COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

BULLETIN No. 24.

BAUXITE IN AUSTRALIA

BY

H. B. OWEN.

Issued under the Authority of Senator the Hon. W. H. Spooner, Minister for National Development.
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COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

Minister : SENATOR THE HON. W. H. SPOONER.

Secretary : H. G. RAGGATT.

BUREAU ON MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

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This publication was prepared in the Geological Section.

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INTRODUCTION.

HISTORY.

Nearly all the aluminium produced to-day is extracted from bauxite, which is a naturally-occurring mixture of hydroxides of aluminium together with more or less ferric oxide and other impurities.

The production of aluminium from bauxite (or other aluminium ore) is conducted in two distinct stages; first pure aluminium oxide (alumina—Al_2O_3) is prepared, and secondly the oxide, dissolved in a bath of molten cryolite (sodium aluminium fluoride—Na_3AlF_6), is electrolyzed to produce metallic aluminium at the cathode.

Within the past twenty years the importance of aluminium as an industrial metal has increased greatly, and its future is assured. The aircraft industries of the major belligerent countries during the Second World War consumed such large quantities of the metal that production rose to quadruple that of the years immediately before the outbreak of war. Since the end of hostilities in Europe and Eastern Asia in 1945 the expanded aircraft industry and the increasing use of aluminium for structural purposes, fabrication of railway rolling stock, road vehicles, and barges, and in building construction, have maintained a steadily increasing demand for the metal at a rate much higher than the pre-war figures.

A review of statistics shows that annual world production of aluminium fell from 270,000 long tons in 1930 to 140,000 tons in 1933 and then rose steadily to a peak of nearly 2,000,000 tons in 1943. Production during 1948 totalled 1,210,000 tons, showing a steady increase from 1945 as accumulated stocks were consumed. Accurate figures are not available for all countries but it is probable that production for 1951 amounted to about 1,900,000 tons. The principal producing countries are greatly increasing their production capacity at the present time.

Until the plant now under construction at Bell Bay, Tasmania, begins to function Australia is wholly dependent upon imports of metal from North America. Imports for recent calendar years, in long tons, are—

Year.	1948.	1949.	1950.	1951.
Ingot aluminium	4,726	7,191	5,916	11,379
Rods, bars, sheets, &c.	1,435	3,801	3,609	5,077
Total	6,161	10,992	9,525	16,456

Production of bauxite in Australia is relatively small and averages about 5,000 tons per annum. It is used for the manufacture of aluminium chemicals in Melbourne and Brisbane, and a ferruginous pisolitic variety produced in New South Wales is used in small quantities as flux in open-hearth steel furnaces.

At Newcastle and Port Kembla, unrecorded quantities of pisolitic laterite and bauxite are used for surfacing roads and paths.

The question of producing aluminium in Australia had been considered by several large industrial organizations without any finality being reached; and in 1941 the Commonwealth Government set up the Commonwealth Copper and Bauxite Committee to assess, *inter alia*, Australian domestic resources of bauxite. Information laid before the Committee indicated that further exploration in South Gippsland, Victoria, where bauxite had been discovered in 1924 and worked in a small way since, might be profitable. Accordingly an investigation of the area was undertaken by this Bureau (then the Mineral Resources Survey) in co-operation with the Victorian Department of Mines and Messrs. Sulphates Pty. Ltd., the principal bauxite lease-holders in that State. Results of this campaign were published by the Mineral Resources Survey in 1945 (Raggatt, Owen and Hills, 1945).

During 1945 an agreement was made between the Commonwealth and Tasmanian Governments to provide for the production of ingot aluminium in Tasmania by a joint Government agency, and the Australian Aluminium Production Commission (hereinafter referred to as the Aluminium Commission) was established under the terms of the Aluminium Industry Act to implement this agreement.

Early in 1945 the Bureau in conjunction with the Tasmanian authorities continued an examination of bauxite deposits, which had been begun by the Mines Department in that State. Before the end of the year the Aluminium Commission joined in the investigation, which, under the auspices of the Commission, was later extended to Victoria, New South Wales, Queensland, and, in 1951 and 1952, to the Northern Territory.

Scope of this Bulletin.

The principal purpose of this Bulletin is to record the results of the testing campaigns which were conducted by the Bureau and the Aluminium Commission during the years 1945 to 1952. All this exploratory work was carried out under the supervision of the author, aided from time to time by geologists and engineers from the Commission, the Bureau, State Geological Surveys, and other organizations, but it is necessary and desirable to include the observations of other workers who have reported upon areas not examined by the writer.

The writer has sought to include more than statements of tonnages and grades of various deposits, which make wearisome reading, although embellished with detail. The Bulletin is set out in three parts, of which the first contains introductory matter and definitions necessary to a full appreciation of what follows. Part II—Resources—contains the statements of reserves, references to localities and access, and descriptions of individual deposits, and geology of the areas in which they occur. The treatment has not been entirely consistent throughout for two reasons, viz., the work has been done over a period of several years during which time methods and staff underwent changes with the result that exactly comparable information was not always forthcoming; secondly some variation of style in setting out the results has been introduced to avoid a deadly monotony reminiscent of a railway timetable.

The third part of the work discusses the origin, age, and constitution of bauxite. Much of this part is occupied by factual statements descriptive of structure and composition, but some controversial matter is introduced and it is hoped that a small contribution has been made to the already voluminous literature on the origin of bauxite.

The question of minor constituents in Australian laterite has been raised and discussed at as great a length as the relative paucity of information will allow. It is believed that geochemical prospecting would benefit greatly from a study of the distribution of—say—uranium, copper, nickel, cobalt, and chromium in laterites.

METHODS OF PROVING.

The reserves were proved by boring or pitting at the intersections of rectangular grids. The spacing between test-holes was varied from place to place in accordance with local conditions of uniformity or otherwise of shape or composition of the orebody. In Tasmania and Victoria the spacing commonly used was 100 feet, in New South Wales 200 feet or, less commonly, 400 feet, and in the Northern Territory a spacing of 200 feet by 400 feet was used. Scout testing in Kingaroy, Queensland, was conducted on parallel lines spaced 1,000 feet apart with bores or shafts sunk at intervals of 200 or 400 feet along these lines.

Most holes were sunk through the bauxite into recognizable kaolinized bedrock, except on Marchinbar Island, Northern Territory, where testing was mostly restricted to the pisolitic zone. A few holes at Campbell Town, Tasmania, and Inverell, New South Wales, were carried deep into the bedrock.

Two methods of sampling were used: (*a*) vertical channel sampling in pits or shafts, and (*b*) percussion drilling with drive pumps.

For the former method the shaft face to be sampled was cleaned by picking to a depth of ¼ or ½ inch over a vertical band about 6 inches wide and a channel sample was then cut from the cleaned strip with a hand sampling pick to yield as far as possible a uniform weight of sample per unit length of channel. The aim was to take not less than one pound per foot. No arbitrary length of channel was chosen for each individual sample, but each was taken to conform with changes in the apparent character of the bauxite. Where no change occurred in a considerable thickness of bauxite the maximum length for any one sample was fixed at 5 feet. Channel samples, except those from Marchinbar Island, were despatched to the laboratory without any treatment or reduction. These practices were varied in the Northern Territory, where samples from Marchinbar Island were limited to a maximum channel length of 4 feet, screened to remove sand, crushed, and reduced to about 250 grammes. This latter step was rendered necessary by transport difficulties, as nearly all samples from the island were taken out by light aircraft.

Bore samples were recovered by boring with a drive pump (churn drilling) in a manner similar to that used for testing alluvial deposits. The holes were drilled with 4-in. tools and cased with 5-in. casing. When bauxite was encountered, the casing was seated firmly by driving it a few inches into the bauxite and the hole was pumped clean and flushed. Flushing and pumping was continued until clean water was returned in the bailer. Boring was then continued with the drive pump until the necessary length of sample (2 feet for the first sample in each bore and 5 feet for subsequent samples) had been obtained and deposited in a numbered drum. The casing was then driven to the bottom of the hole and the loose bauxite broken by the passage of the casing shoe was pumped out and added to the sample already collected.

The bore samples were recovered in varying degrees of moistness, but usually as a slurry which settled overnight, allowing some clear water to be decanted. The wet samples were dried on iron trays over wood fires, with constant stirring to hasten drying and avoid local overheating. Most of the bore samples were too bulky for despatch to the laboratory without reduction and this was effected by coning and quartering followed by division through a Jones sampler. Large lumps, which were uncommon, were broken with a hammer on an iron plate to about ¼-in. size before reduction of the sample.

Comparison of the analytical results obtained from shaft and bore samples from the same deposit show no constant difference between two such sets of samples. The deposits on Marchinbar Island, which are relatively thin and, except for a few inches of soil, exposed, were tested by pits exclusively.

QUANTITY CALCULATIONS.

The volume of bauxite contained in any of the deposits cannot be exactly calculated to an equivalent weight of ore. The ore is porous and in eastern Australia contains moisture ranging between 9 and 22 per cent. in the samples tested. Density figures for "green" (i.e., moist) ore as it occurs *in situ* were obtained by direct measurement and by laboratory determination of moisture and specific gravity, samples for this purpose being packed in air-tight containers without loss of time.

It is readily apparent that the moisture content of a porous rock lying at or near the surface will show a wide range and also be subject to appreciable fluctuations in accordance with climatic conditions. Therefore, any figure which is accepted as the moisture content of "green" ore is at best an approximation; nevertheless the deduction of an allowance for moisture content enhances the accuracy of the tonnage calculation.

The factor for computing tonnages in the Inverell area was determined by measuring by displacement the volume occupied by weighed samples freshly cut from shafts. For this purpose a simple apparatus was devised. It consisted merely of a 5-ft. length of 5-in. bore casing sealed at the lower end and partly filled with water. The free space above the water surface was measured before and after adding the weighed sample (20 to 30 lb.) of bauxite. Duplicate samples were checked by laboratory determinations. It was found that the moisture content ranged between 9.4 and 17.0 per cent. and averaged 13.5 per cent. Specific gravity of the dry ore ranged between 2.23 and 3.3. Field determinations of density showed a similar range and averaged about 136 lb. of moist ore per cubic foot, equivalent to 1.6 tons per cubic yard, or 1.39 tons of dry ore per cubic yard.

For the denser Moss Vale bauxite, which is mainly derived from the concretionary zone, the conversion factor used is 1.65 tons of dry ore per cubic yard.

Reserves in Gippsland have been calculated on the basis of 16 cubic feet to the ton (1.7 tons per cubic yard), less 10 per cent. moisture.

At Ouse direct measurement by Dickinson (1943) indicated a density factor of 1.60 tons of moist ore per cubic yard. A moisture figure of 12 per cent., giving a conversion factor of 1.40 tons of dry ore per cubic yard, has been accepted for the Ouse deposits.

Moisture and specific gravity determinations conducted on St. Leonards ore gave an average moisture content of 14 per cent. and average specific gravity of dry ore of 2.3. These figures indicate a conversion factor of 1.3 tons of dry ore per cubic yard. Density determinations in the field with large specimens of Marchinbar ore and by the writer using wax-coated specimens indicated that the porosity ranges between 8 and 22 per cent. The average density of this ore when dry is 17 cubic feet to the ton, equivalent to 1.59 tons per cubic yard. The ore *in situ* has a lower moisture content ranging up to 5 per cent., but it is probable that this figure would increase during the rainy season from December to April.

DEFINITIONS.

Several of the terms as used herein have a special or restricted meaning, and others such as "bauxite" and "laterite" may convey to the reader either a wider or narrower significance than that intended; consequently these terms are here defined.

Laterite.

The term laterite was introduced by Buchanan in 1807 when he described a variegated ferruginous rock occurring in southern India. This rock was much used for building purposes because when freshly quarried it could be cut with a trowel into desired shapes, but on exposure it hardened into a strong brick-like material. No analyses were made of Buchanan's laterite but his description (Fox, 1932, page 2) of the rock (*see* page 171 of this Bulletin for quotation) is in great detail and leaves little doubt that he referred to part of the massive or tubular ferruginous zone. The writer has examined 16th century Portuguese fortifications built of squared blocks of typical tubular laterite. Tool marks on the blocks indicate that it was softer when cut than it is at the present day. This accords with Buchanan's description. Since Buchanan's day the name has been applied to the whole " laterite profile ", which includes the topmost pisolitic and ferruginous zone and the light-coloured leached zone, which normally occur respectively above and below Buchanan's laterite. Another school of thought reserves the word for the ferruginous zone only.

The former use conveys a stratigraphical rather than petrographical meaning and no simple satisfactory definition to include all products of lateritization, including the partially decayed parent rock, can be made.

As used herein laterite is defined as essentially a mixture of oxides of iron, more or less hydrated, with aluminium hydroxides, formed as a relatively insoluble precipitate and residue resulting from prolonged sub-aerial leaching of certain rocks and oxidation of the leached products. This definition is stripped to the bare essentials and omits all reference to other common constituents of laterites, and the physical and chemical circumstances necessary to its development, which are further discussed in pages 171ff.

Bauxite.

This term has virtually lost any scientific meaning other than perhaps as a rock name. It is most usefully employed to denote aluminium ore which consists mainly of aluminium hydroxide.

In Australia bauxite is an aluminous variant of laterite; the aluminium is present as gibbsite (aluminium hydroxide—$Al(OH)_3$) or a colloidal equivalent usually with minor to appreciable amounts of boehmite—a basic oxide, $AlO(OH)$. Commonly there is insufficient combined water to hydrate all the iron oxide, which is present probably as a colloidal mixture of ferric oxide and the equivalent of turgite ($2Fe_2O_3.H_2O$). No sharp division between bauxite and laterite can be drawn (but it is sometimes convenient in the field to draw a distinction when " laterite " signifies lateritic material low in aluminium): bauxite is simply aluminous laterite. The term bauxite is here so used and includes those bauxites in which secondary changes have concentrated the alumina by subtraction of iron. Bauxite which consists chiefly of gibbsite is known as trihydrate ore, and European bauxites which contain a large proportion of boehmite ($AlO.OH$) or, perhaps, diaspore ($HAlO_2$) are referred to as monohydrate ores. These terms are derived from the empirical formulae $Al_2O_3.3H_2O$ and $Al_2O_3.H_2O$ respectively.

Economic Bauxite.

Changing economic conditions impose difficulties in the way of attempts to define commercial bauxite. During the course of testing operations in eastern Australia the Aluminium Commission set out specifications for ore which linked the alumina content with the probable consumption of alkali which might be experienced in Bayer plant practice. Accordingly " economic bauxite " was defined as aluminous laterite which contains not less than 30 per cent. of available alumina that can be extracted with a loss of alkali not exceeding the limits shown in the following scale:—

Available Alumina (soluble in hot alkali solution under pressure).	Soda-loss. Maximum permissible loss of alkali in hundredweights of Na_2O per ton of available alumina.	
	Eastern Australia.	Marchinbar Islands. (Wessel Islands).
Per cent.		
30	1.20	0.8
31	1.31	1.0
32	1.41	1.2
34	1.56	1.6
36	1.70	2.0
38	1.83	..
40	1.95	..
44	2.05	..
46	2.24	..
48	2.32	..

The scale for ore from Marchinbar Island was not taken further as all samples containing over 36 per cent. available alumina yielded a figure far below the maximum permissible soda-loss.

Available Alumina.

The amount of alumina (Al_2O_3) which can be extracted from the ore by pressure digestion with alkaline solution containing sodium hydroxide and carbonate under conditions simulating those of the Bayer process is termed "Available Alumina". The available alumina figures given in this report are a close measure of the amount of alumina present in the bauxite as gibbsite $Al(OH_3)$, or a colloidal equivalent.

Soda Loss.—The figures given under this heading express the loss of alkali as Na_2O in hundredweights per ton of alumina extracted. This unrecoverable alkali remains in the insoluble matter ("red mud") left after digestion of the bauxite with caustic soda and is a measure of the alkali-soluble silica present in the original ore.

Free Alumina and Free Silica.—Some analyses of bauxite carried out by the Tasmanian Mines Department Laboratory and quoted herein give figures for the soda-soluble alumina and soda-soluble silica. These determinations have been made by extracting the bauxite with boiling 10 per cent. caustic soda solution under atmospheric pressure. The alumina and silica which are dissolved by the alkali solution are reported by alumina technologists as "free alumina" and "free silica" respectively. The "free" silica so determined occurs in the ore mainly in combination as kaolin or as finely disseminated and opaline silica. Quartz, unless very finely divided, is not appreciably attacked by caustic soda solution.

Ton.—Throughout this Bulletin the term ton signifies the long ton of 2,240 lb. All ore reserves are expressed as long tons of dry ore.

Acknowledgment of Chemical Analyses.

Unless otherwise acknowledged in the text all chemical analyses quoted herein, and many hundreds of partial analyses and laboratory determinations from which averages have been computed, are the work of the staffs of the Department of Mines Laboratory, Launceston, Tasmania, and of the Aluminium Commission under the respective direction of Messrs. W. St. C. Manson and R. A. Dunt. Analyses of Victorian bauxites from Deposits No. 1 to 22 inclusive (Buln Buln) were made by Messrs. Sulphates Limited and have been taken from a previous publication by the then Mineral Resources Survey, and from private communications from Mr. W. S. Curteis, Mining Engineer to that company.

The writer is deeply indebted to Messrs. Manson and Dunt for their willingness to make determinations additional to the routine analyses when requested, and for the promptness and care with which the work has been carried out, frequently in the face of staff shortages. Thanks are also due in this connexion to Mr. W. H. Williams, Director of Mines, Tasmania, who never withheld permission for his departmental laboratory to examine samples from extra-Tasmanian sources. Determinations made by the Tasmanian Mines Department are prefixed by (T.) throughout the text unless specifically acknowledged.

Thanks are also due to the Commonwealth Scientific and Industrial Research Organization and to Dr. A. B. Edwards for permission to reproduce two reports as Appendices I and II.

RESOURCES.

Summary of Reserves.

The following tables show the bauxite reserves which have been proved or indicated in the eastern States and Northern Territory. The information is not complete in that a few minor deposits of very small tonnage have been omitted, but details of these will be found in the ensuing sections.

Where ranges of composition are shown the figures refer to averages of individual deposits, some of which are of substantial volume. Individual samples from which these figures have been calculated show a much wider range of composition, but the use of such figures would add no real meaning to the table.

The totals are not a final assessment of Australian resources of bauxite. Further exploration may reveal commercially valuable deposits on Cape York Peninsula, Queensland, and in Western Australia where systematic testing of known bauxite occurrences has not yet been undertaken.

A preliminary reconnaissance of a deposit of pisolitic bauxite at Yirrkala (Gove), Arnhem Land, Northern Territory, indicates that systematic testing may reveal very substantial tonnages of ore of similar grade to that on Marchinbar Island.

Some bauxite deposits have been explored in an extremely thorough manner by pits or cased bores at intervals of 100, 200, or, less commonly, 400 feet, and many hundreds of samples have been submitted to chemical analysis. Reserves calculated from this wealth of detail are shown in the following table as "Proved Reserves".

Other deposits which have been sampled at few and widely spaced points are included in the "Indicated Reserves" in the same table, but no deposit has been so included unless the total thickness has been measured and sampled in at least one place.

TABLE 1.—SUMMARY OF AUSTRALIAN BAUXITE RESERVES AS KNOWN AT 30TH JUNE, 1953.

State or Territory and Locality and Number shown on Fig. 1.	Reserves—Thousands of Tons.		Percentage Composition.			
	Proved.	Indicated.	SiO_2.	Al_2O_3.	Fe_2O_3.	Soda-soluble Al_2O_3
Queensland—						
1. Tamborine Mountain	473	..	7.0	37.3	24.6	
	..	1,020	4.0	41.0	22.0	39.0
2. Hampton ..	..	250	1.9	37.8	32.7	36.7
	473	1,270	..	..	..	..
New South Wales—						
3. Inverell area ..	9,610	..	2.7–5.8	36.9–40.8	28.0–31.1	33.1–36.4
	..	5,960	3.6–6.6	35.7–42.9	26.3–31.1	..
4. Moss Vale area ..	518	..	2.9–7.5	35.3–40.7	29.6–33.3	31.2–33.1
	..	3,600	3.9–7.5	31.0–53.9	5.7–37.4	..
5. Trundle	..	40	4.9–7.9	43.0–55.0	9.7–19.6	39.7–51.5
	10,128	9,600	..	..	..	..
Victoria—						
6. County of Buln Buln	785[4]	..	3.7–11.5	43.8–53.0	5.4–16.1	36–50
	..	116	6–15	45.8–52.2	3.5–13.5	..
Tasmania—						
7. Ouse	627	..	5.6–6.1	38.6–41.0	25.7–30.2	35.8
8. St. Leonards ..	142	..	5.6–7.1	40.9–41.7	25.7–27.4	36.5–37.7
9. Myalla	..	10	2.0[1]	..	..	46.0
	..	180	1.4–8.0[1]	..	..	29.9–46.7
	769	190	..	..	..	..
Northern Territory—						
10. Marchinbar Island ..	8,980	..	4.1–8.8[2]	48.0–53.3	6.4–17.0	43.5–47.8
	..	800	6.8[3]	47.7	17.2	42.8
Total ..	21,100	12,000	..	..	..	..

(1) Soda-soluble silica only.
(2) Includes 1.1 to 3.8 per cent. quartz.
(3) Includes 2.4 per cent. quartz.
(4) *Less* 16,000 tons mined to end of 1952.

Expressed in another way the known Australian reserves may be summarized as in the following table:—

TABLE 2.—SUMMARY OF AUSTRALIAN BAUXITE RESERVES BY GRADE.

Grade—Soda-soluble Alumina.	Reserves.		
	Proved.	Indicated.	Totals
	Tons.	Tons.	Tons.
30 to 40 per cent.	11,400,000	10,900,000	22,300,000
Over 40 per cent.	9,700,000	1,000,000	10,800,000
Totals	21,100,000	11,900,000	33,100,000

From the foregoing tables it will be seen that more than 90 per cent. of the known bauxite that contains over 40 per cent. of available alumina occurs on Marchinbar Island, Northern Territory.

QUEENSLAND.

INTRODUCTION.

Although laterite has been developed on early Tertiary basalts over wide areas of south-eastern Queensland, zones sufficiently enriched in alumina to constitute bauxite have been discovered only at Tamborine Mountain and near Hampton on the Dividing Range in the neighbourhood of Toowoomba.

Laterite containing nodules of gibbsite has been extensively quarried within the city area of Toowoomba, but sampling of the quarry faces by the State Geological Survey indicated an average grade of only 26 per cent. soda-soluble alumina (Shepherd and Connah, 1948).

Thorough sampling of laterite bodies near Kingaroy, described below, failed to disclose commercially valuable enrichments of alumina, and an examination of an area of 1,500 square miles of the Atherton Tableland in North Queensland by the Geological Survey also produced negative results.

Proved and indicated reserves of bauxite in Queensland, which are shown in Table I above, are not large, but it is probable that substantial additions would be found by further sub-surface prospecting on Tamborine Mountain, and the possibility of new discoveries on the Dividing Range has not been ruled out by the work which has been done to date. Potentially valuable deposits on Cape York Peninsula, to which further reference is made, await examination.

TAMBORINE MOUNTAIN.

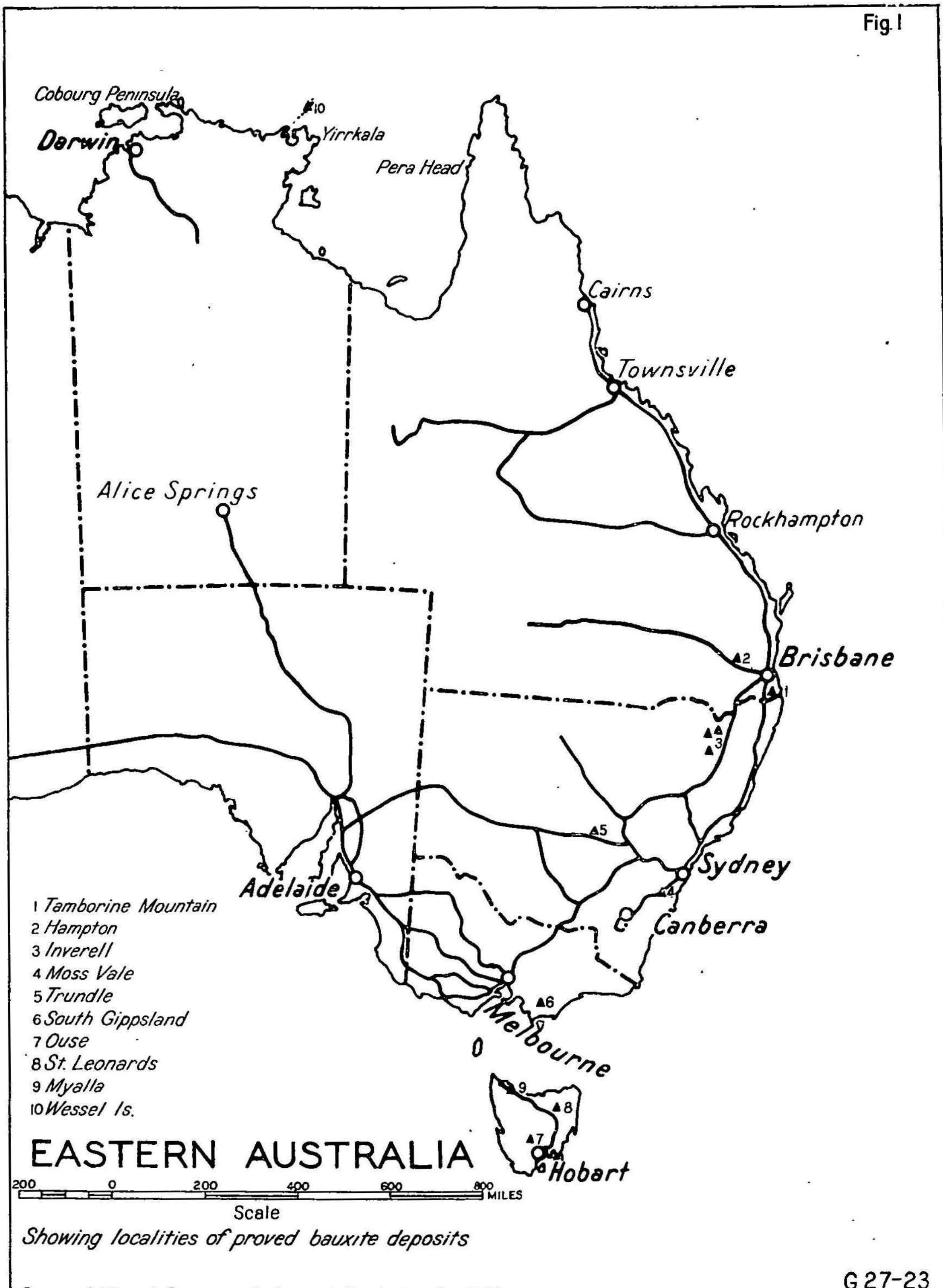
Tamborine Mountain lies about 35 miles south-south-east from Brisbane; the distance by road from the capital to North Tamborine village is 45 miles.

The mountain is an outlier of the Lamington Plateau and rises steeply from the coastal plain to a plateau surface with a maximum height above sea-level slightly over 1,800 feet. The surface, formed by basalt and andesite flows, has been dissected to a depth of about 100 feet by Cedar and Sandy Creeks. All higher points of the present land surface have a common elevation at a little above 1,800 feet, from which it may be inferred that before erosion the lava field possessed a nearly level surface.

The plateau surface is roughly rectangular in plan, with a maximum length from north to south of 5 miles, but Guanaba Gorge, a deep embayment in the eastern flank, has nearly divided the mountain in two.

Laterite and associated bauxite occur chiefly in the north-western portion of the mountain and in general occupy the more elevated areas.

The bauxite deposits have been known for many years and have been exploited as a source of road metal and more recently for the manufacture of aluminium sulphate. Production is from a quarry on the western edge of North Tamborine village, from where the bauxite is trucked down a steep road to the railway at Tamborine, 1590 feet below the quarry level.



[To face page 16.]

The bauxite occurrences have been described briefly by Ball (1940), Curteis (1942), and Connah (1950). W. S. Curteis conducted testing operations by shaft-sinking on behalf of Messrs Sulphates Limited during 1947. The results of this work have been made available to the writer by the Company, have been used herein, and are gratefully acknowledged.

During June, 1950, the writer accompanied T. H. Connah of the Queensland Geological Survey to Tamborine Mountain during a very short visit, and again examined the area in November of that year.

Geology.

Tamborine Mountain is capped with volcanic rocks, mainly lavas, with a total thickness of 700 to 800 feet. Along the western side of the mountain the volcanics overlie Bundamba sandstone of Upper Triassic age, but on the northern and eastern flanks Palaeozoic schists crop out immediately below the lavas.

The volcanic rocks, which have been described by H. C. Richards (1916), attain a maximum thickness of 3,000 feet at Lamington Plateau, and have been poured out during three periods separated by lulls in the volcanic activity. Accordingly the resulting lavas and tuffs fall into three groups or divisions which display characteristic petrological differences. At Tamborine the lowest division, which consists of basaltic members, is about 100 feet thick, the middle division, largely composed of trachytes and rhyolites, is of similar thickness, and the topmost division, 400 to 500 feet thick, is represented by basalt and porphyritic andesite.

Richards (pages 125 and 131) considers that the vulcanicity which resulted in the wide distribution of these volcanic rocks in south-eastern Queensland probably began in the Lower Cainozoic and concluded in the Upper Cainozoic. He correlates the upper division of basalts and andesites with the Newer Volcanics of Victoria and with the Pliocene basalt of Inverell.

The writer is not able to agree that the upper basalts of Tamborine Mountain are as young as suggested by Richards, and believes that they should be correlated with the lateritized basalts of Inverell which disconformably underlie volcanics and paludal sediments of probable lower Pliocene age. If the writer's contention is correct it becomes apparent that the three periods of vulcanicity represented at Tamborine Mountain all occurred in early Cainozoic time and probably were restricted to the Eocene and Oligocene epochs.

This view gains further support from the enormous erosion which has taken place since the last of the Tamborine volcanic rocks was extruded, and presumably since the formation of the laterite. The Canungra and Coomera valleys, of which the former has reached a fair degree of maturity, have been cut to levels about 1,500 feet below the plateau surface.

The laterite forms a superficial cover over the volcanics, and at the one place where a complete section can be studied passes to massive basalt from which it has been derived. Textures derived from the parent rock may be traced in the laterite up to the nodular and pisolitic zones.

Although it is probable that the lavas finally attained a virtually horizontal plane surface, it is noteworthy that the laterite does not occupy only the highest points on the plateau but may be found at elevations ranging from slightly over 1,800 feet to about 1,700 feet near Geissmann's quarry and West's Road (*see* Fig. 2).

From this observation it appears that lateritization continued for some time contemporaneously with slow erosion and that as the water-table was lowered the lateritic process continued at slightly lower levels.

Changed conditions brought a halt to laterite formation with the result that much of the laterite was stripped by continuing erosion to expose the underlying parent basalt.

Immature ferruginous laterite occurs at elevations both above and below that of the bauxite. Apparently the retreat of the water table was halted at an intermediate stage, permitting continuation of the lateritic process to an advanced stage while the immature laterite that had formed previously remained unaltered out of reach of fluctuations of the water table and stabilized by oxidizing conditions.

Further retreat of the water table permitted attack on the basalt down-slope from the bauxite with the formation of massive ferruginous immature laterite directly overlying basalt. Lowering of the water table continued too quickly for this process to reach completion.

Description of the Bauxite.

There is no good natural exposure of the bauxite, but a very complete section is revealed in Mr. B. R. Geissmann's quarry in Portion 82 on the western outskirts of North Tamborine village.

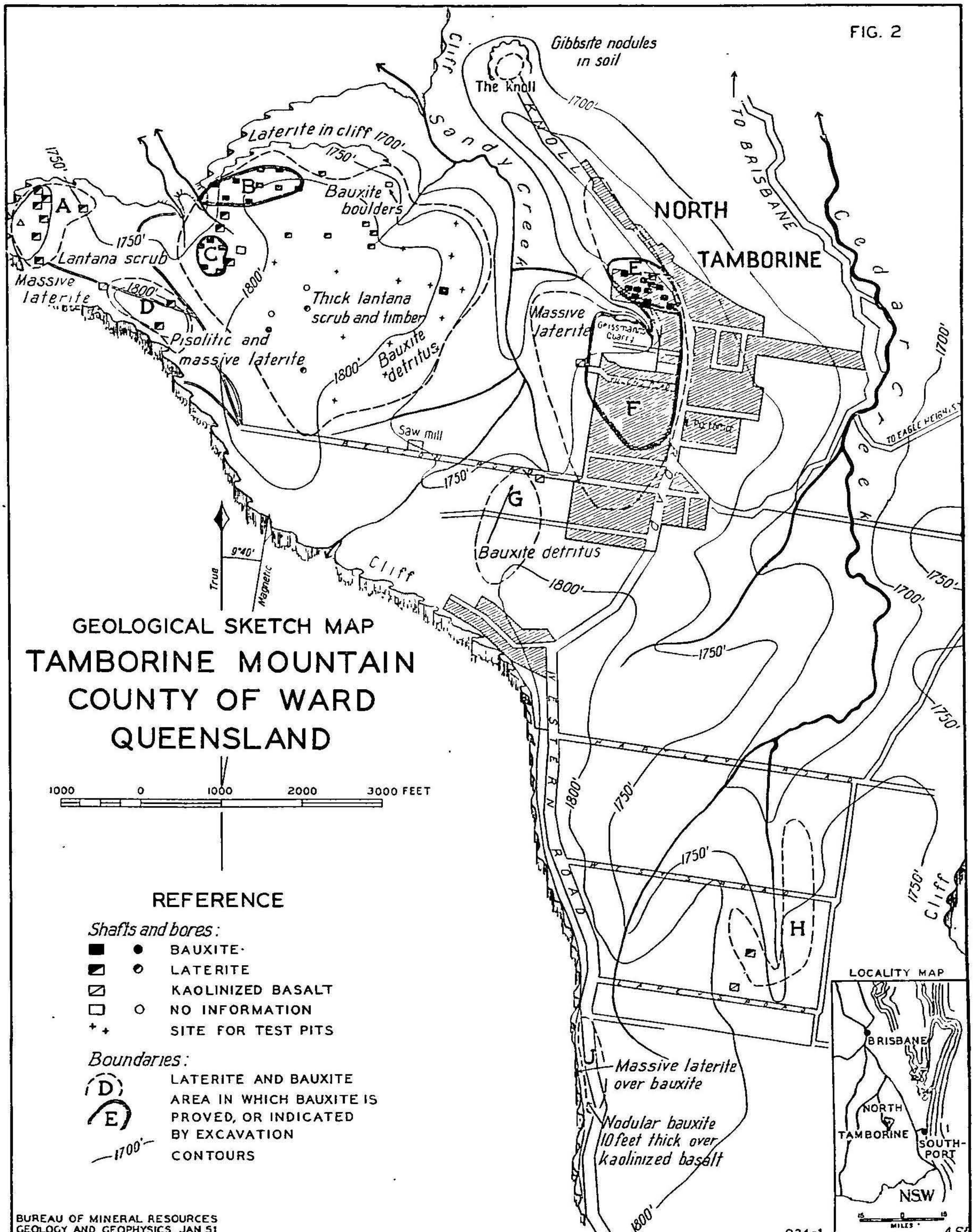
At its greatest depth the quarry face measures 27 feet from natural surface to floor.

A measured section, with chemical determinations reported by the Geological Survey of Queensland, is given below:—

SECTION—GEISSMANN'S QUARRY.

Depth in Feet.		Description.	Soda-soluble.		Total.	
From	To		SiO_2.	Al_2O_3.	Al_2O_3. (Average)	Fe_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.
0	2	Soil	..	..	..	..
2	4	Soil with ferruginous pisolites ..	..	..		..
4	8	Loose pisolites .. .. .. }	..	24	28	..
8	10	Coarse ferruginous nodules .. }				
10	21	Yellow and red nodular bauxite(1)	0.1 to 0.3	30 to 49	40	20 to 33
21	27	Yellow and red hard earthy bauxite	1.8	42	43	20

(1) Nodular bauxite — average soda-soluble Al_2O_3 = 37 per cent.



[To face page 18.]

The coarse ferruginous nodules are rounded and commonly measure 2 to 4 inches in diameter. Externally they may be stained with a greenish tinge which is more common in the pisolitic zone above, but internally they are uniformly dull brown and textureless and do not show concentric banding indicative of concretionary growth. With increase in iron content the fractured surface of the nodule shows the resinous lustre of limonite.

The nodular bauxite consists of irregular rounded masses of hard bauxite, up to several inches across, set in a loose earthy matrix. Near the top of this zone the nodules consist of dense dull brown cliachite containing blebs of white mineral, presumably gibbsite. These nodules contain cavities and tubes lined with small pisolites.

Most of the bauxite nodules have a finely granular texture internally and a poorly shown concentric banded structure developed about a central core that may be very friable and more ferruginous than the outer layers.

The lowest zone is composed of hard earthy bauxite divided by numerous horizontal partings that give the rock a false appearance of stratification. Closer examination shows that the bauxite has developed by concentric or onion-skin alteration initiated from joint planes. The concentric structures are elongate in section with the longer axis lying horizontally, and the closely stratified appearance of the rock as a whole is due to the accentuation of the horizontal portions of the partings between concentric shells. The earthy bauxite is markedly granular in texture and contains recognisable plagioclase phenocrysts replaced by gibbsite and round blebs of gibbsite(?) replacing glass in the parent basalt.

A patch of blue-grey clay occurs near the base of the earthy bauxite zone. This clay is a mixture of small pisolites, fragments of kaolinized basalt, and grains of waxy gibbsite or halloysite, in a matrix of bluish clay. On analysis at the Tasmanian Mines Department laboratory, Launceston, a sample of this blue-grey bauxite clay yielded 16.4 per cent. insoluble matter, 48.5 per cent. total alumina, 4.7 per cent. ferric oxide, 5.7 per cent. titania, 23.2 per cent. loss on ignition, and 39.0 per cent. soda-soluble alumina.

The clay is believed to be secondary in origin and developed along an underground drainage channel or sink-hole which can be traced upwards to the surface. Along the line of this channel the nodular zones have been destroyed and replaced by loose earth and pisolites.

The underlying basalt is exposed at one place in the quarry floor. It is a very dark grey medium-grained rock containing phenocrysts of glassy plagioclase and round blebs of black glass.

Reserves of Bauxite.

The accompanying plan (figure 2) shows areas on Tamborine in which laterite, whether bauxitic or not, is known to occur. The boundaries of these areas as shown are only approximate but serve as a guide in attempts to assess the maximum possible reserves.

Prospecting operations, carried out chiefly by Sulphates Limited during 1941, have defined certain areas of bauxite so that it is possible to state proved reserves with confidence, but the places tested total only a small proportion of the areas known to be occupied by laterite and in part by bauxite.

The areas shown on the plan by the letters A to J are discussed here.

Area A.—At the western extremity of the plateau, seven shafts were sunk by Sulphates Limited and revealed siliceous laterite averaging 6 feet in thickness. The best result was obtained from one of these shafts which was sunk to a depth of 32 feet and revealed 12 feet of laterite containing 28 per cent. total alumina. The work at this locality indicated a total of 38,000 tons containing 16.9 per cent. SiO_2, 23.3 per cent. Al_2O_3, and 27.8 per cent. Fe_2O_3.

Area B.—This area of about 8 acres occupies the north-western margin of a much larger area of laterite, which has been very incompletely tested on account of the thick lantana scrub. Sulphates Limited have estimated that Area B contains 288,000 tons of low-grade bauxite containing 6.8 per cent. SiO_2 and 35.3 per cent. Al_2O_3.

Area C.—A small patch of bauxite of similar grade to the above and occurring within the same large area of laterite was tested by a group of shafts sunk within an area of 3 acres. Reserves have been estimated at 144,000 tons containing 7.6 per cent. SiO_2 and 41.2 per cent. Al_2O_3.

Possible reserves of bauxite contained within the larger area of laterite which encloses A and C cannot be estimated. Bauxite has been observed outside the two small areas tested and significantly lies on or below the 1,800-ft. contour. The highest ground within the laterite area has been tested by a few bores which did not disclose bauxite.

Bauxite may occur over an area of about 30 acres between the 1,800-ft. and 1,750-ft. contours along the eastern and north-eastern margin of the laterite body.

Area D.—It is improbable that any significant quantity of bauxite occurs in this small area in which laterite outcrops for a distance of 1,000 feet along the track to the Beacon. Two shafts disclosed low-grade material only.

Area E.—This area is part of the large area of bauxite and laterite which lies to the west of North Tamborine village and in part underlies the village. Area E is nearly separated from the main body by Sandy Creek, which has cut its channel through the bauxite and into the underlying basalt.

Twelve shafts in an area of 3½ acres showed bauxite of fair quality ranging in thickness from 3 to 21 feet.

Reserves have been estimated at 41,000 tons containing 4.4 per cent. SiO_2 and 39.6 per cent. Al_2O_3.

Area F.—Extending south from Sandy Creek, this area includes Geissmann's quarry. Little prospecting has been done, but it is known that the bauxite in the quarry is at least 16 feet thick and that it continues to south of Yulong Road.

W. S. Curteis has estimated the bauxite in Area F at 115,000 tons, but further exposure in the quarry since his inspection and additional field evidence suggest that this estimate is very conservative and it is believed that the total volume of bauxite is not less than 900,000 tons.

The grade of ore in the quarry shows a considerable range vertically and it is certain that similar variations would be encountered elsewhere. In the absence of sampling shafts south of the quarry it must be assumed that the average grade of ore would be similar to that obtained from the quarry and in Area E.

The average grade of ore exposed in Geissmann's quarry, excluding ferruginous pisolitic material, is approximately—

Total.			Soda-soluble.	
SiO_2.	Al_2O_3.	Fe_2O_3.	SiO_2.	Al_2O_3
Per cent. 4	Per cent. 41	Per cent. 22	Per cent. 0.7	Per cent. 39

Area G.—Scattered bauxite detritus occurs south of Area F. No solid outcrop of bauxite or laterite was seen at this locality and it is not possible to make any estimation of the possible value of this area without boring or shaft-sinking. However, the prospects are not considered to be good.

Area H.—Bauxite of good quality outcrops in West's-road. This bauxite is reddish-brown in colour, very hard and nodular. Samples chipped from the outcrop have assayed over 50 per cent. Al_2O_3. No accurate estimate of tonnage can be made, but under the most favorable circumstances the total possible reserves are not likely to exceed 120,000 tons.

Area J.—Nodular bauxite overlies kaolinized basalt near the cliff top by the side of the western road at 1¾ miles south of North Tamborine. The deposit is very small and is not of commercial importance.

The following analyses of specimens collected by the writer from areas D and J have been carried out by the Chief Chemist and Metallurgist at the Mines Department Laboratory, Launceston, through the courtesy of the Director of Mines, Tasmania.

No.	1.	2.	3.
Area on Plan	D.	D.	J.
	Per cent.	Per cent.	Per cent.
Insoluble matter	11.0	2.3	2.8
Alumina, total	(*a*) 30.2	51.3	59.4
Alumina, soda-soluble	24.7	51.2	59.3
Ferric oxide	32.9	13.9	4.5
Titania	6.9	3.8	2.8
Ignition loss	17.2	27.1	29.5

(*a*) Extracted for three hours with boiling 10 per cent. NaOH solution at atmospheric pressure.

1. Dark red. clayey ferruginous laterite.
2. Light brown granular and finely tubular bauxite with yellowish gibbsite replacing felspar phenocrysts.
3. Gibbsite nodules from outcrop of nodular bauxite, western road.

TABLE 3.—TAMBORINE MOUNTAIN—SUMMARY OF BAUXITE RESERVES.

Area.	Reserves. Proved.	Reserves. Inferred.	SiO_2.	Al_2O_3.	Fe_2O_3.	Remarks.
	Tons.	Tons.	Per cent.	Per cent.	Per cent.	
A	..	..	16.9	23.3	27.8	No bauxite. 38,000 tons of siliceous laterite of composition indicated
B	288,000	..	6.8	35.3	27.3	Surrounding body of laterite might contain 70,000 tons of bauxite per vertical foot, lying to the east of Areas B and C
C	144,000	..	7.6	41.2	19.3	
D	..	..	..	..	..	Probably very small. Low grade laterite disclosed in two shafts
E	41,000	..	4.4	39.6	23.0	Soda-soluble SiO_2 about 0.7 per cent.
F	..	900,000	4.0	41.0	22.0	Soda-soluble Al_2O_3 about 39 per cent.
G	..	..	..	..	..	Probably small
H	..	Not more than 120,000	..	..	..	Specimens from outcrop contain more than 50 per cent. Al_2O_3
J	..	..	..	..	..	Probably very small

HAMPTON.

Nodular laterite containing both ferruginous and aluminous nodules occurs in Portions 215, 216, and 189, Parish of Geham, County of Aubigny, on the Toowoomba to Crow's Nest road 14 miles north of Toowoomba. It is well exposed in a railway cutting between Taylor and Mount Luke sidings, and in nearby shallower road cuttings and quarries.

Chip samples taken from the road quarries by Shepherd and Connah (1948) yielded on analysis by the Queensland Government Analyst—

Locality, Parish of Geham.	Alkali-soluble. SiO_2	Alkali-soluble. Al_2O_3.	Total SiO_2.	Total Fe as Fe_2O_3.
	Per cent.	Per cent.	Per cent.	Per cent.
Road cutting, Portion 216	3.6	34.0	4.6	28.8
Quarry, Portion 215	1.2	39.5	1.3	29.1
Quarry, Portion 215	1.1	42.0	1.1	24.5
Quarry, Portions 189 and 190	0.2	39.5	1.6	27.8

Channel samples taken by the writer from the railway cutting had the following composition:—

Approximate Depth below Natural Surface.	Description.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2	Ignition Loss.	Soda-soluble Al_2O_3.
Feet.		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0 – 3 ..	Soil and sub-soil ..	..	..	..	..	..	..
3 – 7 ..	Nodular ferruginous laterite	3.6	23.2	45.6	4.1	17.5	26.0
7 – 8.5 ..	Hard earthy laterite ..	3.1	31.7	39.6	5.9	18.1	30.0
8.5–10 ..	Inaccessible (bridge timbers)	..	..	..	..	..	..
10 –13 ..	Hard earthy laterite ..	1.3	40.9	29.2	4.4	23.0	40.0

Analyst: W. St. C. Manson, Department of Mines, Launceston, Tasmania.

