and is situated in Allotment 16B, 5 miles by road southeast from the small township of Boolarra. Boolarra lies in the valley of the Little Morwell River just above its junction with the Morwall River and is an intermediate point on the railway between Mirboo North and Morwell.

Topography. The summit of the ridge in the vicinity of the lease has an elevation (by aneroid) of 980 feet above sea level and rises slightly to the east. The southern flank falls steeply to Waratah Creek which flows west to join the Morwell River. On the north the hill is drained by Bolbrook (or Sassafras) Creek which flows north into the Parish of Yinnar and joins the Morwell 2 miles below Boolarra.

Landslips are a common feature on the south side of the ridge.

Workings. Advantage has been taken of the partial removal of overburden by a landslip to open a quarry near the centre of the lease. The quarry now has an area of about 1/5th acre and some 400 tons of bauxite have been produced from it.

Geology. Dark grey sandy soil thinly covers the surface, but exposures in the quarry and in road cuttings east from the lease indicate the usual sequence which has been demonstrated elsewhere.

Basalt, decomposed to mottled clay with a ferruginous capping, forms the bedrock. Bauxite overlies the basalt under a cover of sand and sandy clay. At the face of the quarry the thickness of the overburden is between 25 and 30 feet consisting of 6 feet of yellow sand overlying the bauxite and the remainder sandy clay.

In the quarry where the contact between basalt and bauxite can be seen plainly, the bauxite rests directly upon clay still retaining the original basaltic texture, but the logs of bores sunk to the northeast of the quarry show several feet of clay between bauxite and decomposed basalt. This, however, is believed to represent completely decomposed basalt in which, where the clay is highly coloured, the texture is masked by iron stain, but in some cases it may be low-grade bauxite.

No traces of lignite or ligneous material are revealed in the quarry, but in one bore, No. 10, ligneous clay was recognised. The log of this bore and one other follow:-

Bore No. 6

0 - 2	Grey sand	
2 - 4	Yellow clay	
4 -19	Sandy clay	
19 -22	Yellow sand	
22 -24	Sandy clay	
24 -39	Sand	
39 -41	Grey clay	
41 -56	Bauxite	
56 -69	Red & grey clay	Basalt
69 -70	Decomposed basalt	Basalt

Bore No. 10

0 - 1	Loam	
1 -13	Yellow and grey clay	
13 -14	Gravelly clay	
14 -47	Sandy clay with thin bands of sand	
47 -61	Sand	
62 -69	Sandy clay	
69 -71	Yellow clay	
71 -73	Ligneous clay	
73 -80	Yellow and grey clay	Basalt
80 -81	Decomposedbasalt	Basalt

<u>The Ore-Body.</u> The outline of the body, as far as it has been proved at present is shown in the accompanying plan, which indicates that in general the body is oval in plan with its longer axis trending northeast. It is roughly symmetrical, the greatest thickness being developed centrally (see Plates 8 and 9).

A narrow tongue protruding to the south has been proved by costeans which have picked up the western margin, and boring results indicate that a similar tongue under heavy overburden extends north-easterly beyond the lease boundaries.

<u>Reserves.</u> The attached table shows that proved reserves total 49,400 tons containing 50.0 per cent. alumina on a moisture-free basis. Information regarding the quality is not as complete as that used for determinations of the grade at Napier's No. 1 and Payne's leases as only one analysis is available for bauxite in the quarry face, and none for the costeans, or the shaft between Nos. 1 and 2 Bores. The figures given for the average alumina and silica content for the whole tonnage are derived from analyses of fifteen samples from Bores 1 to 6 and 17, and the analysis of bauxite from a shfat sunk on the site of the present quarry.

GREENWOOD'S, BUDGEREE.

LINE	BAUXITE			OVERBURDEN		RATIO
	Tons (2240 lb.)	Composition Al_2O_3%	SiO_2%	Cu.Yd.	Tons (2240 lb.)	Overburden / Bauxite
From quarry through bores 6, 5, 4 to 3.	19,000	49.5	9.6	51,000	91,800	4.83
From quarry through Bore 1, shaft to Bore 2.	20,000	50.0	5.6	71,000	127,800	6.39
Bore 17	6,200	50.9	5.7	28,300	50,900	8.21
Costeans	4,200	-	-	5,000	9,000	2.14
	49,400	50.0	7.3	155,300	279,500	5.66

<u>THE PINES LEASE.</u> Lease Appln. 6991, Parish of Allambee East, Watkin's Napier's No. 2 Deposits.

This lease comprises a narrow strip extending to the north-east from inside the northern boundary of Allotment 125A. It crosses Allotments 97A, a corner of 98A, and 97, and terminates in Allotment 96, 1¼ miles north from Payne's lease in Allotment 99.

The lease is approximately 1 mile long by 20 chains wide and crosses several different farm holdings. Portions of the lease are known by the names of the holders of the land embraced, as, for example, bodies of bauxite in the centre and north eastern end of the property are known as Napier's No. 2 deposit and Watkin's deposit respectively.

Topography. The lease lies mainly on the north western slope of the Lydiard Range, which is part of the divide between the drainage systems of the Morwell and Tarwin Rivers. The elevation is about 800 feet above sea level near the foot of the range at Parkins' and about 1200 feet above sea level at Watkin's.

The south western portion of the lease at Parkins' includes the head of a major creek which flows west to the western branch of the Tarwin River.