The deposit occurs on the crest of the Dividing Range; it is limited to the north and west by outcropping basalt and in the opposite direction by steeply falling ground. In all probability bauxite of the grade indicated by sampling, i.e., 35 per cent. soda-soluble alumina, occupies an area of 17 acres excluding road and railway reserves, and the quantity therefore may amount to approximately 250,000 tons.

Other Localities.

Cabarlah.

A similar but larger occurrence of nodular laterite, which did not, however, present opportunities for sampling in depth, was examined by Shepherd and Connah in Portion 115, Parish of Geham, and the adjoining portion 291, Parish of Murphy. Samples chipped from the surface showed an average of 25 per cent. alkali-soluble alumina. Other local enrichments in alumina in the Parish of Geham were observed in Portions 299 (32.5 per cent.), 264 (39.5 per cent.), 432 (38.5 per cent.) and 449 (32.5 per cent.).

Toowoomba.

Reference has been made already to the nodular laterite exposed by quarries at Toowoomba, and it will suffice to add that visible reserves of this material, which is used by the civic authorities for road-making, amount to about 1,000,000 tons, containing 26 per cent. soda-soluble alumina.

At Hay Park on the west of the Divide 9 miles south of Toowoomba an isolated occurrence of laterite is capped with a few residual boulders of bauxite which contain 48 per cent. alkali-soluble alumina, and 19.2 per cent. ferric oxide.

Maryvale.

Laterite containing more than 30 per cent. alkali-soluble alumina occurs at Maryvale, on the road between Warwick and Cunningham's Gap. The locality is 44 miles south-south-east of Toowoomba and about 70 miles south-west of Brisbane. The deposit has been extensively quarried by the Main Roads Commission. Channel sampling of quarry faces by Shepherd and Connah in 1947 yielded the following results:—

Depth from Surface.	Alkali-soluble Al_2O_3.	Total SiO_2.	Total Fe as Fe_2O_3.
Feet.	Per cent.	Per cent.	Per cent.
0 - 3	32.0	3.0	27.3
3 - 8	30.5	2.3	30.6
8 -11.5	31.0	3.9	31.4
11.5-13	19.0	15.7	33.1

(Analyses by Queensland Government Analyst.)

Basalt exposed to east and west of the quarry appears to limit the deposit to an area of 7 acres.

Kingaroy.

More encouraging results obtained by Shepherd and Connah (1947, pages 163-167) in the vicinity of Kingaroy led to thorough testing in this area by the Aluminium Commission during the latter part of 1947; although the final results were disappointing they are of considerable interest and are treated here in some detail.

Sampling by Shepherd and Connah was necessarily confined to surface outcrops or, at best, exposures in shallow excavations such as minor road cuttings and drains. The samples taken were either from selected gibbsitic nodules or were representative of the restricted exposures available. Analyses of both types of samples taken from laterite outcrops in the vicinity of Kingaroy by the Queensland geologists and analysed by the Queensland Government Analyst are quoted:—

No	Remarks.	Alkali-soluble.[1]		Total.	
		SiO_2	Al_2C_3.	SiO_2	Al_2O_3.
		Per cent.	Per cent.	Per cent.	Per cent.
386/GS	Channel cut from outcrop in Portion 322, Wooroolin	2.1	15.0	..	..
387/GS	Selected from nodules, same outcrop as 386/GS	2.6	45.7	5.6	46.9
389/GS	Average sample from outcrop in Portion 239v, Wooroolin	3.4	23.7	17.3	36.9
390/GS	Selected from nodules same outcrop as 389/GS	2.0	47.0	4.3	50.0
395/GS	Chipped from boulders, Portion 194v, Wooroolin	2.8	23.4	13.2	36.0
398/GS	Selected nodules, Portion 196v, adjoining 194v, Wooroolin	2.5	56.0	5.6	59.7
400/GS	Channel cut from quarry adjoining Portion 141v, Booie ..	3.5	32.3	23.5	35.6
401/GS	Channel cut from quarry adjoining Portion 141v, Booie ..	3.7	11.9	..	..
402/GS	Channel cut from quarry adjoining Portion 141v, Booie	5.3	15.5	..	..
406/GS	Average sample, Portion 97v, Coolabunia	3.3	24.9	15.8	37.3

(1) Alkali-soluble determinations by digestion with NaOH solution of S.G. 1.45 at pressure of 5 atmos for 30 minutes.

This sampling of laterite outcrops near Kingaroy suggested that the average composition of the less ferruginous laterite is approximately 13 per cent. SiO_2, 39 per cent. Al_2O_3, 22 per cent. Fe_2O_3, with 32 per cent. alkali-soluble Al_2O_3 and 3 per cent. alkali-soluble SiO_2.

During August to October, 1947, the Aluminium Commission examined six areas in the vicinity of Kingaroy by shaft-sinking and churn drilling. Owing to the unfavorable results in this locality other areas mentioned by Shepherd and Connah were not explored by sub-surface methods.

The results of the Commission's operations are not without interest and therefore a brief description of the locality and of one of the laterite bodies tested is given.

Kingaroy is 145 miles north-west of Brisbane by road via Ipswich and Esk, and lies in the Parish of Wooroolin, County of Fitzroy, within the South Burnett District.

The area is one of moderate relief with laterite-capped hills, generally flat-topped ridges, rising to about 300 to 400 feet above the general level of the undulating plain. The town of Kingaroy lies at a low level in the plain and has an elevation at the railway station of 1,417 feet above sea level. The gently rounded surfaces of the laterite ridges lying to the north-north-east and south-east of the town from 2 to 4 miles distant have an elevation of 1,900 to 1,950 feet.

The area is drained by the Stuart River, flowing north-north-west, and by Barker's Creek, which flows in a generally north-north-easterly direction. The discontinuous laterite ridges to the east of Kingaroy divide the two drainage systems.

The plains and lower slopes are covered with red basaltic soil of considerable agricultural value, and the higher ground is occupied by massive laterite, poor soil derived from the laterite, or basalt completely kaolinized.

No beds younger than the laterite were encountered, but in one example 6 miles east from Kingaroy a thin bed of laterite with relict basaltic texture at the base overlies quartzite which may be of Triassic age.

There is no direct evidence therefore from which the age of the laterite may be determined, but as the laterite continues southward through Toowoomba to at least as far south as Maryvale, it may very reasonably be correlated with the laterite of the Emmaville and Inverell areas, New South Wales, which is known to be older than Pliocene.

The areas in the County of Fitzroy which were tested are—

1. Portions 194v, 195v, 196v, Parish of Wooroolin.
2. Portions 207v, Wooroolin, and 157v, Booie.
3. Portion 144v, Kunioon.
4. Portion 237, Kunioon.
5. Road adjoining Portion 238v, Wooroolin.
6. Road adjoining Portion 29v, Coolabunia.

Three other occurrences were examined but were not tested by sinking.

As the deposits are very similar in character and none is of commercial importance only the first of the six listed is described here.

Portions 194v to 196v, Wooroolin, lie about 4 miles north of Kingaroy and are bounded to the west, north, and east by roads. The eastern edge of Portion 194v and 195v is also the boundary between the parishes of Wooroolin and Booie.

The parish boundary runs along the flattened crest of a ridge which has a width from east to west of a few hundred feet to about half a mile and an elevation of about 1,950 feet above sea level. The ridge is bounded on the east by a vertical scarp approximately 20 feet high which crowns a steep unbroken slope falling two or three hundred feet. On the west, however, the scarp-like edge of the laterite is shallow, about 10 feet to the top of the talus slope, and from its foot the ground surface falls to the west in a comparatively gentle stepped slope.

The laterite dips gently to the west and is also divided into fault blocks stepped down to the west.

Sixteen shafts were sunk on the crest of the ridge within an area of 150,000 square yards in Portion 194v, two bores and four shafts were put down in Portion 195v which adjoins to the south, and two shafts and three bores were sunk in Portion 196v on a down-faulted block of laterite about ½ mile west of the area tested on the crest of the ridge. The depths sampled by the sixteen shafts in Portion 194v ranged from 14 feet to 40 feet and 119 channel samples were despatched to the laboratory for examination.

Of the 119 samples only eight contained available Al_2O_3 in excess of 30 per cent., the highest figure being 32.9 per cent., and twenty samples yielded available Al_2O_3 between 25 and 30 per cent.

Logs of two shafts, the first sunk near the crest of the ridge and the second from near the western scarp, with field descriptions of the samples and laboratory results, are given.

Depth in Feet.	Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
3– 6	Compact red laterite	..	..	..	..	13.3	..
6–11	Compact red laterite with white patches	..	..	..	..	17.4	..
11–16	Compact red laterite	..	..	..	..	18.4	..
16–21	Compact red laterite with bluish-white patches	7.3	34.7	33.6	6.0	19.0	26.9
21–26	Compact red laterite with light-coloured nodules	9.1	36.9	28.5	5.3	20.1	29.6
26–30	Red clay	..	..	..	..	16.7	..
4– 8	Red laterite with red bauxite nodules ..	7.6	32.6	32.5	5.3	19.3	25.7
8–12	Red laterite	9.4	37.8	26.7	4.9	20.6	29.1
12–16	Red laterite with whitish patches ..	..	..	..	..	17.3	..
16–28	Red laterite with whitish patches ..	Average of 3 samples				15.4	..
28–31	Red laterite with whitish patches with clay	..	..	..	..	15.7	..

Results obtained at the other areas examined were very similar. From the second area mentioned, Portions 207v and 157v, Wooroolin and Booie, of a total of 140 samples only twelve contained more than 30 per cent. available alumina.

It was concluded that although zones enriched in alumina do occur within the laterite, no bodies of commercial bauxite are likely to be developed. The aluminous zones are not rich enough, large enough, or of sufficiently regular distribution, to be regarded as potential ore reserves. Also the laterite does not contain a sufficiently high proportion of aluminous nodules to warrant a process of concentration by washing or other means.

In outcrop the laterite is a dark-brown moderately hard rock containing rounded and irregular nodules of lighter colour which give the rock a pseudo-fragmental appearance. Where the outcrop forms a vertical scarp presenting a face 8 to 10 feet high for inspection, little variation in appearance may be seen but a relict basaltic texture may be discerned at a few places near the base immediately above kaolinized basalt into which the laterite passes.

No pisolitic or tubular and massive laterite characteristic of the ferruginous zones occurs, nor did the material penetrated in the shafts generally possess the hardness noted in the outcrops. The less soft patches of laterite encountered usually had a somewhat higher alumina content than average.

The laterite recovered from below the surface consisted essentially of textureless red clay-like material containing sparsely distributed hard nodules occurring in horizontal bands. Much of this red earth, after short exposure at the surface, broke into small angular fragments—commonly tetrahedral forms with slightly concave faces—and finally crumbled to powder.

The absence of the normal concretionary capping, the high iron content, and the poor development of aluminous enrichments, suggest that the process of laterization was halted at an intermediate stage. Much of the silica is present as residual clay and not as secondary kaolin formed during resilication of the laterite, of which process there is no evidence.

Atherton Tableland.

During September, 1947, A. K. Denmead and J. E. Ridgway, geologists of the Queensland Geological Survey, examined an area inland from Cairns of approximately 1,500 square miles between Kuranda in the north and Tully Falls in the south.

The following is quoted verbatim from the report made by these officers to the Chief Government Geologist (Denmead and Ridgway, 1947) :—

> "The search proved disappointing, as on investigation no laterization was found to have taken place at the present surface level. Eight samples were taken. Actually the best of them yielded only 14.4 per cent. free alumina. We are of opinion that the district offers no inducement for further examination or testing. The geological features of the region are relatively simple. The basement rocks are of three kinds—rhyolite, granite and schist. The first-named rock is found in the south-eastern portion of the region while the schist and invading granites occur in the northern and eastern parts. Basalt forms a discontinuous cover over all three types of basement rock. The base of the basalt was found at many levels indicating a surface of considerable relief at the time of the lava outporing. In places water-sorted tuffs and/or sediments, at the base of the basalt, point to the former existence of small lakes. It was in the water-sorted tuffs and associated thin lava flows at the *base* of the basalt that evidence of laterization was found and most of our samples came from this source."

Cape York Peninsula.

Pisolitic ironstone of lateritic origin and occurring discontinuously for a distance of 150 miles along and near the north-west coast of Cape York Peninsula is mentioned by Jackson (1902), who expressed the opinion that detailed examination of the occurrences might reveal commercially valuable deposits of iron-ore, and, presumably, bauxite, which he mentions in another context. Some confirmation of his opinion is afforded by the following partial analysis of a specimen from Pera Head (Lat. 13° 00′S., Long. 141° 40′E.), which was submitted to analysis by the Geological Survey of Queensland in 1949[1] :—

	Per cent.
Alkali-soluble alumina	38.8
Total iron as ferric oxide	22.9

New South Wales.

INTRODUCTION.

The first reference to bauxite in New South Wales was made by J. B. Jaquet (1899) who pointed out that the pisolitic ironstone in the vicinity of Wingello contained sufficient free alumina to be regarded as bauxite. However, earlier references to pisolitic ironstone were made by C. S. Wilkinson (1875) and T. W. E. David (1887) both of whom observed the ferruginous laterite on the New England tin-fields. In 1899, J. B. Jaquet identified bauxite from Wingello and later described the deposits and published analyses (1901). J. E. Carne (1911), discussing the concretionary ironstone near Inverell, expressed the view that the free alumina content was too low to permit classification of the laterite as bauxite.

During 1920-22 L. F. Harper noted additional deposits of ferruginous bauxite near Wingello, and compared the ore with the low-grade bauxite of Antrim, Northern Ireland (Harper 1921, 1924).

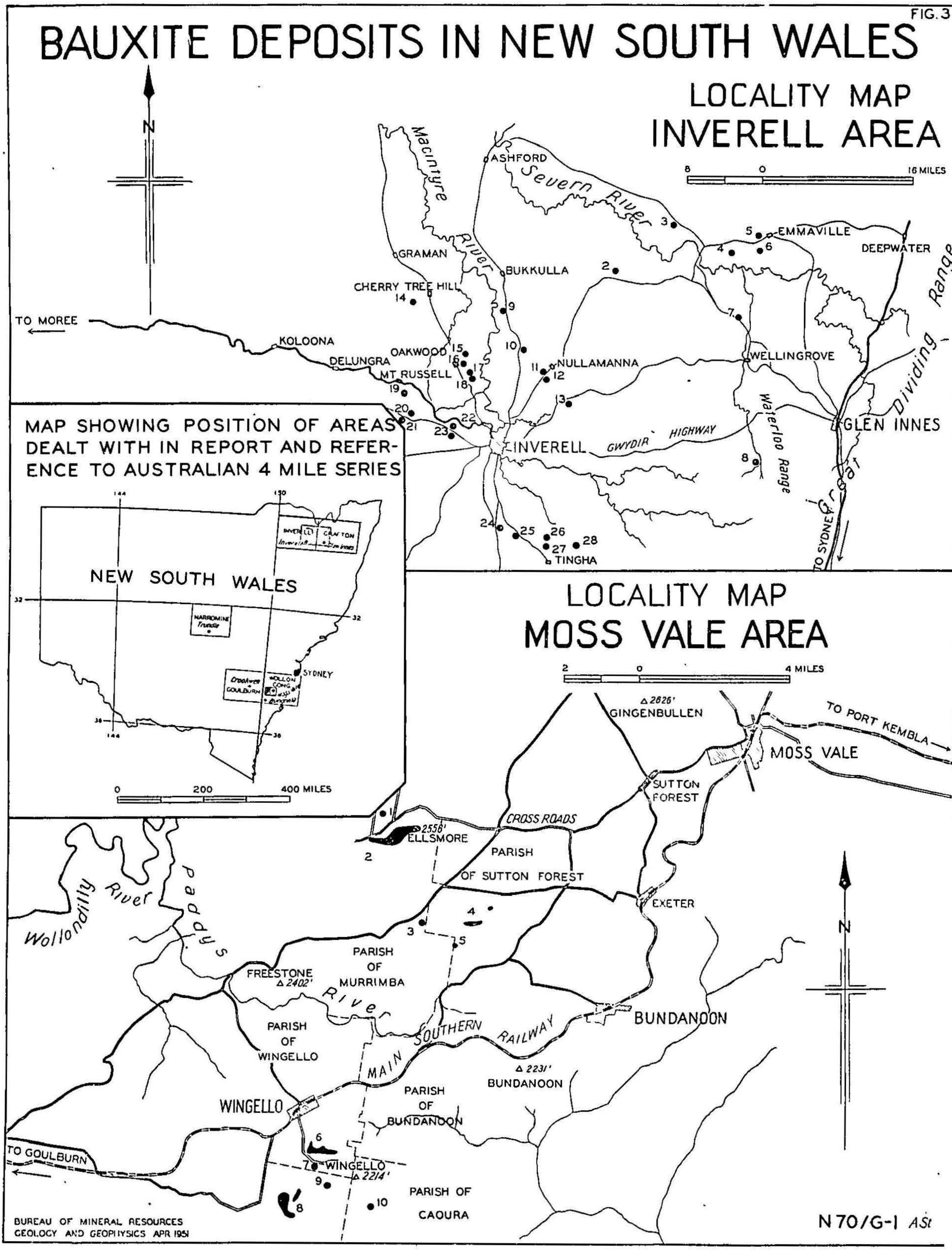
In 1939 H. G. Raggatt undertook a survey of the ferruginous bauxites of the Moss Vale district, which includes Wingello. The results of this survey were embodied in an unpublished report to the Government Geologist (Raggatt, 1939).

During 1940 Raggatt began a similar survey of the bauxites of the Inverell area (Tingha-Inverell-Emmaville), and this survey was completed in 1941 by F. W. Booker and F. N. Hanlon (1944).

These two reports have been freely consulted by the writer of this Bulletin who found them of great value and who has included much information from them in this present work.

In January, 1947, the Aluminium Commission began sub-surface testing by shaft-sinking on a small bauxite occurrence near the village of Oakwood, 12 miles north-west from Inverell. This work was extended to include other nearby, but previously unreported, deposits and more distant localities near Nullamanna and Emmaville. The work resulted in the discovery and proving of the largest single body of bauxite known in Australia, a discovery since eclipsed in alumina content though not in gross tonnage by Able deposit on Marchinbar Island, Northern Territory.

(1) Private communication.



[To face page 29.]

In June, 1948, operations were transferred to Wingello, 100 miles south-west of Sydney, where sampling of the original deposit described by Jaquet in 1899 was conducted. During the early part of 1949 another group of deposits in the Moss Vale area was tested. Much of the work carried out on behalf of the Aluminium Commission covered ground already examined by the State authorities and it was noted that tonnage estimates were, in many instances, in fairly wide disagreement. These discrepancies are explained by the fact that strict comparison between the two investigations is not possible. Different methods of analysis of the samples were used, and much material included as bauxite in the reserves estimated by officers of the Geological Survey failed to reach the minimum grade of economic bauxite as defined at a later date by the Aluminium Commission, and therefore was excluded. The sinking of many shafts and bores in addition to those which had been available to the earlier workers yielded a wealth of detail and permitted more accurate definition of the boundaries of orebodies than had been possible before.

Accessibility.—The bauxite deposits of both the Inverell and the Moss Vale areas are readily accessible by road and all lie within comparatively short distances of railways. Unfortunately the Inverell deposits lie at a great distance by rail from Newcastle, which is the nearest sea port.

Road and rail haulages involved in getting bauxite from the deposits to a port are shown below. The numbers correspond with those given on the locality plans.

Area and Deposit	Road Haul to Railway at—		Rail Haul to—	
Inverell area—				
No. 1.—Emmaville	Deepwater	19 miles	Newcastle	349 miles
No. 2.—Campbell	Inverell	9 miles	Newcastle	412 miles(1)
No. 3.—Champagne	Byron	9 miles	Newcastle	406 miles(2)
No. 4.—Lockwood's	Byron	9 miles	Newcastle	406 miles (2)
No. 5.—Parish's	Byron	6–7 miles	Newcastle	406 miles(2)
Moss Vale area—				
No. 2.—Ellsmore	Moss Vale	12 miles	Port Kembla	47 miles
No. 4.—Sutton Forest	Exeter	6 miles	Port Kembla	55 miles
No. 5.—Murrimba	Exeter	7 miles	Port Kembla	55 miles
No. 6.—Wingello	Wingello	2 miles	Port Kembla	66½ miles

NOTE.—These distances will be reduced by approximately (1) 44 and (2) 32 miles if the rail link between Inverell and Glen Innes is completed.

THE INVERELL AREA.

As used in this Bulletin the term "Inverell area" embraces the whole area shown on the accompanying locality map (Figure 3), which includes Glen Innes, Emmaville and Tingha. The area has been searched systematically for bauxite deposits, and numerous occurrences, both large and small, not previously reported have been found and examined.

A summary of the reserves proved in the area is given in the following table in which the numbers allotted to the deposits accord with those on the locality plan.

TABLE 4.—INVERELL AREA.

No. on Locality Plan. *See* Fig. 3.	Locality.	Reserves.	Composition.					
			SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O. Loss.
		Tons.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
1	Lorne	1,420,000 (*b*)	5.2	..	26.3	..	40.3	..
3	Astley	2,280,000 (*b*)	4.0	39.2	31.0	..	..	..
4	Strathbogie ..	1,480,000 (*a*)(*c*)	3.3	40.8	31.1	3.9	34.7	0.88
		1,300,000 (*c*)	4.4	39.0	31.0	3.6	34.7	0.89
5	Emmaville Common	985,000 (*b*)	6.6	35.7	..	..	..	..
6	Scone	800,000 (*b*)	3.8	38.6	31.1	4.1	33.2	..
10	Burgundy ..	65,000 (*c*)	2.8	36.9	30.8	5.1	34.2	0.94
12	Campbell ..	650,000 (*a*)(*c*)	2.9	39.4	29.3	4.4	36.1	0.77
14	Cherrytree Hill ..	160,000 (*c*)	2.7	40.0	29.0	3.6	36.4	0.79
15	Champagne ..	740,000 (*a*)(*c*)	3.6	38.8	29.5	5.0	34.0	1.04
17	Lockwood's ..	140,000 (*a*)(*c*)	3.1	38.5	29.1	5.8	34.9	0.80
18	Parish's (Byron) ..	4,755,000 (*a*)(*c*)	3.2	38.6	30.1	5.0	33.7	1.00
22	Wade's	110,000 (*c*)	5.8	39.5	28.0	..	33.1	1.4
25	Clive	160,000 (*b*)	5.0	42.9	29.5	2.2	35.2	..
26	Herbert	65,000 (*d*)	4.7	42.0	30.0	2.3	..	..
27	Swinton	50,000 (*d*)	3.6	40.4	32.8	..	31.7(*e*)	..
28	Topper's Mountain	200,000 (*d*)	4.7	39.5	30.3	..	..	..
	Total ..	15,360,000	..	..	..	..	..	..

(*a*) Held by Australian Aluminium Production Commission.
(*b*) Tonnage estimated by Geological Survey of New South Wales
(*c*) Tonnage estimated by writer from original field work.
(*d*) Tonnage estimated by writer from results and plans of Geological Survey of New South Wales.
(*e*) Al_2O_3 soluble in 10 per cent. NaOH solution boiling at atmospheric pressure.

GENERAL GEOLOGY.

The crest of the Great Dividing Range crosses the south-east corner of the area shown on the locality map (Figure 3), where the range attains elevations of 4,800 feet in the south and 3,600 feet on the eastern margin of the map.

From the Waterloo Range the general level of the surface, which has considerable relief, falls from 4,000 feet to the valley of the MacIntyre River, which has an elevation of 1,900 feet at Inverell. West of the MacIntyre the surface has less relief but remnants of a basalt sheet form flat-topped hills rising about 150 to 200 feet. Most residuals of laterite and bauxite are low inconspicuous hills, partly flanked by low steep scarps and commonly standing at 30 feet or so above the local level.

The area is drained by the MacIntyre and Severn Rivers which join in the vicinity of Ashford and flow north-westerly to the Dumaresq River.

The greater part of the area of the locality map is occupied by pre-Tertiary rocks which have little bearing on the development of laterite on the early Tertiary basaltic lavas.

Stratigraphy.

The stratigraphical units present are—

Quaternary—	
Recent and Pleistocene ..	Alluvium, lacustrine deposits; gravel, sand, silt, clay.
Tertiary—	
Pliocene(?)	Basalt.
Lower Pliocene(?) ..	Clay, sand, loosely consolidated gravel. Lignite, lignitic clay. Basalt. Quartz gravels.
Pre-Pliocene Eocene(?) to Oligocene	Laterite and bauxite. Basalt (older basalt). Gravels (New England deep leads).
	Intrusive: Keratophyre.
Palaeozoic—	
Late Permian	Intrusive: Granite.
Permian	Conglomerate and coarse felspathic sandstone. Ashford Coal Measures: conglomerate, sandstone, shale and coal.
Carboniferous(?) ..	Intrusive: granite, porphyry, basic dyke rocks.
Lower Carboniferous ..	Quartzite, siltstone, claystone, chert, tuff.

Only brief reference to the pre-Tertiary units will be made.

Lower Carboniferous Sediments.

The oldest rocks in the area are the sharply folded and faulted Lower Carboniferous sediments. The strike of these beds is for the most part between 320° and 40° and dips range from nearly horizontal to vertical within short distances. Near Byron fairly consistent westerly dips at angles 40°–45° were observed.

The rocks are very silicified in most places, but at Inverell thick claystone beds are quarried for brickmaking.

Carboniferous(?) Granite.

Biotite granite, intrusive into the Lower Carboniferous beds, outcrops near Arthur's Seat (27 miles north of Inverell) and north of Ashford. Its exact age cannot be determined as its juxtaposition with the Permian Coal Measures at Ashford is the result of faulting and it is possible that it post-dates them.

Permian Coal Measures.

Permian terrestrial sediments occur intermittently from Arrawatta (10 miles north of Inverell) to Bonshaw, which is north of Ashford beyond the limits of the locality map. The beds consist of coarse to fine blue-grey breccia or conglomerate, sandstone, blue-grey grit, grey and black carbonaceous shale, and coal seams. The basal beds at Arthur's Seat consist of fairly coarse conglomerate. A coal seam reported to be 10 feet thick and dipping westerly at 55° to 60° is known in the bed of the MacIntyre River at Arrawatta and useful reserves of medium-volatile bituminous coal have been proved at 8 miles north of Ashford (Owen and Burton, 1954).

Late Permian Granite.

A very acid granite of late Palaeozoic age occupies large areas of the New England district and outcrops in close proximity to basaltic laterites at Emmaville and Tingha.

Tertiary; pre-Pliocene: Gravels.

Tin-bearing gravels derived from the late Palaeozoic granite and differentiates constitute the famous New England deep leads which have been extensively mined at Emmaville, Tingha, and elsewhere in the region.

Basalt.

Extensive vulcanicity continued intermittently through a great part of the Tertiary Period. The earliest flows, which are probably of Oligocene age, flooded a topography of considerable relief, covering the important deep-lead system and leaving eminences of resistant Lower Carboniferous sediments standing above the lava fields. The maximum thickness of the older basaltic flows is unknown but the greatest observed thickness is beneath the Champagne deposit where an incomplete section reveals about 100 feet.

The basalt is a fine-textured dark-coloured rock containing olivine. Two specimens of fresh basalt from beneath bauxite were analysed with the following results:—

—	1.	2
	Per cent.	Per cent.
SiO_2 ..	45.6	41.5
Al_2O_3 ..	14.8	13.8
Total Fe as FeO	10.5	18.7
TiO_2 ..	1.9	2.54
MgO ..	7.8	10.1
CaO ..	9.5	8.5
K_2O ..	1.54	1.54
Na_2O ..	2.81	2.39
P_2O_5 ..	0.37	0.55
Ignition loss	2.4	1.28

1 Parish's depcsit. 2. Champagne depcsit

Laterite and Bauxite.

Near Inverell the laterite and bauxite occur on an interbasaltic horizon in striking resemblance to the Antrim laterites of Northern Ireland which have been described recently by V. A. Eyles (1952, page 4). Severe erosion has taken place since the extrusion of the post-laterite (Pliocene) basalts and only small remnants are left covering parts of Champagne, Lockwood's, Parish's, and Swanbrook deposits. In some places, e.g., at Swanbrook deposit, near Bukkulla, and near the MacIntyre River at Byron, thin beds of gravel, sand, and clay accumulated on the laterite surface before the outflow of the younger lavas. Similar thin beds, including lignite at Byron, are interbedded with flows of the Pliocene basalt.

The laterite (including bauxite), which is described in considerable detail later, occurs as a horizontal sheet resting upon the older basalt from which it is derived. The usual pisolitic capping is extremely well developed at Emmaville and is present near Tingha, but is absent from the deposits in most other parts of the region. Lower Carboniferous rocks that have been lateritized are exposed in the river bed at Byron.

Pliocene: Basalt Flows and Interbedded Sediments.

The younger basalt mentioned above, the basal flows of which are probably lower Pliocene in age, rests directly on bauxite in many localities and partially fills the valleys between bauxite deposits in the vicinity of Oakwood. It is apparent that the bauxite in this locality had suffered considerable erosion before the outpouring of the early flows of the younger basalt; recemented laterite near Oakwood has been covered by the basalt. After the first period of vulcanicity in the Pliocene Epoch a small accumulation of paludal and fluviatile sediments, including lignitic clay, lignite, sand, and gravel, formed at low levels on the surface of the lava field. These sediments, which are probably of lower Pliocene age, were in turn covered by basalt.

The following section was revealed by boring and pit-sinking on the western bank of the MacIntyre River at Byron, 6 miles north of Inverell.

No. 1 BORE, BYRON.

Depth in Feet.		—
From—	To—	
0	1	Black soil
1	8	Black and grey clay (weathered basalt)
8	14	Sandy clay
14	20	Cemented gravel with lenses of sandy clay
20	27	Lignitic clay
27	30	Lignitic clay finely bedded
30	31.5	Grey clay
31.5	35	Altered vesicular basalt

Samples of the lignitic clay were found to contain fragments of diatoms and the age was tentatively determined as Pliocene, probably lower Pliocene (I. Crespin, private communication).

Lateritized older basalt, not penetrated in the bore, outcrops in the river bed within a few hundred feet north-east of the bore and at an elevation approximately 20 feet lower than the bore collar.

The basalt in which the bore bottomed was described by W. B. Dallwitz as an altered vesicular basalt in which the network of small plagioclase laths is well shown. These laths commonly contain light-green serpentinous material. The vesicles contain calcite, probably after zeolite minerals.

Structure.

Pre-Tertiary structure, which has been touched on above, will not be described further, as it has little or no bearing on the attitude of the bauxite deposits except insofar as it controlled the topography which limited the spread of the parental basalt.

The laterite occurrences are horizontal or gently tilted sheets of great lateral extent compared to thickness. The under surface may be slightly irregular and is a reflection of the low relief of the surface on which the laterite formed (*see* Sections: Plates 2, 3, 4, and 6).

Internal structure is dealt with in the section on Constitution and Origin.

Deposits are bounded by erosion scarps or may (uncommonly at Inverell) thin out against rising bedrock. Some deposits are bounded by small-scale faults; small step-faults along the eastern edge of Parish's deposit have carried the laterite surface down to the bed of the MacIntyre River, a total drop of approximately 100 feet in a distance of 1.6 miles. Minor faults cross the surface of many of the deposits and have served as loci for erosion. Such faulting undoubtedly caused breaking up and consequent erosion of large areas of laterite.

Geological History.

The older basalts were poured out in sufficient volume to produce wide lava fields of low relief interrupted by hills and ridges of Lower Carboniferous rocks which remained above the levels of the lava plains. Shortly after the conclusion of this early Tertiary vulcanism lateritic attack on the basalts began and continued until a mature laterite profile had developed. This development represents a considerable lapse of time and the lateritization probably continued into Miocene time, when it was terminated by uplift, block-faulting with only minor differential movement, and the consequent introduction of a new cycle of erosion. The attack on the soft but chemically inert laterite stripped off the pisolitic zone in the vicinity of Inverell, and deposited "secondary" laterite containing broken pisolites in stream channels at, to name two places, McCosker's and Parish's deposits. Loosely coherent quartz gravels were deposited on the laterite in places.

Volcanic activity in lower Pliocene time flooded the area in the vicinity of Inverell with basalt which covered and protected from further erosion the remnants of laterite and bauxite. During a lull in the volcanic activity stable detrital material, mainly quartz gravel and sand, and some clay, accumulated in low-lying areas of the new lava field. Also vegetation sufficient to provide a thin seam of lignite became established, probably in swamps where siliceous waters favoured the growth of diatoms.

Renewed vulcanism buried the new surface under about 100 feet of successive flows, but since then severe erosion has stripped off most of the younger volcanics, re-exposing the laterite and large areas of the older basalt.

DESCRIPTION OF DEPOSITS—INVERELL AREA.

No. 1 Area, Lorne.

This deposit lies in Portions 29, 31, 32, 37, 36, and 34, Parish of Lorne, and Portion 11, Parish of Lockerby, County of Arrawatta, in a rather inaccessible locality 45 miles by road from Deepwater.

The bauxite-bearing areas are held under lease by the Broken Hill Pty. Co. Limited.

The deposit forms three flat-topped hills capped with pisolitic and tubular laterite.

Results from the sampling of five shafts enabled the Geological Survey of New South Wales to estimate 1,420,000 tons of reserves containing material ranging in composition from 20.6 per cent. SiO_2 and 30.8 per cent. free Al_2O_3, to 5.36 per cent. SiO_2 and 45.1 per cent. free Al_2O_3, and 0.70 per cent. SiO_2 and 39.3 per cent. free Al_2O_3, and averaging about 5.2 per cent. SiO_2, 40.3 per cent. free Al_2O_3, and 26.3 per cent. Fe_2O_3.

No. 2 Area, Pindaroi.

Pindaroi Station homestead lies between Inverell and Emmaville, on the main road connecting the two places, and is about 26 miles north-north-east from Inverell and 18 miles from Emmaville.

The bauxite deposit, which was inspected by the writer on 1st January, 1947, consists of a capping of laterite on the summit of a small isolated flat-topped hill. It is situated about two miles east of the homestead in the north-east corner of the Parish of Pindaroi, County of Arrawatta.

The possible reserves are very small and are estimated at about 25,000 tons of laterite, which was not sampled. It was considered that the deposit is too small to justify the work necessary for sub-surface sampling.

No. 3 Area, Astley.

This deposit comprises eight separate flat-topped hills, capped with bauxite, lying in Portions 1, 2, 5, 6, 11, and 31, Parish of Astley, County of Arrawatta. Deepwater, 28 miles east from the deposits, is the nearest point on rail, and the distance to Inverell by road is about 39 miles.

The Broken Hill Pty. Co. Limited holds mining leases in Portions 1, 2, 11, and 31, which include the greater part of the deposits.

Reserves have been estimated by the Geological Survey of New South Wales from the results from seven shafts sunk in five of the bauxite bodies.

Analyses of samples showed compositions ranging from 1.66 per cent. SiO_2. 45.4 per cent. Al_2O_3, to 17.1 per cent. SiO_2, 30.2 per cent. Al_2O_3, and it is estimated that the total reserves amount to 1,780,000 tons containing 4 per cent. SiO_2, 39.2 per cent. Al_2O_3, and 31 per cent. Fe_2O_3, in addition to 500,000 tons of unknown composition.

Using the rather meagre information available the writer considers that the whole deposit may contain a total of 1,060,000 tons of economic bauxite of which 640,000 tons is alienated.

No. 4 Area, Parishes of Strathbogie and Scone.

Summary.

A group of four laterite deposits occurs in Portions 514, 513, 512, and 516, Parish of Scone, and Portions 700, 699, 703, 704, 38, 29, 35, 694, and 702, Parish of Strathbogie, all in the County of Gough.

The Broken Hill Pty. Co. Ltd. holds mining leases over the greater part of the laterite lying in Portions 512 and 516, Scone, and Portion 38, Strathbogie, and the Aluminium Commission has secured titles covering all significant parts of the remaining laterite areas.

The four deposits are marked "A", "B", "C" and "D" on the accompanying plan (Plate 1).

The whole of Deposit A is enclosed by B.H.P. leases Nos. 565, 3109, and 3114. Deposits B and C, except for the extreme northern end of the former, are held by the Aluminium Commission. Deposit D is small and has not been taken up.

Sub-surface prospecting was conducted by shaft-sinking, and in all 24 shafts were sunk on the areas and fifteen existing shafts were re-sampled. Of these shafts four were put down on B.H.P. ground and three old shafts within the company's leases were re-sampled. Three new shafts and four old ones in ground outside the B.H.P. and Commission holdings were also sampled. All the remaining shafts were sunk on areas that had been taken up on behalf of the Commission.

The results of this prospecting are summarized in Table 5:—

TABLE 5.—No. 4 AREA BAUXITE DEPOSITS (EMMAVILLE).

Deposit. *See* Plates 1 and 2.	Approximate Area.	Number of Shafts giving Positive Results.	Bauxite.							Overburden.
			Long Tons.	SiO_2.	Al_2O_3.	Fe_2O_3	TiO_2.	Available Al_2O_3.	Soda Loss.	
	Acres.			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
A ..	54	5	1,300,000	4.4	39.0	31.0	3.6	34.7	0.89	620,000
B ..	30	8	880,000	3.2	40.0	30.9	3.9	35.4	0.91	534,000
C ..	25	6	710,000	3.3	41.7	30.9	4.1	34.0	0.83	420,000
D ..	4	1	100,000	5.3	38.6	31.2	3.9	33.8	1.04	18,000
Total	..	..	2,990,000	3.8	40.0	31.0	3.8	34.8	0.90	1,592,000
RESERVES UNDER CONTROL OF AUSTRALIAN ALUMINIUM PRODUCTION COMMISSION.										
B ..	25.5	8	770,000	3.3	40.0	31.2	3.8	35.3	0.93	490,000
C ..	25	6	710,000	3.3	41.7	30.9	4.1	34.0	0.83	420,000
Total	..	..	1,480,000	3.3	40.8	31.1	3.9	34.7	0.88	910,000

Description of Deposit A.

Three leases numbered 565, 3109, and 3114, held by the Broken Hill Pty. Co. Ltd., enclose this deposit, which straddles the boundary between the Parishes of Scone and Strathbogie.

The accompanying plan (Plate 1) gives salient information including topographical form, positions of shafts, leases, and Parish boundaries.

The surface of the deposit is covered by thin reddish-brown soil containing fragments of laterite immediately overlying pisolitic or hard nodular laterite.

The log of one shaft (No. 16 at 2000N/1800E) near the centre of the deposit is given—

Depth in Feet.		Field Description.	Analysis.			
From—	To—		SiO_2.	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.
0	3	Red soil	..	..	..	
3	8	Pisolitic laterite	16.7	35.5	26.7	24.9
8	13	Pisolitic laterite	5.6	38.9	32.3	33.8
13	18	Brown nodular laterite ..	4.4	39.8	32.9	34.9
18	23	Brown nodular laterite ..	4.6	37.3	34.0	33.5
23	28	Hard brown laterite ..	4.0	34.3	37.8	32.1
28	31	Hard brown laterite ..	3.5	40.4	29.8	36.5
31	33	Lateritized basalt ..	12.1	34.4	32.8	21.8
8	31	Composite sample ..	5.1	36.9	33.3	32.2

All samples from this shaft between 8 feet and 31 feet were found to yield sufficient "available alumina" with low enough soda consumption to come by a narrow margin within the Commission's definition of economic bauxite and, for the purposes of this report, all material of similar composition will be referred to as ferruginous bauxite or simply bauxite.

It will be noted from the sections on Plate 2 that the pisolitic zone does not extend to the southern margin of the deposit, from which it has been removed by erosion.

Reserves and Composition of Bauxite.

Experience of other laterite bodies with bauxitic zones within them has shown irregularities of form which preclude highly accurate computation of reserves in the absence of closely spaced controls. Perusal of later parts of this report dealing with other, more exhaustively tested, areas and reference to the cross-sections on the accompanying plates will make this point clear.

It will be apparent that the accuracy of the estimation of both volume and composition of the orebody will be proportional to the number of points tested in any given area.

In this present instance, the testing has been more limited than that applied to other areas and consequently it is probable that further work would reveal the presence of larger reserves than the figure herein given, viz. 1,300,000 tons.

For example, it has been assumed, on the evidence of a single shaft at 200N/2450E, that Deposit A does not extend easterly beyond 2400E, whereas it is possible that a narrow tongue of bauxite may extend at least as far as 3800E, increasing the reserves by some 300,000 tons.

For the purpose of calculating the reserves it has been assumed that the bauxite zone is lenticular in section and has an average thickness of 10 feet. On this basis the volume of economic bauxite amounts to 880,000 cubic yards equivalent to 1,300,000 long tons.

The composition has been computed from weighted averages of composite samples from Shafts III, 16, 7, and 5. These analytical results are set out below in Table 6:—

TABLE 6.—GRADE OF BAUXITE—DEPOSIT A.

Shaft. No.	Thickness.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.
	Feet.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
III. ..	30	2.1	39.2	33.9	3.5	33.8	0.54
16 ..	23	5.1	36.9	33.3	3.4	32.2	1.21
7 ..	20	7.5	38.3	27.8	4.0	35.8	0.90
5 ..	15	3.8	42.4	25.9	3.7	38.4	1.18
1,300,000 tons ..	..	4.4	39.0	31.0	3.6	34.7	0.89

Overburden.

The overburden consists of thin soil and laterite which is below the economic limits and cannot be regarded as bauxite.

The soil, which consists of reddish-brown pulverulent material containing abundant fragments of laterite, does not exceed a thickness of 3 feet on the crest of the deposit but may be thicker on the slopes. No analyses of this material have been made.

The remainder of the overburden consists chiefly of pisolitic laterite of which an analysis is given in the shaft log quoted above.

The overburden covering Deposit A has a maximum thickness of about 15 feet, and averages about 7 feet. The total volume of overburden above the bauxite is estimated at 620,000 cubic yards.

Deposit B.

The greater part of this deposit lies in Portion 704, Parish of Strathbogie, with small extensions, northerly into Portion 512, Scone, and westerly and southerly into Portions 29, 35, and 702, Strathbogie. Except for the small area lying in Portion 512 and occupying a reserved road between Portion 512 and 704, the deposit is held by the Aluminium Commission.

The main part of the deposit occupies a narrow strip measuring 3,300 feet from north to south with a maximum width at the centre of about 900 feet. The total area of this body is about 44 acres, of which 25 acres are underlain by economic bauxite. In addition to this area, two small areas together occupying about 5 acres, narrowly separated from the main area, and lying in Portion 29, are included in the reserves of Deposit B and are within the area taken up by the Aluminium Commission.

Two shaft logs typical of sections encountered in Deposit B are given—

Depth in Feet.		Field Description.	Analysis.				
From—	To—		SiO_2.	Al_2O_3.	Fe_2O_3.	Ignition Loss.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT No. 14—1600N/800W.					
0	2	Soil	..	..	..	..	..
2	7	Pisolitic laterite	4.7	42.2	33.6	..	31.2
7	12	Pisolitic laterite	2.2	40.7	33.9	..	36.1
12	17	Nodular laterite	2.2	42.2	29.1	..	39.9
17	21	Nodular laterite	2.2	41.9	25.8	..	40.5
21	25	Lateritized basalt	14.8	36.6	23.6	..	24.3
		SHAFT No. 10—1200S/300E.					
0	2	Soil	..	..	..	..	..
2	7	Pisolitic laterite	..	..	..	17.9	30.2
7	12	Pisolitic laterite	..	..	..	18.0	30.3
12	17	Pisolitic laterite	..	..	..	15.8	30.6
17	22	Pisolitic laterite	..	..	..	16.0	29.2
22	25	Nodular laterite becoming clayey	..	..	..	19.2	31.5
25	26	Lateritized basalt	..	..	..	..	..

Reserves and Composition of Bauxite.

Reserves proved in the main part of Deposit B amount to 720,000 tons under 444,000 cubic yards of overburden, and the two small detached areas together contain 160,000 tons beneath 90,000 cubic yards of overburden.

The composition of the total tonnage of economic bauxite in the deposit, viz., 880,000 tons, has been computed from the weighted averages of composite samples from eight shafts as given in the following Table 7:—

TABLE 7.—GRADE OF BAUXITE—DEPOSIT B.

Shaft No.	Thickness.	SiO_2	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.
	Feet.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
14* ..	14	2.7	40.4	29.3	4.3	36.5	0.75
8 ..	15	3.0	42.0	26.3	3.7	36.6	0.72
13 ..	9	1.9	39.4	33.1	3.6	37.4	0.48
19 ..	20	3.6	29.8	33.8	3.4	34.2	0.95
XIIA. ..	7	2.2	44.9	29.8	3.2	41.1	0.82
VIII. ..	18	3.7	36.9	34.1	4.2	32.8	1.20
VII. ..	24	3.8	39.2	31.2	4.5	34.5	0.81
VIIA. ..	18	3.5	41.6	28.6	3.3	36.6	1.03
880,000 tons		3.2	40.0	30.9	3.9	35.4	0.91
Excluding Shaft 14 770,000 tons		3.3	40.0	31.2	3.8	35.3	0.93

* Shaft 14 is outside the area taken up by the Aluminium Commission.

Overburden.

The overburden ranges in thickness from 22 feet at Shaft VIII to 2 feet at Shaft 14, and averages about 10 feet. The bulk of it consists of pisolitic or nodular and earthy bauxite of which no complete analysis is available. The following few determinations are a guide to the composition of this material:—

Shaft No.	Depth in Feet.		Field Description.	SiO_2.	Ignition Loss.	Al_2O_3
	From—	To—				
				Per cent.	Per cent.	Per cent.
8 ..	3	8	Pisolites and clay	N.D.	17.4	..
13 ..	3	13	Pisolitic laterite	N.D.	17.5	..
XIIA. ..	5.5	11	Hard mottled red and purple laterite	N.D.	18.3	28.9(*a*)
6 ..	1	11	Pisolitic laterite	5.0	19.1	39.6(*b*)

(*a*) Available. (*b*) Total.

The total volume of overburden covering the bauxite in Deposit B is estimated at 534,000 cubic yards, of which 490,000 cubic yards overlies the reserves in the area taken up by the Aluminium Commission.

Deposit C.

This deposit consists of three separate bodies of bauxite lying almost wholly in Portions 700, 699, and 703, Parish of Strathbogie, and about 100 feet west from Deposit B.

All the known deposit, except for insignificant extensions into Portion 513, Parish of Scone, and parts underlying reserved roads, is held by the Aluminium Commission. The northern boundary of the deposit has not been adequately defined and it is possible that somewhat larger reserves exist than have been computed, but the areas taken up by the Commission are adequate to contain any northern extension which may exist.

The principal bauxite zone occupies an elliptical area of 17.5 acres, 1,200 feet from north to south by 800 feet wide. The two small detached areas in Portion 700 total about 7 acres, but the north-western body may be larger than the area which has been used for purposes of calculation.

This deposit is characterized by the presence of a higher proportion of pisolitic laterite than either Deposits A or B. Furthermore, much of the pisolitic material is sufficiently high in alumina and low in silica to come within the definition of economic bauxite.

Logs of four shafts are given—

Depth in Feet.		Field Description.	SiO_2.	Al_2O_3.	Ignition Loss.	Available Al_2O_3.	Na_2O Loss.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
		SHAFT No. IX.—2250N/3175W.					
0	2.5	Timber (inaccessible)	..	..	..	..	..
2.5	7.5	Loosely cemented pisolitic laterite ..	10.1*	42.8*	21.9	32.2	1.98
7.5	12.5	Loosely cemented pisolitic laterite ..	10.2*	40.0*	20.3	35.1	1.37
12.5	17.5	Loosely cemented pisolitic laterite ..	6.0*	40.2*	17.2	33.7	0.90
17.5	22.0	Loosely cemented pisolitic laterite ..	5.0*	42.0*	3.7	34.4	0.38
22.0	..	Bottom of shaft	..	..	..	..	..
7.5	22.0	Composite sample	3.7	42.5	20.6	34.0	0.94
		SHAFT No. X.—2050N/2175W.					
0	5.5	Timber	..	..	..	..	..
5.5	10.0	Dense ferruginous laterite	..	..	22.8	37.3	0.85
10.0	15.0	Dense ferruginous laterite with interstitial red earthy matter	..	..	23.0	36.0	0.92
15.0	19.5	Dense ferruginous laterite with interstitial red earthy matter becoming softer and less ferruginous.. ..	..	..	23.6	35.9	0.65
19.5	..	Bottom of shaft	..	..	..	..	..
5.5	19.5	Composite sample	2.5	41.0	23.2	36.8	0.83
		SHAFT No. 21.—1200N/2000W.					
0	4	Soil and brown clay	..	..	..	..	..
4	8	Brown clayey laterite	..	..	14.4	..	..
8	10	Brown clayey laterite	..	..	16.2	16.6	..
10	14	Soft brown laterite	..	..	18.2	23.2	..
14	18	Brown pisolitic laterite	..	..	17.3	31.0	1.88
18	22	Brown pisolitic laterite	..	..	18.3	34.5	0.76
22	26	Brown pisolitic laterite	..	..	17.9	31.6	0.47
26	30	Brown pisolitic laterite	..	..	16.5	31.9	0.56
30	34	Brown pisolitic laterite	..	..	16.6	32.9	0.60
34	38	Brown pisolitic laterite	..	..	16.3	32.1	0.60
38	42	Brown pisolitic laterite	..	..	23.1	39.8	0.50
18	42	Composite sample	2.5	42.7	18.4	33.7	0.60
		SHAFT No. XI.—480E/2050W.					
0	1	Loose pisolites	} ..	..	15.9	29.4	..
1	2	Red earth with few pisolites					
2	3	Loosely cemented pisolites					
3	8	Loosely cemented pisolites	..	..	17.2	32.3	1.05
8	13	Loosely cemented pisolites	..	..	16.8	32.0	0.93
13	18	Cemented pisolites	..	..	16.1	31.5	1.00
18	21	Cemented pisolites	} ..	..	16.2	33.9	0.45
21	23	Loosely cemented pisolites					
	..	Bottom of shaft	..	..	..	..	..
	23	Composite sample	3.4	44.6	17.0	32.1	0.86

* Determinations marked * taken from Booker and Hanlon, op. cit.

Reserves and Composition of Bauxite.

From the results of sampling six shafts, it is computed that Deposit C contains not less than 710,000 tons of economic bauxite beneath 420,000 cubic yards of overburden.

Composition of the bauxite reserves has been computed from sampling results as shown in Table 8:—

TABLE 8.—GRADE OF BAUXITE—DEPOSIT C.

Shaft No.	Thickness.	SiO_2.	Al_2O_3	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.
	Feet.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
IX. ..	14.5	3.7	42.5	29.2	3.6	34.0	0.94
X. ..	14.0	2.5	41.0	27.8	4.7	36.8	0.83
21 ..	24.0	2.5	42.7	31.6	3.6	33.7	0.60
15 ..	30.0	4.0	38.7	32.8	4.9	34.0	0.90
XI. ..	20.0	3.4	44.6	31.3	3.6	32.1	0.90
710,000 tons ..	..	3.3	41.7	30.9	4.1	34.0	0.83

Overburden.

Thickness of overburden at the points tested ranges from 3 feet to a maximum of 19 feet. Descriptions and partial analyses of the overburden are given in the shaft logs quoted above. The bulk of the overburden is pisolitic with some nodular and earthy laterite, and the total volume amounts to 420,000 cubic yards.

Deposit D.

This deposit forms a small elliptical hill in Portion 512, Scone, lying 1,000 feet north of Deposit B. The deposit is not included in any of the areas taken up by the Aluminium Commission.

One shaft was sunk from the highest point of the hill and was continued until it entered apparently siliceous lateritized basalt below 40 feet.

Channel samples from this shaft (No. 17 at 2800N/1000W) yielded the following results on analysis:—

Depth in Feet.		SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3	Na_2O Loss.
From—	To—						
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
3	8	6.7	40.8	30.0	3.6	30.3	2.04
8	13	8.8	38.0	23.4	3.3	31.2	2.57
13	18	3.6	41.1	30.2	3.1	38.3	0.82
18	23	12.6	38.0	25.8	3.4	37.0	3.93
23	28	1.3	38.7	32.9	4.5	37.9	0.43
28	33	1.5	37.9	35.5	4.6	37.4	0.21
33	38	2.0	35.9	36.4	4.8	34.0	0.46
38	40	3.9	35.1	36.8	4.3	30.9	1.14

Reserves contained in this deposit calculated with and without the low-grade material above 23 feet are given below:—

TABLE 9.—GRADE OF BAUXITE—DEPOSIT D.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
100,000 ..	3.3	38.6	31.2	3.9	33.8	1.04	18,000
or 40,000 ..	1.8	38.5	34.9	4.7	36.4	0.36	45,000

No. 5 Area, Emmaville Common.

Deposit No. 5 lies on Emmaville Common and the adjoining Portions 41, 42, and 47, Parish of Hamilton, and Portions 46, 73, 237, 278, and 279, Parish of Strathbogie North, County of Arrawatta, about 1½ miles west from the village of Emmaville.

The deposit has been examined by the Broken Hill Pty. Co. Ltd., but, presumably on account of the low grade, the company allowed its tenure to lapse.

The Geological Survey has estimated the tonnage of bauxite in the deposit to be approximately 985,000 tons whose average composition is estimated by the writer to be 6.6 per cent. SiO_2 and 35.7 per cent. total Al_2O_3.

It is probable that the deposit contains no bauxite acceptable by the Aluminium Commission.

No. 6 Area, Scone.

No. 6 Deposit lies about 2 miles south-westerly from Emmaville and about 1½ miles east from No. 4 area in Portions 520 and 521, Parish of Scone, County of Arrawatta.

The deposit forms a rounded hill with a steep slope to the east and a gentle slope extending as a low ridge to the west. The average width of the deposit is about 750 feet and total length about 2,400 feet.

Bauxite is unusually thick at the eastern end and a shaft sunk from near the crest of the hill penetrated 43 feet of bauxite and bottomed in material assaying 2.7 per cent. SiO_2, 33.3 per cent. Al_2O_3, 36.9 per cent. Fe_2O_3.

The eastern extremity of the deposit is partly covered by a mining tenement, M.L.18.

Positive results from four shafts enabled the Geological Survey to compute reserves as 800.000 tons of the following composition:—

	Per cent.
Free Al_2O_3	33.2
Total Al_2O_3	38.6
SiO_2	3.8
Fe_2O_3	31.1
TiO_2	4.1
Loss on ignition	23.1

No. 7, Wellingrove.

A local resident drew attention to deposits of laterite in Portions 79, 113, and 112, Parish of Gordon, County of Gough, about 5 miles north of Wellingrove.

Examination of the area revealed these deposits to be small remnants with a maximum thickness of 4 or 5 feet.

No. 8, Il Parran.

A very small residual of laterite in the south-west corner of Portion 36, Parish of Waterloo, County of Gough, was examined together with a large surrounding area. No deposit of any economic significance was found.

No. 9, McIntyre Park.

Several small outcrops of laterite in Portions 27, 28, and 141, Parish of Burgundy, County of Arrawatta, at 16 miles north of Inverell, were examined and a limited amount of testing by pit-sinking carried out.

Only negative results were obtained at the points selected for testing and the area was abandoned.

No. 10, Burgundy.

A dissected sheet of laterite covers a large area in Portion 38 and adjoining Portions, Parish of Burgundy, County of Arrawatta, about 13 miles north of Inverell.

Sampling of eleven shafts in Portion 38 showed the laterite to be thin and siliceous except for a small area where two adjacent shafts penetrated economic bauxite with a maximum thickness of 12 feet.

The total economic bauxite contained in the area amounts to about 65,000 tons of the following average composition:—2.8 per cent. SiO_2; 36.9 per cent. Al_2O_3; 30.8 per cent. Fe_2O_3; 5.1 per cent. TiO_2; 34.2 per cent. available Al_2O_3; average soda loss—0.94 cwt. Na_2O.

No. 11, Wandera.

An area of 333 acres on the northern boundary of the Parish of Wandera, County of Arrawatta, including Portions 112 and 123, and the southern part of Portion 14, Parish of Nullamanna, contains three fairly prominent outcrops of laterite which were tested by sinking widely-spaced pits at the most favorable positions.

Altogether 23 pits were sunk and only one encountered economic bauxite of any appreciable thickness. The laterite in this area is characterized by an unusually high silica content, even when the available alumina is relatively high, e.g. one sample assayed:—15.6 per cent. SiO_2; 30.3 per cent. available Al_2O_3; 21.5 per cent. ignition loss.

Nearly all the pits reached recognizable weathered basalt at less than 10 feet below the surface, thus indicating that the deposits in the area are in a late stage of denudation and represent a siliceous zone low in the laterite profile.

In view of the disappointing results the area was abandoned.

No. 12 Area, " Nullamanna East ".

Summary.

A laterite deposit, which occurs just within the northern boundary of the Parish of Campbell, County of Gough, in Portions 215, 216, and 222, constitutes the Nullamanna East area.

Testing the occurrence by shaft-sinking and boring revealed bauxite with a maximum thickness of 27.5 feet.

The bauxite occurs in a narrow body more than 3,000 feet long from west to east with an irregular width ranging up to 1,000 feet and averaging 300 feet. Irregularities in the thickness and depth of laterite are ascribed to faulting.

An extensive sub-surface prospecting campaign showed reserves amounting to 650,000 tons of the following composition:—

	Per cent.
SiO_2	3.0
Al_2O_3	40.0
Fe_2O_3	29.7
TiO_2	4.4
Available Al_2O_3	36.0
	Cwt.
Na_2O loss	0.77

Situation and Access.

The Nullamanna East deposit lies 9 miles north from Inverell by road and about ½ mile east of the Inverell to Emmaville road some 2 miles south of the village of Nullamanna.

Description of Deposit.

The plan and sections (Plate 3) indicate the topographical features of the area and show that the main body of bauxite forms the crest of a hill which rises prominently to about 100 feet above the plains to the south, and is crowned by a nearly vertical scarp of irregular height.

The main laterite body is crossed from north-west to south-east by a narrow faulted trough which is approximately parallel to the scarp that bounds the deposit on the south.

The downthrow of the trough is about 20 feet and its width 200 feet. A small block of laterite which has been tilted to a south-westerly dip occurs towards the eastern extremity of the area, and is separated from the main body by a small gully eroded along a fault zone.

In the trough the bauxite zone lies beneath 10 to 23 feet of low-grade laterite, some of which may be recemented detritus, but elsewhere the overburden is thin.

There is no pisolitic zone in evidence; the bauxite consists of brown, red, and grey, earthy and massive material with irregular bands and patches of hard limonite.

Three shaft logs with partial analyses are given to indicate the composition of the bauxite.

Depth in Feet.		Field Description.	Ignition Loss.	Available Al_2O_3.	Na_2O Loss.
From—	To—				
			Per cent.	Per cent.	Cwt.
		SHAFT 00/900W.			
0	5	Hard brown bauxite	23.0	34.8	0.94
5	10	Hard brown bauxite	24.5	40.0	0.78
10	15	Hard brown bauxite	23.7	40.7	0.42
15	20	Greyish brown friable bauxite ..	24.7	41.3	0.34
20	25	Greyish brown friable bauxite ..	22.4	33.9	1.60
25	27.5	Greyish brown friable bauxite ..	27.3	34.2	0.91
27.5	..	Passing to decomposed basalt ..	..	..	..
0	27.5	Composite sample—2.8 per cent. SiO_2 ; 41.0 per cent. Al_2O_3 ; 26.2 per cent. Fe_2O_3 ; 37.3 per cent. available Al_2O_3 ; 0.79 cwt. Na_2O loss.			
		SHAFT 800S/00.			
0	3	Soil and rubble	..	..	..
3	8	Brown nodular bauxite	23.6	33.9	0.71
8	13	Grey and brown nodular bauxite ..	24.3	35.0	0.58
13	18	Hard nodules in grey friable matrix ..	22.8	39.3	0.48
18	21	Hard nodules in grey friable matrix passing to decomposed basalt ..	21.0	26.8	..
21	23	Decomposed basalt		Not sampled	
3	18	Composite sample—3.0 per cent. SiO_2 ; 38.6 per cent. Al_2O_3 ; 30.8 per cent. Fe_2O_3 ; 36.4 per cent. available Al_2O_3 ; 0.59 cwt. Na_2O loss.			
		SHAFT 1200S/1400E.			
0	4	Dark red earth	12.8	..	..
4	8	Yellow earth with red nodules ..	21.1	27.6	..
8	12	Yellow earth with red nodules ..	24.3	38.1	0.74
12	15	Dark red earth	23.8	37.2	0.65
15	21	Red earth with red nodules	23.3	36.9	0.58
21	27	Red earth with red nodules	22.4	37.0	0.50
27	31	Red earth with red nodules	23.4	36.7	0.60
31	33.5	Mottled red clay	} 14.8	..	..
33.5	35	Mottled yellow clay			
8	31	Composite sample—2.0 per cent. SiO_2 ; 38.4 per cent. Al_2O_3 ; 31.0 per cent. Fe_2O_3 ; 36.4 per cent. available Al_2O_3 ; 0.54 cwt. Na_2O loss.			

The bauxite zone contained in the main body of laterite is divided by a low-grade zone near the western end. The reserves estimated to be in each orebody are given in Table 10 in the following order:—

1. Western orebody within main area.
2. Main body.
3. Detached eastern end.

TALBE 10.—RESERVES AND COMPOSITION OF BAUXITE, NULLAMANNA EAST.

Number of Shafts.	Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
1. .. 2	55,000	2.9	40.0	26.8	4.5	36.8	0.79
2. .. 12	550,000	2.9	39.3	29.7	4.4	36.0	0.77
3. .. 2	45,000	2.8	39.6	28.1	4.7	36.2	0.77
16	650,000	2.9	39.4	29.3	4.4	36.1	0.77

Overburden.

It is estimated that the three orebodies listed above are overlain by the following volumes of overburden:—

1. 2,500 cubic yards.
2. 200,000 cubic yards.
3. 6,000 cubic yards.

A partial analysis of overburden material is given in the log of Shaft 1200S/1400E above.

No. 13, Swanbrook.

A small outcrop of laterite occurs on the south side of the road from Inverell to King's Plains in Portion 161, Parish of Campbell, County of Gough, about 10 miles north-east from Inverell.

The outcrop, which is very small and measures about 100 feet across, forms a small shoulder on an otherwise relatively uniform slope to the west.

The laterite passes under very thick cover of basalt to the north-east and east, but to the south-east underlies Tertiary gravel. In other directions about the periphery of the outcrop the underlying parent basalt is exposed.

No. 14, Cherrytree Hill.

Two occurrences of laterite lying about 7 miles north of Oakwood and 19 miles by road north-west from Inverell were tested by sub-surface sampling.

These occurrences proved to be relatively small remnants of laterite which form two low hills in Portion 422, Parish of Bannockburn, County of Arrawatta. One of these hills in the south-east corner of the Portion extends north-easterly into Portion 424, and the second lies about 1,800 feet west-north-west from the first.

Each outcrop was tested by two shafts, at 00/00 and 00/700W on the easterly and at 1400N/1500W and 1400N/2300W on the westerly outcrop. The last-mentioned shaft was placed too far down the western slope of the hill to encounter bauxite or laterite *in situ*.

Shaft 00/700W intersected 6 feet of good bauxite resting on kaolinized basalt but the shaft at 00/00 yielded a negative result.

On the second outcrop, shaft 1400N/1500W revealed 8.5 feet of fairly good bauxite.

These results indicate the following probable tonnages and grades of bauxite:—

—	First Outcrop.	Second Outcrop.	Total.
Tons	20,000	140,000	160,000
SiO_2	1.7 per cent.	2.9 per cent.	2.7 per cent.
Al_2O_3	40.7 per cent.	39.9 per cent.	40.0 per cent.
Fe_2O_3	29.5 per cent.	28.9 per cent.	29.0 per cent.
TiO_2	3.7 per cent.	3.6 per cent.	3.6 per cent.
Available Al_2O_3	37.6 per cent.	36.2 per cent.	36.4 per cent.
Na_2O loss	0.43 cwt.	0.84 cwt.	0.79 cwt.

The deposits are considered to be of little importance on account of their relative inaccessibility from Parish's area, which is approximately 10 miles by road to the south-east.

No. 15 *Area, Champagne.*

Summary.

The Champagne laterite deposit lies north-east from the village of Oakwood in Portions 72, 73, 74, and 75, Parish of Champagne, County of Arrawatta. A smaller deposit in Portions 79 and 80 is not described in this report but is shown on Plate 4, together with sections of the main body.

Testing by both shaft-sinking and boring revealed bauxite ranging up to 21 feet in thickness and averaging 12 feet over areas of 22.5 and 2.5 acres. Overburden is shallow, ranging from zero to 12 feet and averaging 4.5 feet.

Testing at 27 points within the bauxite zone and at 7 marginal positions revealed reserves of bauxite amounting to 740,000 tons containing—

	Per cent.
SiO_2	3.6
Al_2O_3	38.8
Fe_2O_3	29.5
TiO_2	5.0
Available Al_2O_3	34.0
	Cwt.
Na_2O loss	1.04

Situation and Access.

The deposit is accessible in dry weather by about 1½ miles of road from Oakwood. The track is quite impassable when wet.

Description of Deposit.

The ore deposit consists of two bodies; the principal one is a rectangular area 1,500 feet long from east to west by an average width of 600 feet, and the other forms a small extension to the south-east.

To the west and south, the bauxite crops out on the slopes of a wide gully which has cut through the laterite profile to the parent basalt. On the north and east the laterite thins and passes under basalt.

Three shaft logs with partial analyses showing the sudden passage from low silica bauxite to kaolinized basalt are given. The deceptive appearance of the bauxite is well exemplified by the last log which is quoted in the original terms applied by the foreman.

Depth in Feet. From—	To—	Field Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Ignition Loss.	Available Al_2O_3	Na_2O Loss.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
		SHAFT 300N/500E.						
0	3	Nodular laterite with grey earthy matrix	7.1	33.3	33.3	19.4	..	..
3	6	Grey bauxite	5.7	39.6	26.9	22.6	..	..
6	9	Grey bauxite	3.6	42.4	24.4	24.2	..	..
9	12	Grey bauxite	3.2	44.6	21.1	25.1	..	..
12	15	Red bauxite	2.9	45.0	20.9	24.7	..	..
15	18	Granular grey bauxite ..	2.3	38.3	31.9	21.9	..	..
18	21	Granular grey bauxite ..	2.1	37.5	31.9	22.1	..	..
21	24.5	Soft earthy bauxite passing to clay	1.9	35.3	35.4	20.8	..	..
24.5	..	Weathered basalt	Not sampled					
6	24.5	Composite sample	2.6	40.1	26.9	..	35.7	0.76
		SHAFT 00/300E.						
0	3	Bauxite nodules in soil ..	9.1	37.5	26.8	21.4	31.1	..
3	6	Hard red bauxite	5.6	39.9	27.4	22.2	35.2	..
6	9	Soft red bauxite	4.9	38.3	29.1	21.7	34.4	..
9	12	Soft red bauxite	5.1	36.3	30.1	21.2	32.3	..
12	15	Soft red bauxite	3.1	39.5	28.3	22.9	37.6	..
15	18	Light red bauxite	1.8	38.0	30.1	22.7	36.5	..
18	20.5	Weathered basalt	..	..	..	..	13.0	..
3	18	Composite sample	4.3	38.4	29.1	22.0	32.8	1.28
		SHAFT 300N/700E.						
0	3	Nodules of bauxite in red soil	6.9	36.0	39.0	22.5	30.8	..
3	6	Soft grey clay	3.7	36.4	32.6	22.3	32.6	..
6	9	Soft red clay	3.9	34.3	35.3	20.3	30.1	..
9	12	Soft red clay	3.8	36.8	32.7	21.4	34.5	..
12	15	Soft dark-red clay	2.9	36.7	32.7	21.4	33.7	..
15	18	Soft dark-red clay	2.9	36.2	32.9	21.2	33.1	..
18	20	Dark-red clay with seams showing basaltic texture ..	..	..	..	16.7	..	..
3	18	Calculated average	3.4	36.1	33.2	21.4	32.8	..

Proved reserves of economic bauxite are given in Table 11 :—

TABLE 11.—GRADE AND TONNAGE OF BAUXITE.—CHAMPAGNE DEPOSIT.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
740,000	3.6	38.8	39.5	5.0	34.0	1.04	180,000

Overburden.

The overburden consists of laterite with the exception of a few inches of red soil mixed with fragments of laterite. Analyses of overburden material show approximately the following composition:—

	Per cent.
SiO_2	5.7 to 10.4
Al_2O_3	31.8 to 40.0
Fe_2O_3	24.6 to 36.0
TiO_2	3.3 to 5.9
Available Al_2O_3	17.6 to 34.6

No. 16, *McCosker's.*

This area occupies the eastern halves of Portions 404 and 405, Parish of Byron, County of Arrawatta, and lies about 1 mile east from the village of Oakwood and ½ mile south of the Champagne deposit described above.

McCosker's was the first area in the New England district to be examined by the Aluminium Commission, and although it was realized at a preliminary inspection that erosion of the laterite sheet is well advanced, it was decided to conduct a limited amount of exploration by shaft-sinking.

This exploration showed that the laterite is thin, and for the most part siliceous, and that the area as a whole contains no worthwhile quantity of economic bauxite.

The area contains three small separated bodies of laterite, formerly a continuous sheet, and testing revealed that the southern body in Portion 404 contained about 15,000 tons of bauxite, giving the following average analysis:— 5.3 per cent. SiO_2; 39.6 per cent. Al_2O_3; 26.0 per cent. Fe_2O_3; 6.0 per cent. TiO_2; 35.8 per cent. available Al_2O_3; 1.26 cwt. Na_2O loss.

The northern outcrop in Portion 405 contains a similar quantity of bauxite of about the same grade.

No. 17 *Area, Lockwood's.*

Summary.

The body known as Lockwood's is an outlier of Parish's deposit, and forms a relatively thin capping of laterite on a low hill in Portion 113, Parish of Byron, County of Arrawatta. Its position relative to Parish's is shown on Plate 5.

The zone of economic bauxite within the deposit occupies a rectangular area measuring about 600 feet from north to south by 360 feet wide, with an average thickness of 9.5 feet.

This small area was thoroughly tested with eight shafts yielding positive results and eleven showing thin bauxite or uneconomic material round the margins.

Proved reserves of economic bauxite amount to 140,000 tons containing—

	Per cent.
SiO_2	3.1
Al_2O_3	38.5
Fe_2O_3	29.1
TiO_2	5.8
Available Al_2O_3	34.9

Situation and Access.

Lockwood's deposit lies about ¾ mile north-west of Parish's and 2 miles east from the village of Oakwood. Access is provided by an indifferent road from Oakwood suitable for dry weather use only.

Description of Deposit.

The laterite caps a small hill truncated at the northern end by a scarp which falls steeply to 45 feet below the crest level. To the east and south the slopes are gentle, and on the west the hill is separated by a saddle from a smaller prominence which is capped with basalt and has a narrow outcrop of laterite along its northern flank.

No pisolitic laterite or bauxite occurs in the deposit; most of the material is dense red laterite containing up to 36 per cent. Fe_2O_3, or granular bauxite retaining rather indistinctly the texture of the parent basalt and containing from 2.9 to 5.3 per cent. SiO_2 and from 32.6 to 43.4 per cent. Al_2O_3.

Tonnage, composition, and volume of overburden calculated from the results of channel sampling in eight shafts are given in Table 12 below:—

TABLE 12.—LOCKWOOD'S DEPOSIT.

Tons.	Bauxite.						Overburden.
	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
140,000	3.1	38.5	29.1	5.8	34.9	0.80	44,000

Overburden.

The overburden consists of a thin layer of soil and boulders averaging 2 feet thick above low-alumina laterite which ranges in thickness from zero to 9.5 feet.

Typical composition of the laterite which constitutes overburden is—

	Per cent.
SiO_2	7.1
Al_2O_3	33.2
Fe_2O_3	33.2
TiO_2	6.2
Ignition loss	19.6
Available Al_2O_3	26.2

No. 18 Area, "Parish's" (Byron).

Summary.

The deposit known as "Parish's" occupies an area of approximately 2,800 yards by 1,000 yards in Portions 114, 115, 79, 67, 66, and 52, Parish of Byron, County of Arrawatta, and constitutes the largest proved body of bauxite in Australia. *See* Plates 5 and 6.

Of the total area occupied by bauxite about half has been covered by basalt of a thickness known to exceed 40 feet, which was extruded during Pliocene time after the process of lateritization had reached the stage represented by the present bauxite-laterite bodies.

For the purpose of computing reserves, it has been deemed that the cover of basalt would prevent economic exploitation of the bauxite beneath, and consequently large tonnages of bauxite underlying basalt have been excluded from the reserves.

Very thorough testing by shaft-sinking and boring proved reserves amounting to 4,755,000 tons of dry ore of the following composition:—

	Per cent.
SiO_2	3.2
Al_2O_3	38.6
Fe_2O_3	30.1
TiO_2	5.0
Available Al_2O_3	33.7
	Cwt.
Soda loss	1.00

Situation and Access.

The south-western extremity of the deposit in Portion 79 lies on the northern side of the Inverell-Yetman road within 200 yards of the 10th-mile post from Inverell. The nearest point on the Inverell-Moree railway is Byron siding, 4 miles by road south-east from the deposit.

Description of Deposit.

The deposit forms a roughly rectangular mass measuring 2,800 yards from south-west to north-east, with an average width of about 1,000 yards.

Except for a small outlier in Portion 67, the deposit is bounded on the south by the channel of Appletree Gully, which has cut through the Pliocene basalt to reveal an older valley partially filled with recemented detrital bauxite.

The bauxite crops out in the banks of Appletree Gully and of lateral watercourses which drain southward from the crest of the deposit.

To the north and north-west, the bauxite passes under Pliocene basalt, and sub-surface prospecting was not continued in this direction.

Depressions in the surface of the laterite caused partly by erosion and partly by faulting have been filled with the younger basalt, and these areas have been partly explored by boring.

The parent basalt, possibly of Oligocene age or older, is exposed over relatively small areas on the northern, eastern, and southern margins of the deposit.

Hand specimens of the bauxite do not show great variation. The dominant colour of the ore is brown and brownish-red, and the hardness ranges from a friable earth to a moderately hard, tough rock which may be broken with a hammer without much difficulty.

The mineral composition is not apparent to the unaided eye. In the main, the ore consists of a dull earthy mass, which may show minute crystalline flakes of gibbsite, and close inspection may reveal narrow veinlets and cavity linings of gibbsite.

Some of the bauxite has a fragmental appearance due to irregular distribution of iron. Near the base the bauxite exhibits a granular texture derived from the parent basalt.

Numerous analyses indicate that the ore consists of a mixture of clay, gibbsite, and ferric oxide, leucoxene and ilmenite, with minor amounts of boehmite, and limonite. Usually combined water is present in sufficient amount only to satisfy the gibbsite molecule and it is evident that most of the iron is present as anhydrous ferric oxide.

At least some of the bauxite in Appletree Gully is recemented detritus. One shaft sunk in this material showed it to be below economic limits.

A total of 343 shafts and bores were sunk on the deposit, including many sunk through the younger basalt into laterite or bauxite. The grade and tonnage figures here given have been calculated from results obtained by sampling 177 shafts and bores which gave positive results.

The sub-surface prospecting showed the economic bauxite to have a maximum thickness of 30 feet and to average 13.9 feet thick over a total area of 151½ acres. It was found that much sub-standard laterite occurred round the margins of the outcrop, especially in the southern, eastern, and northern quarters. A few small outlying outcrops of laterite were tested and also found to be below acceptable grade.

The factor for computing tonnage was determined by measuring the volume occupied by a weighed sample freshly cut from a shaft. Duplicate samples packed in air-tight jars were sent to the laboratory for determination of moisture and specific gravity. It was found that the moisture content showed a range from 9.4 to 17.0 per cent. and averaged 13.5 per cent. Specific gravity of dry ore ranged between 2.23 and 3.3. Field determinations of density showed a similar range and averaged about 136 pounds of moist bauxite per cubic foot *in situ*.

This figure is equivalent to 1.6 tons per cubic yard and this factor has been used for computing the reserves of moist ore containing 13.5 per cent. of free water. It is to be expected that the moisture content will show much variation from place to place within the deposit according to the drainage conditions, and that there will also be marked seasonal fluctuations.

For convenience in calculating results as the work progressed the whole outcrop area was divided into square blocks with sides measuring 1,200 feet in length. Some of these squares were found to contain no economic bauxite, but a total of fifteen included reserves, ranging from 18,000 to 608,000 tons of dry ore in a block. The boundaries of these blocks are shown in Plate 5.

The total reserves for the whole of Parish's deposit are set out in Table 13, in which the separate results of each block are given to provide an indication of the ranges of composition encountered.

Overburden.

The salient figures for overburden are given in the same Table from which it will be seen that the ratio of overburden to bauxite is about 1 to 2.5.

This overburden consists mainly of laterite but also includes weathered basalt in the marginal areas.

TABLE 13.—RESERVES, PARISH'S DEPOSIT.

Block	Bauxite.								Overburden		
	Dry Ore.	Average Thickness.	Analysis.						Maximum Thickness.	Average Thickness.	Cubic Yards.
			SiO_2.	Al_2O_3	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.			
	Tons.	Feet.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Feet.	Feet.	
A	200,000	19.7	3.0	38.6	29.1	4.6	34.3	0.90	11	5.4	40,000
B	374,000	10.0	3.7	37.3	31.0	4.3	32.8	1.23	12	6.4	175,000
C	194,000	13.7	3.1	38.3	29.9	5.3	32.7	1.03	12	9.4	97,400
D	256,000	12.8	3.8	39.7	27.9	4.8	33.4	1.21	14	7.3	119,000
E	520,000	18.0	3.1	38.9	29.0	5.2	34.1	0.91	10	5.7	120,300
F	437,000	12.0	3.4	38.8	28.8	4.8	33.8	0.99	15	3.5	93,000
H	538,000	16.6	3.7	37.6	30.1	5.3	32.1	1.11	14	6.4	151,700
J	608,000	15.0	2.6	39.2	30.2	5.3	34.1	0.78	12	5.5	163,000
K	18,000	9.0	4.0	37.5	29.3	5.1	31.7	1.32	2.5	2.5	2,000
L	23,000	12.0	4.6	37.5	28.7	5.5	32.1	1.66*	0	0	..
M	81,000	11.0	3.7	38.7	29.5	4.8	33.2	1.10	5	4.0	23,700
N	374,000	12.4	4.6	40.5	28.1	4.8	32.9	1.42	13.5	7.7	148,000
O	606,000	16.6	2.6	37.4	31.0	5.2	33.5	0.84	14	5.7	150,400
P	426,000	16.4	2.4	38.8	29.9	5.1	34.1	0.79	13	4.1	77,600
Q	100,000	12.0	2.6	37.4	32.6	5.6	32.9	0.90	10.5	8.2	48,500
	4,755,000	14.25	3.2	38.6	30.1	5.0	33.7	1.00	15	5.75	1,409,600

* The figures for Block L are the result of analysis of a single composite sample. The average calculated from analyses of the three samples from which the composite was made is- 4.5 per cent. SiO_2; 38.4 per cent Al_2O_3, 28.5 per cent. Fe_2O_3; 5.7 per cent. TiO_2 and 22.5 per cent. Ignition loss. Available Al_2O_3 averaged 33.9 per cent. extracted with soda loss equivalent to 1.34 cwt of Na_2O.

No. 19, Mount Russell.

Five small areas of outcropping laterite occur along the boundary between the Counties of Murchison and Arrawatta, extending south-easterly for about 1½ miles from Portion 175, Parish of Bannockburn, County of Arrawatta, to the north-west corner of Portion 180, Parish of Little Plain, County of Murchison. For convenience these deposits are designated A. B, C, D, and E from south to north. Deposit E lies 2 miles by road south-east from Mount Russell railway station and 15 miles by road west-north-west from Inverell.

A. This deposit differs from the others in the locality in that it covers a greater area of lower relief. Hard red laterite crops out over most of an area measuring about 1,000 feet long from north to south by 400 feet wide. The laterite is well exposed in a shallow quarry near the northern end of the deposit. Three shafts sunk to test the deposit entered basalt at depths ranging from 10 feet to 14 feet.

A slightly greater thickness of laterite might have been penetrated had the shafts been placed 200 feet east of the positions chosen, but it is very unlikely that any notable difference in results would have been achieved. Only two samples were tested for available alumina and these yielded 23.8 and 18.8 per cent.

The occurrence consists of a thin capping of ferruginous laterite which passes into the parent basalt at about 14 feet below the surface.

Except as a source of road material the deposit has no economic value.

B. At the crest of a low rounded hill a thickness of 8.5 feet of bauxite containing 33.3 per cent. available alumina was sampled, but apparently the silica is high as the soda loss figure was 2.25 cwt. Na_2O per ton of alumina.

High soda consumption and very limited reserves render this deposit valueless.

C. Very similar to A. The capping of laterite has a maximum thickness of 17 feet and a probable area of 120,000 square feet. The alumina content is low. Two shafts were sunk but neither encountered economic bauxite.

D. A small hill, similar to the above, is capped with ferruginous laterite mainly present as residual boulders embedded in red earth. A shaft sunk from the top of the hill passed through earthy laterite into kaolinized basalt at 11 feet from the surface. The area is of no importance.

E. This occurrence forms a small round hill capped by a thin band of bauxite under dark-red weathered laterite. The possible area that could be underlain by bauxite is so small that the deposit cannot be regarded as of any importance.

One shaft sunk from the crest of the hill revealed 2.5 feet of bauxite containing 32.7 per cent. available alumina beneath 10 feet of weathered ferruginous laterite, and resting on lateritized basalt.

No. 20, Little Plain.

Laterite is exposed on the north side of the Inverell to Warialda road 10 miles west of Inverell and about 600 yards from the road. The deposit passes easterly from Portion 180, Parish of Little Plain, County of Murchison, into Portion 141, Parish of Bannockburn, County of Arrawatta.

The deposit forms a low red hill rising steeply on the south side about 30 feet above the general level and sloping away gently to the north and west. Six shallow pits were sunk on the crest and flanks of the outcrop, and results showed that the deposit is in the final stage of denudation and consists of a thin remnant of ferruginous laterite capping kaolinized basalt. The body of laterite occupies an area about 400 feet in diameter and has a maximum thickness of 5.5 feet.

Only two samples, of a total of 22, lost more than 18.5 per cent. on ignition and these two assayed:—

—	Thickness.	Ignition Loss.	Available Al_2O_3.
	Feet.	Per cent.	Per cent.
1.	31.0	19.0	23.7
2.	5.5	20.8	28.7

An apparently somewhat larger deposit of similar appearance in Portions 139 and 140, Parish of Bannockburn, was not tested.

No. 21, *Station 2NZ* (*Warialda-road*).

Laterite forms a small prominent hill on the south side of the Inverell to Warialda road at 11 miles west from Inverell. The hill, which straddles the boundary between Portion 357, Parish of Bannockburn, County of Arrawatta, and Portion 27, Parish of Gum Flat, County of Murchison, is flat-topped and stands about 60 feet above the surrounding surface. The crest of the hill is about 800 feet long from north to south and about 300 feet wide. The southern end of the hill in the Parish of Gum Flat was occupied by the transmitter of broadcasting station 2NZ at the time of the survey, but the transmitter has since been moved.

Two trial pits were sunk. The northern one revealed 4 feet of yellowish laterite containing 24.3 per cent. of available alumina, and the other shaft 700 feet south yielded 11.5 feet of siliceous ferruginous bauxite containing 30.5 per cent. Available alumina was extracted with a loss of 2.29 cwt. Na_2O per ton. It is obvious from these results that the deposit is not of commercial value as a source of aluminium.

Pisolitic laterite also occurs to the north-east of the former site of station 2NZ in Portions 357 and 356 and the Travelling Stock Route adjoining the Warialda road. A road quarry has been opened in the deposit; a shaft sunk in the floor of the quarry by Broken Hill Pty. Co. Ltd. showed a thickness of 10.5 feet of laterite of the following average composition:—11 per cent. SiO_2; 27 per cent. Fe_2O_3; 36 per cent. Al_2O_3 (soluble in H_2SO_4).

The southerly extension of the deposit was not tested in view of the unfavorable results obtained at station 2NZ and on the northern side of the Warialda road in Portion 141.

No. 22 *Area, Wade's* (*Warialda-road*).

Wade's deposit is in Portion 358, Parish of Byron, County of Arrawatta, on the north side of the Inverell-Warialda road at 4 miles from Inverell. At various times the Broken Hill Pty. Co. Ltd., and other interested parties, have secured mining rights over the deposit, but each time the rights have been allowed to lapse.

The deposit consists of two narrowly separated bodies lying on the southern slope of a low flat-topped ridge. The westernmost body, which is the larger of the two, has been quarried for road material.

The area has been examined and reported upon by officers of the Geological Survey of New South Wales (Booker and Hanlon, 1944).

Testing by the Commission was confined to the western body and included the deepening of one of the old shafts previously sampled by the State Mines Department and the sinking of six additional shafts.

These shafts were inspected and sampled by the writer during April, 1947.

Only one shaft outside the quarry encountered bauxite; the remaining shafts, 200 feet and 400 feet north and 200 feet south of the quarry, entered kaolinized basalt below a thin mantle of soil and detritus.

The log of Shaft 63 and the two shafts 200 feet north and south of Shaft 63 are given in full—

SHAFT No. 33.—CO-ORDINATES. 200S/00.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Ignition Loss.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	6	Red soil and clay	..	Not sampled		..
6	9	Red clay	27.9	24.5	30.3	10.5
9	13	Light brown granular weathered basalt passing to clay	26.3	24.9	30.9	11.5
13	17	Light brown and grey mottled clay (weathered basalt)	26.7	25.7	29.7	11.9
17	20.5	Light brown and grey mottled clay (weathered basalt)	26.2	24.8	31.3	11.7
20.5	26	Finely mottled white and brown clay (basalt)	31.8	29.0	22.2	13.1
26	33	Finely mottled white and brown clay (basalt)	..	..	..	..
33	38	Red and purple clay (basalt)	28.9	26.8	26.9	12.3

SHAFT No. 63.—CO-ORDINATES. 00/00.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	9	Reg soil and clay, few nodules of bauxite	..	Not sampled		..
0	10	Nodular bauxite	12.4	39.3	23.5	28.9
10	12	Nodular bauxite, nodules embedded in red clayey material	} 8.4	41.1	24.2	34.3
12	16	Red clayey material				
16	22	Dark purplish clay with few nodules ..	5.7	38.4	30.2	33.5
22	28	Dark purplish clay with few nodules ..	5.1	36.6	32.6	32.8
28	32.5	Dark-red earthy friable hard ferruginous nodules	4.8	40.2	23.0	35.8
32.5	34	Clayey material with few ferruginous nodules	3.8	36.8	34.7	32.5

SHAFT No. 2.—200N/00.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3	Ignition Loss.
From—	To—					
0	6	Red soil and clay	..	..	..	..
6	8	Red soil and clay with fragments of bauxite	} ..	..	..	12.6
8	9	Red soil and clay with fragments of bauxite merging with weathered basalt				
9	15	Weathered basalt (red and grey clay) ..	..	..	..	12.7
15	20	Weathered basalt (red and grey clay) ..	..	..	..	12.8
20	23.5	Weathered basalt (red and grey clay) ..	..	Not sampled		..

Samples cut from the north face of the quarry near the line of section yielded the following results on analysis:—

Vertical Depth below Surface.		Description.	SiO_2	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
From—	To—					
Feet.	Feet.		Per cent.	Per cent.	Per cent.	Per cent.
0	2.5	Red soil	..	Not sampled		..
2.5	5.5	Nodules of hard basaltic bauxite in red soil	3.5*	45.7*	20.6*	41.8*
5.5	9.5	Nodular bauxite	..	37.0	..	30.0
9.5	13.5	Nodules in soft friable earthy red matrix	8.0	38.7	27.0	32.7
13.5	17.5	Nodules in soft friable earthy red matrix	6.7	40.2	28.2	32.6
17.5	19.5	Nodules in soft friable earthy red matric	..	Not sampled		..
A shaft sunk below the floor of the quarry was sampled by the New South Wales Geological Survey with the following results :—						
20.0	29.5	.. ..	3.5	41.3	24.8	39.0†
29.5	35.0	.. ..	4.0	40.5	26.6	40.3†

* Nodules only. No soil included in sample. † Al_2O_3 soluble in H_2SO_4.

The results obtained by the Commission necessitated a revision of the reserves previously estimated.

Total proved reserves are estimated at 110,000 tons with average thickness 24 feet, of following grade:—

	Per cent.
SiO_2	5.8
Al_2O_3	39.8
Fe_2O_3	28.0
Avail. Al_2O_3	33.1
	Cwt.
Soda loss	1.4

This bauxite is covered by 40,000 tons of overburden about 8 feet thick, consisting of red soil and clay with nodules and fragments of bauxite.

By rejecting the upper 8 feet of the bauxite included in the reserves given above the figures are brought to—

Bauxite.	SiO_2.	Al_2O_3	Available Al_2O_3	Na_2O Loss.	Overburden (Average Thickness 13 Feet).
Tons.	Per cent.	Per cent.	Per cent.	Cwt.	Tons.
90,000	5.1	39.5	35.3	1.2	60,000

It is possible that deepening of the old shafts at about 00/300E and 00/600E might disclose a relatively small addition to reserves under about 20 feet of overburden.

Conclusion.

It is improbable that this deposit could be regarded as a useful source of bauxite. The advantage that it possesses through proximity to the railway is offset by the low grade of the material. The nodular bauxite would be amenable to beneficiation by washing, but the quantity available is probably too small to justify the installation of trommels and the provision of a water supply.

No. 23, *Garley's, &c.* (*Warialda-road*).

A discontinuous sheet of laterite in Portions 79, 80, 82, 83, 109, 144, and 168, Parish of Auburn Vale, County of Hardinge, occupies an area of approximately 600 acres and is a southerly extension of Wade's deposit. It was tested by groups of shafts at three points, without disclosing the presence of economic bauxite.

On Garley's property, Portion 80, one shaft showed a total thickness of 17.5 feet of siliceous bauxite containing 8.1 per cent. SiO_2 and 32 per cent. available Al_2O_3 extracted with a loss of alkali equivalent to 2.2 cwt. Na_2O per ton of Al_2O_3.

The best result obtained on Portion 144 (Humphries) was 11.9 per cent. SiO_2, 30.6 per cent. available Al_2O_3, with soda loss equivalent to 3.67 cwt. Na_2O.

On Portion 83 (McDonald's) the least unsatisfactory result was 4 feet of bauxite containing 4.8 per cent. SiO_2, 33.4 per cent. available Al_2O_3, with 1.46 cwt. Na_2O consumption. This lay beneath 1 foot of soil and 7 feet of laterite containing 31.9 per cent. available Al_2O_3 extractable with a loss of 1.47 cwt. Na_2O per ton of alumina.

No. 24, *Bundarra-road.*

Deposit No. 24 is situated on Portions 33, 43, 73, 276, 406, and 409, Parish of Clive, County of Gough, about 10 miles south of Inverell on the road to Bundarra.

Fifty-two channel samples were taken by members of the New South Wales Geological Survey from twenty old shafts and eight samples were taken of ferruginous pisolitic laterite exposed in shallow quarry faces.

The 60 samples taken were examined in the Mines Department laboratory for alumina soluble in caustic soda solution, and it was found that 25 samples contained less than 20 per cent., and only four samples contained more than 30 per cent. free alumina.

In view of these results, it was considered that no examination of the deposit for the Aluminium Commission was necessary.

No. 25 Area, Clive (Tingha).

Deposit No. 25 is in the Parishes of Clive and Swinton which lie on either side of the boundary between the Counties of Gough and Hardinge, about 10 miles south of Inverell on the Tingha road.

The occurrence contains much pisolitic laterite but towards the south-western margin it is reported that the laterite becomes less ferruginous and more siliceous.

Only two shafts of the six that were sampled by the Geological Survey showed bauxitic material with greater thickness than 5 feet. Silica ranged from 1.6 to 9.5 per cent. and total alumina from 37.8 to 44.6 per cent.

The Mines Department estimate of reserves is 160,000 tons containing—

	Per cent.
SiO_2	5.0
Al_2O_3	42.9
Fe_2O_3	29.5
TiO_2	2.2
Ignition loss	21.0
Free Al_2O_3	35.2

The writer has examined this area and is in substantial agreement with the tonnage estimate here given.