Geology. The following notes are based chiefly on an unpublished geological map of the Parish of Allambee East by O.A.L. Whitelaw of the Geological Survey of Victoria and the results of hand-boring conducted by Messrs. Sulphates Pty. Ltd.

Practically the whole area of the lease is covered with timber and dense bracken and undergrowth, but the eastern and southern portions of the lease border on cultivated ground consisting largely of basaltic soil, with, in places, decomposed basalt at a shallow depth below the surface.

At the north western end of the lease, basalt and bauxite lie beneath a cover of sand and clay ranging from 3 feet to 35 feet thick over the area of 10 acres that has been tested by boring.

At about 20 chains southwest of the area bored the geological map shows an exposure of pre-Volcanic Tertiary sediments over a width of 10 chains in a small saddle.

Further southwest basalt is shown on the map. In this area and ½ mile southwest from Watkin's, a small triangular area of 2½ acres has been bored revealing from 3 to 30 feet of sand and clay overlying bauxite and basalt. This deposit is known as Napier's No. 2.

The south western extension of the lease in Allotment 125A is occupied by basalt in the creek channels and basaltic soil on the lower slopes. Boulders of bauxite lie at the base of a low hill between two creeks, and the hill is capped with coarse sandy soil typical of the post-Volcanic Tertiary sediments.

The Ore-Bodies.

1. Watkin's. Exploration of the bauxite deposit at the northern end of the lease is not yet complete, but sufficient boring has now been carried out to indicate the outlines of the body with fair accuracy and to prove the existence of 235,000 tons of bauxite under 400,000 tons of overburden. The deposit is shown in plan in Plate 10(a) but this plan will require some minor modification when the position of the bores in the eastern half of the body have been surveyed.

Sampling of two shafts shown on Plate 10(a) gave the following results:-

Shaft	Thickness Feet	SiO_2 %	Ignition Loss %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %
1	15	9.7	28.2	51.3	5.8	5.0
2	16	10.4	28.3	51.9	5.0	5.5

NAPIER'S NO. 2. Hand-boring on this deposit has disclosed the presence of a small body of bauxite under shallow overburden. A total of 24 bores was sunk in an area of acres and only six bores entered bauxite. The deposit contains a total of 19,000 tons of bauxite lying under 21,000 tons or 11,500 cubic yards of overburden, and is shown in plan and section in Plate 10 (b).

Samples taken from the shaft yielded on analysis:

Sample	Thickness	SiO_2	Ignition Loss	Al_2O_3	Fe_2O_3	TiO_2
Feet	Feet	%	%	%	%	%
Bulk	11	10.0	26.8	50.8	7.6	4.8
8-15	7	12.8	27.0	50.2	4.8	5.2

PARKINS'. Prospecting by hand-boring on Allotment 125A proved disappointing. Light coloured bauxite had been observed around the flanks of a rounded hill occupying the northern side of the allotment. A line of six hand-bores sunk along the crest of this hill penetrated decomposed basalt at shallow depth and failed to reveal the presence of bauxite. This area can, therefore, be disregarded as a potential source of bauxite.

BOOLARRA DEPOSITS. Mineral leases held by Sulphates Pty. Ltd. in the southern portion of the Parish of Narracan South enclose two deposits of bauxite. Of a group of leases two are here described. They are M.L.6689 in Allotment 116D and M.L. 6873 on the adjoining Allotment 116C. The former, known as "Sulphates Open Cut" occupies 15 acres and the latter is known as Orgill's and has an area of about 8 acres.

These leases are about 2 miles west from the railway at Boolarra and are connected with the town by a motor track.

Topography. The workings on the leases are a few hundred yards north and east from the junction of Burchells Creek with the Little Morwell River, and M.L. 6689 partly occupies a concave bend of the river. East of this lease and within the boundaries of Orgill's lease, a small creek flowing west-southwest to the river has incised a steep walled gully to a depth of 30 feet. The southern and western portions of the former lease extend close to the river channel and enclose the lower slopes of the valley walls. The accompanying plan shows topographic contours at a vertical interval of 10 feet and referred to a zero datum which is about 400 feet above sea-level.

Geology. Basalt is exposed in the river bed below M.L.6689, but at higher levels is masked by sand and clay which has slumped down to the river. According to the geological map of the parish, Jurassic rocks are exposed in the left bank of the river about half a mile downstream from Burchell's Creek. No. 2 Bore sunk in 1889 at a point about half a mile east from the quarry on M.L. 6689, at a surface elevation of 615 feet above sea-level encountered Jurassic rocks at 272 feet. This bore passed through 67 feet of post-Volcanic sediments and 105 feet of basalt before entering Jurassic sandstone (Plate 3).

In the quarries on both leases the bauxite is resting directly on clay possessing a basaltic texture without any intercalations of sand or post-basaltic clay.

The cover of post-Volcanic sand and clay which constitutes the overburden averages 12 feet in thickness at the present quarry face on M.L.6689 and is more than 40 feet thick at the opposite edge of the deposit 450 feet to the east. Lignite has not been encountered in the excavations on this lease.

On Orgill's lease the overburden is thinner, ranging from zero to 6 feet in thickness along the northern and northwestern edge of the deposit to a maximum of 36 feet near the centre of the body.