No. 26 Area.

An apparently large deposit of laterite occurs on Crown Land near the northern boundary of the Parish of Swinton extending northwards into the Parish of Herbert.

Sampling of old tin-mining shafts by geologists of the New South Wales Survey revealed that laterite containing 30 per cent. or more of alumina was confined to a small area at the southern end of the occurrence at a point 2½ miles north of the village of Tingha.

It was estimated from the sampling of one shaft that the deposit contained approximately 140,000 tons of laterite assaying:—

	Per cent.
SiO_2	10.1
Al_2O_3	43.1
Fe_2O_3	25.2
TiO_2	2.3
Ignition loss	22.5
Free Al_2O_3	26.8

From a critical examination of the individual shaft records it appears that reserves of economic bauxite as defined by the Aluminium Commission would amount to not more than 65,000 tons containing—

	Per cent.
SiO_2	4.7
Al_2O_3	42
Fe_2O_3	30

No. 27 Area.

This deposit is a small one forming a rounded hill in Portion 209, Parish of Swinton, County of Hardinge, about 2 miles north from Tingha.

Total reserves have been computed by the State Mines Department to be 60,000 tons of the following composition:—

	Per cent.
SiO_2	5.5
Al_2O_3	40.0
Fe_2O_3	33.1
Free Al_2O_3	29.3

By rejection of high-silica material near the surface, the probable reserves are reduced to amout 50,000 tons and the grade raised to—

	Per cent.
SiO_2	3.6
Al_2O_3	40.4
Fe_2O_3	32.8
Free Al_2O_3	31.7

No. 28 Area, Topper's Mountain (Tingha).

This deposit consists of four separate bodies at Topper's Mountain, 4 miles north-east from Tingha and about 23 miles by road south-east from Inverell.

These separate bodies lie in Portions 419, 229, 173, and 434, Parish of Herbert, County of Gough.

The Broken Hill Pty. Co. Ltd. prospected the deposits by shaft-sinking and then made the results available to the New South Wales Department of Mines. With this information the Geological Survey was able to estimate reserves at approximately 500,000 tons.

Using the Broken Hill Pty. Ltd.'s figures and the State survey plan the writer estimates reserves of economic bauxite in Portions 229, 419, and 434 at not less than 200,000 tons containing 4.7 per cent. SiO_2, 30.3 per cent. Fe_2O_3 and 39.5 per cent. Al_2O_3 soluble in sulphuric acid.

Description of the Bauxite.

The three zones recognizable in a complete laterite profile, viz. ferruginous, mottled, and pallid, are not all easily distinguishable at the bauxite occurrences described.

A sharply defined ferruginous zone does not exist at Parish's and other nearby deposits, but is represented at Emmaville and Tingha by pisolitic ore. At Emmaville this zone consists of closely packed dark red pisolites, either loose or set in a ferruginous cement. and attains a thickness exceeding 20 feet. Notwithstanding the deep colour it usually contains only slightly higher iron content than the earthy bauxite at Parish's.

Chemical analyses indicate that the pisolitic ore consists essentially of a mixture of aluminium hydroxide and hematite or goethite with or without an appreciable amount of basic aluminium oxide ("monohydrate"). At Deposit C, Emmaville, the composition probably ranges between the following extremes:—

<table>
<tr><th>—</th><th>Per cent.</th><th>Per cent.</th></tr>
<tr><td>Clay</td><td>4.5</td><td>5.0</td></tr>
<tr><td>Al $(OH)_3$</td><td>45.0</td><td>61.0</td></tr>
<tr><td>AlO (OH)</td><td>13.5</td><td>Very small</td></tr>
<tr><td>Fe_2O_3 H_2O</td><td rowspan="2">33.5</td><td>28.5</td></tr>
<tr><td>Fe_2O_3</td><td>Very small</td></tr>
<tr><td>TiO_2</td><td>4.5</td><td>5.0</td></tr>
</table>

The earthy bauxite, typical of Parish's deposit, is mainly red and brown in colour, and except for a harder surface capping a few feet thick is soft and clay-like in appearance and crumbles on exposure to the weather.

The silica content decreases with depth to the kaolinized zone where it rises steeply as the following analyses illustrate.

Depth in Feet.		SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
From—	To—					
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		PARISH'S AREA. 400S/900W.				
2	7	9.4	46.6	12.0	6.0	24.7
7	11	3.8	49.6	11.9	7.9	26.5
11	15	1.5	48.4	15.3	7.8	25.8
15	19	1.5	42.9	25.4	6.7	23.1
19	23	1.1	36.9	33.8	6.2	21.6
23	27	16.9	26.9	35.4	5.1	14.8
27	30	24.1	25.8	31.6	4.9	12.8
		PARISH'S AREA. 2000S/3300W.				
1.5	6	5.1	39.1	24.7	3.7	22.1
6	10	3.8	36.6	23.4	4.6	22.3
10	14	2.1	34.7	28.2	5.0	21.5
14	18	2.1	34.3	31.9	6.2	21.4
18	22	6.4	28.9	41.0	5.0	16.6
22	25	30.9	28.2	31.4	4.3	13.9
25	27	28.6	26.6	26.6	4.9	12.4

It is evident from the foregoing analyses that very little alumina is present as basic oxide. Samples with low combined water content, however, have been obtained from bores in the south-east corner of Block H, Parish's area (*see* Plate 5), where "monohydrate" may constitute about 5 per cent. of the ore.

The original texture of the parent basalt has been retained near the base of the bauxite with the result that the passage from bauxite to kaolinized basalt is not readily discerned by eye.

A suite of specimens from Parish's area collected by the writer was submitted to the Commonwealth Scientific and Industrial Research Organization for mineragraphic investigation. The resulting report, No. 395, appears as Appendix I.

Nodular bauxite which differs in character from either type mentioned above occurs in a small deposit (No. 22) four miles west of Inverell. This bauxite bears a resemblance to that of Malaya as it consists of aluminous nodules embedded in a soft earthy matrix. The nodules range in size up to about 3 inches diameter and contain about 70 per cent. of aluminium hydroxide and 20 per cent. of hydrated iron oxide. The proportion of nodules contained in the matrix varies over a wide range but probably averages less than 50 per cent.

Moss Vale Area.

The occurrence of ferruginous laterite in the vicinity of Moss Vale, Bundanoon, and Wingello, County of Camden, has long been known and has been the subject of reports by the Geological Survey of New South Wales from time to time.

The laterite has some application in commerce. Small amounts of the pisolitic material are used as flux in the open-hearth steel furnaces at Newcastle and Port Kembla, and some is sold for surfacing paths and roads. Highly aluminous laterite from Sutton Forest is sent by rail to Melbourne for the manufacture of aluminium chemicals.

In order to define any zones enriched in alumina, a sub-surface prospecting campaign was undertaken by the Aluminium Commission at Wingello during July and August, 1948, and at Ellsmore in the early part of 1949.

Summary of Reserves.

The following tables summarize not only the results of the Aluminium Commission's investigations, but also results made available in State reports, to which due acknowledgment is made elsewhere in this present paper.

Detailed work by the Aluminium Commission was confined to Deposits 2 (Ellsmore) and 6 (Wingello); a limited amount of sampling at Deposits 3, 4, and 5 was also done. The Commission holds part of Deposit 6 under mining lease, but all other deposits of potential economic value are alienated.

The results of this work and previous estimates made by earlier workers are summarized in Table 14.

The numbers shown in the first column of the tables are those shown on the locality plan (Figure 3) and are used throughout this report.

TABLE 14.—SUMMARY OF BAUXITE RESERVES, MOSS VALE AREA.

PART A.—PROVED ECONOMIC BAUXITE.

No.	Locality.	Long Tons (Dry Ore).	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
2	Ellsmore A ..	51,000	4.4	40.7	32.7	4.3	31.2	0.83
2	Ellsmore B ..	132,000	2.9	37.7	33.0	5.5	33.1	0.73
2	Ellsmore C ..	90,000	6.5	38.8	29.6	5.0	31.2	1.15
		273,000	4.4	38.6	31.8	5.1	32.1	0.89
6	Wingello	245,000	6.1	37.3	32.8	4.3	32.0	0.82

PART B.—INDICATED BAUXITE.

No.	Locality.	Long Tons (Dry Ore).	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	FeO.	Soda Loss.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Belanglo	3,500			Not sampled			
2	Ellsmore	1,625,000(1)	5.4	39.4	31.1	5.2	0.97	..
3	Murrimba	50,000	3.9	31.0(2)	34.4	..	..	..
4	Sutton Forest ..	170,000	4.2	36.8	35.9	4.2	1.74	..
	Sutton Forest ..	24,000(3)	4.5	53.9	5.7	..	..	..
	Sutton Forest ..	73,000(3)	6.5	43.2	12.6	..	..	..
	Sutton Forest ..	500,000(3)	4.5	31.3	28.8	..	..	..
5	Murrimba and Sutton Forest	270,000	4.0	36.7	37.4	5.0	1.60	..
6	Wingello	1,200,000(4)	..	27.2(5)	..	..	..	..
7	Wingello	Very small	..	..	..	..	..	..
8	Bumballa	175,000	7.5	35.2(2)	30.2	..	..	..
9	Bumballa	10,000	5.5	34.0(2)	34.6	..	..	..
10	Caoura	6,000	7.4	32.5(2)	32.6	..	..	..

(1) Inlcudes 273,000 tons shown in Part A above.
(2) Al_2O_3 soluble in sulphuric acid. Analyses by B.H.P. Co. Ltd.
(3) Figures from C. and B.C. 8th Report, January, 1942. All other figures in Part B, except for No. 6 Deposit from report by Raggatt (1939).
(4) Tonnage estimate from resampling by Aluminium Commission. Includes 245,000 tons given in Part A above.
(5) Available Al_2O_3 determined by Aluminium Commission.

General Geology.

The geology of an area enclosing the laterite bodies is shown in Fig. 4. The area is part of the Southern Tablelands of New South Wales where dissection of a former mature land surface is taking place. A horizontal succession of Permian and Triassic beds overlies folded sediments and intrusives of older Palaeozoic age. In the north-western corner of the area shown in Fig. 4 tributaries of the Wollondilly River have cut down into the basement, and elsewhere, particularly in the western side of the area, the Triassic sandstones have been stripped from wide areas to expose the Illawarra Coal Measures.

In early Tertiary time basic lavas were extruded as a thin sheet on a surface of low relief, composed of horizontal beds of the Wianamatta Group (Upper Triassic) with small accumulations of early Tertiary lacustrine sediments containing plant fossils.

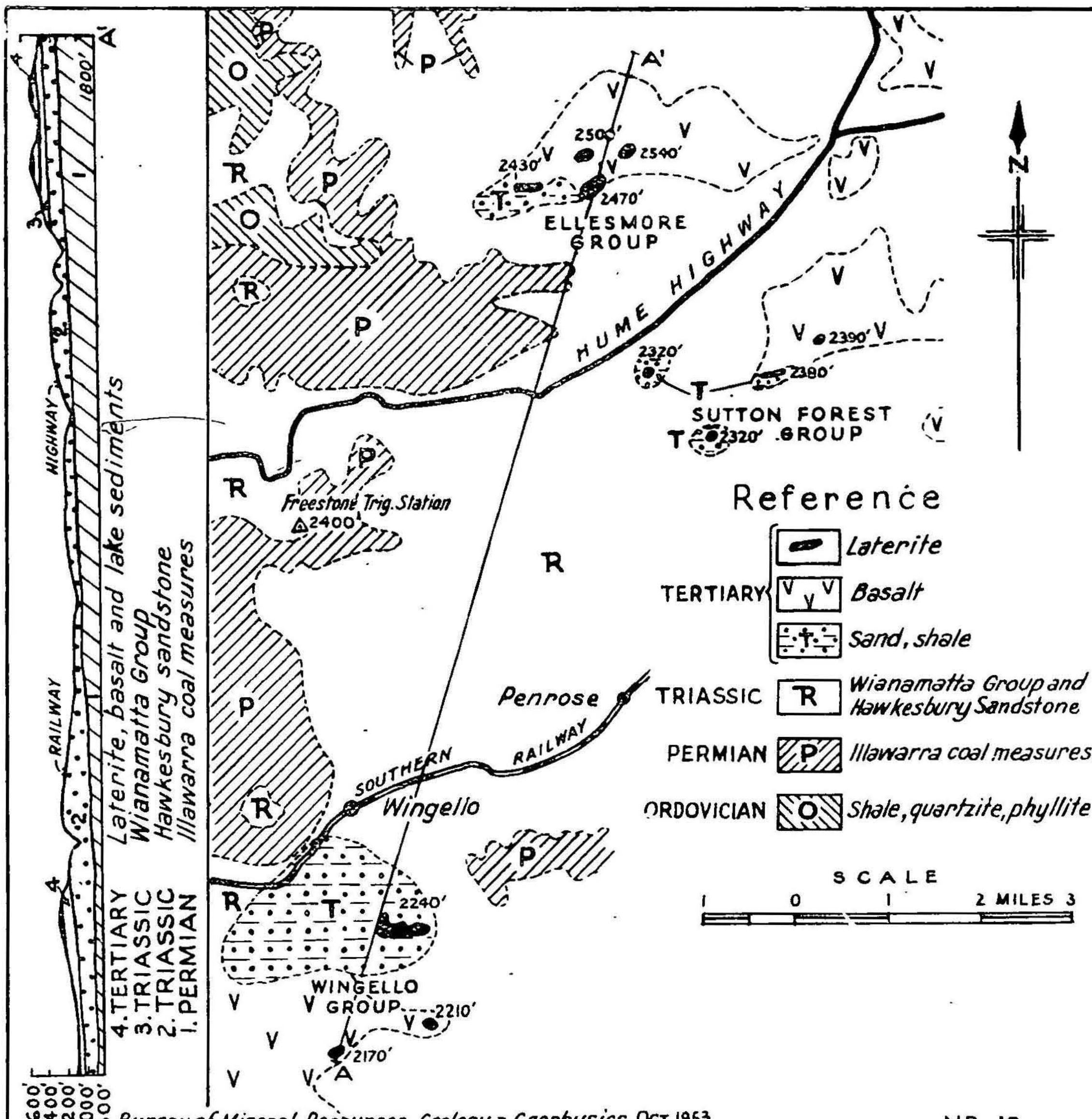


FIG. 4 Geological sketch map showing spot heights on bases of laterite bodies - Moss Vale Area, N.S.W.

[*To face page* 64.]

The lava field presented a land surface of very subdued topography occupied by a chemically unstable rock and it is probable that lateritic attack started soon after volcanic activity ceased.

Only volcanic rocks have been lateritized, though where the basalt is thin underlying sediments have been affected, mainly by the introduction of iron oxide cement between the quartz grains of sandy sediments. At Ellsmore and No. 3 deposit Tertiary sediments underlie the sub-lateritic basalt at too great a depth to come within the laterite profile. Indistinct plant remains have been noticed in the sandy Tertiary lake beds at Ellsmore, and *Cinnamomum* has been identified in argillaceous sediments from beneath the laterite at No. 3 deposit (Jaquet, 1901).

The basalt is not underlain by Tertiary beds at all points within the area being discussed; at Freestone Trig. a small remnant of basalt, with a few residual boulders of ferruginous laterite, was found lying on Triassic sandstone, and near the Cross Roads basalt rests on gently dipping shale of the Wianamatta Group.

None of the laterite bears any cover of younger formations as it does at Inverell and in Victoria and Tasmania.

Several shafts sunk by the Aluminium Commission passed through laterite into kaolinized basalt and exposed the transition from pisolitic ore to parent basalt.

The age of the laterite cannot be stated with precision; the parental basalt is probably not younger than Oligocene, and the very deep dissection of the tableland that has taken place since the laterites were formed suggests a very considerable lapse of time. It is therefore considered that the laterite is Miocene or of an earlier age within the Tertiary Period.

Descriptions of Deposits.

Two areas were examined in detail by the Australian Aluminium Production Commission. The western end of No. 6 Area was taken up by the Commission and tested by sinking shafts and bores at intervals of 400 feet. On the eastern end of this area, where the mining rights are held by Messrs. Alunite (Aust.) Pty. Ltd., old prospecting shafts were sampled with the permission of the lease-holders.

At Ellesmore three or four laterite bodies held by the Broken Hill Pty. Co. Ltd. were tested by sampling old shafts and sinking additional ones at intermediate positions. This work was carried out during the early part of 1949, and most of the work at Wingello was completed during June to August, 1948.

Descriptions of the other deposits, supplemented by some observations by the writer at Nos. 3, 4, and 5, are taken from acknowledged sources. Except for Nos. 2 and 6 deposits, all tonnage estimates given are also quoted from the same sources.

No. 1 *Deposit, Belanglo.* (Raggatt, 1939.)

This deposit occupies a pear-shaped area about 300 feet by 70 feet with the longer axis trending east by south, in Portion 175, Parish of Belanglo, 12 miles west-south-west from Moss Vale. The body has a maximum thickness of 9 feet and an estimated total tonnage of 3,500.

No chemical analyses of the laterite are available.

No. 2 *Deposit, Ellsmore.* (*See* Plate 7.)

Four bodies, remnants of a once continuous sheet, constitute the No. 2 group of deposits and occupy parts of Portions 4, 25, 28, 29, 32, 33, 42, 43, and 52, Parish of Murrimba, about 12 miles west-south-west from Moss Vale and 3 miles west of the Hume Highway.

The pisolitic zone is strongly developed in the area and reaches a maximum thickness of 28 feet on Deposit B. In bodies A, C, and D the pisolitic ore directly overlies variegated lateritized basalt with high silica content. Soft red ferruginous earthy laterite of thickness ranging from about 20 feet to a few inches underlies the pisolitic type in body B.

Logs of some of the shafts with partial analyses of channel samples are given to illustrate typical sections in detail and to amplify the graphical section shown in Plate 7.

Depth in Feet.		Field Description.	SiO_2	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
		Body A.—Shaft Co-ordinates. 100N/410W.				
0	1	Soil	..	..	..	..
1	3.5	Pisolites in red earthy matrix	5.6	33.8	38.1	28.0
3.5	5.5	Red-brown cemented pisolites	3.9	36.6	38.9	28.8
5.5	7.5	Loose brown pisolites	4.8	38.0	36.7	28.0
7.5	10.5	Soft light-brown and hard dark-red pisolitic laterite	4.4	39.9	31.3	31.4
10.5	13.5	Soft light-brown and hard dark-red pisolitic laterite with clay	10.4	38.4	24.0	26.8
13.5	14.5	Red and white clay	30.5	35.8	12.5	11.2
		Body B.—Shaft Co-ordinates. 500S/400W.				
0	1.5	Soil	..	..	..	..
1.5	5.5	Cemented pisolites } Quarry face (0–8.0)	4.9	37.8	36.4	25.3
5.5	8.0	Loose pisolites				
8.0	10.0	Pisolites	Not sampled			
10.0	11.0	Loose pisolites				
11.0	12.5	Cemented pisolites, passing to	7.0	41.1	25.3	34.8
12.5	16.0	Pisolites in soft earthy matrix				
16.0	19.5	Pisolites in light brown clay	..	..	..	27.0

BODY B.—SHAFT CO-ORDINATES. 200N/400E.

Depth in Feet.		Field Description.	Ignition Loss.	Available Al_2O_3.	Soda Loss.
From—	To—				
			Per cent.	Per cent.	Cwt.
0	1.5	Soil	..	..	..
1.5	6.5	Fine loose pisolites passing to	17.0	30.5	0.32
6.5	8.0	Coarse ferruginous nodules, passing to ..	} 20.6	35.0	0.30
8.0	13.0	Light brown earthy bauxite with sparse nodules			
13.0	15.5	Cemented pisolites	} 19.6	30.8	1.45
15.5	18.0	Sub-pisolitic and earthy laterite with hard red clay			
18.0	25.5	Sub-pisolitic and earthy laterite with hard red clay	17.9	24.4	4.20

Composite Sample. (1.5 – 13.0 feet)

SiO_2	1.8 per cent.
Al_2O_3	37.6 per cent.
Fe_2O_3	34.4 per cent.
TiO_2	5.6 per cent.
P_2O_5	0.09 per cent.
V_2O_5	0.10 per cent.
Ignition loss	19.4 per cent.
Available Al_2O_3	33.3 per cent.
Soda loss	0.31 cwt.

BODY B.—SHAFT CO-ORDINATES. 510N/625E.

Depth in Feet.		Field Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	2	Soil	..	..	..	..
2.0	4.5	Sparse nodules in red earthy bauxite ..	5.0	35.0	32.2	31.2
4.5	12.0	Red earthy bauxite	3.9	37.2	32.1	32.2
12.0	12.5	Hard red earthy bauxite	} 2.1	37.8	32.3	36.1
12.5	13.0	Horizontal band of cemented pisolites ..				
13.0	17.0	Hard red earthy bauxite				
17.0	20.5	Hard red earthy bauxite	..	..	..	33.1
20.5	21.5	Hard red earthy bauxite	..	..	..	35.3
21.5	22.5(*i*)	Hard red earthy bauxite	..	..	..	32.5
22.5	24.0(*i*)	Hard red earthy bauxite with clay ..	..	..	..	32.3

Composite Sample. (2.0 – 20.0 feet)

SiO_2	3.75 per cent.
Al_2O_3	37.1 per cent.
Fe_2O_3	32.0 per cent.
TiO_2	5.4 per cent.
P_2O_5	0.10 per cent.
V_2O_5	0.08 per cent.
Cr_2O_3	0.07 per cent.
Ignition loss	20.8 per cent.
Available Al_2O_3	32.9 per cent.
Soda loss	1.20 cwt.

(*i*) Later sampling which overlapped previous sample channels.

Body C.—Shaft Co-ordinates. 1470N/90W.

Depth in Feet.		Field Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	1.5	Soil	..	..	..	..
1.5	6.5	Cemented pisolites	7.1	39.3	27.8	33.1
6.5	11.0	Cemented pisolites, with little clay from 10 feet to 11 feet	12.8	37.4	25.8	26.3
11.0	15.5	Lateritized basalt	21.6	31.6	27.5	11.2

Body D.—Old Shaft No. 1.(*a*)

Depth in Feet.		Field Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	1	Hard capping	} 4.40	41.71	28.14	2.70
1.0	5.0	Pisolitic bauxite				
5.0	10.0	Loosely pisolitic	4.20	41.82	27.71	1.93
10.0	15.0	Loosely pisolitic	6.60	39.71	28.43	0.64
15.0	20.0	Laterite, some lateritized basalt ..	23.92	27.61	29.29	0.26

(*a*) Description and analyses by B.H.P. Co. Ltd. Quoted from Raggatt (1939).

Reference to Plate 7 will show that body A forms a long, narrow outcrop measuring about 2,500 feet long from east to west and averaging 250 feet wide. The deposit caps a low hill with a level crest about 40 feet above the surrounding country. Tertiary sediments with indistinct plant remains underlie the laterite and parent basalt, and outcrop on the southern flank and eastern end of the hill.

Results of sub-surface sampling at the points shown on the accompanying plan revealed small volumes of economic bauxite, at either end of the deposit.

A shaft sunk in a central position encountered 12 feet of pisolitic laterite with low available alumina due to an unusually high proportion of monohydrate, indicated by the low ignition loss figure.

Total measured reserves contained in body A are estimated to be—

TABLE 15.

Tons.	SiO_2.	Al_2O_3.	Available Al_2O_3	Na_2O Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
(*a*) 205,000 ..	5.1	39.7	29.2	1.20	8,000
(*b*) { 25,500(1) ..	3.9	41.0	30.5	0.62	5,000
25,500(2) ..	4.9	40.5	32.0	1.04	3,000
(*c*) 51,000 ..	4.4	40.7	31.2	0.83	8,000

(*a*) Includes all pisolitic laterite.
(*b*) Excludes samples which bring the average for any shaft below 20 per cent. available Al_2O_3.
(*c*) Total of (*b*). Contains 32.7 per cent. Fe_2O_3 and 4.3 per cent. TiO_2.

(1) West end of deposit. Portion 52.
(2) East end of deposit. Portion 28.

Body B is the largest of the group and as mentioned earlier contains a lower zone of earthy laterite beneath the pisolitic capping. At the north-eastern extremity of the deposit the pisolitic zone has been removed by erosion and the earthy material outcrops as a superficially hardened massive laterite.

The results of sampling fourteen shafts are set out in Table 16.

TABLE 16.

Tons.	SiO_2.	Al_2O_3.	Available Al_2O_3.	Na_2O Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
(a) 470,000 ..	..	..	30.1	1.04	330,000
(b) 60,000 ..	2.5	38.2	33.0	0.36	150,000
(c) 72,000 ..	3.3	37.2	33.1	1.06	16,000
(d) 132,000 ..	2.9	37.7	33.1	0.73	166,000

(a) All laterite, excluding samples containing less than 25 per cent. available Al_2O_3. This total includes tonnages (b) and (c).
(b) Pisolitic bauxite (i.e., excluding any below 30 per cent. available Al_2O_3).
(c) Earthy bauxite at north-eastern end of deposit.
(d) Total of (b) and (c). Contains 33.0 per cent. Fe_2O_3 and 5.5 per cent. TiO_2.

Pisolitic laterite forming body C in Portion 33 is similar to that in body A and in the south-western half of body B. Sampling of eight shafts permitted the calculation of the following reserves:—

TABLE 17.

Tons.	SiO_2.	Al_2O_3.	Available Al_2O_3.	Na_2O Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
(a) 160,000 ..	..	..	29.7	1.75	13,000
(b) 90,000 ..	6.5	38.8	31.2	1.15	13,000

(a) All pisolitic laterite, including (b).
(b) Excludes samples which bring the average for any shaft below 30 per cent. available Al_2O_3. Contains 29.6 per cent Fe_2O_3 and 5.0 per cent. TiO_2.

Deposit D, which lies 1,500 feet east from body C, was not tested by the Aluminium Commission. It has been estimated by Raggatt (1939, page 7) that the deposit contains 95,000 tons of pisolitic ore. Samples from one shaft showed the following average composition for a thickness of 15 feet:—5.1 per cent. SiO_2, 41.1 per cent. Al_2O_3, 1.76 per cent. FeO, 28.1 per cent. Fe_2O_3, 17.8 per cent. ignition loss. The ignition loss figure suggests that the available Al_2O_3 content is about 31 per cent.

No. 3 Deposit, Murrimba.

This small deposit lies in Portion 102, Parish of Murrimba, and consists of a small cap of cemented pisolitic laterite overlying light brown earthy laterite, resting in turn on Tertiary sediments.

Raggatt (1939, page 7) gives the following log of a shaft sunk and sampled by the Broken Hill Pty. Co. Ltd.:—

Depth in Feet.		Description.(1)	SiO_2.	Al_2O_3.(2)	Fe_2O_3.
From—	To—				
			Per cent.	Per cent.	Per cent.
0	5	Pisolitic bauxite, loosely cemented ..	2.96	31.85	38.90
5	10	Pisolitic bauxite	2.70	32.12	30.36
10	15	Pisolitic bauxite	3.42	27.56	43.27
15	20	Pisolitic bauxite	3.64	28.10	43.27
20	25	Pisolitic bauxite	4.96	34.91	30.01
25	28	Pisolitic bauxite	4.56	31.52	36.71
28	32	Laterite, earthy in part, with some nodules of basalt	8.32	33.90	24.76

(1) All samples except the last are described as dark-red in colour.
(2) Alumina by extraction with sulphuric acid.

A sample representing a thickness of 6 feet cut by the writer from a quarry face near the base of the laterite and described in the field as pisolitic and earthy bauxite, brown in colour, was submitted to analysis with the following result:—

	Per cent.
SiO_2 ..	3.8
Al_2O_3 ..	28.5
Fe_2O_3 ..	41.3
TiO_2 ..	7.2
P_2O_5 ..	0.25
V_2O_5 ..	0.08
Available Al_2O_3 ..	27.8

Reserves have been estimated at about 50,000 tons containing 4 per cent. SiO_2, 31 per cent. Al_2O_3, and 38 per cent. Fe_2O_3.

No. 4 Deposit, Sutton Forest.

A narrow laterite body trending east and west and approximately half a mile in length and 300 feet wide forms a prominent ridge in Portions 131, 11, and 107, Parish of Sutton Forest.

The deposit is capped by a zone of ferruginous pisolitic and massive laterite about 8 feet thick. Near the eastern end of the deposit this capping overlies earthy mottled pink, red, and buff bauxite of high grade. This zone is absent at the western edge of the ridge where an extensive quarry has been opened in ferruginous laterite, mainly pisolitic, which is about 20 feet thick. A shallow shaft sunk from the floor of the quarry was not accessible at the time of a visit by the writer, but dense laterite and kaolinized basalt were both present in the spoil dump.

Raggatt (1939, page 12) reports mottled clay in the floor of the quarry, and gives the following section from the quarry face and analyses:—

Sample No.	Thickness. Ft.	in.	Description.
103	1	9	Red soil with loose pisolites
104	5	0	Pisolite bauxite, fine-bedded at base, loosely cemented
105	2	3	Pisolitic bauxite, nodular towards base
106	1	6	Dense laterite
107	4	0	Nodular zone
108	6	3	Medium-grained bauxite. Lower part very clayey
109	5	0	Even-grained bauxite
110	3	9	Nodular lateritic zone
111	3	9	Red and white mottled gritty clay

Sample No.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	TiO_2.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
103	11.4	32.3	29.8	1.1	4.5	20.0
104	3.4	33.1	39.2	2.5	5.0	16.7
105	3.8	38.4	31.4	2.4	5.3	18.6
106	3.1	32.2	39.0	1.2	4.8	19.7
107	3.9	32.1	38.6	0.8	4.7	19.4
108	5.1	34.0	34.6	1.5	5.3	19.2
109	4.6	34.5	33.2	1.4	6.1	19.6
110	14.1	36.6	21.8	0.7	4.4	22.0
111	33.0	29.5	18.6	0.5	2.8	15.2

Later prospecting by Sulphates Pty. Ltd. revealed the high-grade material at the eastern end of the deposit. A quarry has been opened in this, and 8 feet of bauxite in the quarry face were sampled by the water with the following result:—

Sample No.	1.	2.
Depth from surface, feet	5 to 9	9 to 13
SiO_2	3.8 per cent.	4.6 per cent.
Al_2O_3	55.3 per cent.	55.3 per cent.
Fe_2O_3	4.2 per cent.	3.3 per cent.
TiO_2	6.7 per cent.	5.8 per cent.
P_2O_5	0.06 per cent.	0.06 per cent.
V_2O_5	Trace	Trace
Cr_2O_3	Trace	Trace
Ignition loss	30.1 per cent.	30.5 per cent.
Available Al_2O_3	50.3 per cent.	50.8 per cent.
Soda loss	0.80 cwt.	0.80 cwt.

It is estimated in a report of the Commonwealth Copper and Bauxite Committee (1942) that reserves of aluminous laterite and bauxite contained in No. 4 deposit amount to—

TABLE 18.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	TiO_2.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
170,000 ..	4.17	36.84	35.88	1.74	4.16
24,000 ..	4.5	53.9	5.7	..	..
73,000 ..	6.5	43.2	12.6	..	..
500,000 ..	4.5	31.3	28.8	..	..

No. 5 *Deposit.*

At this area a roughly circular outcrop of pisolitic laterite straddles the boundary between the Parishes of Murrimba and Sutton Forest.

The laterite has a maximum thickness of 29 feet and the body is approximately 550 feet in diameter.

The Broken Hill Pty. Co. Ltd. sank a shaft near the centre of the deposit with the following results which are reported by Raggatt (1939, page 15).

Sample No.	Depth.	Description.
	Feet.	
24	0 – 5	Loose pisolitic bauxite, red
27	5 – 10	Pisolitic bauxite, brown
38	10 – 15	Pisolitic bauxite, dark red
39	15 – 20	Pisolitic bauxite, dark red
40	20 – 25	Pisolitic bauxite, chocolate
49	29 – 32	Lateritized basalt and grey clay

Sample No.	SiO_2.	Total Al_2O_3.	Al_2O_3 by H_2SO_4.	Fe_2O_3.	FeO.	TiO_2.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
24	3.9	37.9	30.5	36.0	2.2	3.7	15.0
27	4.2	..	34.3	35.4	..	..	..
38	4.2	37.2	33.2	34.3	1.6	5.6	16.5
39	3.3	35.0	30.7	38.3	1.0	5.6	16.2
40	4.6		29.4	43.0	..	..	..
44	6.5	..	27.5	40.7	..	..	..
49	23.3	..	27.8	28.0	..	..	..

One sample of pisolitic laterite, representing the uppermost 6 feet, taken by the writer, yielded on analysis—

	Per cent.
SiO_2	3.6
Al_2O_3	38.2
Fe_2O_3	36.4
TiO_2	5.0
P_2O_5	0.09
Cr_2O_3	Trace
V_2O_5	Trace
Ignition loss	15.7
Available Al_2O_3	27.9
	Cwt.
Soda loss	1.30

Reserves probably amount to 270,000 tons containing 4 per cent. SiO_2, 31.5 per cent. Al_2O_3 soluble in H_2SO_4, and 37.5 per cent. Fe_2O_3.

No. 6 *Deposit, Wingello.* (*See* Plate 8.)

The laterite occurrence in this area constitutes the largest single deposit in the district. It lies in Portions 151 and 159, Parish of Wingello, and is less than 2 miles south and south-east of the Wingello railway station.

The Aluminium Commission's prospecting operations were confined to the western end of the deposit (old P.M.L.'s 3, 4, and 9) where mining rights were secured by the Commission, but old prospecting shafts on alienated ground in the eastern portion of the body (P.M.L. 2) were resampled.

Reference to Plate 8 will show that the laterite body is of large dimensions, measuring 4,200 feet long from east to west by an irregular width averaging about 450 feet.

A pisolitic zone generally about 4 feet thick and ranging to a maximum observed thickness of 7.5 feet lies beneath a thin cover of red soil containing loose scattered pisolites. The pisolitic ore overlies hard dark-brown and red tubular or massive laterite which passes to softer earthy material with hard ferruginous nodules, lying on grey, brown or purple basaltic clay.

Four typical shaft logs are given—

Depth in Feet.		Field Description.	Ignition Loss.	Available Al_2O_3.	Soda Loss.
From—	To—				
			Per cent.	Per cent.	Cwt.
		P.M.L. 3.—SHAFT CO-ORDINATES 00/400W.			
0	2	Soil	..	..	..
2	6	Hard red pisolites in soft earthy matrix	17.8	28.7	..
6	10	Hard red pisolites in soft earthy matrix	21.0	33.9	0.94*
10	14	Soft brown laterite	18.0	25.7	..
14	18.5	Soft brown laterite	15.0	12.6	..
18.5	20.5	Brown sand	..	..	..
		P.M.L. 3.—SHAFT CO-ORDINATES 00/400E.			
0	1.5	Soil	..	..	..
1.5	4	Pisolitic laterite	16.4	23.7	..
4	8	Reddish brown nodular laterite	11.9	..	..
8	12	Clay	10.8	..	..
12	13	Basaltic clay	..	..	..
		P.M.L 2.—SHAFT NO. 3.			
0	2	Not sampled			
2	4	Loose pisolitic laterite	16.4	23.5	..
4	9	Massive red laterite	20.9	34.2	0.32
9	14	Massive red laterite	19.3	26.6	2.44
14	16	Massive red laterite becoming softer at 15 feet and 16 feet	23.1	35.6	0.78
16	20	Soft red earthy laterite	18.8	24.8	..
20	26	Basaltic clay	..	..	..
4	16	*Composite sample.*			
		SiO_2 .. 8.9 per cent.			
		Al_2O_3 .. 34.8 per cent.			
		Fe_2O_3 .. 30.8 per cent.			
		TiO_2 .. 4.8 per cent.			
		P_2O_5 .. 0.40 per cent.			
		V_2O_5 .. 0.06 per cent.			
		Cr_2O_3 .. Trace			
		Ignition loss .. 20.2 per cent.			
		Available Al_2O_3 .. 31.6 per cent.			
		Na_2O loss .. 1.23 cwt.			
		P.M.L. 2.—SHAFT NO. 8.			
0	1	Soil	..	..	..
1	7	Very hard, cemented and massive pisolitic laterite	19.5	29.6	..
7	13	Nodules of dense red laterite in soft earthy matrix	20.0	30.0	1.45
13	14	Nodules of dense red laterite in soft earthy matrix	20.6	32.5	0.43
Below 14 feet		Inaccessible	..	..	..

* 4.2 per cent. SiO_2, 37.7 per cent. Al_2O_3, 31.5 per cent. Fe_2O_3, 4.9 per cent. TiO_2.

The reserves indicated as a result of the sub-surface sampling are summarized in Table 19.

TABLE 19.—TONNAGE: No. 6 DEPOSIT, WINGELLO.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
(a) 60,000 ..	7.5	36.4	31.2	4.4	31.6	0.86
(b) 185,000 ..	5.6	35.0	33.3	4.3	32.2	0.78
245,000 ..	6.1	35.3	32.8	4.3	32.0	0.81
(c)1,200,000 ..	..	..	..	..	27.2	..

(a) Economic bauxite indicated by two shafts, one bore, and quarry face in P.M.L.'s 3 and 4. Held by Aluminium Commission.
(b) Economic bauxite indicated by eight shafts in P.M.L. 2. Alienated. Total is made up of three separate zones containing 75,000, 5,000, and 105,000 tons.
(c) Total laterite in Deposit No. 6. Computed from results of sampling 17 shafts, 6 bores, and quarry faces. Thickness ranges from 3.5 feet to 21 feet and averages 10 feet.

Sampling on P.M.L. 2 was not as thorough as on the western end of the deposit. The opportunity to cut samples from the existing shafts was taken and no new shafts were sunk nor were the old ones cleaned out. It was apparent in a few instances that the total thickness of laterite was not accessible, but it is very improbable that deepening of these shafts would have appreciably increased the measurable volume of economic ore. Some advantage might have been gained by testing at 00/2000E and 00/2400E in P.M.L. 2 but at the time it was not possible to do so.

No. 7 Deposit, Wingello.

A small deposit occurs in Portions 84 and 100, Parish of Wingello, a few hundred yards south of No. 6 area; it has not been examined.

No. 8 Deposit, Bumballa.

This area lies in Portions 36 and 107, Parish of Bumballa, where three narrowly separated outcrops of laterite occur capping low hills. Prospecting by the Broken Hill Pty. Co. Ltd. showed that much of the laterite is in a late stage of denudation and that a large part of the area is covered by detrital boulders of laterite and not solid ore.

One shaft penetrated 15 feet of pisolitic ore containing 5.3 per cent. SiO_2, 35.9 per cent. Al_2O_3 soluble in H_2SO_4, and 30.9 per cent. Fe_2O_3.

Reserves have been estimated at 175,000 tons.

No. 9 Deposit.

At this locality, Portion 16 and Wingello State Forest, Parish of Bumballa, a small deposit containing about 10,000 tons of pisolitic laterite has been prospected by the Broken Hill Pty. Co. Ltd.

The deposit is unusual in that the siliceous zone at the base is pisolitic in habit though it contains more than 20 per cent. SiO_2.

No. 10 *Deposit.*

The laterite deposit at this area in the Parish of Caoura is similar to that at No. 9 and consists of about 6,000 tons of pisolitic laterite with a basal layer of lateritized basalt overlying Tertiary clays. The silica content of the pisolitic zone is about 7 per cent.

DESCRIPTION OF THE BAUXITE.

The laterite displays a variety of textures and characteristics, and may be divided into the following types from the surface downward.

A. Pisolitic, loose and cemented.
B. Massive and tubular (or "vermicular").
C. Earthy, pink and dark red.
D. Clayey, light-coloured, passing to variegated red and buff kaolinized basalt.

A. *The Pisolitic Type.*—To the unaided eye the pisolitic ore consists of roughly spherical pisolites ranging in diameter between about 1.5 and 50 mm. and commonly between 5 and 10 mm. Colour ranges between light brown and deep red, but the lighter pisolites owe their colour to a superficial skin and are a dark reddish-brown or brown in the interior.

The pisolites are closely packed and may be loose or cemented, with varying degrees of coherence, in extreme cases requiring a moderately hard blow with a hammer to break the nodules free from the matrix. Interstitial space between the pisolites amounts to about 30 per cent. of the rock. Where the inter-pisolitic space is filled the cementing material is of similar colour to the pisolites and appears earthy and granular to the unaided eye.

Under magnification thin sections of the cemented ore from body B at Ellsmore show the matrix to consist of closely packed oolites, of an average diameter of about 0.25 mm. surrounded by a narrow rim (0.01 to 0.02 mm. wide) of prismatic gibbsite crystals. These crystals radiate from the surface of the oolites and project into minute cavities. Many of the oolites are formed about a central angular fragment of quartz, and in some instances a quartz grain may possess only a thin rim of limonite or cliachite with a selvage of crystalline gibbsite, or the quartz grain may have gibbsite crystals attached directly to it.

The pisolites contain grains of magnetite and hematite and are uniformly dark-brown and opaque, except for a narrow light-brown rim, but may have a golden-brown isotropic mineral, with a higher refractive index than quartz, filling fine cracks in the interior. This mineral has an ill-defined fibrous texture parallel to the walls of the crack it is filling, and is probably cliachite.

Four typical analyses of pisolitic laterite are given. The analyses have been conducted on dry material.

—	1.	2.	3.	4.
SiO_2	3.6 per cent.	8.1 per cent.	4.1 per cent.	3.5 per cent.
Al_2O_3	38.2 per cent.	39.9 per cent.	42.1 per cent.	38.0 per cent.
Fe_2O_3	36.4 per cent.	29.6 per cent.	28.4 per cent.	34.0 per cent.
TiO_2	5.0 per cent.	4.3 per cent.	4.7 per cent.	5.3 per cent.
P_2O_5	0.09 per cent.	0.24 per cent.	0.28 per cent.	..
V_2O_5	Trace	0.07 per cent.	0.05 per cent.	..
Cr_2O_3..	Trace	..	..	FeO 2.0 per cent.
Ignition loss	15.7 per cent.	17.5 per cent.	19.5 per cent.	15.7 per cent.
Available Al_2O_3 ..	27.9 per cent.	31.1 per cent.	34.7 per cent.	29.5 per cent.
Soda loss	1.30 cwt.	0.39 cwt.	0.99 cwt.	0.37 cwt.

1. Quarry face .. No. 5 Area .. Par. Murrimba–Sutton Forest .. Loose pisolites.
2. Quarry face .. No. 6 Area .. Par. Wingello .. . Loose pisolites.
3. Shaft 6 .. No 2 Area .. Ellsmore "A" .. .. } Cemented pisolites from which specimens
4. Shaft .. No. 2 Area .. Ellsmore "B" .. .. } described above were taken.

B. The Massive and Tubular Types.—Massive and tubular ores occur below the pisolitic zone at No. 6 Deposit, Wingello, and at No. 4 Deposit, Sutton Forest.

The rock is dense, hard, and dark-brown, where exposed in a shallow quarry at Wingello. Its megascopic appearance is similar to that of the interior of the pisolites forming the upper zone. The rock is penetrated by solution channels which are roughly-circular or elliptical in cross-section and generally from 10 to 30 mm. in diameter. These channels, which give the rock its tubular or "vermicular" appearance, have no common orientation, but the majority are vertical or steeply inclined. They are lined internally with a light-brown skin similar to that coating the pisolites, and the larger channels contain imperfectly formed pisolites which were apparently forming at the expense of the massive laterite. Although the passage from pisolitic to tubular types is fairly sharp a gradation may be noticed. Locally the cemented pisolitic material encloses small masses of tubular laterite, and the development of pisolites within the lower zone is conspicuous in places.

A thin section of the massive laterite from Wingello showed it to consist of dark-brown opaque material similar to that in the pisolites described above, and containing rounded quartz grains and fine cracks filled with yellow cliachite(?).

Two channel samples of tubular and massive laterite cut from a quarry face at Wingello were analysed with the following results:—

—	1.	2.
SiO_2	4.6 per cent.	5.3 per cent.
Al_2O_3	34.2 per cent.	32.6 per cent.
Fe_2O_3	36.9 per cent.	37.9 per cent.
TiO_2	3.8 per cent.	4.7 per cent.
P_2O_5	0.24 per cent.	0.23 per cent.
Ignition loss	19.9 per cent.	18.4 per cent
Available Al_2O_3	32.4 per cent.	31.1 per cent.
Na_2O loss	0.42 cwt.	0.63 cwt.

1. Tubular laterite, channel cut from approximately 7 to 9.5 feet below natural surface.
2. Tubular passing to dense laterite from approximately 9.5 to 12 feet below natural surface.

C. *The Earthy Type.*—The hard massive type of laterite characteristic of the Wingello deposit is not present at Ellsmore, where the pisolitic zone is underlain by soft deep-red earthy material, which is however harder in outcrop at body B. At Sutton Forest both pisolitic and massive laterite are underlain by light pinkish earthy bauxite with a gritty friable texture.

The deep-red apparently textureless laterite at Ellsmore contains a few scattered hard ferruginous nodules and, rarely, narrow horizontal bands of pisolites. The pink bauxite at Sutton Forest presents a coarsely mottled or variegated appearance in the quarry owing to irregular patches of brown, red, or deep pink, according to the degree of staining by ferric iron. The ore is sufficiently soft to be broken from the face easily with a pick.

In the hand specimen the ore is seen to be very porous and to contain irregular veins and patches of harder and denser deep pink matter. Under the microscope, a thin section of this bauxite showed the red or deep pink part to be opaque and the lighter portion imperfectly transparent and mostly isotropic. Small aggregates of gibbsite crystals encrusting oolites of cloudy cliachite were seen. Small grains of quartz were numerous and probably account for the greater part of the silica figure given in analyses 4 and 5 set out below.