The lithology of the overburden is shown by the two bore logs here given:-

M.L. 6689

(Sulphates Open Cut)
Bore No. 12

Feet	
0 - 3	Sand
3 - 5	Yellow sandy clay
5 - 9	Clay
9 - 25	Sandy clay
25 - 28	Grey sand
28 - 40	Grey sandy clay
40 - 44	Grey clay
44 - 51	Bauxite
51 -	Decomposed basalt

M.L. 6873

(Orgill's)
Bore No. 6

Feet	
0 - 1	Sand
1 - 4	Yellow clay
4 - 7	Red and grey clay
7 - 11	Red and grey sandy clay
11 - 14	Red and grey clay
14 - 20	Grey clay
20 - 23	Yellow Sand
23 - 34	Grey clay
38 - 39	Bauxite and clay
39	Decomposed basalt

Reference to the accompanying plan and sections will show the essential differences existing between the two deposits herein described. On the other hand there are certain marked similarities. Both deposits contain the same tonnage of bauxite and the ratios of overburden to bauxite are not dissimilar. Both bodies have been truncated by stream erosion on their western or north western sides and both possess dips which bear a not unfavourable relationship to the surface slopes of the overburden. (See Plates 11, 12 and 13).

The Orebodies.

1. M.L. 6689. The deposit on this lease is roughly rectangular in plan and lenticular in section. The length from east to west approaches 600 feet, but approximately 150 feet has been removed from the western and by quarrying operations. The breadth of the deposit ranges up to 400 feet and averages 300 feet. The maximum thickness proved by boring is 15 feet and the average about 9 feet.

The body has the form of a thin nearly horizontal lens bounded by undulating surfaces, but possessing a predominant dip to the northwest. The upper surface is more nearly plane than the lower which reflects erosion features of the underlying old land surface.

The salient features of the deposit are shown in the accompanying plates. Plate 11 shows the body in plan with thickness contours added. It will be noticed that the greatest thickness of bauxite extends east from the southern side of the quarry as a sinuous tongue which lies in a depression in the basalt surface. This structure reveals a typical stream pattern with tributaries joining the main stream from the vicinity of Bores 3 and 14.

2. M.L. 6873 (Orgill's). This body is more oval than rectangular in plan and has its longer axis 600 feet in length trending northwest. The breadth is 300 feet and the average thickness a little over 8 feet. Owing to the smooth outlines without re-entrants the deposit occupies a larger area than that on the adjoining lease 6689. The sections (Plate 13) show that the bauxite lies on a relatively plane floor of basalt, and the plan (Plate 11) indicates that the thicker portion of the deposit does not occupy a narrow branching stream channel or similar depression in the old land surface.

In section the body takes the form of a wedge-shaped lens which thins very gradually to the southeast and terminates abruptly on the opposite side where it outcrops along the top of a creek bank. The body dips west down the slope of the hill at an average angle of 4 degrees.

Exposure of the western edge of this deposit by a small quarry has shown that the body here terminates abruptly tapering sharply from a thickness of 12 feet to one foot or less in a horizontal distance of approximately 10 feet. The upper surface of the bauxite is exposed in the quarry over an area of about 250 square feet. This surface is irregular and bears a sharp trough-like depression parallel to the strike, together with pot-holes. The under surface, which rests on basaltic clay, dips east at about 40 degrees. Sections compiled from the results of boring and shaft-sinking show that this steep dip is not maintained and that actually both the upper and lower surfaces of the bauxite rise gently to the east from points only a few feet east of the western edge of the deposi These features which are the results of erosion are shown in Plate 13.

Reserves and Composition of Bauxite. The following tables show that the total reserves proved by shaft sinking and boring on the two properties amount to 106,600 tons of bauxite under 141,000 cubic yards or 263,500 tons of overburden; in round figures 2.5 tons of overburden to 1 ton of bauxite. The total reserves of bauxite are divided almost equally between the two deposits, but Orgill's lease has the more favourable overburden-bauxite ratio.

Information regarding the composition of the bauxite on M.L. 6689 is not complete, but Messrs. Sulphates Pty. Ltd. have advised that the average analysis of bauxite removed from the quarry over a period of four years is:-

SiO_2	Ignition Loss	Al_2O_3	Fe_2O_3	TiO_2
%	%	%	%	%
5.0	31.0	53.0	6.5	4.5

These figures have been accepted as representative of the whole deposit.

With regard to Orgill's deposit, figures are given in the table for each block of ore proved by the individual sections. These figures are averages of analyses of samples obtained from shafts or bores on or near the lines of section, but in some instances lower results have been obtained from samples from intermediate shafts and the following analyses are quoted:-

	SiO_2	Ignition Loss	Al_2O_3	Fe_2O_3	TiO_2
	%	%	%	%	%
(a)	5.3	28.8	53.2	6.9	5.7
(b)	4.0	29.0	55.1	6.9	5.0
(c)	4.1	28.2	49.2	13.2	4.6
(d)	4.1	27.8	50.9	9.2	4.5

(a) Average of bores 4, 5, 7 and shaft 4, representing 20,900 tons of reserves.

(b) Average of parcel of 40 tons from shaft. To a certain extent this ore would be selected for despatch to factory.

(c) Average of 39 samples from fifteen shafts representing total footage sampled of 158½ feet and including low grade material.

(d) Average of twenty-six samples from shafts representing 150 feet and excluding analyses showing less than 48.6 per cent. Al_2O_3.

It is believed that the grade shown in the table of reserves for Orgill's deposit may be slightly higher than could be actually recovered, but the above analyses tend to show that any reduction in grade will not bring the alumina percentage below fifty.

SULPHATES' LEASE M.L.6689, ALLOTMENT 116D, PH. OF NARRACAN SOUTH.
Proved Reserves of Bauxite.