Three analyses of the dark red earthy laterite from Ellsmore and two of the pinkish bauxite from Sutton Forest follow:—

—	1.	2.	3.	4.	5
SiO_2 ..	5.0 per cent.	3.9 per cent.	2.1 per cent.	3.8 per cent.	4.6 per cent.
Al_2O_3 ..	35.0 per cent.	37.2 per cent.	37.8 per cent.	55.3 per cent.	55.3 per cent.
Fe_2O_3 ..	32.2 per cent.	32.1 per cent.	32.3 per cent.	4.2 per cent.	3.3 per cent.
TiO_2 ..	6.3 per cent.	5.2 per cent.	5.7 per cent.	6.7 per cent.	5.8 per cent.
P_2O_5 ..	0.25 per cent.	0.25 per cent.	0.24 per cent.	0.06 per cent.	0.06 per cent.
V_2O_5 ..	0.05 per cent.	0.05 per cent.	0.04 per cent.	Trace	Trace
Cr_2O_3 ..	..	..	..	Trace	Trace
Ignition loss	20.7 per cent.	21.2 per cent.	21.6 per cent.	30.1 per cent.	30.5 per cent.
Available Al_2O_3	31.2 per cent.	32.2 per cent.	36.1 per cent.	50.3 per cent.	50.8 per cent.
Soda loss ..	0.87 cwt.	1.37 cwt.	0.52 cwt.	0.80 cwt.	0.69 cwt.

1. Shaft No. 9, No. 2 deposit, Ellsmore "B"—Depth 3 to 4.5 feet.
2. Shaft No. 9, No. 2 deposit, Ellsmore "B"—Depth 4.5 to 12 feet.
3. Shaft No. 9, No. 2 deposit, Ellsmore "B"—Depth 12 to 18 feet.
4. Quarry, No. 4 deposit, Sutton Forest—Depth 5 to 9 feet.
5. Quarry, No. 4 deposit, Sutton Forest—Depth 9 to 13 feet.

D. *The Clayey Type.*—The clayey type represents the mottled zone of a laterite profile and is characterized by incomplete lateritization with the resulting presence of much kaolin. The zone contains hard ferruginous concretions, and softer iron-stained patches embedded in brown and buff clay which may show a relict texture of the parent basalt. These clays pass downward into dark-red and purplish clay in which the basaltic texture may be clearly preserved.

Analyses of examples from the Ellsmore deposits are given; numbers 2, 3 and 4 are a vertical sequence from the same shaft.

—	1.	2.	3.	4.
	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	18.3	29.5	32.3	32.7
Al_2O_3	25.5	23.6	29.5	28.2
Fe_2O_3	39.9	25.5	22.2	21.2
TiO_2	2.9	2.9	2.3	3.0
P_2O_5	..	0.18	0.15	0.16
V_2O_5	..	0.02	0.02	0.04
Cr_2O_3	..	0.06	0.05	0.04
Ignition loss	13.4	13.8	14.0	14.6
Available Al_2O_3	7.2	2.8	2.6	2.9

1. No. 3 deposit, Ellsmore—Variegated lateritized basalt immediately underlying pisolitic zone.
2. No. 2 deposit, Ellsmore—5 feet to 9 feet, immediately below pisolitic laterite containing 6.4 per cent. SiO_2
3. No 2 deposit, Ellsmore—9 feet to 12 feet, same shaft as 2.
4. No. 2 deposit, Ellsmore—12 feet to 18.5 feet same shaft.

OTHER LOCALITIES.

Laterite which contains appreciable quantities of alkali-soluble (free) alumina occurs in localities other than those mentioned and notably at (*a*) 10 miles northerly from Trundle which is 220 miles east-north-east of Sydney, (*b*) Crookwell, 50 miles west of Moss Vale, and (*c*) south of Bungonia, which is 52 miles south-west of Moss Vale.

The following notes on these occurrences are taken from unpublished reports by C. St. J. Mulholland of the Geological Survey of New South Wales (1941 a, b, and c).

Trundle.

The deposits near Trundle are situated in a locality known as Four Corners about 10 to 12 miles north-east from Trundle. Altogether ten separate occurrences of laterite were mapped in an area of 12 square miles, and others are known to exist in the vicinity.

Two types of laterite occur in the deposits, viz., ferruginous pisolitic material with a clayey matrix, and concretionary laterite or, more properly, nodular bauxite consisting of highly aluminous nodules embedded in red earth. Usually the concretionary bauxite crops out as a narrow fringe along the margins of the pisolitic material.

The pisolitic laterite contains less than 30 per cent. and an average of about 24 per cent. free alumina, but the free alumina figure of the nodular bauxite may be as high as 51.5 per cent. with an average figure of about 42 per cent. Large concretions free from the earthy matrix contain up to 57 per cent. free alumina. Shafts sunk in the nodular ore revealed that the aluminous nodules exceeding ½ inch in diameter constitute 70 to 80 per cent. of the ore, and that the nodular zone averaged 3 feet in thickness.

Incomplete prospecting by pit sinking indicates reserves of nodular ore of 40,000 tons of nodules free from matrix contained in six small deposits, one of which contains a probable 25,000 tons.

The composition and tonnage of the nodular bauxite are shown in Table 20.

TABLE 20.—BAUXITE RESERVES, TRUNDLE AREA.

—	Tons.	Number of Analyses.	Average Composition of Nodules retained on ⅛-in Screen. SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Free Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	2,000	2	5.1	55.0	9.7	0.54	51.5
2	4,000	3	5.4	50.0	11.0	1.05	43.9
3	3,000	1	4.9	43.0	19.6	1.00	40.2
4	5,000	2	7.5	47.4	17.3	1.00	40.2
5	25,000*	2	7.9	45.5	18.5	1.50	39.7

* Insufficient prospecting to permit reliable estimate of this deposit.

1. Portions 10, 12, and 13, Parish Coradgery West ..
2. Portion 6, Parish Salisbury, and Portion 10, Coradgery West
3. Portion 6, Parish Salisbury
4. Portions 6 and 22, Parish Salisbury
5. Portions 18 and 22, Parish Salisbury

} County of Kennedy.

Incomplete estimates of the quantity of ferruginous pisolitic laterite available in the Trundle deposits indicate a probable total of 760,000 tons containing about 24 per cent. free alumina. A typical analysis is—

	Per cent.
SiO_2	24.0
Al_2O_3	41.2
Fe_2O_3	10.4
TiO_2	2.5
Free Al_2O_3	27.5

Crookwell.

The known deposits in this area are small and consist of brown pisolitic laterite overlying basalt with some intervening red clay-like and lithoidal material.

A deposit in Portion 33, Parish of Crookwell, County of King, has a maximum thickness of 10 feet, of which the upper 5 feet consists of pisolites and the lower half of red clay-like material containing sparse aluminous nodules. Samples from the upper horizon contained 42.7 per cent. and from the lower 35.1 per cent. free alumina.

Several separate bodies occur in Portion 59, Parish of Kiamma, County of Georgiana. The largest of these is about 7 feet thick near the centre and gave samples containing between 29.9 and 40.1 per cent. free alumina.

The total tonnage of aluminous laterite in the area is not likely to exceed 30,000 tons containing about 35 per cent. free alumina.

Bungonia.

Twelve occurrences of laterite form the capping of mesa-like hills lying to the south and south-east of Bungonia, and may be regarded as residuals of an extension of the old land surface on which the Moss Vale bauxites were formed.

The Bungonia laterites are characterized by a high silica content ranging from 18 to 45 per cent. which is probably due to the nature of the parent rock.

Two small deposits one mile south of Bungonia rest on weathered porphyry, and the largest deposit of the group, known as Jacqua deposit, overlies altered sandstone and shale.

The log of one shaft sunk on the Jacqua deposit is quoted—

Depth in Feet.		Field Description.	SiO_2.	Free Al_2O_3.	Fe_2O_3.
From—	To—				
			Per cent.	Per cent.	Per cent.
0	5	Cemented grey pisolitic material	28.8	28.6	21.0
5	10	Cemented grey pisolitic material	18.8	30.3	23.5
10	15	Dark red pisolites and white clay	22.3	25.3	31.6
15	18	White clay and chocolate earth, soft	28.3	21.0	30.6
18	20	Dark earthy material	31.3	23.5	26.1
20	26	Soft white clay with slight red staining	38.8	26.5	16.3

Selected specimens from a parcel of mixed ore submitted to the Bureau during 1952 by a prospector who stated that the sample was derived from a locality between Bungonia and Windellama were analysed at the Aluminium Commission's laboratory with the following results:—

—	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Total SiO_2	4.8	11.6	5.4
SiO_2 as quartz	2.5	6.1	1.6
Available Al_2O_3	33.9	27.3	45.4

Descriptions of these specimens are—
1. Pisolitic bauxite—very dark brown resinous pisolites in light brown lithoidal matrix.
2. Similar to above but pisolites are red and dark brown, dull and earthy without resinous lustre.
3. Earthy bauxite—yellow to light brown soft earthy rock with few yellowish pisolites.

VICTORIA.

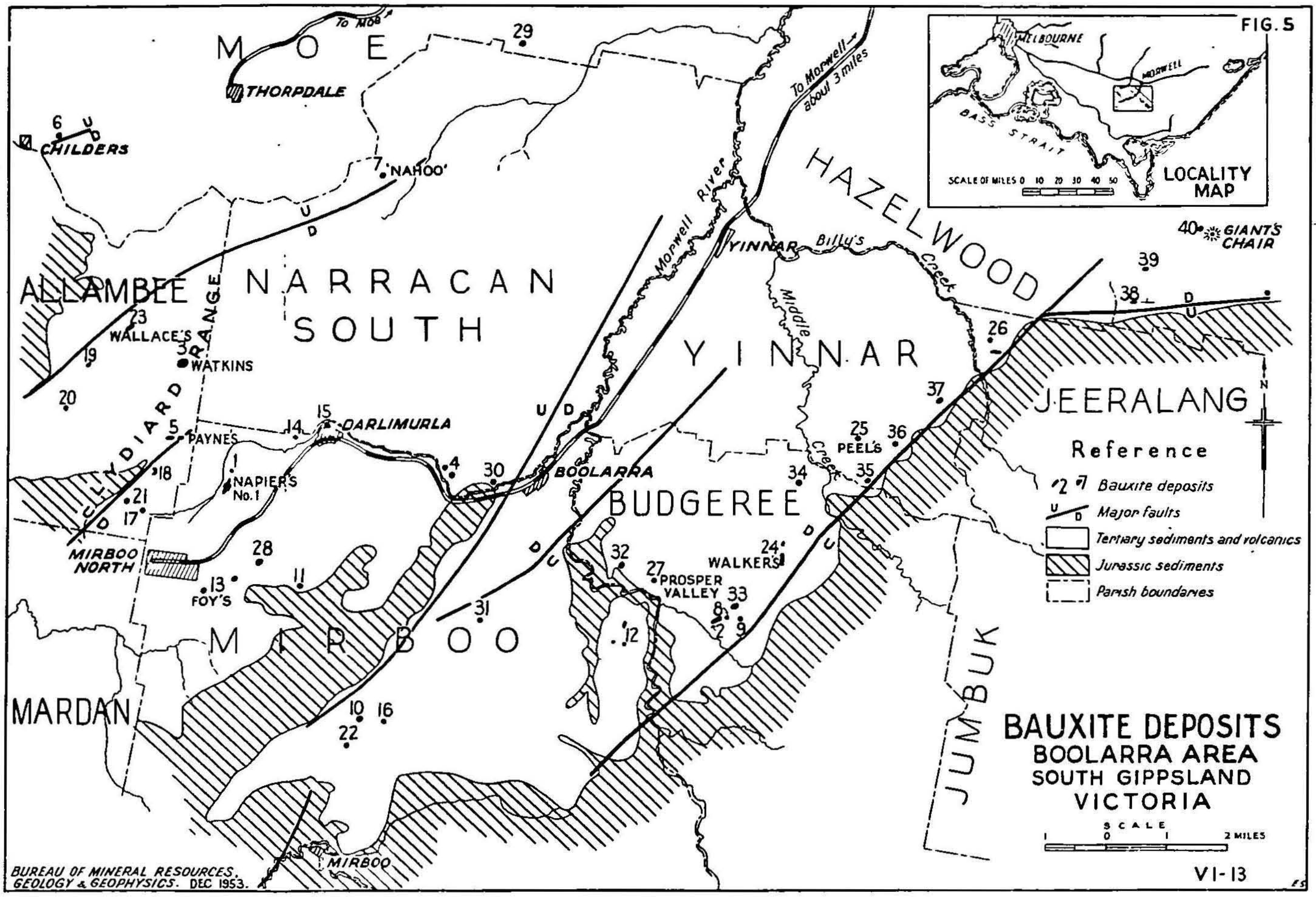
INTRODUCTION.

The most important deposits of bauxite occur within an area of 200 square miles in the County of Buln Buln to the south of the Gippsland railway. The village of Boolarra, which is 75 miles east-south-east of Melbourne in a direct line, is centrally placed in this area, and all known bauxite deposits of commercial significance are within 6 miles of a railway.

Other occurrences of bauxite with little economic value are known near Callignee, Devon, and Gelliondale in the same County. These localities are 18 miles east, 21 miles east-south-east, and 24 miles south-east of Boolarra respectively (Ferguson, 1936; Baragwanath, 1940). Bauxite and bauxitic clay have been reported on Mornington Peninsula, 36 miles south of Melbourne (Keble, 1950).

COUNTY OF BULN BULN.

The results of the joint investigation in South Gippsland conducted by the Mineral Resources Survey, the Victorian Mines Department, and Sulphates Pty. Ltd., in 1942-43 have been published in a Bulletin (Raggatt, Owen, and Hills, 1945), but the essential information is repeated here.



[To face page 81.]

Towards the end of 1946 the Aluminium Commission began an examination of several bauxite deposits in the same region. Concurrently a geological reconnaissance of a wide area was conducted in a search for additional occurrences.

SUMMARY OF RESERVES.

The following table (21) of reserves incorporates both the earlier results taken from the work cited and brought up to date in the light of more recent information, and the later results obtained during the course of the Aluminium Commission's prospecting operations. Many small deposits (Nos. 28 to 40) examined during the second campaign are omitted from this summary but are briefly described in the text.

All the deposits described in Mineral Resources Survey Bulletin 14 are listed in Table 21 and are numbered from 1 to 22 in the same order as that used previously, and also are distinguished on the locality plan (Figure 5) by the same reference numbers. The new or previously unreported occurrences are numbered from 23 onwards.

The proved reserves have been calculated to dry ore and are not reported as "green" ore *in situ* as had been done previously.

Following the example of the earlier paper the writer has divided the latter into two parts, A and B; the first sets out the more important deposits in which the reserves have been measured by systematic sub-surface exploration, and the second part shows less important occurrences or alienated deposits about which little is known.

TABLE 21.—SUMMARY OF RESERVES, COUNTY OF BULN BULN.

PART A.

No.	Deposit.	Measured Reserves.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
		Long tons dry ore.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
1	Napier's No. 1(2) ..	188,000(4)	5.6	51.6	10.0	6.0	..	..
2	Greenwood's	43,400	7.3	50.0	8.8	6.0	..	..
3	The Pines—							
	(i) Watkin's(1) ..	206,900	10.1	51.6	5.4	5.3	..	..
	(ii) Napier's No. 2 ..	17,000	10.0	50.8	7.6	4.8	..	..
4	Boolarra—							
	(i) Sulphates ..	46,600	5.0	53.0	6.5	4.5	..	..
	(ii) Orgill's	47,100	5.0	52.5	6.5	4.5	..	..
5	Payne's—							
	Western body ..	54,000	8.0	52.8	5.5	6.1	..	..
	Eastern body(1) ..	44,000	9.1	52.1	6.0	5.4(3)	..	..
23	Wallace's	27,000	3.7	50.2	14.2	5.0	47.4	0.60
24	Walker's	47,000	5.0	46.6	16.1	5.8	43.4	1.02
25	Peel's	36,000	11.5	43.8	16.1	4.9	36.0	..
26	Jerralang	28,000	7.7	51.5	6.5	6.0	44.8	1.56
	Total	785,000	7.6	50.7	8.5	5.5	..	..

(1) Data incomplete.
(2) Average grade of ore quarried by Sulphates Ltd. during—
(*a*) 1950—5.0 per cent. SiO_2, 55.0 per cent. Al_2O_3, 5.2 per cent. Fe_2O_3, 5.4 per cent. TiO_2.
(*b*) First quarter of 1952—6.2 per cent. SiO_2, 55.3 per cent. Al_2O_3, 3.4 per cent. Fe_2O_3, 5.3 per cent. TiO_2.
(3) Composition shown is average grade of ore quarried.
(4) Deduct 16,000 tons quarried to October, 1952.

No.	Deposit.	Reserves.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
		Long tons.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
6	Childer's or Rodda's ..	Unknown probably small	11.0	51.0	4.5	6.0	..	..
7	Nahoo(5)	About 50,000	15.0	52.0	3.5	4.0	..	..
8	Bond's	Probably very small, overburden exceeds 100 feet	..	..	..	..	..	..
9	Roy's	Probably negligible	..	..	..	..	..	..
10	Crutchfield's(5) ..	Nil	..	..	..	..	..	..
11	De Hais	Probably small	..	..	..	..	..	..
12	Fox's	Unknown ..	..	..	..	..	..	..
13	Foy's(5)	4,200	13.0	51.0	3.9	..	..	..
14	Lovell's(5)	Nil	..	..	..	..	..	..
15	Sargent's	Unknown ..	..	..	..	..	..	..
16	Tierney's(5)	Nil	..	..	..	..	..	..
17	Harrison's	Very small ..	..	..	..	..	..	..
18	King's—							
.	North(5)	9,000	..	..	..	..	..	..
	South	21,400	10.0	51.7	4.9	7.0	..	..
19	Polley's	Probably small	..	..	..	..	..	..
20	Smith's Mill	19,000	7.0	45.8	13.5	7.2	..	..
21	Wanke's	6,000	6.0	50.0	9.0	..	..	..
22	Martin's	Negligible ..	..	..	..	..	..	..
27	Prosper Valley ..	7,000	6.5	52.2	7.6	6.1	47.1	1.40
28 to 40, *see* text.								

(5) Tonnage and composition reported by Sulphates Limited.

Compositions of deposits 1–22 inclusive computed from analytical data supplied by Messrs. Sulphates Ltd., Melbourne.

GENERAL GEOLOGY.

Stratigraphy.

The area covered by the locality map has been geologically mapped by the Victorian Mines Department in the course of its systematic survey of parishes, and extensive reconnaissances together with detailed mapping of small areas have been carried out in connexion with the bauxite investigations. As a result of this, and other work in adjoining areas, details of the stratigraphical sequence are fairly clear. The succession commonly revealed is as follows:—

Quaternary ..	Recent and Pleistocene ..	River alluvium ..	Gravels, &c.
		.. .. ..	Sand and clay
Tertiary ..	Oligocene to Eocene ..	Yallourn Formation ..	Lignite, clay, sand
	Eocene	Older Basalts	Bauxite; Basalt and tuff with intercalated sand, clay and lignite
Mesozoic ..	Jurassic	Wonthaggi Coal Measures	Sandstone, siltstone, black coal
Palaeozoic ..	Lower Ordovician ..	Lancefieldian	Shale, sandstone, quartzite, and chert

The ages ascribed to the units younger than Mesozoic are somewhat tentative. In 1945 it was considered that the Yallourn Formation was not older than upper Oligocene and probably occupied a place low in the middle Miocene sequence. (Singleton, 1941; Crespin, 1943.)

As a result of further work Miss Crespin[1] now considers that the Yallourn Formation is older than formerly believed and that coal deposition continued from about middle Eocene to Oligocene time.

The Older Basalt (and derived bauxite) in Gippsland therefore must be older than middle Eocene, a view which is confirmed by R. A. Keble's work (1950) on Mornington Peninsula.

Keble (*op. cit.* page 30), mentioning that the question of the age of the Older Basalt is a vexed one, deduces, largely on palaeogeographical evidence, that the extrusion of the Older Basalt was completed before upper Eocene time, and that the age of the basalt is at least middle Eocene and may be greater.

On these views it is clear, therefore, that the bauxite is middle or lower Eocene in age.

Structure.

Extensive block faulting followed the deposition of the Yallourn beds, resulting in the formation of grabens in which great thicknesses of Tertiary sediments have been preserved. The Latrobe River valley occupies one of these troughs and a minor one extends south-westerly from Morwell to Boolarra, where 800 feet of sediments, including 350 feet of lignite and lignitic clay overlying basalt, have been preserved. The major faults have a general north-easterly trend in the area of the locality map, but north of this area the strike swings to the east.

Present-day topography is largely a reflection of the major fault structure. On the downthrown side greater or lesser thicknesses of Tertiary rocks, both sedimentary and volcanic, have been preserved as indicated in the preceding paragraph. On the upthrown sides of the major faults the higher ground has been denuded of Tertiary formations and the Jurassic bedrock is exposed. The approximate positions of the major faults in the region are shown on the locality plan (Figure 5).

The dislocations in the compact Mesozoic and Palaeozoic bedrocks developed as normal faults but the unconsolidated Tertiary sediments and possibly the flows and tuffs of the Older Basalt yielded by warping into monoclinal folds over the bedrock faults. Bauxite bodies which became involved in the folding are much shattered by minor dislocations with throws of a few feet.

Insofar as the bauxite deposits are concerned the significance of the block faulting is twofold. First, bauxite bodies are found over a wide range of elevations between 500 feet above sea level near Boolarra and 1,200 feet at Watkin's deposit, 3 miles north of Mirboo North. Secondly, where bauxite occurs above or close to a major fault zone, as at Deposits 26 and 38, it is tilted

(1) Private communication.

to high angles of dip and, as mentioned, traversed by numerous small faults. These fractures have provided loci within the bauxite for detrimental secondary chemical activity characterized by the introduction of silica and development of halloysite from gibbsite.

DESCRIPTION OF DEPOSITS.

The deposits distinguished by the Nos. 1 to 22 have been described previously by Raggatt *et al.* (1945) in some detail, but the principal features of the more important of these deposits (Nos. 1 to 7 and 21) are repeated here together with such additional information as may be available.

1. *Napier's No.* 1 *Lease.* (*See* Plate 9).

Two narrowly separated deposits of bauxite occur in the Parish of Mirboo on the eastern side of, and adjoining, the road from Mirboo North to Trafalgar, at a distance of 1½ miles north-north-east from the former town.

Two quarries, one in each orebody, have been opened on bauxite outcrops adjoining the road and a total of 92 percussion bores were sunk for sampling purposes. These bores were drilled at lateral intervals of 100 feet, and the greatest depth attained was 128 feet.

Boring showed the southern body to be 1,400 feet long from north to south by an average width of about 300 feet. The northern body is much smaller, being 550 feet long by 200 feet wide. The maximum thicknesses of high-grade bauxite in the two deposits are 24 and 21 feet respectively.

Logs of two of the deeper bores show that the bauxite underlies alternating beds of sand, clay, and lignite.

Southern Body.		Northern Body.	
Depth in Feet.	*Bore* 40.	Depth in Feet.	*Bore* 92.
0 – 1	Soil	0 – 1	Soil
1 – 4	Grey sand	1 – 5	Yellow sandy clay
4 – 7	Brown sand	5 – 8	Grey and brown sand with clay
7 – 10	Yellow sandy clay	8 – 18	Grey and brown sand
10 – 16	Grey sandy clay	18 – 19	Grey clay with sand
16 – 20	Grey clay	19 – 25	Plastic grey clay
20 – 22	Grey sand	25 – 28	Brown sand
22 – 29	Brown sand	28 – 32	Grey sand with clay
29 – 39	Lignitic clay	32 – 40	Grey and brown sand
39 – 53	White sand	40 – 41	Plastic grey clay
53 – 54	Yellow sand	41 – 47	Lignitic clay
54 – 64	Lignite	47 – 49	Bauxite— 6.9 per cent. SiO_2 53.7 per cent. Al_2O_3
64 – 76	Gritty lignitic clay	49 – 54	Bauxite— 3.4 per cent. SiO_2 53.4 per cent. Al_2O_3
76 – 78	Bauxite— 5.9 per cent. SiO_2 53.0 per cent. Al_2O_3	54 – 59	Bauxite and quartz gravel
78 – 83	Bauxite— 4.8 per cent. SiO_2 55.2 per cent. Al_2O_3	59 –	Basaltic clay
83 – 85	Bauxite— 6.9 per cent. SiO_2 48.6 per cent. Al_2O_3		
85 –	Basaltic clay		

Normally the bauxite rests directly on basaltic clay, but there are places where an appreciable thickness of sediments, commonly coarse quartzose sand, is interposed.

The basaltic clay has a finely mottled appearance, contains small specks of ilmenite, and is usually bluish in colour 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—when recovered from below the level of the water-table—grey or bluish-grey. The grey bauxite is of poor quality and has a higher iron content than the other varieties owing to the presence of siderite and pyrite.

Petrological examination of the bauxite revealed crystalline and cryptocrystalline gibbsite, ilmenite, iddingsite(?) and secondary encrusting pyrite and veinlets of siderite.

The basalt surface on which the bauxite has developed is undulating with a gentle dip to the south-east. The bauxite lies in depressions in this surface. From the western edge of the deposit the upper surface of the bauxite dips to the east and south-east at 7 to 10 degrees; the central and eastern portions lie horizontally and in some places along the eastern margin the dip is gently towards the centre.

Reserves.—The total high-grade bauxite contained in the two bodies amounts to 188,000 tons of dry ore of the composition shown in Table 22.

TABLE 22.—RESERVES, NAPIER'S No. 1 LEASE.

Body.	Bauxite.			Overburden.		Ratio. Overburden/ Bauxite.
	Tons.	SiO_2.	Al_2O_3.	Cubic Yards.	Tons.	
		Per cent.	Per cent.			Per cent.
Northern	33,400	4.3	53.2	79,400	142,900	4.27
Southern	154,600	5.8	51.5	292,600	526,700	3.42
Total ..	188,000	5.6	51.6	372,000	669,600	3.56

Average iron (expressed as Fe_2O_3) and titania content are 10 and 6 per cent. respectively.

2. *Greenwood's Lease.*

This lease is in Allotment 15B, Parish of Budgeree, and is 5 miles by road south-east of Boolarra; it occupies the western end of the crest of a ridge with an elevation of 980 feet above sea-level. A quarry has been opened in the southern flank of the hill where a landslip had revealed bauxite.

Basalt weathered to a mottled clay with a ferruginous band at the top underlies the bauxite, which is 13 feet thick in the quarry face. The bauxite is overlain by 6 feet of yellow sand, and the remainder of the quarry face consists of sandy clay. Lignite is not present in the quarry but was encountered as lignitic clay in deeper bores sunk from the crest of the ridge.

The texture of the bauxite ranges from fine soft reddish earth to nodular types in which numerous hard lumps up to a few inches across are set in a fine matrix. Bedding is indicated by the arrangement of coarse and fine material. On washing, the fine earthy bauxite leaves a residue of clay pellets, leucoxene, quartz, plagioclase, and ilmenite. In the hard lumps ilmenite is abundant and detrital minerals are absent. Under the microscope the fine bauxite shows stratification.

The orebody is roughly elliptical in plan and measures 600 feet long from south-west to north-east by a maximum width of 300 feet. The greatest thickness is 20 feet and the body dips gently to the north-east into rising ground. Proved reserves are shown in the following table:—

TABLE 23.—RESERVES, GREENWOOD'S LEASE.

Tons (Dry Ore).	Bauxite.				Overburden.		Ratio. Overburden/ Bauxite.
	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Cubic Yards.	Tons.	
	Per cent.	Per cent.	Per cent.	Per cent.			
43,400	7.3	50.0	8.8	6.0	155,300	279,500	6.44

3. *The Pines Lease.*

As originally pegged this lease comprised a strip of land approximately 1 mile long by 20 chains wide lying along the north-western slope of Lydiard Range in the Parish of Allambee East. The principal bauxite deposit within this area occurs at the north-eastern end of the original lease and is known as Watkin's deposit (*see* Plate 10).

This occurrence was tested by hand-boring and shaft-sinking which indicated the outlines of the deposit with fair accuracy. The body is roughly triangular in shape and could be contained within an equilateral triangle with sides 1,000 feet long. The maximum thickness of bauxite is 27 feet and the cover ranges from 3 to 29 feet thick. The grade has been established by two sampling shafts which yielded the following results on analysis of channel samples:—

Thickness.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
Feet	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
15	9.7	51.3	5.8	5.0	28.2
16	10.4	51.9	5.0	5.5	28.3

Reserves indicated by the hand-boring programme are estimated at 206,000 tons of dry ore which lie beneath 400,000 tons of overburden.

Napier's No. 2 Deposit is half a mile south-west from Watkin's and is a small body containing 17,000 tons of bauxite under 21,000 tons of sand and clay overburden. Samples from one shaft gave the following result for a thickness of 11 feet:—10 per cent. SiO_2, 50.8 per cent. Al_2O_3, 7.6 per cent Fe_2O_3, 4.8 per cent. TiO_2, 26.8 per cent. ignition loss.

4. *Boolarra Deposits.*

Two bauxite deposits, known as Sulphates and Orgills, on the north bank of the Little Morwell River in the Parish of Narracan South, and 1½ miles west of Boolarra, have been worked by small quarries and prospected by shafts and bores. The bauxite rests on weathered basalt and is overlain by sand, clay, and sandy clay. Logs of two bores, one on each deposit, are given to show the nature of the overburden.

Sulphates.		Orgill's.	
	Bore 12.		*Bore* 6.
Feet.		Feet.	
0 - 3	Sand	0 - 1	Sand
3 - 5	Yellow sandy clay	1 - 4	Yellow clay
5 - 9	White clay	4 - 7	Red and grey clay
9 - 25	Sandy clay	7 - 11	Red and grey sandy clay
25 - 28	Grey sand	11 - 14	Red and grey clay
28 - 40	Grey sandy clay	14 - 20	Grey clay
40 - 44	Grey clay	20 - 23	Yellow sand
44 - 51	Bauxite	23 - 34	Grey clay
51 -	Weathered basalt	34 - 38	Bauxite
		38 - 39	Bauxite with clay
		39 -	Weathered basalt

The bauxite is nodular in character, similar to that exposed in the quarry on Greenwood's Lease. Microscopic examination showed that the hard nodules are altered basalts, and consist of pseudomorphs of crystalline gibbsite after felted plagioclase laths. The interstices contain considerable leucoxene as probable pseudomorphs of pyroxene and as altered ilmenite. Unaltered grains and skeletal crystals of ilmenite also occur. Some of the lumps contain numerous phenocrysts of olivine, now altered to iddingsite, and there is considerable variation in the content of ilmenite. The softer bauxite consists almost wholly of gibbsite in all stages of crystallinity from large euhedral crystals to cryptocrystalline masses. Small quantities of detrital minerals—quartz, zircon, and bleached biotite—also occur in the earthy bauxite.

Reserves.—The two deposits contain a total of about 94,000 tons of dry bauxite nearly equally divided between them. Both bodies are roughly rectangular in plan and the principal dimensions are—

Body.	Length.	Breadth.	Maximum Thickness.
	Feet.	Feet.	Feet.
Western or Sulphates	600	300	15
Eastern or Orgill's	550	250	16

Further details of the proved reserves and composition are given below in Table 24.

TABLE 24.—RESERVES, BOOLARRA DEPOSITS.

Body.	Bauxite.			Overburden.		Ratio. Overburden/ Bauxite.
	Tons.	SiO_2.	Al_2O_3.	Cubic Yards.	Tons.	
		Per cent.	Per cent.			
Sulphates	46,600	5.0	53.0	79,340	142,700	3.05
Orgill's	47,100	5.0	52.5	61,580	110,800	2.35
Total ..	93,700	5.0	52.7	140,920	253,500	2.70

5. *Payne's Deposits.*

Two deposits occur in Allotment 99, Parish of Allambee East, on a small spur extending easterly from the Lydiard Range. These bodies are about 250 feet apart and underlie the usual cover of sand, sandy clay, and clay. Lignitic clay was intersected in one bore only. The bauxite rests upon kaolinized basalt.

The western body was thoroughly proved by machine bores but the eastern one was tested with hand bores which were inadequate for defining the eastern boundary and for the recovery of samples for analysis.

The bauxite is buff to cream-coloured and finely cellular. Much of it shows a relict basaltic texture and consists of cryptocrystalline gibbsite with a little partly altered ilmenite. The iron content of samples from the western body ranges between 6.5 and 4.1 per cent.

A quarry has been opened in the eastern body and has disclosed that the bauxite and overlying sands have been folded into a monocline trending northerly and with downthrow to the east. The bauxite contains irregular masses of halloysite.

Reserves.—The total recoverable bauxite contained in the western body amounts to 54,000 tons of dry ore, and the quantity indicated by hand-boring the eastern deposit is approximately 44,000 tons. Further exploration to the east is not likely to disclose very large additions to this latter figure.

TABLE 25.—RESERVES, PAYNE'S DEPOSITS.

Body.	Bauxite.			Overburden.		Ratio. Overburden/ Bauxite.
	Tons.	SiO_2.	Al_2O_3.	Cubic Yards.	Tons.	
		Per cent.	Per cent.			
Western	54,000	8.0	52.8	110,300	198,500	3.68
Eastern(1)	44,000	9.1	52.1	29,200	52,000	1.18
Total ..	98,000	8.5	52.4	139,500	250,500	2.56

(1) Incomplete. Composition from average of ore trucked.

6. *Rodda's or Childers.*

This small deposit in Allotment 148, Parish of Moe, has been worked to produce siliceous bauxite for the manufacture of firebricks. The composition of the bauxite 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.

The geological features surrounding the deposit are in large part obscured by soil and the usual relationship between bauxite and basalt cannot be directly observed, and no excavation to the base of the bauxite has been made. E. S. Hills (Raggatt *et al.* 1945, page 41) suggests, on the evidence of basaltic clay 800 feet from and 30 feet above the bauxite, that the bauxite and the overlying sand and clay occupy a position near the base of the Teritiary succession and underlie the Older Basalts. This interpretation gains support from a similar apparent relationship of bauxite to basalt at the " Nahoo " deposit.

The section above the bauxite is similar to that revealed at other localities, even to the detailed mineralogy of the sand; the area is one of considerable tectonic disturbance—the bauxite is truncated by a fault on its southern limit—and in the absence of exposures of underlying rocks in close proximity to the bauxite, the present writer does not consider that a prima facie case can be made out for placing this deposit so much lower in the stratigraphical column than its neighbours.

7. *" Nahoo ".*

Similar difficulties of interpretation arose at " Nahoo ", the site of the first bauxite discovery in Gippsland in 1918, where siliceous bauxite with low iron content has been extracted for chemical manufacture from a relatively small deposit in Allotment 8, Parish of Narracan South.

The bauxite occurs at about 1,000 feet above sea level on a spur between two small creeks. Dense vegetation along the creeks and a spoil dump at the mouth of the quarry make observation difficult.

The section in the quarry shows that the bauxite, which has a very gentle dip to the north-west, rests upon white clay; the exposed succession is—

0–20 feet	Coarse current-bedded sand
20–28 "	White sandy clay
28–29 "	Quartzite lenses in sandy clay.
29–32.5 "	Bauxite with halloysite masses.
32.5–44.5 "	Light-coloured bauxite.
44.5–46.5 "	Red granular bauxite with limonite.
46.5–? "	White clay.

The base of the white clay is not exposed, but surface mapping indicates a considerable thickness (perhaps as much as 40 feet) of clay and sandy sediments beneath the bauxite. Jurassic standstone occurs 700 feet downslope to the south-east from the quarry at an elevation 100 feet below the base of the bauxite. Disturbance of the surface by landslips and the wide dissemination of transported sandy soil prevent certain recognition of the rock (if any) interposed between the sediments beneath the bauxite and the Jurassic bedrock. The writer has taken discolouration of the soil and boulders of basalt in the creeks to indicate the normal sequence, with a greater thickness of sediment beneath the bauxite than noted elsewhere.

An inferred normal fault, parallel to one striking north-easterly which is exposed in the quarry, truncates the Jurassic bedrock at a distance of 850 feet south-east of the quarry, and causes a repetition of the bauxite bed and associated sediments with fairly clear evidence that the sequence overlies basalt.

The red granular bauxite consists of iron-stained granules of clayey bauxite and contains, in addition, rounded grains of quartz and the heavy minerals brookite, tourmaline, ilmenite, leucoxene, rutile, zircon, white mica, and zoisite. Hills, who contributed this description, comments (Raggatt *et. al* page 44) that there seems no doubt that this material is of sedimentary origin and affords the only known occurrence of a bauxitized rock other than volcanic ash and basalt in South Gippsland.

The light-coloured bauxite contains no detrital minerals such as quartz, zircon, or tourmaline.

On account of its low iron content this bauxite was used by Messrs Sulphates Ltd. for chemical manufacture, but all requirements are now met from Napier's No. 1 deposit, which is nearer railway facilities and housing.

The average grade of the bauxite quarried at "Nahoo", as reported by Sulphates Ltd., and probable reserves, are shown in the following table:—

TABLE 26.—PROBABLE RESERVES, "NAHOO" DEPOSIT.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.
	Per cent.	Per cent.	Per cent.	Per cent.
50,000	15	52	3.5	4

8 *to* 20 *and* 22.

Deposits numbered 8 to 20 and 22 are of little importance and it is unnecessary to repeat details other than those given in Part B of Table 21. It should be noted however that probable reserves for Foy's deposit, No. 13, which, by a typographical error, were previously shown as 100,000 tons, are now reduced to the negligible quantity of 4,200 tons.

21. *Wanke's.*

Bauxite crops out over an area of approximately 100 feet by 200 feet on the slopes of a small creek bank in Allotment 104, Parish of Allambee East, 1 mile north-west of Mirboo North.

The deposit is of little or no economic importance but the locality is interesting chiefly for the reason that tilting of the beds, which dip south-east at about 35 degrees, has exposed, fairly clearly, a section from the Jurassie to the post-volcanic sand.

The bauxite overlies basalt with intervening blue mottled clays probably representing weathering products of the basalt, which itself rests on ferruginous sands locally altered to quartzite. The Jurassic bedrock forms a range of hills —Lydiard Range—to the north-west of the locality. Overlying the basalt is

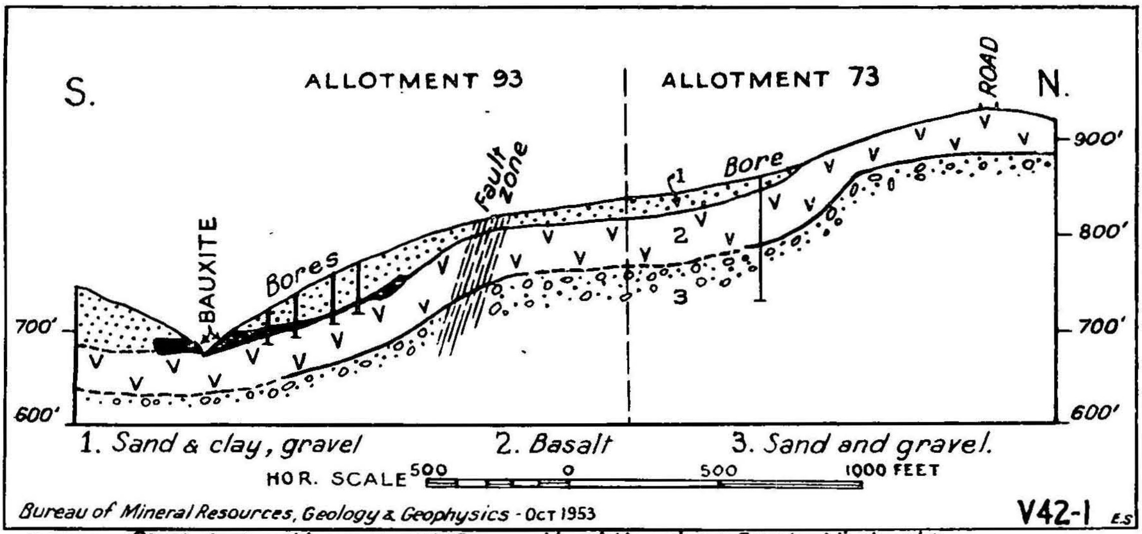


FIG. 6. Sketch Section, No. 23 Deposit, Allambee East, Victoria.

[To face page 91.]

a thick sequence of sands, clays, and coarse grits, together with the bauxite, which forms bouldery outcrops between the post-Volcanic sediments and the basalt.

The bauxite is nodular or rubbly in texture. Hard lumps were found to consist of (*a*) very coarse-grained bauxitized olivine basalt and (*b*) fine-grained bauxitized olivine basalt, rich in ilmenite. The very marked difference between these two types indicates that the original rock was a basalt tuff.

23. *Wallace's.*

Wallace's deposit occurs in Allotment 93, Parish of Allambee East, 4½ miles by road south-south-west from the railhead at Thorpdale. Access to the deposit is difficult as it lies at the bottom of a steep-sided valley and is approached by a descent of approximately 350 feet in a distance of 700 yards south from the Dingley Dell road.

The creek on which the bauxite is situated flows south-westerly to join the western branch of the Tarwin River at a point ¾ mile downstream from the village of Allambee South.

The outcrop occurs at about 670 feet above sea level and extends along the right bank of the creek for a distance of 350 feet. As defined by boring and shaft-sinking the body occupies a roughly rectangular area 150 feet wide by 350 feet long. It has a gentle south-easterly dip towards the creek and consequently is overlain by relatively shallow overburden, consisting mainly of soil and low-grade weathered bauxite along the north-western margin. The bauxite rests on basalt, which is exposed in the watercourse and was encountered in shafts and bores.

Bores sunk to the north of the body and at a higher elevation passed through sand, sandy clay, and gravel into kaolinized basalt.

Text Figure 6 shows a section from the deposit to the Dingley Dell road.

Reserves.—Testing of the deposit revealed a maximum thickness of 17.5 feet of ore and an average thickness for the whole body of 13.7 feet. Thicknesses of overburden range between 2.5 and 12.5 feet, averaging about 6 feet, equivalent to a total volume of 10,000 cubic yards.

The composition of the economic ore is unusual for the Gippsland deposits in that the silica content is low and the ferric oxide figure relatively high.

Analyses of samples from two shafts are quoted to illustrate the composition of the bauxite. The first is the highest-grade bauxite encountered and the second represents material excluded from the reserves because of the low alumina content.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.	Soda Loss.
From—	To—								
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
		SHAFT 200S/210E.							
0	3	Soil	..	..	..	..	..	..	..
3	5	Hard ferruginous bauxite ..	1.5	47.8	20.1	4.2	26.2	46.3	0.38
5	9	Hard ferruginous bauxite ..	0.95	46.2	22.6	3.9	26.1	45.1	0.16
9	13	Hard ferruginous bauxite ..	0.75	48.7	20.2	3.8	27.3	47.8	0.13
13	17	Soft brown bauxite with seams of soft clachite	0.80	50.9	15.9	4.1	28.0	49.0	0.25
17	20		1.10	52.4	15.3	3.2	27.6	51.2	0.16
20	22	Not sampled—under water ..	..	..	..	..	..	..	..
22	..	Kaolinized basalt	..	..	..	..	..	..	..
		SHAFT 300S/00.							
0	5	Soil and detrital bauxite ..	..	..	..	..	..	..	..
5	7	Ferruginous bauxite ..	5.0	35.2	32.5	4.7	22.6	32.0	1.21
7	9.5	Ferruginous bauxite ..	4.3	32.2	39.5	3.9	20.6	29.7	..
9.5	12.5	Ferruginous bauxite ..	2.3	43.7	25.2	4.4	25.0	42.7	0.52
12.5	19	Not sampled—under water ..	..	..	..	..	..	..	..
19	..	Kaolinized basalt	..	..	..	..	..	..	..

Total reserves proved in the deposit amount to 27,000 tons of dry ore containing 3.7 per cent. SiO_2, 50.2 per cent. Al_2O_3, 14.2 per cent. Fe_2O_3, 4.5 per cent. TiO_2, and 47.3 per cent. available Al_2O_3. The average soda loss figure is 0.59 cwt. Na_2O per ton of available alumina.

24. *Walker's.*

Small separate bodies of bauxite form inconspicuous outcrops in the central and northern parts of Allotment 26D, Parish of Budgeree, at 5½ and 6 miles by road east-south-east from Yinnar railway station.

The more important of the six known occurrences in the locality, including one in Allotment 28, lie in the eastern side of a valley deeply incised into the Older Volcanics by a branch of Belbrook Creek.

The northernmost outcrop is a narrow, nearly horizontal, band of bauxite trending north-westerly along the contours of the valley side for a distance of 330 feet. The outcrop lies at an elevation of roughly 700 feet above sea level and is from 70 to 90 feet above the creek channel.

The topographic slope westerly from the bauxite to the creek is very steep, with an average drop of 4 feet in 7, but above the outcrop the rise to the east is only 1 in 8.

Boring along a line parallel to and 120 feet north-east of the outcrop showed that the bauxite thins in this direction and lies on a basalt surface which dips north-easterly into the steeply rising slope at about 14°.

The southern bauxite occurrence in Allotment 26D makes a poor showing at the surface as a discontinuous line of boulders strewn along the contact between the basalt and the sediment for a distance of 1,200 feet. Sub-surface testing showed that this occurrence consisted of three small detached bodies of bauxite probably separated from each other by small faults.

The northernmost of these three bodies outcrops at an elevation of about 740 feet above sea level on the eastern slope of the valley in a position analogous to that of the first body described. The bauxite lies on an apparently irregular surface of weathered basalt with a mean dip to the east-south-east of about 17°. This feature brings the bauxite beneath more than 50 feet of overburden at 130 feet from the outcrop. The maximum thickness of economic bauxite in the deposit is 19 feet.

The central body crops out at a slightly higher elevation than its northern counterpart and has a maximum thickness of only 9.5 feet, but it has a shallower dip, of about 10°, to the east-north-east, and consequently lies under shallower overburden.

The southern body lies in a shallow trough in the basalt surface which plunges to the north-west at about 5°. Boring showed that economic bauxite was limited to an area measuring 200 feet long by a maximum width of 80 feet. One of the deeper bores penetrated 22.5 feet of bauxite, much of which contained siderite.

The usual geological succession was encountered in the deeper bores, of which the following logs are typical.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Ignition Loss.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
		BORE 5, NORTHERN OUTCROP.				
0	1	Soil	..	..	..	..
1	7	Yellow sandy clay	..	..	..	..
7	36	Yellow sand	..	..	..	..
36	52	Orange sand	..	..	..	..
52	55	Grey clay	..	..	..	..
55	60	Brown clay	..	..	..	..
60	62	Bauxite and clay	..	..	..	16.1
62	65	Ferruginous bauxite	1.6	36.8	32.9	22.0
65	68	Ferruginous bauxite	2.4	35.4	36.2	21.3
68	71	Clay	..	..	..	12.8
71	72	Soft clayey bauxite	..	..	..	17.2
72	75	Basaltic clay	..	..	..	..
		BORE 3, SOUTHERN OUTCROP.				
0	2	Soil and sand	..	..	..	..
2	4	Sandy clay	..	..	..	..
4	14	Clay	..	..	..	..
14	46	White sand	..	..	..	..
46	50	Lignitic clay	..	..	..	..
50	54	Lignite	..	..	..	..
54	60	Clay	..	..	..	..
60	62	Clay and nodules of bauxite	..	..	..	..
62	68	Basaltic clay	..	..	..	..