LINE	BAUXITE Tons (2240 lb)	OVERBURDEN Cu. yd.	OVERBURDEN Tons	RATIO Overburden / Bauxite
200W	13,100	28,480	51,200	3.92
100W	10,400	15,900	28,600	2.75
00	13,200	15,900	28,600	2.27
100E	8,800	12,880	23,200	2.64
150E	6,300	4,620	8,300	1.32
250E	1,200	1,560	2,800	2.33
	53,000	79,340	142,700	2.70

Average analysis of bauxite from quarry - Al_2O_3 53 per cent., SiO_2 5 per cent.

ORGILL'S LEASE, M.L.6873, ALLOTMENT 116C, PH. of NARRACAN SOUTH.
Proved Reserves of Bauxite.

LINE	BAUXITE Tons (2240 lb)	Composition Al_2O_3%	Composition SiO_2%	OVERBURDEN Cu.yd.	OVERBURDEN Tons	RATIO Overburden / Bauxite
300N	4,500	52.0	5.0	2,400	4,320	0.96
200N	25,400	52.1	4.8	20,200	36,360	1.24
100N	12,100	54.4	5.0	27,040	48,700	4.03
00	8,800	51.5	6.0	10,000	18,000	2.23
100S	2,800	52.1	3.7	1,940	3,450	1.23
	53,600	52.5	5.0	61,580	110,830	2.06

PAYNE'S LEASE.

Location. The lease has an area of 11 acres and is situated in Allotment No. 99, Parish of Allambee East adjoining the northern boundary of the allotment. It lies about $3\frac{1}{2}$ miles by road north from the township of Mirboo North which is the terminus of the branch railway from Morwell.

Topography. The lease lies on the crest of a small spur of the Lydiard Range and is flanked by steep slopes on the north, east and south. The summit of the spur is about 1,000 feet above sea-level and the fall to the Little Morwell River, 1 mile to the east, is 500 feet. The accompanying plan (Plate 14) shows topographic contours at a vertical interval of 10 feet. Small creeks on either flank of the hill drain eastward to the river.

Geology. Black clayey soil containing angular quartz grains obscures the surface on the crest and flanks of the hill, and the adjacent gullies are choked with dense and rotting vegetation. A thin band of cemented brown sand is exposed in wheel ruts and by upturned roots of fallen trees on the crest and northern slope of the spur.

One small outcrop of bauxite occurs on the southern flank of the hill at an elevation of 35 feet lower than the top of the ridge. Large detrital boulders of bauxite lie below and to each side of the outcrop and scattered fragments can be picked up over a broad ard following the contours round the face of the spur. Similar fragments and large boulders embedded in soil lie in a group near the southeastern corner peg of the lease.

The bauxite forms two separate deposits which are shown on Plate 14. The western deposit consists of two bodies, lenticular in section and joined by a thin sheet of bauxite. The eastern deposit is separated from the western and central bodies by about 250 feet. These latter bodies have maximum thicknesses of 9 feet and 17 feet respectively and occupy an erosion hollow in the basalt surface.

The maximum thickness of the eastern deposit is not known as it has not been found possible to drill through the bauxite with hand augers which have been used for the prospecting of this part of the lease, but the bauxite is known to be not less than 18 feet thick at one place, and not less than 15 feet and 12 feet thick at others. The eastern limit of this body has not yet been defined.

Basalt does not outcrop on or in the immediate vicinity of the lease, but chocolate bassaltic soil is evident on cultivated land near the foot of the hill on the southern side.

Landslips have carried down much sand and probably some bauxite on the southern and southeastern flanks, and to a lesser extent on the northern side.

The overburden above the bauxite consists of sand and clay. The sand contains both coarse (3 to 5 mm.) and fine (0.5 mm.) angular and subangular grains of quartz. It derives the colours ascribed to it in the drilling logs (yellow and brown) from admixed clay or surface staining of the component grains.

The bauxite recovered from boring operations onthe western deposit is buff or brownish pink in colour and is rather harder and more compact than that of other deposits. Analyses show the composition to be that of gibbsite, Al_2O_3, $3H_2O$, but only rarely can any crystalline component be observed by megascopic examination.

The following description by Dr. F. L. Stillwell is quoted from Council for Scientific and Industrial Research, Mineragraphic Report No. 290, "Bauxite and Clay from Mirboo North, South Gippsland".

"The bauxite is buff to creamy coloured, and finely cellular. No. 1 specimen (from Bore No. 11) appears to consist of cemented fragments, but the other three (from below No. 1 in the same bore) appear uniform.

In thin section, No. 1 is seen to be irregularly ironstained, and it is the unequal distribution of the stain that gives it its fragmental appearance. Much of the rock shows a relic basaltic texture, and consists of finely cryptocrystalline gibbsite, with a little ilmenite more or less altered to leucoxene.

Specimen No. 2 is practically colourless in thin section and consists essentially of cryptocrystalline to microcrystalline gibbsite, with which are associated laths and skeletal crystals of ilmenite showing all stages of alteration to leucoxene".

The iron content, expressed as Fe_2O_3, for all bauxite containing not less than 49.8 per cent. Al_2O_3 averages 5.6 per cent. and ranges between 6.5 and 4.1 per cent. Titania (TiO_2) content averages 6.1 per cent. with a range between 6.5 per cent and 4.8 per cent.

With one exception all bores within the area of the western deposit where bauxite occurs in sufficient thickness to warrant quarrying revealed bauxite containing more than 50 per cent. Al_2O_3 for the whole thickness of the bed at the point bored. In the one excepted instance, the figure is 49.8 per cent.

Traces of lignite were found in only one bore hole on the lease. These traces consisted of broken fragments of woody lignite embedded in finely mottled clay of greyish colour. This clay contains minor amounts of rounded grains of clear glassy quartz ilmenite very finely divided, and small grains of apparently amorphous bauxite.

The completely decomposed basalt penetrated in each bore is generally greyish-white or pale brown in colour with a finely stippled texture and containing small specks of heavy black material which is probably ilmenite. Dr. Stillwell, in the report quoted above, has identified ilmenite and leucoxene in specimens of clay from immediately below the bauxite on this lease. The clay did not show any trace of basaltic texture.

Typical bore logs which show the section above the basalt are:-

Bore No. 2
Depth in Feet

From		To	
0	-	2	Soil
2	-	4	Grey sand
4	-	23	Brown sand
23	-	24	Sandy clay
24	-	41	Bauxite
41	-	-	Decomposed basalt

Bore No. 3
Depth in Feet

From		To	
0	-	2	Soil
2	-	4	Grey sand
4	-	24	Brown sand
24	-	27	Grey sandy clay
27	-	29	Yellow sand
20	-	50	Grey sandy clay
50	-	55	Grey clay
55	-	56	Brown clay
56	-	60	Grey clay
60	-	61	Clay with trace of bauxite
61	-	-	Decomposed bauxite

Bore No. 7
Depth in Feet

From		To	
0	-	2	Soil
2	-	3	Grey sand
3	-	44	Brown sand and clay
4	-	9	Brown clay
9	-	11	Grey sandy clay
11	-	12	Clay with trace bauxite
12	-	-	Decomposed basalt

Bore No. 13
Depth in Feet

From		To	
0	-	2	Soil
2	-	5	Grey sand
5	-	20	Brown sand
20	-	27	Yellow sand
27	-	31	Grey sand
31	-	35	Grey sandy clay
35	-	50	Bauxite
50	-	-	Decomposed basalt

The accompanying sections (Plate 15) suggest that the sands and clays overlying the bauxite were also deposited in a small closed basin.

<u>Structure</u>. The bauxite which constitutes the western deposit, that is the western and central bodies, lies in a depression in the basalt and dips at about 5 degrees to the east-northeast. Structure contours on the upper surface of the basalt are now shown on the plan as the shape of this surface is relatively simple and is evident from the sections.

The basin is somewhat asymmetrical being deeper on the eastern side where the greater thickness of bauxite lies. Subsequent erosion has removed the greater part of the bauxite from the centre of the hollow in which it was deposited unless it had been folded into a gentle syncline.

The large body occupying the eastern side of the basin, or forming the eastern limb of the syncline, is lenticular in cross-section and has an average thickness of 16 feet for a distance of 300 feet along its long axis. The average width from east to west along this length is 200 feet. The body is nearly symmetrical about the north-south axis, but a short tongue projects to the north from the northwest corner.

Exploration of the eastern deposit is not yet complete, but results of boring to date indicate that the upper surface dips at about 15 degrees to the northeast. The attitudes of the eastern and western deposits suggest that a continuous bed of bauxite has been thrown into parallel folds and that subsequent erosion has removed the apex of the anticline, separating the bauxite into two bodies. It is, however, possible that the two bodies were formed by deposition in separately existing topographic basins and that the present shapes are due to extensive erosion of the bauxite.

The accompanying sections suggest that the sands and clays overlying the bauxite were deposited in a small closed basin.

Reserves. Figures in the following table indicate that a total of not less than 111,500 tons of bauxite has been proved by boring to exist on the lease.

Of this total 61,500 tons lies in the western deposit and has been tested by power drilling which recovered uncontaminated samples for analysis. The whole deposit, including marginal areas which are too thin or too deeply buried to be recoverable, occupies an area of 5 acres and has been tested by 23 boreholes.

This bauxite is overlain by 198,500 tons or 110,000 cubic yards of overburden and has the following average composition when dry.

Al_2O_3	...	52.8
SiO_2	...	8.0
Fe_2O_3	...	5.6
TiO_2	....	6.1
Ignition Loss	....	27.1

As this tonnage (61,500) represents virtually the whole of the bauxite which can be recovered from the western deposit irrespective of the composition, the figure cannot be increased by lowering the acceptable grade except in minor amount and at the cost of greatly increasing the volume of overburden to be stripped.

The tonnage available in the eastern deposit is shown as 50,000. Testing of this body is being conducted by hand-boring and is not yet completed. The extent of the deposit so far proved is shown in Plate 14.

WESTERN DEPOSIT.
Western Body.

LINE	BAUXITE Tons (2240 lb.)	Composition Al_2O_3%	SiO_2%	OVERBURDEN Cu.Yd.	Tons (2240 lb.)	RATIO Overburden / Bauxite
100N	6,000	52.2	10.4	20,280	36,500	6.08
200N	13,000	52.7	7.5	21,110	38,000	2.92
Total:	19,000	52.5	8.3	41,390	74,500	3.92

Central Body

LINE	BAUXITE Tons (2240 lb.)	Composition Al_2O_3%	SiO_2%	OVERBURDEN Cu. Yd.	Tons (2240 lb.)	RATIO Overburden / Bauxite
100N	7,800	51.7	10.0	6,120	11,000	1.41
200N	9,940	56.0	5.0	14,450	26,000	2.61
300N	14,380	51.8	9.0	30,550	55,000	3.82
400N	10,380	53.0	7.1	17,770	32,000	3.08
Total:	42,500	52.9	7.9	68,890	124,000	2.92
Grand Total:	61,500	52.75	8.03	110,280	198,500	3.23

EASTERN DEPOSIT (Data incomplete).