Reserves.—Reserves of bauxite proved in Allotment 26D, Parish of Budgeree, in the area referred to as "No. 24 Deposit—Walker's" are summarized as follows:—

TABLE 27.—RESERVES, WALKER'S DEPOSIT.

Body.	Long Tons (Dry Ore).	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Na_2O Loss.	Overburden.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
Northern ..	22,500	4.8	48.2	16.5	5.8	43.6	0.97	33,000
Southern—								
North ..	13,000	5.2	46.4	17.5	5.5	42.8	1.07	27,000
Centre ..	6,500	6.5	49.6	11.0	6.0	44.8	1.19	8,300
South ..	5,000	3.6	45.7	17.9	6.6	42.7	0.90	7,000
Total ..	47,000	5.0	46.6	16.1	5.8	43.4	1.02	75,300

25. *Peel's.*

A small outcrop of light-coloured bauxite in Allotment 19, Parish of Yinnar, and lying ½ mile to the west of another small occurrence in Allotment 23, appeared likely to represent a fairly extensive body, but drilling revealed it to have a maximum length of only 500 feet by an average width of about 100 feet.

The bauxite contained in this deposit is siliceous and fairly ferruginous and therefore unlikely to be attractive for any commercial purpose. One bore log with analyses of bauxite is given—

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.
From—	To—							
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0	1	Soil	..	..	..	..	..	..
1	39	Sand with ferruginous staining	..	..	..	..	..	..
39	41	Red and grey clay ..	..	..	..	..	..	..
41	43	Pink bauxite	29.4	43.1	5.1	3.4	20.1	34.4
43	47	Pink bauxite	14.3	49.1	8.3	4.8	24.2	40.1
47	51	Red bauxite	9.6	47.0	18.4	4.4	20.7	38.0
51	55	Red bauxite	8.6	46.2	18.6	4.4	23.0	41.2
55	57	Red clay-like bauxite ..	6.9	43.8	22.1	4.1	23.0	37.4
57	58	Grey basaltic clay	..	..	..	..	..	..

Proved reserves of siliceous bauxite total 36,000 tons of the following composition:—11.5 per cent. SiO_2, 43.8 per cent. Al_2O_3, 16.1 per cent. Fe_2O_3, 4.9 per cent. TiO_2, with 36 per cent. available Al_2O_3.

The average thickness of overburden is 23.5 feet and the total volume of overburden is 58,000 cubic yards.

26. *Jeeralang.*

Small outcrops of bauxite, and bauxite containing much halloysite, occur on the northern, southern, and eastern boundaries of Allotment 4, Parish of Jeeralang, and were explored with shafts.

The depth of overburden became too great at relatively short distances from the outcrops, but it was apparent that the three bodies tested were originally joined in a continuous sheet with a total area of approximately 40 acres.

The area is adjacent to the main fault on the eastern side of the Morwell River trough and is flanked on the east by an uplifted block of Jurassic sediments. The Tertiary formations have been warped into a monocline over the fault, and the upper limb has been removed by erosion, leaving the bauxite exposed as a narrow bed dipping north-west at 60° to 70°. This outcrop is exposed on a short spur which extends north-westerly into Allotment 4 and has an elevation of 790 feet above sea level. At 1,800 feet north-west and 800 feet east of the first outcrop, the bauxite again appears as a near-horizontal sheet at elevations of 580 and 600 feet respectively (*see* Fig. 7).

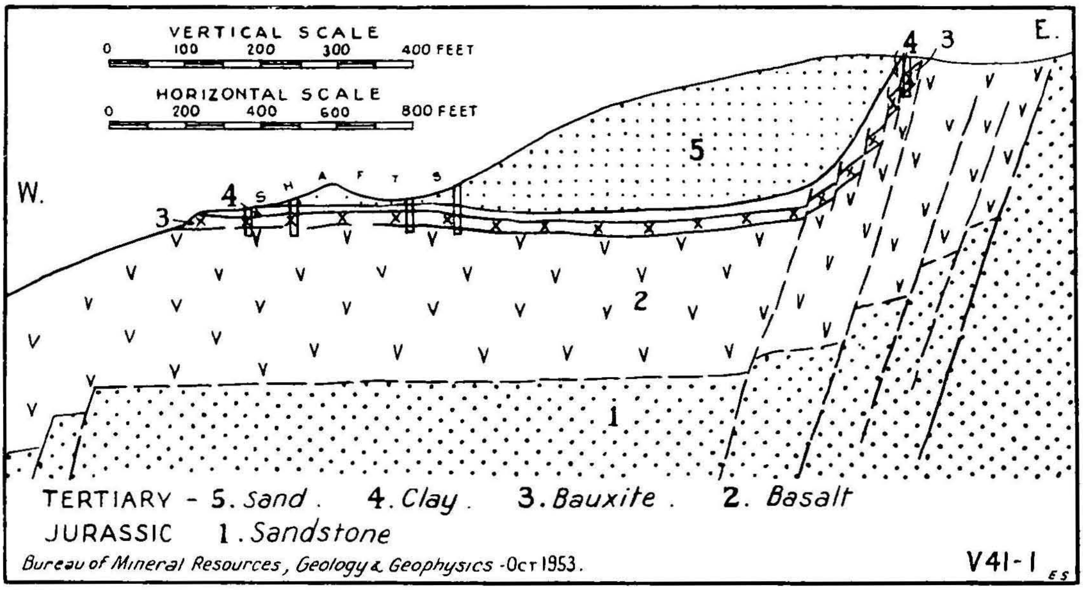


FIG. 7 Section Deposit 26, Parish of Jeeralang, County of Buln Buln, Victoria.

The bauxite rests directly upon kaolinized basalt and is overlain by sand. The sand is well bedded in places and dips in conformity with the upper surface of the bauxite.

The passage from bauxite to basalt is usually sharp, as shown by the shaft logs given below.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT 1000N/300E.					
0	1	Soil	..	..	..	..	..
1	17	Sand	..	..	..	..	..
17	21	Grey clay with few bauxite pisolites increasing towards base	..	..	..	..	..
21	23	Pisolites of bauxite in grey clay matrix	16.9	49.5	5.2	4.7	24.7
23	27	Grey and red bauxite, earthy ..	13.3	51.3	6.7	4.8	25.8
27	28.5	Red bauxite resting on thin limonite band	9.2	52.1	6.4	4.9	27.6
28.5	30.5	Basaltic clay	..	..	..	..	..
21	23	Pisolites washed free from clay clay	2.2	57.3	4.9	4.2	31.2
		SHAFT 630N/400E.					
0	20	Clayey sand	..	..	..	..	..
20	24	White and brown clay ..	..	..	..	..	..
24	28.5	White clay	..	..	..	..	..
28.5	30.5	Grey bauxite, nodular ..	14.1	49.2	4.4	6.3	25.6
30.5	34.5	Grey bauxite, nodular ..	6.7	53.3	5.6	5.9	28 3
34 5	38.5	Grey and brown bauxite, earthy	6.6	51.4	8.3	5.7	27.9
38 5	40.5	Grey bauxite, clay-like ..	8.5	49 2	9.8	5.7	26 7
40.5	42.5	Mottled grey clay (weathered basalt)	..	..	..	..	18.0

The resources of useful bauxite are much reduced by the presence of halloysite, of which one specimen yielded on partial analysis:—

	Per cent.
Silica	45.6
Alumina	36.2
Ferric oxide	0.7
Ignition loss	14.6

The reserves proved in the vicinity of each of the three outcrop areas mentioned are given in Table 28 below.

TABLE 28.—PROVED RESERVES, No. 26 DEPOSIT—JEERALANG.

Outcrop.	Tons (Dry).	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.	Overburden.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
North-west ..	16,000	8.2	52.2	6.5	5.3	44.8	1.61	13,000
South	10,000	7.0	50.2	7.0	7.0	44.4	1.44	21,000
South-east ..	2,000([1])	7.3	53.5	3.8	6.1	47.0	1.80	3,000
Total ..	28,000	7.7	51.5	6.5	6.0	44.8	1.56	37,000

([1]) Tonnage to depth of 30 feet down dip.

27. *Prosper Valley.*

Bauxite of good quality crops out on the boundary between Allotments 14F and 15A, Parish of Budgeree, 4 miles by road south-east from Boolarra.

The exposure occurs in the bank of a short steep tributary to the Morwell River and lies about 400 feet above sea level. The usual stratigraphical succession is in evidence: Jurassic sandstone overlain by basalt is exposed in the river bank 400 yards south of the bauxite outcrop and at about 40 feet lower elevation. The bauxite, which rests on the basalt, is overlain by grey clay under sand.

The log of the deepest shaft sunk on the deposit is—

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
0	2	Soil	..	..	..	..
2	5	Sand and clay	..	..	..	..
5	22	Coarse brown sand	..	..	..	..
22	34	Fine brown sand	..	..	..	..
34	45	Grey clay	..	..	..	..
45	47	Soft grey bauxite	5.2	54.7	6.1	7.0
47	50	Bauxite passing to clay	12.0	45.2	14.4	4.9
50	52	Kaolinized basalt	..	..	..	..

The bauxite has a maximum thickness of 12 feet near the outcrop and dips at 15° in a northerly direction into the steeply rising ground. Not only does the bauxite thus pass under an increasing thickness of overburden, but also the body thins out and depreciates in grade down dip.

Easily accessible bauxites of fair grade underlies a strip no more than 50 feet wide by 200 feet long and amounts to 6,000 long tons. A further 2,000 tons of somewhat lower grade could be obtained by removal of double the amount of overburden.

Reserves are shown in the table below:—

TABLE 29.—RESERVES, PROSPER VALLEY DEPOSIT.

Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.	Overburden.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.	Cubic yards.
6,000 ..	6.5	52.2	7.6	6.0	47.1	1.4	4,000
or							
8,000 ..	7.0	51.4	8.2	6.0	45.8	1.6	8,000

Other Deposits.

During the course of the search in the area numerous small occurrences of bauxite were found or reported by local residents. Of these eight were tested by pit-sinking or boring and the remainder were rejected by surface inspection only.

As none of these occurrences contained useful quantities of bauxite the descriptions of them which follow have been compressed to a statement setting out the locality of each and such brief remarks as appear desirable. In addition to the occurrences listed small residuals of bauxite have been observed in the Parish of Allambee East.

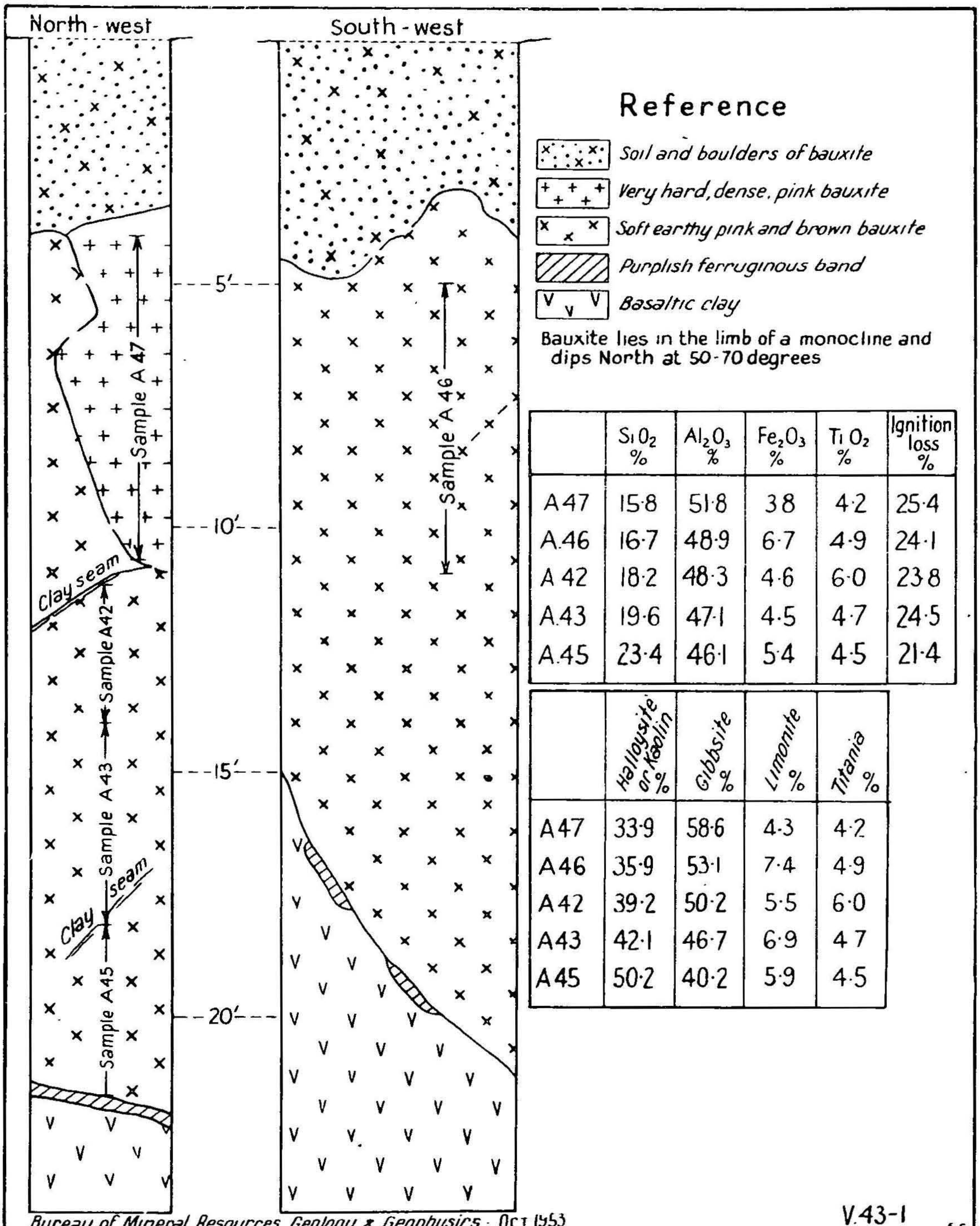
No. on Plan.	Parish.	Allotment No.	Remarks.
28	Mirboo ..	148A	Hand-boring showed that bauxite did not extend as much as 100 feet from an outcrop.
29	Narracan South	26	Bauxite is contained in slumped material and probably a small body occurs *in situ*. Access is difficult.
30	Narracan South	120A	A small quarry has been opened in bauxite on the north bank of the Little Morwell River about 2 mile west of Boolarra. The bauxite is faulted and contaminated with clay.
31	Mirboo ..	Timber Reserve	Shafts and bores 3 miles south of Boolarra showed very limited extent of bauxite beyond visible traces.
32	Budgeree ..	14A	Bauxite is exposed on a very steep slope in the Morwell River valley and dips into the rising ground
33	Budgeree ..	27	Bauxite occurs in a deep gully very difficult of access. The deposit is small and probably detrital in origin.
34	Budgeree ..	10H	Bores and shafts revealed small separate bodies of grey bauxite containing about 12 per cent. SiO_2.
35	Yinnar ..	9	Only broken bauxite in slumped material could be found by pit-sinking.
36	Yinnar ..	22	A small outcrop of high-grade material occurs near the northern boundary of the allotment in a position inaccessible to wheeled vehicles.
37	Yinnar ..	25	Traces of bauxite were found about 100 feet below the crest of a steep hill, consequently thick overburden precludes the development of this deposit.
38	Traralgon ..	38, 38A, 40 and 42A	A narrow outcrop of bauxite striking east was found to dip north at 50° to 70°. Sections of the bauxite disclosed in a vertical shaft and analyses of channel samples are shown in Fig. 8.
39	Traralgon ..	40A and 58C	A thin body of bauxite, with maximum thickness of 3 feet, was intersected by shafts and found to be dipping east at 25° and intersected by numerous faults.
40	Traralgon ..	30	A flat-topped hill 600 yards north-west of Giants Chair is capped with residual boulders and fragments of bauxite.

Gelliondale.

Ferruginous bauxite occurs near Gelliondale in the Parish of Alberton West, County of Buln Buln, half a mile north-east of the Gelliondale railway station and 8 miles south-west from Yarram.

Gelliondale is situated on the coastal plain and is about 26 miles south-east from Boolarra.

The bauxite overlies basalt with which it forms a low rounded hill rising to about 40 feet above plain level. An area of approximately 600 feet by 100 feet is occupied by massive ferruginous bauxite without overburden. A quarry opened near the centre of the outcrop discloses a thickness of 6 feet of bauxite and it is believed that the maximum thickness of the body is not likely to exceed 10 feet.



	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	Ignition loss %
A47	15·8	51·8	3·8	4·2	25·4
A.46	16·7	48·9	6·7	4·9	24·1
A 42	18·2	48·3	4·6	6·0	23·8
A.43	19·6	47·1	4·5	4·7	24·5
A.45	23·4	46·1	5·4	4·5	21·4

	Halloysite or Kaolin %	Gibbsite %	Limonite %	Titania %
A47	33·9	58·6	4·3	4·2
A46	35·9	53·1	7·4	4·9
A42	39·2	50·2	5·5	6·0
A43	42·1	46·7	6·9	4·7
A45	50·2	40·2	5·9	4·5

FIG. 8 Scale drawings of North-west and South-west faces of shaft at Deposit 38, Parish of Traralgon, Victoria.

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Where exposed in the quarry face the bauxite consists of light-brown hard ferruginous concretions. Hollow shells of hard black and red hematite and limonite 1 inch thick and as much as 12 inches in diameter enclose soft light-brown and grey bauxite.

It is considered that the deposit contains about 10,000 tons of bauxite which is much contaminated with sandy soil and clay introduced from the surface into joints.

Unfortunately samples which were collected went astray in transit to the laboratory and only one analysis reported by Baragwanath (1940) can be quoted. Reduced to the dry basis for comparison with the other analyses herein it is—

	Per cent.
SiO_2	6.2
Al_2O_3	42.0
Fe_2O_3	21.7
TiO_2	3.5
Ignition loss	24 9
	98 3

DESCRIPTION OF THE BAUXITE.

It will be apparent from the foregoing descriptions of the bauxite in the Boolarra district that it bears little superficial resemblance to the lateritic bauxites which are known in the other States. The descriptions already given are not repeated here, but the principal characteristics are presented in such a way as to emphasize the contrasts between Gippsland bauxite and the aluminous laterites.

Colour.

The Gippsland bauxite has a wide range of colours, and is commonly light brown, pink, buff, and creamy near its upper surface, passing to white, grey, and bluish-grey at depth. Darker shades of red or brown are less common. The lighter colours are in strong contrast with the deep reddish-brown hues of the primary lateritic bauxites. The mottled appearance of many laterites, caused by the uneven distribution of ferric iron, or by the development of gibbsite nodules in a dark matrix, is not apparent in Gippsland.

Texture.

The zones characteristic of a well-developed primary laterite have been almost completely obliterated by secondary changes, and the texture ranges from that of a fine earth, with or without irregular hard lumps of gibbsitic material with relict basaltic texture, to a coarsely gritty earth which readily crumbles when wet. Most of the bauxite is finely cellular and the higher grade material contains very numerous fine crystals of gibbsite. Veinlets of gibbsite are visible in thin section.

A much altered pisolitic zone 6 feet thick was observed at Jeeralang, where pisolites of gibbsite (57.3 per cent. Al_2O_3) were partly replaced by clay in a manner similar to that observed at St. Leonard's, Tasmania, and in Arkansas (Bramlette, 1936, page 30).

No textures which could be referred to the massive or tubular zones of a laterite profile were clearly recognized, but hard ferruginous bauxite at Wallace's deposit (No. 23) in the Parish of Allambee East might be representative of a zone analogous to the massive zone at Wingello, New South Wales.

Chemical Composition.

The composition of the bauxite is dependent upon the character and degree of secondary chemical change which has taken place under the influence of deep burial and reducing conditions. Where erosion of the overlying beds has re-exposed the bauxite or brought the water-table to a level below it, oxidizing conditions have reversed the chemical change and tended to restore the bauxite to its former primary composition. It might be expected, therefore, that the buried or formerly buried Gippsland bauxites may be divided into three categories, viz., re-oxidized, silicated or reduced. All three types may occur in one deposit. The first, of course, contains ferric iron; the second may result from a more or less uniform attack on the bauxite from the upper surface downwards, in which gibbsite is converted to kaolin or halloysite, or may result from the development of halloysite as irregular masses. The third variety is characterized by its greyish colour (sometimes coloured brown by abundant siderite) and the presence of ferrous iron.

No sharp lines divide the different types, which have resulted from the influence of changing chemical environment that has penetrated the mass in a manner akin to diffusion. Chemical analyses of examples are given below:—

1. RE-OXIDIZED BAUXITE.

OUTCROP, WALLACE'S DEPOSIT.

	(a)	(b)
Thickness	4.5 Feet.	2 Feet.
	Per cent.	Per cent.
Silica	1.5	6.3
Alumina	50.0	34.2
Ferric oxide	16.7	35.0
Titania	4.8	5.2
Ignition loss	27.3	19.2
	100.3	99.9
Available alumina	48.7	29.8

Both samples were taken from immediately beneath a thin cover of soil and detritus and consisted of brown ferruginous bauxite with veins of amorphous gibbsite. Ferrous oxide, if any, was not determined.

2. RE-SILICATED BAUXITE.

Thickness	(c) 2 Feet.	(d) 2.5 Feet.	(e) 3 Feet.	(f) 2 Feet.
	Per cent.	Per cent.	Per cent.	Per cent.
Silica	16.9	10.3	7.1	26.9
Alumina	49.5	48.8	51.6	43.3
Ferric oxide	5.2	9.4	7.4	2.9
Titania	4.7	6.5	6.4	6.0
Ignition loss	24.7	24.9	27.3	20.1
	101.0	99 9	99.8	99.2
Available alumina	35.2	38 9	45.2	22.9

(c) Re-silicated pisolitic bauxite, Jeeralang.
(d) and (e) Re-silicated earthy bauxite, Budgeree; (d) and (e) are in downward sequence in the same shaft.
(f) Pink bauxite with irregular masses of grey halloysite, Jeeralang.

3. REDUCED BAUXITE.

Thickness Depth from Surface	(g) 3 Feet. 60–63 Feet.	(h) 3 Feet. 63–66 Feet.	(i) 3 Feet. 66–69 Feet.	(j) 3 Feet. 69–72 Feet.	(k) 1.5 Feet 72–73.5 Feet.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silica	1.5	1.1	2.7	2.9	6.4
Alumina	44.0	47.0	45.1	41.8	42.2
Ferric oxide	24.1	17.2	14.7	10.1	13.1
Ferrous oxide	0.9	2.8	5.3	11.6	9.2
Titania	6.0	4.9	5.2	5.3	5.6
Carbon dioxide	0.8	1.7	3.4	6.9	5.7
Lime (CaO)	Nil	Nil	Nil	0.3	Nil
Magnesia (MgO)	Nil	Nil	Nil	Nil	Nil
Combined water	22.5	25.1	21.5	21.3	16.9
	99.8	99.8	97.9	100.2	98.7
Available alumina	42.6	46.0	41.9	38.8	35.5
Total iron as Fe	17.6	14.3	14.5	16.1	16.3

These five analyses represent a continuous thickness of 13.5 feet of brown bauxite resting on basaltic clay and overlain by 9 feet of red bauxite containing from a trace to 3 per cent. of ferrous oxide and from 19 to 22 per cent. of ferric oxide. The samples were recovered from a bore in Allotment 26D, Parish of Budgeree (Walker's deposit). Results from the total thickness of bauxite in this bore are shown graphically in figure 3 of Plate 27.

Mineralogical Constitution.

The purer bauxite consists largely of gibbsite, a monoclinic form of aluminium hydroxide ("trihydrate", $Al(OH)_3$) or an amorphous equivalent, hematite or a ferric hydrate of low degree of hydration such as goethite, and titanium as leucoxene, or dispersed titania, and residuals of ilmenite. Boehmite, basic aluminium oxide ("monohydrate", AlO.OH) also may be present in appreciable amount. Apart from these normal lateritic constituents detrital minerals originally present in the parent which resist the destructive effect of lateritization are still present. These include rare grains of quartz, zircon, tourmaline, and biotite.

The hard nodular bauxite which retains the basaltic texture of the parent rock appears to consist almost wholly of crystalline gibbsite, but gibbsitic pisolites from Jeeralang do not appear to be crystalline. Also an amorphous form of aluminium hydroxide occurs at Wallace's deposit, Allambee East, as irregular veins and patches in otherwise massive bouldery bauxite. Unfortunately none of this material was reserved for separate analysis, because it was mistaken for clay. Representative channel samples which included a substantial proportion of this material yielded astonishingly low silica figures on analysis as the following two examples, described in the field as "hard ferruginous bauxite and clay", show:—

	Per cent.	Per cent.
Silica ..	0.75	1.1
Alumina	48.7	52.4
Ferric oxide	20.2	15.3
Titania	3.8	3.2
Ignition loss	27.3	27.6
	100.75	99.6
Available alumina	47.8	51.2

An analysis such as the second one above suggests the presence of boehmite unless the iron and titanium oxides are anhydrous, which seems unlikely. Also, as the presence of "monohydrate" had been noted at Inverell, its discovery in the Gippsland bauxites was not altogether unexpected. In June, 1952, a private communication received from W. S. Curteis, of Sulphates Limited, contained several analyses of bauxite from Napier's No. 1 deposit near Mirboo North, which clearly revealed the presence of boehmite in appreciable quantities. Two typical works analyses, each representative of a 16-ton truck load, are—

	Per cent.	Per cent.
Silica ..	7.2	5.3
Alumina	60.0	58.5
Ferric oxide	4.0	4.8
Titania	5.3	5.0
Ignition loss	24.2	26.9
	100.7	100.5

Examination of a specimen of this bauxite with low combined water content was made by F. L. Stillwell (1952), who demonstrated the presence of boehmite by X-ray powder pattern.

MORNINGTON PENINSULA.

Bauxite and bauxite clay, which are developed upon the Older Basaltic lavas, have been observed at several places on Mornington Peninsula, 40 miles south of Melbourne and 70 miles west of Boolarra (Keble, 1950). The extent and composition of the deposits is not known but Keble (page 70) gives the following analysis of one sample from Allotment 23, Parish of Wannaeue, in the vicinity of Arthur's Seat:—

	Per cent.
Insoluble matter ..	9.1
Alumina (soda-soluble)	44.8
Ferric oxide	16.5
Titania ..	4.6
Ignition loss	25.4

TASMANIA.

INTRODUCTION.

The presence of bauxite in Tasmania is noted in a monograph of the Imperial Institute issued in 1925 (Rumbold, 1925, 14), and what may be a reference to the bauxite near Launceston occurs in R. M. Johnston's monumental work of last century (Johnston, 1888) on page 295, from where the following is quoted:—" Clay ironstone, in nodular masses, occurs in great abundance in the lower parts of the Launceston Tertiary Basin ".

It was not until August, 1941, however, that interest was revived by discoveries of bauxite in the vicinity of Ouse, and subsequently additional occurrences were found near Campbell Town in the Midlands, St. Leonards, near Launceston, and Swansea, East Coast. Bauxite of basaltic origin was located near Myalla, North-west Coast, in October, 1944, and numerous minor discoveries of no economic significance have been made since.

Before the end of 1941 testing of the deposits near Ouse was begun by the Tasmanian Mines Department. The results obtained from four shafts were considered to be sufficiently encouraging for systematic exploration of the largest outcrop area by shafts sunk at the intersections of a square grid at intervals of 200 feet. At the same time some sporadic shaft-testing was conducted on the smaller deposits at Ouse and also at Campbell Town and Fordon.

The results of this work were recorded by D. R. Dickinson (1943) in a report to the Director of Mines, Tasmania. This report has been freely consulted by the writer and due acknowledgment of its value is made. Analyses quoted of Tasmanian bauxite are by the Tasmanian Mines Department unless otherwise stated.

During 1945, the Tasmanian Mines Department carried out a scout-drilling programme at Myalla, at first under the supervision of Dickinson, and later, on his resignation from the Department, under that of the writer. The results of this work are embodied herein.

In 1945, the Bureau of Mineral Resources (then the Mineral Resources Survey), acting in conjunction with the Tasmanian Mines Department, initiated a campaign of drilling to supplement the previous shaft-sinking at Ouse and elsewhere, and to explore the other deposits which had not up to that time been examined in detail. This work was started at Ouse towards the end of May, 1945, moved to St. Leonards in the following April, and was concluded at Swansea and Campbell Town in December, 1946. During the course of the work at St. Leonards minor deposits at Hillside, Cormiston and Rosevale were tested by pit-sinking. In supervising this work the writer was assisted by D. E. Gardner, a geologist of the staff of the Bureau.

Towards the end of 1945 the Australian Aluminium Production Commission took an active part in the field work and provided additional staff and labour, which permitted shaft-sinking to be conducted in addition to boring.

Total reserves of bauxite known in Tasmania are not large and amount to 960,000 tons of ferruginous ore containing an average of approximately 42 per cent. total alumina.

Distribution of Deposits.—Eleven bauxite localities are shown on Figure 9, but of these only three, Ouse, St. Leonards, and Myalla, are of importance. Small quantities of bauxite from Myalla are produced by the Hydro-electric Commission of Tasmania and used for purifying transformer oil.

Ouse Area.

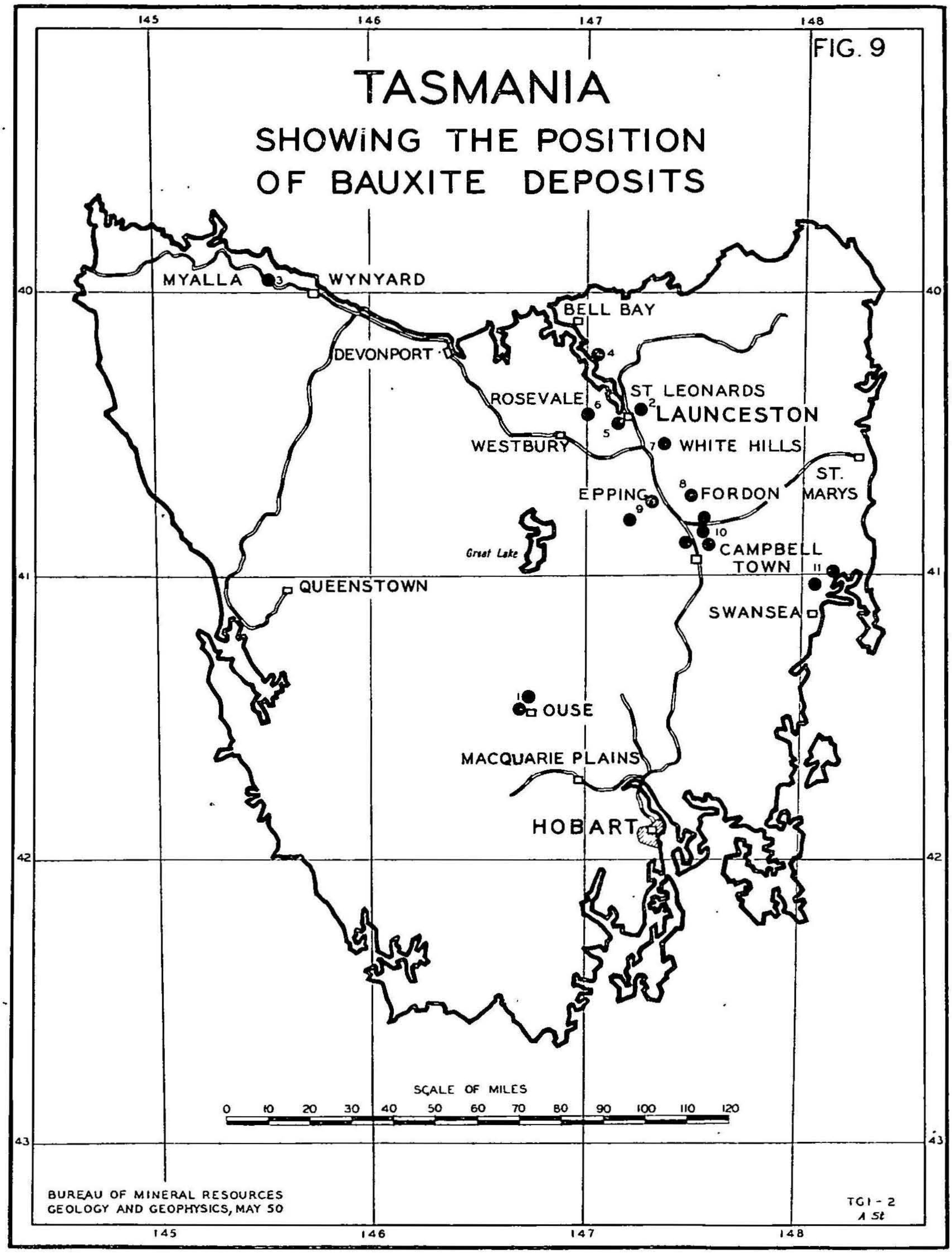
Introduction.

Ouse is a village on the river of that name, in the Parish of Kenmere, County of Cumberland, at the junction of the Lyell and Tarraleah Highways, 55 miles by road north-west from Hobart, and about 25 miles north-west from Macquarie Plains, the nearest railway station.

In all fifteen bauxite deposits are known in the locality, and two others rather more distant from the village are also mentioned here. Those near the village are shown on the accompanying geological plan, Plate 11.

Deposits 1 to 12 inclusive, numbered from north to south, lie along a line extending southwards from a point 2½ miles north-north-west of the village to 1½ miles south-south-west. Deposits 1 to 5 are grouped near the northern end of the line, and Nos. 6 to 12 towards the opposite end. The gap of 6 miles between Deposits 5 and 6 is occupied by the valley of Kenmere Rivulet. The very small deposits numbered 13 and 14 lie 1½ and ½ mile south of the village respectively, and No. 15 crops out in the left bank of the River Derwent near Dunrobin Bridge, about 4 miles south-east of Ouse.

Summary of Reserves.—Reserves proved in the Ouse area are summarized in Table 30. The reserves are set out in two ways: the tonnages shown in column (*a*) have been calculated from only those samples which conformed to the Aluminium Commission's definition of economic bauxite. Tonnages in column (*b*) include all bauxite which in a continuous thickness contains not less than 35 per cent. Al_2O_3.



[*To face page* 104.]

TABLE 30.—SUMMARY OF RESERVES, OUSE AREA.

Deposit No.	Tons. (a)	Tons. (b)	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
2 ..	320,500	..	4.4	41.6	27.8	2.3	37.8
	..	422,500	6.1	41.0	27.5	2.3	..
6 ..	5,000	..	5.8	42.1	25.2	2.1	37.4
	..	9,200	9.7	39.3	26.4	2.1	..
8 ..	3,600	..	6.7	39.3	29.4	2.1	35.0
	..	42,200	10.7	40.2	26.0	2.1	....
9 ..	3,600	..	5.2	38.1	30.3	2.0	36.5
	..	12,700	10.3	37.6	29.7	2.1	..
10 ..	11,000	..	5.4	43.2	24.9	2.5	37.9
	..	15,300	5.6	40.8	25.7	2.5	..
11 ..	56,000	..	4.9	40.6	28.8	2.1	36.6
	..	60,000	5.6	40.4	28.7	2.1	..
12 ..	92,300	..	4.6	39.3	30.4	2.2	35.8
	..	130,500	6.1	38.6	30.2	2.2	..
Totals ..	492,000	..	4.7	41.0	28.9	2.2	37.2(1)
	..	692,400	6.4	40.4	28.0	2.2	..

Column (a)—Economic bauxite as defined by A.A.P.C.
Column (b)—Bauxite containing not less than 35 per cent. total alumina.
(1) Extracted with average soda loss of 1.03 cwt. of Na_2O per ton of available Al_2O_3. Available Al_2O_3 determined by Aluminium Commission, remainder of figures computed from analyses by Tasmanian Mines Department.

GENERAL GEOLOGY.

The broad picture at Ouse is that of an area occupied by sandstone of Triassic age which has been intruded by a sill of dolerite. Prolonged erosion stripped the cover from the dolerite and reduced it to a nearly level surface of low relief on which lateritic weathering developed a mantle of ferruginous bauxite. The lateritized land surface was faulted, tilted, eroded, and then buried beneath fresh-water sediments and basalt flows. Renewed erosion has revealed the small remnants of the old land surface still carrying a mantle of bauxite.

The dolerite bearing the northern group of deposits, Nos. 1 to 5, is truncated to the west by a steep erosion scarp which forms the eastern wall of the Kenmere Valley. The southern group is bounded on the west by rising bedrock against which the bauxite feathers out.

At a point about ½ mile east of No. 2 deposit the dolerite thins out to expose the sandstone floor beneath the sill, but the sandstone does not show evidence of lateritization.

Much of the bauxite is exposed at the surface but several bodies pass under the fresh-water beds down the dip to the east.

Stratigraphy.

Drilling and shaft-sinking through limited thicknesses of overburden to test the concealed bauxite revealed that the overlying sediments consist mainly of clay and sandy clay with thin beds of lignite. Fragmentary leaf impressions are fairly common, and impressions of leaves and woody fragments are also associated with a thin band of concretionary ironstone which outcrops as a horizontal line of boulders east of No. 2 Deposit. These beds are recognizable as members of the Derwent Tertiary lake sequence, but their age cannot be established with precision. They may, however, be correlated tentatively with the Yallourn Formation of Victoria, which is now believed to have considerable range in time, probably from middle Eocene into Oligocene.

At Thistle Hill, and elsewhere in the vicinity, the lake beds at least 200 feet thick are capped with basalt to form flat-topped residual hills, remnants of a former plateau.

The succession exposed or intersected in bores is as follows:—

Pleistocene	River terraces	Boulders, sand, &c.
Pliocene	Newer volcanics	Basalt and agglomerate
Oligocene to middle Eocene ?	Derwent lake beds and intercalated volcanics	Current-bedded sand, concretionary ironstone, clay, lignite, basalt
Eocene ?	Laterite	Bauxite and clay zone
Jurassic	Intrusive	Dolerite, parent of bauxite
Triassic	Felspathic sandstone ..	Sandstone, shale, coal

Structure.

As a result of their mode of formation and the effects of subsequent erosion, bauxite bodies occur in forms ranging from wide sheets, thinning at the edges, to lenticular or pod-like bodies.

The largest single body of bauxite in the district occupies a central position at No. 2 Area and has a very irregular outline. Its principal dimensions are approximately: length, 1,300 feet; average width, 650 feet; maximum thickness, 17 feet. No. 9 Deposit has a regular elliptical outline and measures 400 feet by 350 feet with a maximum thickness of 7 feet, but the volume of economic bauxite contained in it is very much less.

The deposits lie on an undulating surface of dolerite which has an easterly dip ranging from an average of 6° at the northern group to about 10° or 12° at No. 12 deposit. Local variations in the amount and direction of dip may be observed, but these are consistent with the irregular surface on which the bauxite was formed.

The bauxite tends to occupy shallow depressions in the dolerite and consequently it thins out against a rim of the bedrock.

Somewhat abrupt changes in the thickness and attitude of the bauxite suggest that the bodies may be traversed by small faults, but no actual dislocations have been observed.

DESCRIPTION OF DEPOSITS.

No. 2 *Deposit.* (*See* Plates 12, 13, and 14.)

The deposit on Gladfield Estate may be regarded as consisting of five lenticular bodies of economic bauxite narrowly separated from each other or joined by a thin sheet of bauxite. The central body consists of three such conjoined lodes.

For the purpose of presenting a more detailed picture of the tonnage and composition of the reserves of bauxite, the volume of each of these bodies has been calculated separately and the resulting figures are presented in Tables 31A and 31B.

Reference to the plans (Plates 12 and 13) will quickly show the relative positions of the five bodies, which are for convenience designated the Western, Central, and Southern bodies, of which the Central is further subdivided into three blocks.

The Western and the greater part of the Central body underlie shallow overburden consisting of brown clay with disseminated ferruginous pisolites with fragments and boulders of bauxite, but a small part of the Central area is covered to a maximum depth of 25 feet. The average thickness of overburden is less than 4 feet, and much of this contains boulders of bauxite which could be recovered by screening and washing.

The Southern body passes north-easterly under heavy cover of Tertiary sediments and has not been drilled to its limits along its north-eastern margin; but it is believed that the concealed bauxite does not continue more than 100 or 200 feet beyond the area drilled.

Shaft and bore logs with partial analyses of bauxite samples from each body within No. 2 deposit are given.

Depth in Feet. From—	To—	Description.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.
		WESTERN BODY—SHAFT 31.				
0	1.5	Timber and filling	..	..	..	..
1.5	3	Clay and ferruginous gravel	..	..	..	..
3	5	Hard brown bauxite	} 6.0	46.6	19.9	39.7
5	7	Soft clay-like bauxite				
7	10	Clay with little bauxite	..	..	..	..
10	10.5	Ironstone with dark speckled clay ..	..	..	..	..
10.5	11	Yellow and grey clay	..	..	..	..
		CENTRAL BODY—SHAFT 18.				
0	2	Timber and filling	..	..	..	..
2	4	Hard ferruginous bauxite with light-coloured pisolites	2.4	41.6	28.9	40.3
4	6	Inaccessible	..	..	..	..
6	8	Soft bauxite with ferruginous concretions	4.3	45.4	22.4	41.2
8	12	Soft bauxite and grey clay	9.7	34.9	31.8	25.2
12	14	Grey clay with bauxite nodules ..	} ..	..	..	14.7*
14	16	Brown clay passing to hard speckled clay				
16	18	Grey clay veins penetrating hard speckled clay	} ..	..	..	18.5*
18	27	Hard speckled clay (weathered dolerite)				

* Al_2O_3 soluble in hot caustic soda solution at atmospheric pressure.

Depth in Feet.		Description.	Insoluble Matter.	Al_2O_3	Fe_2O_3.	Available Al_2O_3.
From—	To—					
			Per cent.	Per cent.	Per cent.	Per cent.
		CENTRAL BODY—SHAFT 65.				
0	1.25	Red clayey soil	..	..	..	..
1.25	2.25	Bauxite boulders and soil	..	..	..	..
2.25	5.25	Ferruginous pisolitic bauxite	4.3	26.9	46.1	24.4
5.25	6.25	Yellow pisolitic bauxite; band of concretionary ironstone	} 2.9	44.9	24.1	42.1
6.25	10.25	Yellow earthy bauxite				
10.25	13.25	Friable yellow and red earthy bauxite with ferruginous concretions				
13.25	15.25	Soft clayey bauxite with few ferruginous concretions	} 3.1	42.8	26.0	40.2
15.25	17.25	Dense earthy bauxite				
17.25	18.75	Clayey bauxite with ferruginous concretions	} 4.8	41.7	25.7	36.7
18.75	20.25	Bauxite and clay	..	..	..	..
20.25	20.5	Clay	..	..	..	..
		SOUTHERN BODY—BORE 83.				
0	1	Soil	..	..	..	..
1	6	Yellow clay	..	..	..	..
6	14	Red and white clay	..	..	..	..
14	18	Bauxite	10.3	38.6	26.8	32.7
18	20	Weathered dolerite	..	..	..	..
		SOUTHERN BODY—SHAFT 56.				
0	1.25	Timber and filling	..	..	..	..
1.25	2	Soil	..	..	..	..
2	4	Hard yellow granular bauxite	4.8	35.7	34.2	30.7
4	8	Hard yellow granular bauxite becoming dense to textureless	3.3	37.0	33.5	33.3
8	9	Dense textureless bauxite	..	..	..	..

Reserves.—The reserves of bauxite contained in the deposits at Ouse are presented in two forms—(*a*) the tonnage of economic bauxite as defined by the Aluminium Commission and (*b*) the tonnage calculated from continuous shaft and bore sections which contain bauxite with not less than 35 per cent. total alumina.

The figures for No. 2 deposit are—

—	Tons.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
(*a*)	320,000	4.38	41.6	27.8	2.30	37.8	1.00
(*b*)	423,000	6.14	41.0	27.5	2.29	..	..

Analyses of composite samples made up from assay samples to represent the economic bauxite contained in No. 2 deposit are of interest and are here quoted—

—	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.	Soda Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
(c)	5.7	39.7	27.4	2.9	23.4	36.3	1.31
(d)	5.6	40.7	27.1	2.7	24.4	..	..
(e)	4.9	41.4	26.7	2.3	24.8	..	..

(c) Composite sample analysed by Aluminium Commission.
(d) Composite sample analysed by Dorr Co. Inc., New York, N.Y.
(e) Sample representing 1,200 lb. sample taken from eight shafts. Analyses by Tasmanian Mines Department laboratory.

The proved reserves are set out in greater detail in Tables 31A and 31B.

TABLE 31A.—RESERVES OF ECONOMIC BAUXITE, No. 2 DEPOSIT.

Body.	Tons.	Insoluble Matter.	Total Al_2O_3.	Fe_2O_3.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
Western	8,400	4.90	40.6	28.3	36.8	1.10
Central—						
North block	145,000	4.1	41.7	27.4	38.1	0.97
North-central block ..	38,000	3.8	41.4	28.6	37.6	0.96
South-central ..	77,000	4.36	41.4	27.6	38.1	1.02
Southern	51,600	5.47	42.1	28.3	37.6	1.05
	320,000	4.38	41.6	27.8	37.8	1.00

TABLE 31B.—RESERVES OF BAUXITE CONTAINING NOT LESS THAN 35 PER CENT. Al_2O_3.

Body.	Tons.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Western	15,400	6.45	39.9	28.2	2.21	23.1
Central	350,000	6.35	41.2	27.4	2.24	22.9
Southern	57,500	6.02	40.5	28.9	2.38	22.4
	423,000	6.14	41.0	27.5	2.29	22.7

No. 6, 8, and 9 Deposits.

These deposits form a group on Lientwardine Estate about 2 miles south of Gladfield and are accessible from the Tarraleah road.

The deposits are in a late stage of denudation and the outcrops consist largely of residual boulders and blocks of granular bauxite lying on clay and weathered dolerite; therefore the solid bauxite *in situ* represents a low horizon in the profile and consequently is high in silica.

Small tonnages of economic bauxite which has an average thickness of only 3 feet could be recovered from each deposit.

The proved reserves are set out in Tables 32A and 32B.

TABLE 32A.—RESERVES OF ECONOMIC BAUXITE, No. 6, 8 AND 9 DEPOSITS.

Deposit.	Tons.	Insoluble Matter.	Total Al_2O_3.	Fe_2O_3	TiO_2.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
6	5,000	5.82	42.1	25.2	2.1	37.4	1.16
8	3,600	6.7	39.3	29.4	2.1	35.0	1.47
9	3,600	5.2	38.1	30.3	2.0	36.5	1.06
	12,200	5.9	40.0	27.9	2.1	36.4	1.22

TABLE 32B.—RESERVES OF BAUXITE CONTAINING NOT LESS THAN 35 PER CENT. Al_2O_3.

Deposit.	Tons.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
6	9,200	9.68	39.3	26.4	2.1	22.6
8	42,200	10.74	40.2	26.0	2.1	21.0
9	12,700	10.25	37.6	29 7	2.1	20.3
	64,100	10.45	39.5	26.8	2.1	21.4

No. 10 *and* 11 *Deposits.* (Plate 15.)

These deposits are exposed as two narrow outcrops separated by a small alluvium-filled gully on the western slope of Thistle Hill, Lachlan Vale Estate, 600 yards south-south-east of No. 9 deposit, which is the southernmost member of the group in Leintwardine Estate. The outcrops appear to join under shallow cover to form a single body, but the body may be traversed by a small fault which passes through the gap between the outcrops.

Deposit No. 10 has a length of 500 feet and a maximum thickness of 14 feet near the outcrop. Away from the outcrop in the direction of the north-easterly dip the body thins rapidly while the thickness of the overburden increases so that the economic limit of the ore is reached about 100 feet from the outcrop.

Deposit No. 11 is a tabular body joining or adjacent to No. 10 on the south and dipping at an average of 11° in a direction a little south of east. The body has a maximum thickness of 19 feet and a strike length of 600 feet and maximum width down the dip of 250 feet.

Overburden ranges from a few inches of lateritic soil and detritus over the outcrop to more than 50 feet of sand, clay, and lignite at the eastern margin of the deposit.

One shaft and one bore log are quoted with partial analyses of the bauxite intersected and brief description of the overburden.

Depth in Feet.		Description.	Analyses.			
From—	To—		Insoluble Matter.	Al_2O_3.	Fe_2O_3.	Ignition Loss.
			Per cent.	Per cent.	Per cent.	Per cent.
		No. 11 Deposit.—Bore 11.				
0	1	Sandy soil	..	..	..	..
1	5.5	Dark-grey clay	..	..	..	..
5.5	8	Sand and white clay	..	..	..	..
8	9	} Yellow and white clay fragments of concretionary ironstone				
9	10		..	..	..	..
10	19.5	White clay with lignitic material at 17 feet	..	..	..	..
19.5	20.5	Fine yellow sand	..	..	..	..
20.5	24	Grey clay with traces of carbonaceous material	..	..	..	..
24	25	White sandy clay	..	..	..	..
25	26	Concretionary ironstone	..	..	..	..
26	30	White sand, current-bedded	..	..	..	..
30	32	Light-grey clay	..	..	..	..
32	39	White and yellow sand	..	..	..	..
39	45	Lignitic clay..	..	..	..	..
45	47	Ferruginous laterite	27.4	9.5	50.0	9.4
47	52	Pisolitic and granular bauxite	8.8	26.9	42.4	18.1
52	55	Bauxite and clay	6.2	36.2	32.0	22.7
55	57	Brown clay (weathered dolerite) ..	..	..	..	..
		Shaft D.11.				
0	1	Timber and filling	..	..	..	..
1	2.5	White sandy soil	..	..	..	..
2.5	5	Grey clay	..	..	..	..
5	6	Clay with fragments of bauxite ..	..	..	..	..
6	9	Semi-pisolitic and earthy bauxite, yellow and brown	6.7	34.5	35.0	21.1
9	14	Porous granular and earthy bauxite, brown, with irregular concretions of ironstone	3.5	41.5	27.3	25.0
14	14.75	Dense and semi-pisolitic bauxite, light-brown	} 4.2	40.9	27.7	24.5
14.75	19	Earthy bauxite, light-brown				
19	22	Earthy bauxite, light-brown	3.5	38.7	30.6	24.3

The first bore log is of unusual interest in that it demonstrates the preservation of a richly ferruginous laterite zone, notwithstanding its burial beneath sediments containing organic matter.

TABLE 33A.—RESERVES OF ECONOMIC BAUXITE, DEPOSITS 10 AND 11.

Deposit.	Tons (Dry Ore).	Insoluble Matter.	Total Al_2O_3.	Fe_2O_3.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
10	11,000	5.44	43.2	24.9	37.9	1.23
11	56,000	4.88	40.6	28.8	36.6	1.04
	67,000	4.97	41.0	28.2	36.8	1.07

TABLE 33B.—RESERVES OF BAUXITE CONTAINING NOT LESS THAN 35 PER CENT. Al_2O_3.

Deposit.	Tons (Dry Ore).	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
10	15,300	5.6	40.8	25.7	2.5	23.6
11	60,000	5.6	40.4	28.7	2.1	22.4
	75,300	5.6	40.5	28.0	2.2	22.6

No. 12 *Deposit.* (Plates 16 and 17.)

This deposit outcrops as a discontinuous curve on the south-western slope of Thistle Hill about 300 yards south-east of No. 11 deposit, from which it is separated by a wide deep gully. The central portion of the outcrop forms a prominent shoulder or structural terrace on the hillside and the body dips in a general north-easterly direction under the Tertiary lake beds.

Underground exploration of the concealed deposit shows that it is divided into four lobes by narrow areas in which the bauxite is both thin and of low grade. It appears that the division of the deposit has been brought about by faulting with slight differential tilting of the fault blocks.

The deposit as a whole is capped with a highly ferruginous pisolitic zone in which the iron content may exceed 60 per cent. Fe_2O_3. Also the ferruginous capping and much of the underlying bauxite is siliceous. The volume of economic bauxite is severely restricted as a result of these factors, and in addition the cost of quarrying the ore would be adversely affected by the necessity to remove the hard capping, which averages about 3 feet thick, but does not cover the entire area occupied by bauxite of commercial grade. Overburden, inclusive of the capping, ranges from 2 feet to 49 feet thick and averages 21 feet. The thickness of economic bauxite ranges between 3 and 16 feet, averaging 9.7 feet.

Owing to the increase in depth of overburden to the east, drilling was only pursued to the edge of the deposit opposite the central body, which wedged out on a line parallel to the outcrop and 300 feet north-east from it. Drilling east of the northern block and north-east of the southern area would probably disclose more bauxite of economic grade under cover more than 50 feet thick.

Proved reserves in No. 12 deposit amount to 92,000 tons of dry ore containing 39.3 per cent. total alumina and 4.65 per cent. silica. This reserve scarcely constitutes an attractive source of aluminium, but owing to its proximity to No. 22 deposit and for other reasons it may be exploited. The engineering difficulties which may arise in this event are beyond the province of the writer, but nevertheless it is realized that unfavorable conditions which do not apply elsewhere in the district exist and for this reason more complete details of the deposit are given than has been put forward in the earlier descriptions.

The four bodies of economic bauxite shown on Plate 16 are described individually and the volume of overburden standing vertically above the ore has been calculated, separate figures being given for the sand and clay beds and the heavy ferruginous capping.

The northern body lying to the north of line 300N contains only a narrow strip of ore 350 feet long by 100 feet wide and 6.5 feet thick, underlying an average thickness of 37 feet of overburden including 2 feet of ferruginous and siliceous laterite. The bauxite under shallower cover between the strip of ore and the outcrop is too siliceous and too ferruginous for commercial use.

Two logs for this block are given.

No. 12 DEPOSIT—NORTHERN BLOCK.

Depth in Feet.		Description.	Analyses.			
From—	To—		Insoluble Matter.	Total Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.
		Bore No. 12. 500N/100E.				
0	1	Sandy soil	..	..	..	..
1	5	Grey clay	..	..	..	..
5	9	White clay	..	..	..	..
9	16	Variegated clay with ironstone fragments	..	..	..	..
16	19	Ferruginous bauxite	17.6	18.9	46.6	..
19	21.5	Yellow clay	..	..	..	..
21.5	24	Bauxite	10.7	36.0	29.1	26.7
24	29	Bauxite	11.3	32.2	34.5	..
29	30.5	Bauxite	15.3	29.2	35.4	..
30.5	32	Brown clay	..	..	..	..
		Bore No. 17. 500N/200E.				
0	1	Sandy soil	..	..	..	..
1	5	Grey clay	..	..	..	..
5	6	Sandy clay	..	..	..	..
6	15	Coarse yellow sand	..	..	..	..
15	20	White clay with fragments of concretionary ironstone	..	..	..	..
20	38	Lignitic clay..	..	..	..	..
38	39.5	Clay with fragments of ironstone ..	..	..	..	..
39.5	41.5	Ferruginous bauxite	6.0	27.2	45.2	..
41.5	46.5	Sub-pisolitic and granular bauxite ..	2.5	40.9	30.7	39.1
46.5	52.5	Granular bauxite	4.4	40.4	30.3	34.4
52.5	57.5	Earthy and granular bauxite	6.9	37.2	31.1	27.5
57.5	60	Brown clay with little bauxite	..	..	..	..
60	62	Weathered dolerite	..	..	..	..

The orebody of the Central block is roughly rectangular in plan, measuring about 500 feet by an average width of 250 feet. Thickness of overburden ranges from 2 feet at the outcrop to 28 feet near the eastern edge of the body and averages 11.5 feet. The thickness of the ore averages 10 feet and ranges from 4 feet and 12.5 feet at the outcrop to 16 feet near the centre of the block.

The log of one bore drilled in a central position is given—

No. 12 DEPOSIT—CENTRAL BLOCK.

Depth in Feet.		Description.	Analyses.			
From—	To—		Insoluble Matter.	Total Al_2O_3.	Fe_2O_3.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.
		BORE No. 1. 100N/00.				
0	1	Sandy soil	..	..	..	..
1	3	Brown clay and gravel	..	..	..	..
3	7	Yellow and brown clay	..	..	..	..
7	8	Coarse sand and yellow clay	..	..	..	..
8	9.5	Variegated sandy clay	..	..	..	..
9.5	13.5	Ferruginous bauxite	6.7	32 7	37.0	30.4
13.5	18.5	Soft clay-like brown bauxite	2.2	39 8	31.7	38.6
18.5	23.5	Soft clay-like brown bauxite	2.4	41 4	30.9	39.4
23.5	25	Red-brown granular bauxite	4.5	41.8	28.1	37.0
25	26.5	Red-brown granular clay (?)	..	..	..	..
26.5	28.5	Bauxite with limonite	9.9	29.6	36.7	..
28 5	30	Brown clay, probably weathered dolerite	..	..	..	..

Two small orebodies lying along a south-easterly prolongation of the longer axis of the Central body complete the reserves contained in No. 12 Deposit.

Statements of total reserves and overburden are shown in Tables 34A, B and C.

TABLE 34A.—RESERVES OF ECONOMIC BAUXITE CONTAINED IN No. 12 DEPOSIT.

Body.	Tons (Dry Ore).	Insoluble Matter.	Total Al_2O_3.	Fe_2O_3.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
Northern	16,000	3.78	38.6	32.6	35.4	0.77
Central	54,500	4.70	39.4	29.8	35.6	1.03
Southern bodies.. ..	21,800	5.1	39.6	30.2	36.6	1.11
	92,300	4.65	39.3	30.4	35.8	1.00

TABLE 34B.—RESERVES OF BAUXITE CONTAINING NOT LESS THAN 35 PER CENT. Al_2O_3.

Body.	Tons (Dry Ore).	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Northern	26,500	5.36	38.8	32.0	2.25	22.2
Central	69,000	5.89	39.1	29.7	2.07	22.5
Southern bodies.. ..	35,000	6.9	39.0	29.5	2.23	21.7
Total	130,000	6.08	39.0	30.2	2.15	22.2

TABLE 34c.—OVERBURDEN—No. 12 DEPOSIT.

Body.	Economic Bauxite.	Overburden.		
		Sand and Clay.	Laterite.	Total.
	Tons.	Cubic yards.	Cubic yards.	Cubic yards.
Northern	16,000	25,000	3,000	28,000
Central	54,500	44,000	6,000	50,000
Southern bodies ..	21,800	27,000	Very small	27,000
Total	92,300	96,000	9,000	105,000

Other Deposits near Ouse.

Two other occurrences of bauxite in the vicinity of Ouse have been mentioned. These are on Cleveland Estate and at Father-of-Marshes.

The former, which lies ¾ mile north of a point on the Tarraleah-road, 7¼ miles from Ouse, and at an elevation of about 1,000 feet above sea level, is a small lenticular body measuring 190 feet in length by a maximum width of 80 feet exposed in the southern bank of a creek. To the south the body appears to pass under Tertiary clays, including a band of concretionary ironstone, which are capped with basalt, but a pit sunk just outside the southern edge of the outcrop disproved any concealed extensions of the bauxite.

At Father-of-Marshes about 12 miles north-west from Ouse and at an elevation of approximately 1,800 feet above sea level, two minor occurrences of bauxite are known. The southernmost consists of an area occupying a small saddle and measuring approximately 500 feet by 250 feet in which occur boulders and detached areas of bauxite a few feet across. The area occupied by bauxite is flanked on the east and west by dolerite and truncated at both north and south extremities by falling topographic slopes. One specimen of nodular bauxite from this locality was submitted to analysis with the following result:—

	Per cent.
Insoluble matter	16.2
Alumina	37.9
Ferric oxide	20.8
Titania	1.6
Ignition loss	22.3

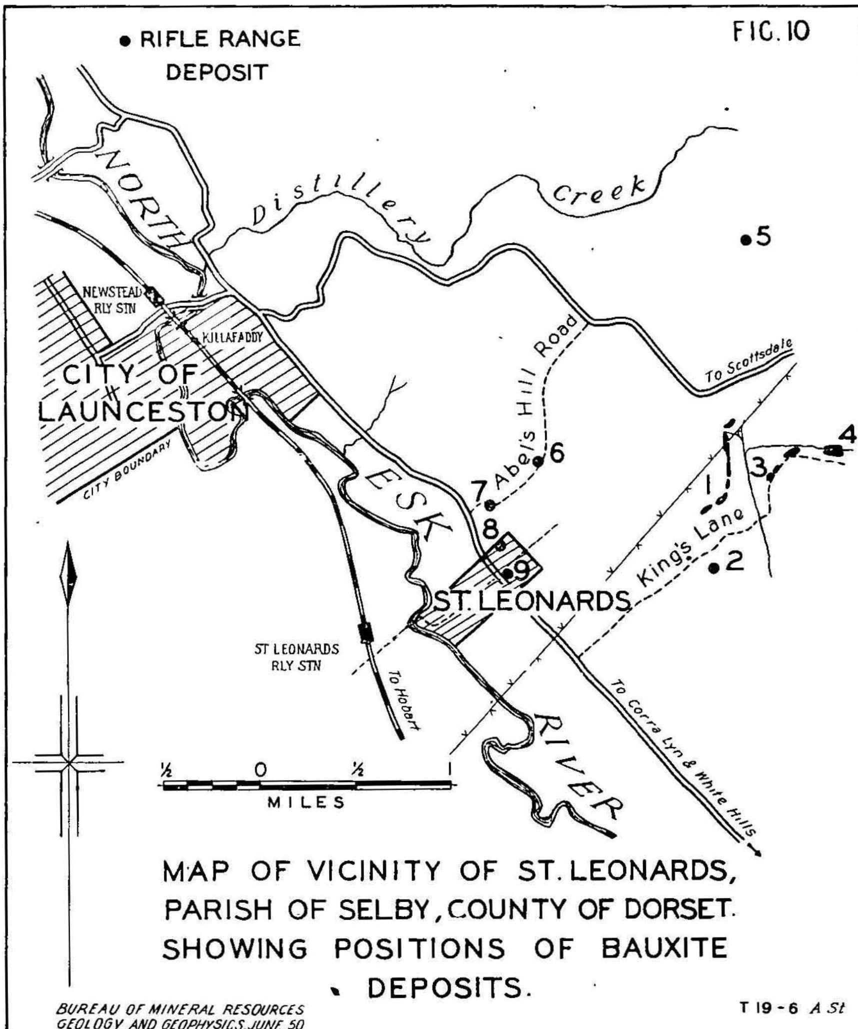
The second deposit occurs about ½ mile north and is separated from the first by the swampy ground from which the locality takes its name. This occurrence of bauxite is described by Dickinson (1943) as " a dipping formation overlying diabase (dolerite) and underlying basalt. The outcrop is indefinite and largely obscured by talus ".

Deposits 1, 3, 4, 5, 7, 13, 14, and 15 at Ouse were found to be small residuals containing no useful quantities of bauxite and are not further discussed.

ST. LEONARDS AREA. (*See* Fig. 10.)

Introduction.

The deposits at St. Leonards are relatively small and would be of doubtful value if they were in a less easily accessible situation than close to the City of Launceston. The group of deposits occurs in hilly country about 1 mile east of St. Leonards village and $5\frac{1}{2}$ miles by road south-east from Launceston. The distance by road to the alumina plant at Bell Bay is 38 miles, and with the exception of about 1 mile of access road to the deposits the roads are metalled or sealed and capable of carrying heavy traffic.



A total of seven separate bauxite bodies has been noted in the vicinity of St. Leonards, but of these only two, Nos. 1 and 3, contain appreciable quantities of economic bauxite.

The bauxite is developed upon dolerite, like that at Ouse.

Summary of Reserves.—Proved reserves of economic bauxite at St. Leonards total less than 150,000 tons and are shown in Table 35 below—

TABLE 35.—RESERVES OF ECONOMIC BAUXITE—ST. LEONARDS.

Deposit No.	Tons.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1.(1)	112,300	5.6	41.7	25.7	2.2	37.7
3.	30,200	7.1	40.9	25.8	2.2	36.5
Total	142,500	5.9	41.5	25.7	2.2	37.4(2)

(1) A composite sample made up from assay samples to represent the No. 1 deposit was analysed by the Dorr Co. Inc., New York, with the following result:—

	Per cent.
Insoluble matter	7.0
Alumina	40.7
Ferric oxide	26.3
Titania	2.7

(2) Available Al_2O_3 extracted with average soda loss equivalent to 1.18 cwt. of Na_2O per ton of alumina extracted.

GENERAL GEOLOGY.

No. 1 Deposit crops out as a narrow bench following the contours along the western slopes of a valley trending south. The bauxite outcrop is continuous for 2,900 feet on the valley side and also appears in small exposures at the head of the valley. The several small discontinuous outcrops which constitute Nos. 3 and 4 Deposits lie on the opposite side of the valley at a similar general elevation. It is probable that these bodies mark the outer edges of a once continuous sheet of laterite which lay on a surface dipping gently to the south-west.

Stratigraphy.

The bauxite rests on dolerite, and where the topography permits passes beneath a cover of the Launceston Tertiary fresh-water beds with, on the eastern side of the valley, an intercalated basalt flow (or flows). The sediments are capped with flat-lying basalt which gives a characteristic mesa-like appearance to the hills in this locality.

The geological picture is similar in most respects to that at Ouse. The stratigraphical succession differs only in minor detail and the base of the dolerite is not exposed. A basalt flow near the base of the Launceston Tertiary beds was poured out after a break in the fresh-water deposition had permitted partial removal of the basal beds down to the bauxite. Consequently tongues of basalt rest directly on the bauxite in places.

It is evident that the underlying surface on which the bauxite formed was partly dissected before the deformation of the Eocene-Oligocene(?) lake beds and volcanics.

One result of the formation of bauxite on an uneven surface in a broad valley is that erosion first attacked the slightly depressed centre of each bauxite deposit, leaving a narrow marginal rim, the width of which depends upon the degree to which the body has been eroded. It is very probable that the form of the long narrow bodies at St. Leonards may be explained in this way.

Structure.

Undulations in the upper surface of the dolerite sill underlying the bauxite are reflected as changes in the dip of the ore. In No. 1 Deposit the bauxite lies horizontally at the northern end of the body, dips gently easterly as it is followed along the strike to the middle of the outcrop, and reverses to a gentle westerly and south-westerly dip. No. 3 and 4 Deposits both have a fairly constant and gentle south-westerly dip.

Towards the southern end of No. 1 Deposit the westerly component of the dip carries the bauxite beneath thick overburden of clay within a comparatively short distance and the western limit of the deposit has not been determined over the greater part of the southern half of the body.

From a constriction near the centre where the economic bauxite thins out to less than 2.5 feet thick, the orebody ranges in width from about 200 to 450 feet and in thickness to 10 feet. South of the constriction the thickness of ore undergoes many changes and attains a maximum of 10 feet at the southern limit of the deposit.

The small changes in dip and thickness are ascribed to the uneven surface on which bauxitization took place and in part to the partial denuding of the bauxite which tended to plane off irregularities of the upper surface.

DESCRIPTION OF DEPOSITS.

No. 1 Deposit, St. Leonards. (*See* Plates 18 and 19.)

Subsurface exploration shows that the bauxite formation is a relatively flat-lying sheet dipping gently west into the hill along the southern half of its length, and reversing the dip to a gentle easterly inclination from the transverse zero co-ordinate to 1,500 feet N. Both the upper and lower surfaces are undulating, but erosion of the upper surface before deposition of the Tertiary clay has stripped many of the higher points rendering it more nearly plane than the base. In a comparatively low-grade deposit it is to be expected that ore-bodies defined by assay boundaries are likely to be irregular. The results of testing show that No. 1 area contains seven separate bodies of economic bauxite divided from each other by areas of low-grade material. In some instances the intervening low-grade bauxite is thin and overlies a high area of the underlying dolerite, suggesting that economic ore has been denuded. Reference to the section in Plate 23 will show that the high-grade ore usually lies at the top of, or at least high in, the existing bauxite profile. The thickness of ore averages 5½ feet, which is approximately half the thickness of the whole laterite formation.

Details of the seven separate bodies of economic bauxite contained within No. 1 area are given in order from south to north in Table 36.

TABLE 36.—BAUXITE AND OVERBURDEN, No. 1 DEPOSIT, ST. LEONARDS.

Block lying between Co-ordinates.	Number of Shafts and Bores in Block.	Bauxite.		Overburden.	
		Average Thickness.	Volume.	Average Thickness.	Volume.
		Feet.	Cubic yards.	Feet.	Cubic yards.
1. 1250S and 1150S ..	1	5	1,400	9	2,500
2. 1350S and 650S ..	16	5.65	31,600	11	61,000
3. 450S and 350S ..	1	7	2,600	23	8,500
4. 250S and 150S ..	1	5	2,000	7	2,800
5. 050S and 050N ..	1	6	2,400	5	2,000
6. 250N and 1050N. ..	15	5.3	30,000	9	51,000
7. 1150N and 1550N ..	8	5.6	15,500	11	33,000
	..	..	86,500	..	160,800

Long Tons "Green" Ore.	Equivalent as Dry Ore.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
1. 2,100 ..	1,800	3.8	42.0	28.2	2.4	38 6	0.70
2. 47,400 ..	41,000	5.9	41.7	25.4	2.0	37 0	1.24
3. 3,900 ..	3,400	7.0	39.0	28.3	2.4	33.0	1.7
4. 3,000 ..	2,600	4.9	38.0	31.7	2.0	33.0	1.22
5. 3,600 ..	3,100	4.8	40.6	25.0	1.8	36.5	1.00
6. 45,000 ..	39,000	5.5	41.4	26.4	2.0	37.6	1.11
7. 24,700 ..	21,400	5.2	43.4	23.8	2.8	40.5	0.74
129,700 ..	112,300	5.6	41.7	25.7	2.2	36.7	1.10
	(a)	7.0	40.7	26.3	2.7	..	..

(a) Composite sample made up from assay samples by Tasmanian Mines Department Laboratory and analysed by the Dorr Co. Inc. New York.

In addition to the above figures 7,700 tons of bauxite proved by bores 43 and 26 and shaft C, containing 5.7 per cent. SiO_2, 40.5 per cent. Al_2O_3, 28.9 per cent. Fe_2O_3, 2.0 per cent. TiO_2, with 33.7 per cent. available Al_2O_3 extractable with a soda loss equivalent to 1.13 cwt. Na_2O, underlies 35,000 cubic yards of clay; this has been excluded from the reserves because of the depth of overburden, but will become available if the overlying clay finds a commercial use.

The overburden consists mainly of clay with interbedded lenses of sand and pebbles or sandy clay. Towards the southern end of the deposit the overburden consists of smooth grey clay under a foot or so of gritty soil. This clay has a maximum thickness of 29 feet at Bore 26 (900S/100W) where it is nearly white in colour. Where intersected in shafts the clay was found to contain very sparsely distributed nodules of magnesite. As the clay appears to have some commercial value a sample from the shaft at 1100S/250W was submitted to analysis at the Tasmanian Mines Department laboratory with the following results:—

	Per cent.
SiO_2	50.20
Al_2O_3	28.96
Fe_2O_3	2.77
MnO	Trace
P_2O_5	Trace
TiO_2	1.40
CaO	Trace
MgO	1.33
Na_2O	0.23
K_2O	0.16
H_2O at 105° C.	4.36
Ignition loss	11.10
	100.51

No. 3 *Deposit.* (*See* Plates 20 and 21.)

Although they are presumably remnants of the single sheet of laterite of which No. 1 deposit forms a part, the smaller and separated deposits of No. 3 area were found to have a generally higher silica and iron oxide content. Consequently only a small proportion of the total bauxite present falls within the permissible limits of economic grade. Four small outcrops occur along a line trending north-easterly for a distance of 1,800 feet and the two areas of economic bauxite occur within the north-eastern half of the area.

A band of pale blue-grey clayey bauxite containing ferruginous pisolites was encountered at the top of the bauxite section in several shafts in this area. The following logs are two typical examples of this type of section:—

Depth in Feet. From—	Depth in Feet. To—	Description.	SiO_2	Al_2O_3	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT 4.—600S/100W.						
0	2	Soil	..	..	..	..	..	..
2	5.5	Soft bauxite; pale brown pisolites in grey matrix	18.0	46.4	12.1	2.3	22.9	28.9
5.5	9	Hard bauxite; brown pisolites in ferruginous matrix	13.4	28.9	38.2	1.7	18.1	20.0
9	12.5	Hard bauxite; brown pisolites in ferruginous matrix..	15.4	28.5	37.5	1.6	16.9	..
12.5	13.25	Soft gritty yellow bauxite	..	..	..	..	..	..
13.25	13.5	Brown nodular bauxite	20.3	22.5	41.8	1.2	14.3	..
13.5	14.25	Brown earthy bauxite						
14.25	14.75	Brown nodular bauxite						
14.75	16	Yellow clay and weathered dolerite with ferruginous concretions ..	Not sampled					
16	19	Yellow weathered dolerite	..	..	..	..	..	..

Feet in Depth. From—	To—	Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT 16.—500N/00.						
0	2	Brown clay	..	..	..	..	..	..
2	7	Blue-grey clay with pockets of magnesite	..	..	..	..	..	..
7	8.5	Soft bauxite; brown pisolites in grey and brown matrix	14.3	45.3	13.1	2.8	24.5	35.2
8.5	12	Soft bauxite; pale brown gritty ..	7.7	39.2	27.4	2.0	23.6	34.9
12	13.5	Hard bauxite; pale brown dense matrix with few dark brown pisolites	11.9	36.9	27.4	2.0	21.9	27.5
13.5	16	Brown clay	Not sampled.					
16	19	Brown and grey weathered dolerite ..						

The two areas of economic ore are divided by a narrow block measuring 100 feet wide and containing approximately 5,000 tons of low-grade bauxite of the following composition:—7.0 per cent. SiO_2, 37.1 per cent Al_2O_3, 31.6 per cent. Fe_2O_3, 30.9 per cent. available Al_2O_3, with soda loss about 3 cwt. Na_2O per ton of extractable Al_2O_3.

Details of the reserves contained in the two blocks of economic ore are—

TABLE 37.—BAUXITE AND OVERBURDEN, No. 3 DEPOSIT, ST. LEONARDS.

Block.	Lying between Co-ordinates.	Number of Shafts or Bores.	Bauxite. Average Thickness.	Bauxite. Volume.	Overburden. Average Thickness.	Overburden. Volume.
			Feet.	Cubic yards.	Feet.	Cubic yards.
West ..	250W and 150E ..	8	5.6	19,000	8.5	29,000
East ..	200E and 350E ..	2	4.3	4,300	9.0	9,000
		..	..	23,300	..	38,000

Block.	Long Tons "Green" Ore.	Long Tons Equivalent as Dry Ore.	SiO_2.	Al_2O_3.	Fe_2O_3	TiO_2.	Available Al_2O_3.	Soda Loss.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
West ..	28,700	24,600	6.9	40.7	26.0	2.2	36.5	1.42
East ..	6,500	5,600	7.6	41.6	25.2	2.0	36.4	1.65
	35,200	30,200	7.1	40.9	25.8	2.2	36.5	1.47

The higher iron oxide and silica contents which increase the specific gravity of the dry ore are offset by a higher moisture content and accordingly the same conversion factor as that used for No. 1 area, namely, 1.30 tons of dry ore per cubic yard, has been applied in computing reserves in No. 3 area.

The thickness of the economic bauxite ranges between 3 and 8.5 feet and averages 5.3 feet. The overburden consists of clay, with thin pebble and boulder beds, and ranges in thickness from a few inches to 19.5 feet averaging 9 feet.

Two small extensions of No. 1 deposit, one to the south and the other to the north-east, were tested and found to be too small in the one case, and too low-grade in the other, to be included in the reserves.

No. 4 Deposit.

This deposit is a continuation of No. 3 and crops out over a large area immediately to the east. It is divided by a narrow watercourse into northern and southern bodies, both of which have been exhaustively tested by pits and bores. To the south the bauxite passes under yellow and grey clay containing lenticular pebble and sand beds and with an intercalated narrow tongue of basalt. This sequence is capped with columnar basalt about 20 feet thick and lying 70 feet stratigraphically above the bauxite.

A plan and sections of No. 4 area are shown together with details of No. 3 deposit on Plates 20 and 21.

Pit-sinking and boring disclosed small isolated areas sufficiently enriched in alumina and low enough in silica to come within or nearly within the definition of economic bauxite, but the great bulk of the bauxite contained 10 per cent. or more silica.

Logs of two shafts with partial analyses of samples are given—

Depth in Feet.		Description.	SiO_2.	Al_2O_3	Fe_2O_3.	Ignition Loss.	Available Al_2O_3.	Soda Loss.
From—	To—							
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
		SHAFT No. 1.—100N/500W.						
0	1	Soil	..	..	..	..	..	..
1	3.25	Grey clay	..	..	..	..	..	..
3.25	4	Clay and pisolites of bauxite ..	..	..	..	..	..	..
4	6	Brown granular and pisolitic bauxite with grey clay in joints	6.5	38.9	26.3	23.9	35.0	1.43
6	8.5	Red-brown granular and earthy bauxite	5.3	41.4	24.6	25.4	38.5	0.93
8.5	10.5	Pale brown granular bauxite ..	7.9	40.9	24.1	24.4	33.9	2.04
10.5	12	Pale brown clayey bauxite	15.1	37.4	22.9	21.4	24.5	..
12	15	Pale brown clayey bauxite	13.6	37.3	24.4	22.1	26.7	..
15	17	Pale brown and grey granular clay (weathered dolerite)	..	..	..	17.5	..	..

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	Ignition Loss.	Available Al_2O_3.	MgO.
From—	To—							
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT No. 15.—100N/100W.						
0	1	Soil	..	..	..	..	..	..
1	2.75	Grey clay passing to weathered basalt	..	..	..	..	..	..
2.75	5.3	Basalt	..	..	..	..	..	..
5.3	8	Boulders and pebbles in clayey matrix	..	..	..	..	..	..
8	8.5	Brown nodules in hard dark matrix ..	17.3	39.4	17.3	21.2	26.0	1.97
8.5	9.5	Brown nodules in red-brown hard matrix	15.0	41.6	16.8	22.2	29.9	1.74
9.5	10.5	Brown earthy bauxite with few nodules						
10.5	12.5	Brown earthy bauxite with few nodules	13.5	42.1	17.3	22.3	31.6	(a)1.7
12.5	14.5	Brown earthy bauxite with few nodules	11.9	40.8	20.3	22.8	31.4	pres. (b)
14.5	17.5	Hard pink-brown clay	16.6	34.5	26.2	19.4	20.6	..
17.5	20.0	Pale brown and red clay	..	..	..	..	..	..
20.0	20.5	Pale brown granular weathered dolerite	..	..	..	..	..	..

(a) Na_2O loss 3.96 cwt. (b) Na_2O loss 3.35 cwt.

Reserves of economic ore in No. 4 deposit are negligible. Shaft 1, of which the log has been quoted above, disclosed a thickness of 6.5 feet of ore averaging 6.5 per cent. SiO_2, 40.5 per cent. Al_2O_3, 25.0 per cent. Fe_2O_3, 2.4 per cent. TiO_2, with 36.1 per cent. available Al_2O_3 and soda loss of 1.43 cwt. Na_2O.

Bore No. 1 on the 100S line revealed 6 feet of siliceous bauxite under 20 feet of overburden. This bauxite is somewhat unusual in its behaviour in that the soda consumption is relatively low considering the high silica content, as the following figures representing the total thickness of 6 feet of bauxite show:—10.1 per cent. SiO_2, 45.9 per cent. Al_2O_3, 16.5 per cent. Fe_2O_3, 24.5 per cent. ignition loss, 39.9 per cent. available Al_2O_3, and 1.69 cwt. soda loss.

Two adjacent shafts in the north-west corner of No. 4 area showed a volume of bauxite totalling about 8,000 tons and containing 8.0 per cent. SiO_2, 35.3 per cent. available Al_2O_3, with 1.75 cwt. soda loss.

Other Deposits near St. Leonards.

No. 2 Deposit.—A low, rounded hill lying 1,200 feet south of the southern extremity of No. 1 Deposit is capped with brown lateritic soil containing boulders and small irregular patches of ferruginous bauxite. Dolerite crops out on the lower slopes and around the base of the hill.

Pits sunk on a line across the hill failed to disclose solid bauxite *in situ* although all the pits were carried down to dolerite.

No. 5 Deposit.—A bauxite body which occurs 4½ miles east of Launceston and ½ mile north of the Scottsdale road was tested by pit-sinking.

The deposit is oval in plan with the longer axis trending east and west and measuring 700 feet in length. The maximum width is rather less than 400 feet. The body dips westerly at a slightly lesser angle than the topographic slope with the result that the bauxite thins out on an indistinct western boundary. The deposit is surrounded by dolerite, but the southern boundary is partly obscured by Recent alluvium.

Of four pits sunk, only one (B), which was 100 feet south from the middle of the northern edge of the deposit, disclosed economic bauxite.

Another pit 100 feet south of B would probably have shown similar results, but it was abandoned in the hard pisolitic capping when the limited extent of possible economic ore was realized.

Where penetrated in pit B the section showed 4 feet of pisolitic bauxite overlying 2.5 feet of granular yellow and brown bauxite with relict dolerite texture. By increase in clay content the granular bauxite passes downward into kaolinized dolerite.

The maximum reserves of economic bauxite which could be developed in this deposit are of the order of 15,000 tons, containing 4.5 per cent. SiO_2, 42 per cent. Al_2O_3, 25 per cent. Fe_2O_3, and 2.1 per cent. TiO_2, with 25.5 per cent. ignition loss.

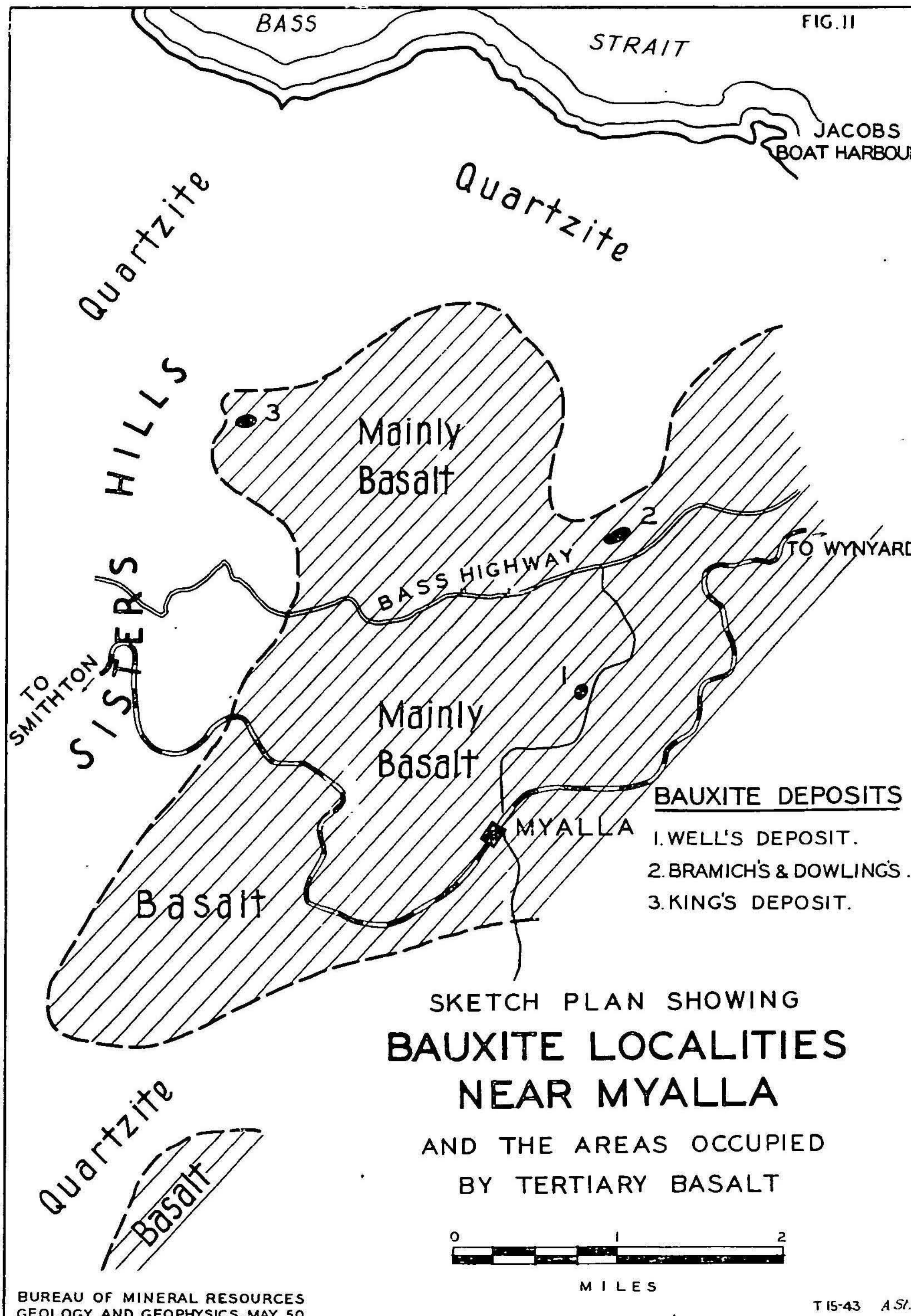
Four small occurrences of bauxite have been observed in close proximity to the village of St. Leonards. These are all too small for commercial exploitation; also the largest occurs within the village and could not be mined without payment of disproportionate compensation to property owners.

These deposits, which have been numbered from 6 to 9 inclusive, are briefly described here for purposes of record.

No. 6 *Deposit.*—Pisolitic bauxite of light colour crops out along the north-western side of Abel's Hill road at ¾ mile north-north-east of the village. The body extends northerly into adjoining grazing land and has maximum dimensions of 400 feet by 200 feet. Where exposed in the roadside it was channel-sampled, and the samples were submitted to analysis with the following results.—

—	1. Surface to 2 Feet Pisolitic.	2. 2 to 3 Feet Granular, Doleritic.
SiO_2	10.1 per cent.	9.1 per cent.
Al_2O_3	38.0 per cent.	37.8 per cent.
Fe_2O_3	25.5 per cent.	27.4 per cent.
TiO_2	2.4 per cent.	2.0 per cent.
Ignition loss	23.0 per cent.	23.0 per cent.
Available Al_2O_3	33.1 per cent.	34.3 per cent.
Soda loss	1.97 cwt.	1.31 cwt.

No. 7 *Deposit.*—A small narrow body of granular bauxite containing kernels of unweathered dolerite crosses Abel's Hill road about 600 yards north of the village.



[To face page 125.]

One specimen yielded the following on analysis:—

	Per cent.
Insoluble matter	10.0
Al_2O_3	40.4
Fe_2O_3	23.5
TiO_2	2.1
Ignition loss	24.2
SiO_2 (soluble in NaOH)	4.6
Al_2O_3 (soluble in NaOH)	37.1

No. 8 Deposit.—A narrow body of pisolitic and nodular bauxite, passing downwards to granular material overlying dolerite, outcrops for a distance of about 600 feet along the bank of a small gully 600 yards north of the St. Leonards police station. No samples from this occurrence have been analysed.

No. 9 Deposit.—A roughly circular body, of which the outline is somewhat obscured by buildings, outcrops at the rear of the "Village Inn" and to the east in nearby roads within St. Leonards village. The exposed surface is characteristic of the nodular and pisolitic capping seen at No. 8 and elsewhere in the locality. No analyses of this bauxite have been made.

MYALLA.

Introduction.

Myalla lies on the railway from Stanley to Burnie, 11 miles west of Wynyard and 3 miles south of the Bass Highway.

Bauxite of basaltic origin was first discovered in the locality in October, 1944, on Lot 12029 about 2 miles north from Myalla railway station. Other occurrences were found soon after when the Tasmanian Mines Department investigated the original discovery.

Three areas, here referred to as No. 1 or Wells, No. 2 or Bramich's and Dowling's, and No. 3 or King's, deposits, and shown in Figure 11, were tested by the Mines Department by shaft-sinking and scout drilling.

Major stratigraphical units present in the area are—

Tertiary volcanics—basalt and basaltic tuff with associated bauxite.
Tertiary fresh-water or estuarine sediments.
Pre-Cambrian quartzite and slate.

The Pre-Cambrian rocks, which form prominent hills ranging in elevation from 500 to 1,500 feet above sea-level, surround the lava field on the north, west, and south, and less prominent inliers of quartzite occur within the area occupied mainly by the volcanics.

The Tertiary fresh-water and estuarine beds consist of gravel, sand, and clay, exposed where stream channels have cut through the overlying basalt.

Within the basalt area the land surface is mainly composed of rich agricultural soil, but weathered and fresh basalt is exposed in road cuttings and in a few natural outcrops. The bauxite occurs on the flat crests of low hills which are remnants of a former more or less plane surface that sloped downwards gently to the north (towards the coast) at an inclination of 80 to 100 feet per mile. Remnants of this former surface have elevations of some 800 feet 2 miles south of Myalla and 400 feet at Nos. 2 and 3 deposits.

Three types of bauxite have been observed in the locality. First, a grey-blue material with the outward appearance of normal weathered vesicular basalt. The vesicles are filled with blebs of white gibbsite, and veins up to one inch thick of white, yellow, or brown gibbsite also occur. This variety of bauxite is well developed in No. 1 Shaft on Wells' deposit. Secondly, nodular bauxite in which nodules of gibbsite are embedded in a clayey matrix occurs in the part of Wells' deposit which was tested by Shaft 2. This material bears a fairly close resemblance to the bauxite at Wade's deposit near Inverell, New South Wales, and is not unlike the nodular bauxite at Telok Mas, Malacca, and Pulau Kopok, Johore (Owen, 1948). The third variety of bauxite seen is brown in colour and largely consists of angular and subangular nodules of fine-grained gibbsitic rock embedded in a softer lighter matrix. In this respect it somewhat resembles the "pseudo-fragmental" doleritic bauxite at Ouse, St. Leonards, and elsewhere in Tasmania. The whole rock is highly gibbsitic and contains 40-50 per cent. "free" alumina and less than 2 per cent. "free" silica.

DESCRIPTION OF DEPOSITS.

No. 1 or Wells' Deposit.

Bauxite crops out on the flat crest of a small thickly wooded hill with an elevation of about 450 feet above sea level.

Two shafts were sunk about 150 feet apart on a north-south line and later two bores were drilled at 40 feet and 140 feet east of No. 1 (the northern) shaft. The two shafts and the nearer bore disclosed good quality bauxite with an average thickness of 7 feet. The second bore revealed only 1.5 feet of bauxite.

The following logs of the two shafts are quoted (slightly abridged) from an unpublished Tasmanian Mines Department report by D. R. Dickinson dated 12th January, 1945.

Depth in Feet.		Description.	Analyses. (Soluble in Caustic Soda.)		Fe_2O_3.
From—	To—		Al_2O_3.	SiO_2.	
			Per cent.	Per cent.	Per cent.
		SHAFT No. 1.			
1	3	Brown, hard; some earthy bands particularly towards base; blebs and seams of gibbsite	51.5	0.8	..
3	5		48.3	0.8	19.6
5	7		47.9	1.0	..
7	8.5	Brown, mixed hard and soft bands showing gibbsite	46.5	1.6	..
8.5	9.5		47.3	1.7	..
9.5	14.5	Soft, brown, sandy to clayey, with white veins and black carbonaceous patches	22.6	9.9	..
14.5	20		18.3	12.1	..
		SHAFT No. 2.			
3	4.5	Mixed nodules in red soil	46.5	0.9	..
4.5	9	Red and green clayey formation with mixed nodules	30.5	3.1	..
4.5	9	Nodules free from matrix	40.2	0.7	29.0
9	11	Angular pale green nodules and larger concretions in green to yellow matrix ..	43.1	3.4	..
9	11	Nodules and concretions without matrix ..	53.4	1.7	..

From the results of shaft and bore sampling it has been computed that Wells' deposit contains a limited tonnage, probably not more than 10,000 tons of bauxite containing 46 per cent. "free" alumina and 2 per cent. "free" silica.

No. 2 (Bramich's and Dowling's) Deposit.