200N	9,000	-	-	5,800	10,000	-
300N	14,000	-	-	6,700	12,000	-
400N	20,000	-	-	12,500	22,500	-
500N	7,000	-	-	4,200	7,500	-
Total:	50,000	-	-	29,200	52,000	-

OTHER DEPOSITS.

Only brief reference can be made to those deposits listed in Group 2 on page 9 of this report.

Bond's, Parish of Budgeree. The southwest corner of this lease is separated from the northeast corner of Greenwood's lease (M.L.6717) by the width of a road. The corner peg and two bores are shown on Plate 8. To date three bores have been sunk on this lease and one of them has penetrated 4 feet of bauxite at a depth of 120 feet from the surface. The bauxite is of good quality and appears to be an extension of that proved on M.L. 6717. The bores are interesting in that they encountered lignite and ligneous clay. The log of Bore 14 is quoted:-

Depth in Feet From	To	
0	1	Soil
1	21	Yellow, grey and red clay
21	36	Sandy clay
36	39	Grey clay
39	57	Sandy clay
57	97	Sand
97	102	Brown clay
102	120	Lignite and ligneous clay
120	124	Bauxite
124	133	Decomposed basalt

Roy's, Parish of Budgeree. Roy's lease adjoins Bond's on the east. No bores have been drilled on this lease, but bauxite fragments are embedded in slumped material towards the southern side of the lease. Three bores drilled half a mile to the east of this holding and at a slightly higher elevation entered decomposed basalt at a shallow depth.

Crutchfield's, Parish of Mirboo. Crutchfield's farm is situated on Allotments 61 and 59 about 5 miles southwest from Boolarra and 4 miles southeast from Mirboo North. Two outcrops of bauxite are known on Allotment 61. One occurs on the crest of a rounded hill and the other in the bank of a creek about 20 chains to the east and 60 feet below the top of the hill.

It is thought that the higher body is only a small residual. There is insufficient exposure of the bauxite in the creek bank to form a basis for any extimates.

De Hay's, Parish of Mirboo. Messrs. Sulphates Pty. Ltd. have reported that a deposit of bauxite exists on Allotment 34 and that the ore is approximately of similar composition to that from M.L. 6689, Parish of Narracan South, i.e. 53 per cent. alumina, 5 per cent. silica, but alumina might be a little lower. The company considers it doubtful if any considerable tonnage could be obtained from this deposit.

Fox's, Parish of Mirboo. Fragmental bauxite has been found on the slopes below the crest of a high ridge in Allotments 10C, 10E, 18 and 131 near the eastern boundary of the parish. The ridge has an elevation of 1,000 feet above sea-level and is capped with post-Volcanic sands underlain by basalt. Landslips have carried sand down the slopes and mixed it with basaltic soil on Allotment 18. Bauxite fragments in a shallow road cutting on the western slope of the ridge was probably carried there by slumping.

There is no information regarding the extent of the deposit on this lease.

Foy's, Parish of Mirboo. Foy's property lies about ½ mile east from the railway station at Mirboo North. Two occurrences of bauxite are known on this farm and Messrs. Sulphates Pty. Ltd. have carried out some test boring on the southernmost of the deposits, about ½ mile south of the main road from Mirboo North to Boolarra. As the company was unable to come to any satisfactory agreement with the owner of the farm, the boring was not carried to a conclusive stage. Four bores encountered bauxite at an average depth of 8 feet from the surface and indicated the presence of 10,000 tons. The ore is high grade averaging 56 per cent, alumina and 4 per cent silica.

About 100 yards south of the Mirboo North-Boolarra road, boulders of bauxite are showing in a patch of thick bracken. It is not known whether they are in situ but the large size of some of them suggests that they mark the edge or top of an outcropping deposit.

Lovell's, Parish of Mirboo. Pebbles and boulders of bauxite can be picked up for a distance of about 200 yards near the crest of a large hill ¾ mile west from Darlimurla railway station. No further information regarding this deposit is at present available.

Sargent's, Parish of Mirboo, in Darlimurla Township. Bauxite occurs on the slopes of a low hill about 200 yards north of the railway line at Darlimurla and a lease has been taken up by Messrs. Sulphates Pty. Ltd. No further information is available.

Tierney's, Parish of Mirboo. This is an area adjoining Crutchfield's farm on the east and occupying high uncleared ground in Allotment 53. Fragments of bauxite picked up on the surface yielded an analysis of 1.9 per cent. SiO_2, 56.3 per cent. Al_2O_3, but to date the area has not been further prospected.

Rodda's, Parish of Moe. This deposit is situated in Allotment 148 on the south side of the road from Thorpdale to Childers.

Some bauxite has been produced from a small open cut from which ore has been raised with a windlass. This bauxite is siliceous and is used chiefly by the Ordish Firebrick Pty. Ltd. in the manufacture of firebricks.

The deposit has not been examined in detail, but is believed to be small. The composition of the bauxite won from the open cut shows a fairly wide range and averages about 11 per cent. SiO_2, 51 per cent. Al_2O_3, 4.5 per cent. Fe_2O_3 and 6 per cent TiO_2.

Nahoo, Parish of Narracan South. Messrs. Sulphates Pty. Ltd. have worked the deposit known as Nahoo for some years as a source of bauxite for chemical purposes. The average composition of the bauxite won is:-

15 per cent. SiO_2, 52 per cent. Al_2O_3, 3.5 per cent. Fe_2O_3 and 4 per cent. TiO_2

Although possibly large, this deposit has been omitted from the reserves on account of the high silica figure.

Harrison's Allotment 103, Parish of Allambee East. Bauxite outcrops, which appear to be part of a flat-bedded deposit occur on the south side of a creek a few chains upstream (west) from the road from Mirboo North to Payne's. A few hand bores have been put down by Messrs. Sulphates Pty. Ltd. on the south side of the outcrops, but no bauxite was encountered. It is impossible on present information to form any estimate of the extent of this deposit.

King's, Parish of Allambee East. This lease lies to the south of Payne's and is at about the same elevation, namely 1,000 feet above sea level. The lease has an area of 45 acres and lies in Allotment 101.

A road runs north outside the western boundary of the lease and turns in an easterly direction crossing the lease near the centre. Bauxite is exposed in a shallow cutting at the side of this road a few yards southwest from the southwest corner peg, and in the table drain of the road within the lease boundaries.

Three prospecting shafts have been sunk, one a few yards north from the second exposure of bauxite mentioned above, and the other two 600 feet and 900 feet further north respectively. Only the first shaft encountered bauxite; the others entered decomposed basalt at less than 20 feet from the surface. Where intersected by the shaft the upper surface of the bauxite is steeply inclined, but as the shaft was not continued through the bauxite, it cannot be said whether an erosion or bedding surface was met with. Much more prospecting is required here before an opinion can be expressed on the size of the deposit.

Polley's Parish of Allambee East. A large lease, 2½ miles north-west from Mirboo North takes in portions of Allotments 91, 124A and 124B. This area has not yet come under review and nothing is known about it.

Wanke's, Parish of Allambee East. Bauxite outcrops over a small area, approximately 100 feet by 200 feet, on the slopes of a creek bank in Allotment 104. The deposit has been opened by a quarry at a level about 10 feet above the creek and its extent has been proved by boring. The body has the form of a lens, roughly circular in outline 16 feet thick near the centre and 200 feet in diameter. This lens dips southeast at about 35 degrees. Probably as much as a quarter of the original deposit has been removed by erosion.

Owing to the high angle of dip a large part of the bauxite lies beneath deep overburden and is below the level of the nearby creek. Owing to these unfavourable circumstances combined with the smallness of the body this deposit has been omitted from the reserves. The grade of bauxite recovered from the quarry averages about 6 per cent. SiO_2, 50 per cent. Al_2O_3, 9 per cent. Fe_2O_3.

9. ORIGIN.

Bauxite used to be regarded as a mineral with the composition Al_2O_3 H_2O, but it is now known that it consists of one or more of the following hydrates of aluminium.

Gibbsite	- Trihydrate of aluminium	-	$Al_2O_3.3H_2O$
Boehmite, Diaspore	Monohydrate of alumina	-	$Al_2O_3.H_2O$

The first two are soluble in hot caustic soda, the last is not.

It is generally believed that bauxite forms as the result of a special kind of chemical weathering of rocks with a relatively high alumina content. Carbonated groundwater with humic acid are the main reagents. Lime, magnesia, potash and soda go into solution as bicarbonates; carbonic and organic acids break up the silicates. The process is thus one of enrichment of the lateritic constituents (Al_2O_3, Fe_2O_3, TiO_2), due to removal of silica and the alkalis. The residuum is a rock composed mainly of one or more of the hydrates of aluminium with oxides of iron and titanium as the chief impurities. Usually also some silica remains combined with alumina in one of the clay minerals.

The special conditions necessary for the formation of bauxite are provided by a monsoonal climate. Chemical alteration and solution takes place in the wet season when the water table is high; in the dry season, these solutions drain away taking the impurities with them.

This hypothesis can be applied to the bauxite deposits of New South Wales, which have been studied in some detail by one of us (H.G.R.). There it can be demonstrated that the bauxite formed as a special type of sheet lateritisation. Shafts sunk in these deposits show that the bauxite formed as the result of alteration of basalt flows in place, there being gradual change downwards from bauxite to fresh basalt. Where the rim rock of the basalt flows, or where the rocks underlying the flows, came within the zone of lateritisation, they also underwent the same type of chemical alteration as the basalt which gave rise to the bauxite.

The foregoing statement is necessarily brief, but is given because it seems probable that these general principles should apply to the mode of formation of the Gippsland bauxite. However, it will be seen that there are some features of these deposits which are difficult to fit in with the conventional view. We can do little more than outline the problem here.

F. L. Stillwell, who has examined specimens collected during this investigation, has shown that the bauxite is derived from a volcanic rock of basaltic type (Mineragraphic Investigations, Council for Scientific and Industrial Research No. 242, 275 and 290). It has been pointed out in this report that the bauxite rests upon basalt, but from a study of the contact of the bauxite and the basalt, it is clear that the bauxite was not derived from the basalt upon which it rests. The upper surface of the basalt still retains features produced by the normal processes of subaerial weathering - spheroidal structures and red and yellow clays. Moreover, the bauxite does not change gradually to basalt; where the contact is direct it is sharp, and, in places, sand and clay intervene between the two.

Comparing the Victorian with the typical New South Wales bauxite deposit, the feature most difficult to explain is how the alteration of one basalt was brought about without the other on the same level being affected. Perhaps the explanation is that the later basalt or tuff was relatively much more porous than the earlier and/or that the clayey weathered surface of the earlier basalt produced conditions favouring the formation of bauxite. If this was so, the conditions were those of the perched acquifer and not those of the normal water table. F. L. Stillwell has independently put forward a similar suggestion (Mineragraphic Investigations, Council for Scientific and Industrial Research, Report No. 290). That this may be true, in part at least, is supported by the evidence revealed by the drilling of Napier's deposit. Reference to typical cross-sections of this deposit (Plates 5 and 6) will indicate that low grade ore was found in the lower part of the deposit. This condition was not found anywhere else. Since Napier's deposit is the lowest so far tested and water was struck in all bores sunk in it, it may be that the lowest parts of the deposit have been waterlogged for a very long time and thus not subject to bauxite-forming processes to the same extent as the higher parts. There is an implication in the foregoing remarks that although there was a main bauxite-forming period in the Miocene, the process has been a continui one. How far this can be supported by the evidence cannot be argued here, but it may be noted that boulders of bauxite exposed to weathering are almost invariably higher grade than bauxite under cover, due apparently to modern leaching.

It cannot be overlooked that many of the features of the Victorian deposits could be readily explained if they were regarded as transported, but it is also true that there is an absence of positive evidence in this direction such as one would expect to find. For instance rude stratification has been noted only in one place - the northern quarry, Napier's deposit. The limited exposures available for study make it difficult to develop a satisfactory hypothesis for the origin of the deposits. Undoubtedly as quarries are opened many interesting features will be revealed bearing on this and other aspects of bauxite formation.

Two points of general interest are worth mentioning.

During testing of the deposits a relatively high silica zone was noted at the top of the bauxite. For a time it was thought this was due to contamination of the samples by sand or clay from the overlying beds, but it now seems, that although comtamination sometimes occurs, most of the silica is inherent in the bauxite. This is a feature common to bauxite deposits in many parts of the world and is believed to be due to concentration at the surface by evaporation of silica-bearing solutions.

The common association of lignite deposits with bauxite has led some observers to suggest that organic acids derived from the lignite have taken part in the bauxite-forming process. In Gippsland, however, this argument cannot apply. It can be shown that high grade bauxite was formed where there is little likelihood that it was ever overlain by lignite. It seems definite also, as already mentioned, that the bauxite was formed and eroded before the lignite deposits were laid down.

10. BENEFICIATION TESTS.

Some rough beneficiation tests have been carried out by Sulphates Pty. Ltd. on ore from five of the deposits with the results given in the table hereunder. In these tests the bauxite was crushed to ¼" mesh. Fines were removed by agitation in water, suspended material being decanted and the operation being repeated till clear washings were obtained.

Deposit	Per Cent.	SiO_2 %	Loss on Ign. %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %
(1) (a) Boolarra Open Cut						
Crude Ore ..	100	6.5	28.0	53.6	6.9	5.0
Fines ..	30	13.0	23.1	45.3	9.7	9.0
Coarse ..	70	3.6	30.0	57.1	5.6	3.2
(b) Boolarra Open Cut						
Crude Ore ..	100	8.75	28.5	51.35	4.9	6.5
Fines ..	32	13.65	25.8	47.5	5.56	7.5
Coarse ..	68	4.8	30.5	56.92	3.63	4.25
(2) (a) Napier's Nthrn. Quarry						
Crude Ore	100	6.15	29.0	54.7	5.4	4.75
Fines	20	13.1	23.0	43.1	12.1	8.7
Coarse	80	4.4	30.5	57.6	3.7	3.75

Deposit	Per Cent	SiO_2 %	Loss on Ign. %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %
(b) Napier's Centre Quarry						
Crude Ore	100	8.8	30.0	54.2	2.3	4.7
Fines	20	20.4	24.0	44.6	2.3	8.7
Coarse	80	5.9	31.5	56.6	2.3	3.7
(c) Napier's Centre Quarry						
Crude	100	10.0	28.4	54.66	2.16	4.46
Fines	30	27.5	27.0	42.0	-	2.7
Coarse	70	2.5	29.0	60.1	3.2	5.2
(3) Watkin's Deposit.						
Crude Ore	100	8.15	28.3	55.9	3.2	4.75
Fines	38	13.9	24.9	50.4	4.3	6.5
Coarse	62	5.25	29.9	58.1	2.5	4.25
(4) Nahoo Quarry						
Crude Ore	100	13.0	26.9	52.23	3.12	4.75
Fines	37	13.3	25.7	50.1	4.4	6.5
Coarse	63	12.85	27.2	52.7	3.0	4.25
(5) Napier's No. 2						
Crude Ore	100	10.0	26.8	50.8	7.6	4.75
Fines	32	13.2	24.5	44.4	11.5	6.0
Coarse	68	8.5	28.0	53.8	5.8	4.25

The results obtained indicate that, with the exception of the ore from Nahoo, the grade of the bauxite may be greatly improved by the simple method adopted in these tests, but it will be noted that there are also considerable losses entailed. At the present time, it is not possible to make much further useful comment on these results. Refinement in procedure might result in greater percentage recovery of the high grade product; on the other hand it might be found that chemical industry could absorb such quantities of the lower grade product as might be produced by the simple method used in the tests, having regard to the tonnage of high grade ore required for the manufacture of aluminium.

H. G. Raggatt

DIRECTOR.

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GEOLOGIST

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