This area, occupying a low rounded ridge in Lots 9793 and 11381, has been prospected with 23 scout bores which have indicated the presence of bauxite with an average thickness of 8 feet over an area of about 40,000 square yards, equivalent to approximately 180,000 tons. The grade of this bauxite has a wide range from 29.9 to 46.7 per cent. "free" alumina and 8.0 to 1.4 per cent. "free" silica.

The results of scout boring may be summarized as follows:—

Bore No.	Thickness in Feet.		Soluble in Caustic Soda.	
	Overburden.	Bauxite.	Al_2O_3.	SiO_2.
			Per cent.	Per cent.
5	..	13.5	39.0	4.8
6	16.5	2.0	38.4	4.6
7 and 8	..	Nil	..	..
9	8.5	7.0	41.8	4.8
10	4	8.5	46.7	1.4
11	9	7.5	35.1	6.2
12	4	5.5	42.0	3.4
13	5	3.5	40.0	3.4
14	5	4.0	35.4	4.9
15	19	2.5	34.8	5.0
16	5	7.0	42.4	4.0
17	9	4.0	29.9	8.0
18	..	Nil	..	..
19	4	7.0	38.2	4.3
20	3.5	9.5	41.4	4.3
21	7	14.0	30.9	5.4
22	8	8.0	37.7	2.8
23-27..	..	Nil	..	..

More detailed analyses of several samples from No. 2 deposit are given:—

—	Insoluble Matter.	"Free" SiO_2.	Total Al_2O_3.	"Free" Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
(*a*)	7.4	4.6	47.4	45.0	17.4	2.6	24.5
(*b*)	30.7	11.8	29.0	14.2	21.6	3.4	14.4
(*c*)	18.6	5.8	36.9	27.0	20.1	6.3	19.0
(*d*)	14.0	8.2	16.7	12.2	51.8	3.7	13.1
(*e*)	13.0	7.9	11.4	10.5	57.8	5.4	11.2

(*a*) Bore 16.—From 13 to 14 feet.
(*b*) Bore 18.—From 7 to 9 feet.
(*c*) Bore 21.—From 7 to 9 feet.
(*d*) Bore 23.—From 3 to 5 feet.
(*e*) Bore 23.—From 5 to 7 feet.

No. 3, King's Deposit.

Bauxite boulders were found distributed on the surface and in the soil over a wide area on the crest of a flat hill at this locality, but boring showed little or no bauxite *in situ* and most bores entered partially lateritized basalt beneath soil cover. Three adjacent bores from a total of ten penetrated bauxite with an average thickness of 6 feet and an average grade 32.5 per cent. alumina and 4.8 per cent. silica soluble in caustic soda solution. The range of composition of samples from these three bores is from 29.4 per cent. "free" alumina with 6.6 per cent. soda-soluble silica, to 35.4 per cent. alumina and 3.5 per cent. soda-soluble silica, and the quantity indicated totals about 15,000 tons.

Of the three deposits tested only No. 2 has yielded results which indicate the possible presence of bauxite in commercial quantity, but it is improbable that it could be used economically unless the soda-soluble silica content can be reduced.

Geological reconnaissance of an area of 15 square miles surrounding Myalla failed to locate additional deposits of any significance but the negative result of this search in the vicinity of Myalla does not necessarily mean that other deposits may not exist farther afield. It is possible that new discoveries may be made in the large areas occupied by Tertiary volcanic rocks extending south from the coast between Wynyard and Devonport.

MINOR DEPOSITS.

East Tamar.

Hillwood.—A small outcrop of ferruginous laterite which lies between Leam and Hillwood on the east bank of the Tamar was tested by pit-sinking and found to be too small and too low in grade.

Typical analyses of sub-surface bauxitic material from Hillwood are—

—	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.	Soda Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
(1)	10.1	44.5	17.9	4.6	37.2	2.50
(2)	12.2	33.7	29.8	2.3	27.4	..

(1) Pit C.—From 8 feet to 8.5 feet.
(2) Pit A.—From 7 feet to 11 feet.

Thorp.—Doleritic bauxite of granular texture outcrops on a farm named Thorp at about 1½ miles north-west of Dilston Post Office and ½ mile east of the Georgetown road. The bauxite, which is believed to be thin, wedges out against dolerite to the north, east, and south, but may continue to the west where a small exposure is visible in highly improved land adjacent to the farmstead. The deposit is not sufficiently large to warrant interference with the farm property.

Rifle Range.—Light-coloured granular bauxite lying beneath thin remnants of ferruginous pisolitic laterite was revealed in practice trenches dug on Defence Department property 2 miles east of Invermay, Launceston. The deposit probably occupies an elliptical area measuring not more than 350 feet by 150 feet but boundaries are obscured by soil and buckshot gravel. Dolerite crops out 300 feet to the south and 150 feet to the north-west of the probable margins of the bauxite.

The granular character of the bauxite indicates that it represents a low horizon in the normal lateritic sequence and is probably thin.

Other small deposits of bauxite have been noted at numerous places in East Tamar, notably near the 11 and 13 mile pegs on the Georgetown road, near Nelson's Hill on Windermere Promontory, and 1½ miles north-west of Mount Direction. None of these deposits are of any value.

Launceston.

Three occurrences of bauxite are known within or partly within the city boundaries in West Launceston and Cataract Gorge picnic ground. These deposits are of no commercial importance, being either too small or, as at Connaught Crescent, occupying a built-up residential area, but they have considerable bearing on questions of origin of the doleritic bauxite and are therefore described in some detail. A geological sketch plan showing their positions and topographic contours at vertical intervals of 50 feet is also given (Plate 22).

In order of size the deposits are (*a*) Connaught crescent, (*b*) Gorge and (*c*) Basin road.

Connaught crescent.—This deposit is best exposed in a road cutting on the south side of Connaught crescent between Brougham and Laura street. The bauxite rests directly on dolerite which outcrops near the intersection of Laura street with the crescent. Reference to Plate 22 will show that the deposit lies on a fairly steep slope to the north-east, formerly the flank of an old valley trending to the south-east.

The bauxite has a capping several feet thick of coarsely pisolitic material containing angular and rounded blocks of bauxite which retain the texture of the parent dolerite. This zone passes downward into soft earthy bauxite and thence into doleritic bauxite.

Small marginal outcrops of the pisolitic bauxite are exposed in Nieka avenue to the east and Laura street to the west of the exposure in the road cutting.

On the assumption that the body is continuous between these exposures it is probable that the deposit contains 100,000 tons of bauxite. Small detached remnants of the Connaught-crescent deposit occur to the east and west and also at about ¼ mile north-north-east.

The Gorge and Basin-road deposits may be considered together. Both occur on the walls of steep-sided valleys, lateral to the South Esk River, well below the summit of the dolerite, and both conform to the valley slopes and dip towards the South Esk River. Neither of the bodies is considered to be recemented detritus derived from a higher level, and it is believed that they were formed *in situ*. The Gorge deposit, which lies about 200 yards north-west from the Tea Rooms in the picnic ground, has a capping of nodular and pisolitic material passing to doleritic bauxite. It overlies dolerite which outcrops above and below the deposit, and the passage from doleritic bauxite to kaolinized dolerite is exposed in an excavation just outside the park gates. Some of the upper capping which is showing inside the park consists of a dense brown matrix with small ferruginous pisolites.

The smaller Basin-road deposit on the opposite bank of the South Esk River consists of pilolitic bauxite in the upper portion passing through earthy bauxite and bauxitic clay to weathered dolerite.

West Tamar.

Under this heading several bauxite occurrences distributed over a fairly wide area from Beaconsfield to near Launceston and as far west as Westbury are discussed in the following order:—

(*a*) Beaconsfield.

(*b*) Cormiston East.

(*c*) Cormiston West.

(*d*) Rosevale.

(*e*) Westbury.

Beaconsfield.—A fairly massive outcrop of pisolitic laterite occurs on a gentle slope 1 mile west-north-west from Beaconsfield, surrounded by grey sandy soil, clay, and buck-shot gravel. Shallow road quarries about 300 feet south of the outcrop and 10 to 20 feet above it have disclosed brown sandy clay with pebbles and boulders of laterite to a depth of 4 feet.

At the outcrop the laterite has a thin capping of loosely coherent pisolites over dense ferruginous material with a few included quartz grains. It is apparent that this deposit consists of recemented detritus.

Cormiston East.—A small highly ferruginous body of laterite occurs on the southern slope of a low rounded hill 4½ miles north-west of Launceston and ¾ mile west of the West Tamar Highway. Fresh dolerite crops out immediately to the north of the laterite and at a higher elevation. Some years ago a misguided prospector had driven an adit in a northerly direction into the laterite; as the direction of the adit was up the dip of the laterite it passed into the underlying kaolinized dolerite at 25 feet from the portal and was abandoned at 35 feet. The maximum true thickness of laterite exposed by the adit is 10 feet. Six samples cut from 4 vertical channels in the walls of the adit and its approach were analysed at the Mines Department laboratory with the following results.—

Sample No.	Thickness.	Insoluble Matter.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
	Feet.		Per cent.	Per cent.	Per cent.	Per cent.
1	4.25	19.1	30.6	31.5	2.0	15.9
3	3	13.7	31.2	34.1	2.2	17.6
4	3.5	18.6	29.8	32.5	2.1	15.7
5	3	15.6	37.4	26.4	2.0	18.1
6	3	16.6	34.0	28.9	2.1	17.5
7	4	15.4	35.0	29.1	2.3	17.7
582	..	6.6	23.2	48.4	3.0	14.6

Sample 582 was chipped from the outcrop and was analysed at the laboratory of the A.A.P.C.

The deposit is small—rough estimate of the quantity indicates a total of about 10,000 tons.

Cormiston West.—Doleritic bauxite was observed in the roadway and table drains of the Ecclestone road at a point 2½ miles west of the West Tamar Highway and 6 miles from Launceston. Search of the vicinity revealed discontinuous outcrops, mainly on the northern side of the road, distributed over an area measuring ¼ mile wide by 1 mile long from east to west. Some of the outcrops are marginal to areas of sands and clay which overlie the dolerite, and it was considered possible that the bauxite might continue under the younger sediments. However, testing with shallow pits proved disappointing as it was found that the bauxite had been extensively eroded before the deposition of the clayey sediments and did not extend beyond the visible outcrops.

In brief the results of test-pitting showed that no appreciable thickness of bauxite remained west of pits 14 and 15 which are only 500 feet from the eastern extremity of the outcrops.

Logs of these pits are—

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3	TiO_2.	Available Al_2O_3.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		PIT No. 14.					
0	1	Soil	..	..	..	..	..
1	2.5	Brown clay	..	..	..	..	..
2.5	4.5	Brown and white clay with pebbles of bauxite	..	.. Not sampled	..	..	..
4.5	5.5	Brown and white clay with pebbles of bauxite with bauxite predominant	..	..	..	..	..
5.5	8	Dolerite bauxite with clay.. ..	10.8	36.8	27.9	2.5	31.3
8	11	Red and white clay with low plasticity	..	Ignition loss 13.1 per cent.			..

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		PIT NO. 15.					
0	1	Sandy soil	..	..	..	..	..
1	4.25	Red-brown sandy clay and seams of brown clay	..	..	..	..	..
4.25	6	Brown granular clay	..	..	..	..	..
6	8	Pale brown clayey pisolites in matrix of hard white clay	25.9	42.4	7.9	3.0	20.9
8	10	Pale brown clayey pisolites in matrix of hard white clay passing into clayey bauxite with small ferruginous pisolites	9.2	35.7	30.2	2.6	29.5
10	12.5	Red non-plastic clay	26.9	29.8	27.4	1.5	..
12.5	17.5	White and pinkish-red non-plastic clay	..	Ignition loss 12.9 per cent.			..
17.5	18.5	White and pinkish-red non-plastic clay	..	..	..	..	..

Rosevale.—Five outcrops of bauxite occur in the vicinity of the small village of Rosevale which lies 11 miles west of Launceston and 11 miles by road north of Hagley, the nearest railway station.

Three (Nos. 3, 4 and 5) of the five bauxite occurrences form a group 8 miles by road from Hagley and 3 miles south-west from Rosevale on the road to Selbourne. No. 1 deposit lies 1 mile from the village in the north-west corner of the town reserve, and No. 2 100 yards east of the main road in the village.

Brief descriptions of the individual deposits follow:—

No. 1 Area.—No solid bauxite *in situ* is visible but large boulders and smaller fragments occur over a roughly circular area with a diameter of 900 feet. Dolerite bounds the area on the northern and eastern margins but no defined boundary was observed elsewhere. Most of the bauxite is finely granular with the texture of the parent dolerite partially preserved. It is evident that only residual boulders of a former solid body now remain embedded in clay and resting in dolerite.

No. 2 Area.—This area comprises a very small showing of doleritic-textured bauxite surrounded by dolerite. The deposit has no economic importance.

No. 3 Area.—Bauxite occurs partly in solid outcrop and partly as scattered fragments in brown bauxitic soil in a narrow strip about 2,000 feet long with a maximum width of 150 feet, occupying a shallow depression.

The deposit is completely surrounded by dolerite but there was a possibility that bauxite was concealed under alluvium near the centre of the deposit. This possibility was explored by a pit which passed through 3 feet of brown sedimentary clay into grey clay which is probably weathered dolerite. A second pit chosen at an apparently more favorable place revealed an irregular bauxitization of dolerite for about 3 feet and then entered red and white clay with relict texture of dolerite.

No further work was conducted on the deposit which is considered to be worthless.

No. 4 *Area.*—At this deposit, which lies 800 feet west of and sub-parallel to No. 3, the area occupied by bauxite and detritus is elliptical in plan, about 1,400 feet long by a maximum width of 500 feet. Like No. 3 this deposit occurs in gently undulating country, and occupies a shallow depression in the dolerite surface.

Nine pits spaced 200 feet apart on a rectangular grid were sunk on No. 4 deposit with unfavorable results. Six of the nine shafts entered kaolinized dolerite at depths ranging from 3 to 5 feet after passing through soil and bauxite boulders or bauxite seamed with clay. Logs of the remaining three shafts with partial analyses of channel samples are given.

ROSEVALE No. 4 AREA.—SHAFT LOGS.

Depth in Feet. From—	Depth in Feet. To—	Description.	SiO_2.	Al_2O_3	Fe_2O_3.	TiO_2.	Available Al_2O_3.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		SHAFT No. 3.					
0	1.3	Soil	..	..	..	..	..
1.3	2.5	Brown and grey clay	..	..	..	..	..
2.5	3	Hard nodular bauxite with fine texture	4.1	38.3	29.2	3.6	36.1
3	5.5	Nodular bauxite; large granular nodules in hard dense matrix ..	4.3	38.9	28.8	2.6	36.4
5.5	8	Soft bauxite, both clay-like and granular clay seam					
		SHAFT No. 6 (WEST FACE).					
0	2	Boulders of bauxite in soil and clay	Not sampled				
2	8	Granular bauxite with seams of clay	10.8	38.7	25.0	1.7	30.3
8	9	Brown and grey clay and partly bauxitized dolerite	Not sampled				
		SHAFT No. 6 (EAST FACE).					
0	2	Boulders of bauxite in soil and clay	Not sampled				
2	5	Brown and grey clay with bands of granular bauxite					
5	8	Granular bauxite with brown and grey clay	10.7	38.4	25.7	1.7	29.7
		SHAFT No. 7.					
0	1.5	Soil	Not sampled				
1.5	2.3	Yellow-brown pisolitic bauxite and grey clay					
2.3	3.2	Pale brown soft earthy bauxite and grey clay					
3.2	3.7	Dense granular red bauxite ..	9.0	41.5	22.3	2.8	35.0
3.7	4.7	Dull brown friable pisolitic bauxite					
4.7	8	Red-brown earthy bauxite with grey clay					
8	?	Pinkish brown clay	Not sampled				

Only the samples from Shaft 3 come within the definition of economic bauxite, and therefore the deposit is valueless as a potential source of aluminium.

No. 5 Area.—Bauxite is exposed in a road drain about 500 yards west of the northern end of No. 3 Area and residual boulders of bauxite formerly in the soil have been gathered and stacked during cultivation. The resulting heaps of boulders are the only evidence of bauxite, and it is considered that the boulders are the final remnants of a deposit and little else remains now.

Westbury.

Unusually light coloured bauxite outcrops on the Frankford road about 1½ miles north of Westbury, and extends for a short distance into grazing land on either side of the road. To the west the deposit wedges out against dolerite from which it is probably derived. The deposit is too small to warrant sub-surface testing. One sample cut from a freshly exposed face of the outcrop was analysed with the following result:—

	Per cent.
Insoluble matter	13.3
Total alumina	40.7
Ferric oxide	19.6
Titanium dioxide	2.3
Ignition loss	24.8

White Hills.

Stiff red clay showing a faint relict texture and containing small residuals of grey deeply-weathered basalt is exposed in a shallow road-cutting 3 miles east of White Hills on the Upper Blessington road. The cutting has been made in the northern flank of a small hill with a flattened crest measuring about 200 feet in diameter, and lying at about 800 feet above sea level.

One specimen of pink altered basalt was submitted to partial analysis in the Mines Department laboratory at Launceston in 1946 and yielded 52 per cent. "free" alumina; a more comprehensive collection of specimens from residual boulders of bauxite lying on the flanks and crest of the hill was found to contain 43.2 per cent. available Al_2O_3 extractable with a loss of soda equivalent to 1.01 cwt Na_2O per ton of alumina extracted.

Only a negligible quantity of bauxite of this composition is available in this deposit and its sole claim to importance lies in its high grade and basaltic origin.

A search of the locality failed to find any further bodies of this bauxite, or exposures of the parent basalt at a comparable elevation.

Fordon.

Three outcrops of ferruginous laterite occur on the York Park area of Fordon Estate, 7½ miles by road south-east from Nile village and 13 miles north of Campbell Town. The Tasmanian Mines Department sank eight shallow shafts on the largest of the three bodies and no additional sub-surface work has been conducted.

Dickinson states (1943) that the largest body " covers 40 acres and takes the form of a flat-topped ridge with a north-west to south-east trend . . . The dip coincides with the direction of the ridge, being flat at the north-westerly end and steepening as the formation weakens to the south-east . . . Ten samples averaged 31.1 per cent. Al_2O_3 and 1.7 per cent. SiO_2 ' free ' to caustic soda ".

The smallest of the deposits forms a small conical hill, known as Viney's Sugarloaf, and overlies basalt from which it is derived. No basalt is disclosed beneath the other two bodies, which overlie dolerite, but it is apparent that their origin is the same as Viney's Sugarloaf and that the immediately underlying basalt is obscured by detritus.

A sample chipped from the surface of one of the deposits was analysed at the laboratory of the Aluminium Commission with the following result:—

	Per cent.
SiO_2	2.9
Al_2O_3	28.0
Fe_2O_3	50.0
FeO	1.1
TiO_2	4.7
Ignition loss	12.1
P_2O_5	0.1
V_2O_5	0.08
Cr_2O_3	0.04
	99.02

The preliminary testing by the State Mines Department, when considered in the light of experience gained on the similar deposits at Campbell Town, was considered to be sufficient to establish that the laterite at Fordon is too low in grade to be used as a source of aluminium under present conditions.

Lake River and Epping.

Lake River.—A small deposit of doleritic bauxite occurs about 200 yards south of the road from Cressy to Campbell Town 11½ miles south-east from Cressy. The outcrop trends north-westerly and is about 400 feet in length by a maximum width of about 40 feet. To the south-west the bauxite is flanked by fresh dolerite, and on the opposite side by grey sandy clay.

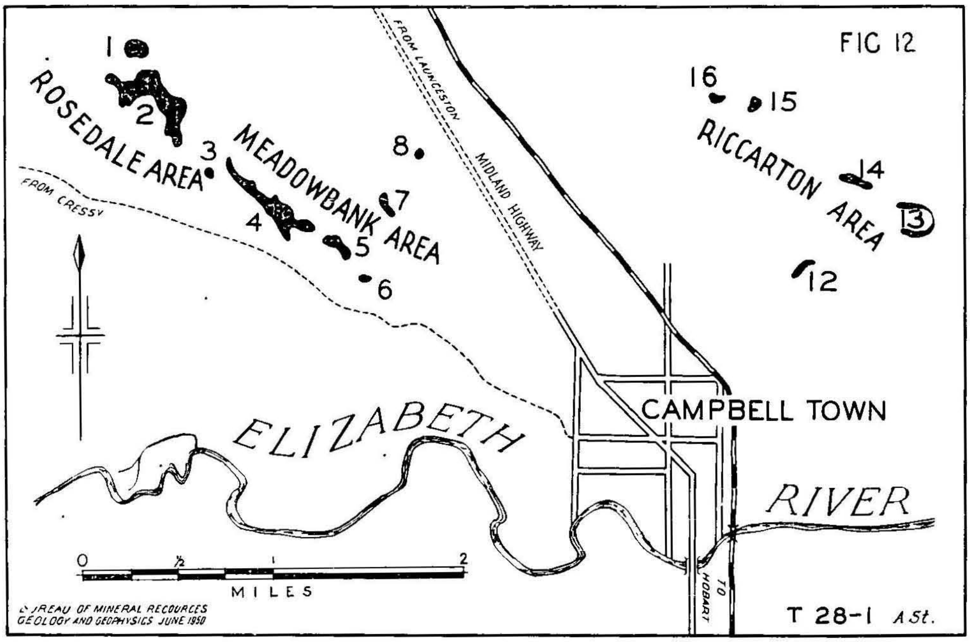
Extension beyond the visible outcrop is considered unlikely.

Epping.—A body of ferruginous laterite shows in a shallow road-cutting 600 yards west of Epping railway station where the road descends a small creek bank. Search of the locality failed to reveal further exposures.

CAMPBELL TOWN.

Introduction.—The numerous deposits in the vicinity of Campbell Town are here referred to by the numbers allocated to them by Dickinson (1943). Their relative positions and proximity to Campbell Town are shown on the accompanying plan, Fig. 12.

Testing by the Mines Department generally gave unfavorable results, but it was considered that in view of the apparently large area covered by laterite some additional testing to provide conclusive results was warranted. Accordingly the Aluminium Commission sank a few shafts and put down a few bores on the larger areas to supplement the work which had been carried out previously by the State authorities. This more extensive work fully proved that the deposits had no economic value.



Notwithstanding the unfavorable conclusion the occurrences are not without interest and brief descriptions of several of the areas are given.

At Riccarton Estate on the north-eastern side of Campbell Town, the deposits retain a highly ferruginous pisolitic zone in which the ferric oxide exceeds alumina and may be as high as 43 per cent. In very restricted areas, as for example on Area 15, the ferruginous cap is underlain by 2 or 3 feet of moderately good bauxite.

On Rosedale and Meadowbank Estates about 2½ miles to the north-west of Campbell Town the bauxite mainly consists of sparse gibbsitic nodules embedded in red and green clay. The upper ferruginous zone is represented by scattered ferruginous pisolites occurring in the overburden.

Throughout the area the bauxite, or at least such small remnants of it as now exist, passes into kaolinized volcanics, largely basalt but containing bands of fine earthy material which is probably ash. Some bores which were sunk to depths well below the lateritized zone encountered variegated clays beneath recognizable weathered basalt which suggest intercalated ash beds. One bore sunk on the Rosedale outcrop penetrated low-grade bauxite to 15 feet, recognizable kaolinized basalt or basaltic tuff to 27 feet, and thence brown and red clays to 65 feet followed by dominantly yellow clays to 85 feet, at which depth a thin ferruginous band immediately overlying dolerite was reported.

Summaries of the results of the testing of Deposits 1 and 2 on Rosedale, 4 on Meadowbank, and 13 and 14 on Riccarton are given, with a brief reference to No. 8 deposit.

Rosedale Estate.—There are three separate areas of which No. 3, which is a small residual of insufficient thickness or area to be of any commercial value, was not tested by either the State Mines Department or the Aluminium Commission.

The Mines Department shafts were for the most part sunk from higher points on the gently undulating surface of the deposits, and consequently intersected a greater thickness of laterite than the holes later sunk at intermediate points. Results of both campaigns are given in tabulated form.

NO. 1 DEPOSIT, ROSEDALE ESTATE.

Shaft No.	Tasmanian Mines Department.			Aluminium Commission.			
	Thickness.	"Free" Al_2O_3.	"Free" SiO_2.	Thickness. Sampled.	Thickness. Econ. Grade.	Available Al_2O_3.	Soda Loss.
	Feet.	Per cent.	Per cent.	Feet.	Feet.	Per cent.	Cwt.
1	6.3	23.3	7.9	5	Nil	..	..
2	7.3	30.3	5.1	12	4	34.1	1.03
3	5.0	36.6	6.6	..	..	Not re-sampled	
4	4.0	44.7	3.7	..	..	Not re-sampled	
5	7.0	33.3	2.4(1)	..	..	Not re-sampled	
6	6.2	28.8	5.5	6	1	36.5	1.44
7	4.5	44.7	3.8	10.5	3.5	43.0	0.65

(1) Shaft 5. Some clay was rejected from the Mines Department sample before assay.

SHAFTS OR BORES SUNK BY ALUMINIUM COMMISSION.

Shaft or Bore	Thickness Sampled.	Thickness of Economic Bauxite.	Available Al_2O_3.	Soda Loss.
	Feet.	Feet.	Per cent.	cwt.
R1	5.5	Nil	..	..
R2	Nil	..	..	..
R3 (B)	13	3	31.6	1.03
R4	Nil	..	..	..
R5 (B)	22	Nil	..	..
R6	10.5	Nil	..	..
R7	4	Nil	..	..
R8	4	Nil	..	..
R9 (B)	24	Nil	..	..
R10 (B)	19	Nil	..	..
R11(1)	6	2	34.0	1.21

(1) Shaft R11 was sunk on No. 1 deposit, all the others on No. 2 deposit.
(B) Signifies percussion bore.

Meadowbank Estate.—This property adjoins Rosedale on the east and the small No. 3 deposit lies across the boundary between the two properties. There are five other areas of outcrop, but only one of them, No. 4, is large.

The Mines Department sank ten shafts at intervals ranging from 500 feet to 200 feet apart on No. 4 area, and a group of twenty shafts at intervals of 25 feet near the southern end of the same area.

Of the ten shafts only three were deemed by the Mines Department to be worth sampling. One of these three and two others were re-opened and sampled by the Aluminium Commission, and eight additional shafts were sunk. The results of this work are summarized below:—

No. 4 DEPOSIT, MEADOWBANK ESTATE.

Shaft No.	Tasmanian Mines Department.			Aluminium Commission.			
	Thickness.	"Free" Al_2O_3.	"Free" SiO_2.	Thickness.		Available Al_2O_3.	Soda Loss.
				Sampled.	Economic Grade.		
	Feet.	Per cent.	Per cent.	Feet.	Feet.	Per cent.	Cwt.
8	5	36.2	6.2	10.5	6	32.9	1.29
11		Not sampled		8	..	Nodules in red clay	
12		Not sampled		3.0	..	23.6	..
16	2.5	33.3	2.1	..	..	Not re-opened	
17	4.2	37.1	6.0	..	..	Not re-opened	

SHAFTS SUNK BY ALUMINIUM COMMISSION.

Shaft No.	Thickness in Feet.		Available Al_2O_3	Soda Loss.
	Sampled.	Economic Bauxite.		
			Per cent.	Cwt.
M1	3	Nil	..	..
M2	4.5	4.5	33.5	0.75
M3	Nil	..	..	..
M4	Nil	..	..	..
M5	3.5	1.2	33.7	1.31
M6	4	Nil	..	..
M7	Nil	..	..	..
M8	5	5	40.8	0.97

Specimens of spoil from the two old shafts (22 and 23) on Area S, a small flat-topped hill near the eastern boundary of Meadowbank Estate, gave a very high result on assay, viz.:—1.0 per cent. SiO_2, 53.8 per cent Al_2O_3, 12.8 per cent. Fe_2O_3, 2.3 per cent. TiO_2, 30.5 per cent. ignition loss, and 53.2 per cent. available Al_2O_3. This is at variance with the logs given in the Tasmanian report which both showed the shafts to have penetrated "earthy formation, no bauxite in section".

Riccarton Estate.—The deposits on Riccarton lie a mile to the north-east of the town and are much smaller than No. 2 on Rosedale and No. 4 on Meadowbank. The two apparently larger bodies on Riccarton, No. 13 and 14, which were tested by the Aluminium Commission, consist of small, narrow, highly ferruginous bodies outcropping along a low ridge with a general trend slightly north of west. Drilling and shaft sinking at sites in close proximity to the outcrops showed that the bodies did not extend appreciably beyond the visible limits.

Four shafts sunk on No. 13 Area entered variegated basaltic clay at depths ranging from 3 feet to 6 feet 6 inches, without encountering solid bauxite.

On area 14 where the ridge exceeds ½ mile in length ten bores were sunk, all with negative results.

A small but massive outcrop forms a prominent low bluff ½ mile north-east from No. 14. This deposit, known as No. 15, has been quarried for road gravel and presents a fairly good section for sampling. Three channel samples representing a vertical thickness of 10 feet from the surface were taken and analysed with the following results:—

—	1.	2.	3.
SiO_2	1.9 per cent.	3.8 per cent.	11.6 per cent.
Al_2O_3	28.4 per cent.	41.0 per cent.	41.6 per cent.
Fe_2O_3	43.0 per cent.	21.7 per cent.	13.4 per cent.
TiO_2	4.5 per cent.	8.7 per cent.	8 3 per cent.
Ignition loss	16.9 per cent.	25.4 per cent.	24 1 per cent.
Available Al_2O_3	..	39.6 per cent.	33 5 per cent.
Soda loss	..	0.45 cwt.	2 95 cwt.

1. Surface to 4 feet. Dense pisolitic ferruginous capping.
2. 4 feet to 7 feet. Earthy bauxite
3. 7 feet to 10 feet. Light-coloured clayey bauxite with few ferruginous pisolites.

East of Conara Junction.—Small and thin deposits of bauxite occur 4 miles east of Conara Junction at the road bridge crossing the St. Mary's railway and at 1 mile north from the road-railway crossing. At the former locality the bauxite is similar to the Riccarton laterite and overlies volcanics weathered to reddish-purple clay. North of the road the bauxite is yellowish-brown and grey in colour and bears a superficial resemblance to earthy doleritic bauxite such as that occurring at Ouse. The silica content is high.

None of the deposits in this locality are of sufficient size to be of any commercial importance.

Swansea.

Small deposits of bauxite occur north of Swansea on the east coast of Tasmania. The largest of these lies adjacent to the Tasman Highway, 7 miles north of Swansea, where shallow quarries have been opened for the supply of road-surfacing material.

This deposit was selected for sub-surface testing with shafts on account of its relatively larger size, and because exposures in an old shaft indicated a reasonable thickness of bauxite containing up to 41.4 per cent. Al_2O_3.

Prospecting subsequently revealed that the body was smaller than at first believed and that much of the apparent outcrop consists of detritus.

The bauxite mainly consists of the granular type in which the texture of the parent dolerite is partially preserved. It rests upon kaolinized dolerite into which it passes with increase in silica content and decline in alumina as shown by the following figures:—

—	Feet.		SiO_2.	Al_2O_3.
	From—	To—		
			Per cent.	Per cent.
Shaft 200S/00	1.5	4.5	9.3	41.4
	4.5	9	7.3	31.2
	9	13.5	12.1	29.9
Quarry 500S/60E approximately 20 feet below shaft collar ..	..	..	24	23.2

The quantity of bauxite of economic grade revealed by shaft sampling is almost negligible. Shaft No. 1 at 100N/100E penetrated 4.5 feet of bauxite containing 5 per cent. SiO_2, 41.4 per cent. Al_2O_3, 25.8 per cent. Fe_2O_3, 3 per cent. TiO_2.

Thicknesses penetrated and compositions are given:—

Shaft No.	Thickness.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3	Soda Loss.
	Feet.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
1	4.5	5.0	41.4	25.8	3.0	38.0	1.07
4	2	4.6	33.8	34.9	5.2	31.2	1.00
200S/00 ..	3	9.3	41.4	19.9	4.2	..	..

The above figures represent a total tonnage of about 9,000 beneath 6,000 tons of overburden.

Description of Tasmanian Bauxites.

The bauxite—and in this section the term is used in its widest sense to include all lateritic and bauxitic material—may be considered as belonging to one of two types according to its derivation from Jurassic dolerite or Tertiary basalt.

Subdivision based on the mode of development of the laterite is also possible; some deposits which form a group are plainly remnants of a former continuous and widespread sheet, while other lenticular or pod-like bodies were formed in depressions with restricted horizontal extent. The doleritic bauxite at Ouse and the basaltic bauxite at Campbell Town, Fordon, and Myalla are examples of the former type, whereas the small bodies of doleritic bauxite at Cataract Gorge, Basin road, and Cormiston have been formed on dolerite in narrow valleys at levels considerably below the crests of the interfluves. The example of "secondary" or recemented bauxite near Beaconsfield is the only one known to the writer, but it is probable that a small outcrop of bauxite reported in the Kenmere valley about ½ mile west of, and some 400 feet below, No. 2 deposit at Ouse is also "secondary" in origin.

The Bauxite Derived from Dolerite.

Three rather ill-defined and irregular zones may be recognized: (*a*) an upper zone consisting of hard coarse pisolitic and nodular bauxite variegated light brown to brownish-red in colour; (*b*) a zone of earthy textureless light brown, or less commonly pinkish, bauxite; and (*c*) a lower zone of light brown to yellowish bauxite which retains the granular texture of the parent dolerite.

Commonly the granular bauxite horizon is missing at Ouse and the earthy zone becomes progressively more clay-like with depth until it passes into kaolinized dolerite. At St. Leonards the granular bauxite commonly passes directly to fresh dolerite, but this sudden transition was not seen at Ouse.

The upper horizon of hard coarsely nodular to pisolitic bauxite usually contains rather more iron and less alumina than the earthy variety. Bauxite from this zone presents a fragmental appearance which falsely suggests that it may have been derived from a pyroclastic rock. Many of the nodules of which it is composed present sub-angular outlines and show apparent differences in the relict doleritic texture of the cores due in part to greater or lesser porosity and diversified staining with iron oxide. The nodules generally are cemented together by dense dark-brown limonitic material, but may occur in a relatively soft matrix of light-brown earthy bauxite.

Granular bauxite, which constitutes the lowest horizon, usually shows a considerable increase in silica content, and generally is somewhat similar in appearance to the cores of the pisolitic or nodular bauxite just described. Petrological descriptions of the three main types mentioned above will be found in Appendix II, which also contains excellent photographic illustrations.

Chemical composition of the bauxite is shown in the following typical analyses of samples from Ouse and St. Leonards:—

No.	Locality.	Dominant Type.	Insoluble or SiO_2	Al_2O_3	Fe_2O_3	Ignition Loss.	Available Al_2O_3.(1)
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Ouse No. 2, Shaft 16	Pisolitic	6.6	31.4	38.3	20.0	24.3
2		Earthy	8.1	49.3	12.4	27.8	41.5
3		Earthy	9.4	43.3	20.2	23.8	34.2
4		Earthy	12.1	43.8	17.7	23.8	30.8
5	Ouse No. 2, Shaft 65	Pisolitic	4.3	26.9	46.1	18.6	24.4
6		Earthy	2.9	44.9	24.1	25.8	42.1
7		Earthy	3.1	42.8	26.0	25.3	40.2
8		Earthy	4.8	41.7	25.7	24.9	36.7
9	Ouse No. 12, Shaft 101	Pisolitic	6.0	21.0	53.3	17.6	..
10		Earthy	6.4	38.0	29.0	24.5	31
11		Granular	8.1	32.5	34.6	22.5	23.8
12	St. Leonards No. 1, Shaft MD2(2)	Pisolitic	5.7	31.7	37.4	20.0	29.2
13		Earthy	4.5	35.6	37.0	20.9	31.4
14		Earthy	3.9	42.2	26.2	25.2	36.6
15		Granular	4.5	42.5	24.3	25.5	39.4
16		Granular	15.8	35.1	24.2	21.1	25.0
17	St. Leonards No. 3, Shaft 23(2)	Pisolitic	8.8	38.4	27.1	23.4	31.6
18		Earthy	5.0	33.8	38.1	22.2	29.3
19		Nodular	8.3	42.5	22.1	24.5	35.5
20		Granular	15.3	38.4	22.4	21.4	25.3
21		Granular	16.7	34.3	26.8	20.2	21.1

(1) All determinations of available Al_2O_3 by Aluminium Commission.
(2) Analyses by Aluminium Commission

Each group of the analyses above represents continuous sampling of a shaft and each shows similar changes in the composition of the bauxite with increasing depth in the profile. With the exception of sample 18, which contained a richly limonitic band, the decrease of iron beneath the pisolitic zone is well demonstrated. A similar decline in silica content is also evident.

The Basaltic Bauxite.

There is a marked difference between the basaltic bauxite at, on the one hand, Campbell Town and Fordon, and on the other hand Myalla and White Hills.

The eastern deposits at Riccarton (Campbell Town) and those at Fordon are characterized by a dense hard ferruginous cap containing as much as 50 per cent. Fe_2O_3, a small percentage of FeO, and a total silica figure ranging from 2 to 3 per cent. This ferruginous capping, which has a maximum thickness of about 5 feet, is composed of very dark-brown pisolites set in a lighter-brown matrix. The pisolites when fractured have a sub-metallic lustre and are strongly magnetic. Edwards (Appendix II) has shown that the matrix consists of fine oolites with gibbsite encrusting the interspaces. In this respect the material is similar to the pisolitic ore from Ellsmore, Moss Vale, New South Wales, described by the writer, but it is harder and more ferruginous than the Ellsmore example.

Towards its base the pisolitic ore becomes less ferruginous and contains scattered nodules of finely granular bauxite surrounded by a shell of brown limonitic material. The ferruginous zone passes to earthy bauxite of lower iron and higher aluminium content. This zone is usually thin, rarely more than 3 feet thick, and is buff, light brown, or greyish in colour. It rests on denser and light coloured clayey bauxite which by increase in clay content passes to kaolinized volcanic bed-rock. Analyses representative of this sequence at Area No. 15, Riccarton, are given in an earlier section of this work (*see* page 139).

The bauxite deposits lying to the north-west of Campbell Town on Rosedale and Meadowbank Estates are of somewhat different character. The dense ferruginous capping is absent, but the deposits are capped by a less strongly marked ferruginous zone containing nodules of granular bauxite. At shallow depth the capping gives way to nodular material, consisting largely of rounded nodules of gibbsitic material embedded in a clay-like matrix. The fine material is commonly red in colour but contains greenish and yellow patches, while the hard nodules of bauxite are commonly red or white. Selected white nodules may contain over 50 per cent. Al_2O_3, but the red nodules are ferruginous and usually contain about equal proportions of Fe_2O_3 and Al_2O_3. No separate analyses of nodules and matrix have been made but it is apparent from the high proportion of fine material and relatively low silica in some samples that the clay-like material approaches the composition of low-grade bauxite.

Differences in the nature of the bauxite may be explained as a reflection of differences in parent rock. Exposure on the flanks of Areas 1 and 3 on Rosedale Estate show the bauxite to be lying on basaltic tuff and beds of fine ash, but at Riccarton the very ferruginous laterite and its associated bauxite horizon appear to overlie massive basalt.

South Australia.

Ferruginous laterite occurs rather sparsely in South Australia but no bauxite has been reported yet. The lack of aluminous varieties of laterite in this state is probably accounted for by the absence of the early Tertiary volcanics which are the preferred parent rocks for bauxite in eastern and south-eastern Australia.

Western Australia.

Introduction.

The writer has only little first-hand knowledge of the laterite of Western Australia and has drawn on published references to aluminous laterite and on information made available by the Geological Survey of Western Australia.

Laterite is of very widespread occurrence and has been recorded at numerous localities from the Kimberley Division in the north to the vicinity of Albany on the south coast.

The laterite has been searched for commercial bauxite in only a few localities on the Darling Range between Perth and Northam, and some sporadic sampling of laterites has been carried out within an area of the Darling Range extending from near Moora in the north to Nornalup in the south, a distance of 300 miles.

Results of sampling showed that zones enriched in alumina do occur and that the proportions of alumina, ferric oxide, and silica have a wide range. In many samples a great part of the silica was present as grains of quartz, which would not appreciably increase the consumption of alkali used for extraction of alumina. Of a total of 154 samples and specimens of laterite from localities in the South-West Division submitted to analysis or partial analysis by the Geological Survey of Western Australia, 57 contained more than 35 per cent. of sola-soluble alumina or, where soda-soluble alumina was not reported, more than 40 per cent. of total alumina.

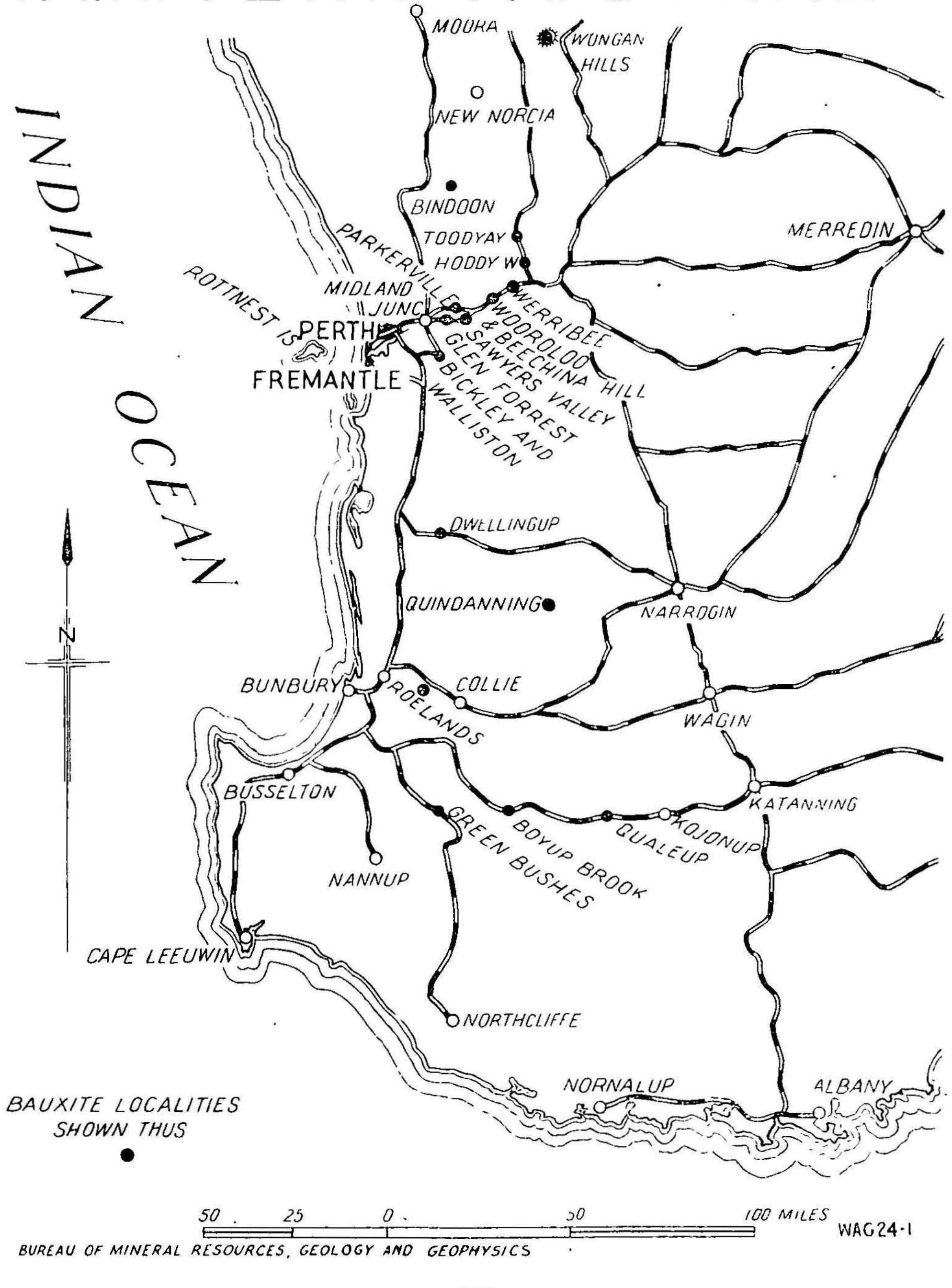
The bedrocks from which the laterite developed consist chiefly of the Archaean granitic complex with associated basic and intermediate intrusives. Small areas of Tertiary, Mesozoic, and Palaeozoic rocks may form parts of the sub-laterite surface.

The Bauxite Localities.

The following notes set out brief details of the principal bauxite localities which are shown in Fig. 13, together with analyses of samples and specimens.

Fig. 13

BAUXITE LOCALITIES SOUTH WEST DIVISION WESTERN AUSTRALIA



Wongan Hills.

This locality is on the Northam to Geraldton railway and is 90 miles north-east from Perth. No estimate of possible bauxite reserves has been made, and only one analysis is available (Simpson, 1902).

	Per cent.
Silica	5.96
Alumina	44.66
Ferric oxide	19.08
Titania	3.10
Combined water	26.44
Moisture	0.58
	99.82

Simpson reported that aluminium silicate was almost entirely absent, and this remark is substantiated by the high percentage of combined water, which indicate that virtually all the alumina is present as hydroxide.

Toodyay.

This town is served by the branch railway from Clackline to Miling, and is 45 miles north-east of Perth. It is believed that reserves of bauxite are very small, but several analyses have been made. Following are three analyses of the highest grade material sampled and of one bulk sample. Similar bauxite, of which one sample assayed 39 per cent. soda-soluble alumina, has been noted at Hoddy Well, 6 miles south of Toodyay.

TOODYAY LOCALITY.

No.	1.	2.	3.	4.
	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2, quartz	12.24	9.10	10.39	10.82
SiO_2, combined	1.70	2.72	2.70	4.94(*b*)
Al_2O_3, acid-soluble	47.86	..	46.01	..
Al_2O_3, soda-soluble	..	..	43.48	39.92
Al_2O_3, total	..	51.01	..	49.04
Fe_2O_3, acid-soluble	13.82	6.40(*a*)	10.14	14.64(*a*)
TiO_2, total	2.86(*c*)	2.23	2.88	..
H_2O, combined	19.00	26.25	..	24.22
Insoluble, other than SiO_2	1.70	1.05	0.36	..

(*a*) Total Fe_2O_3. (*b*) Soda-soluble silica. (*c*) Acid-soluble TiO_2.

1. and 2.—From about 1 mile south of Toodyay on crest of ridge.
3. Bulk sample, south of butts, Toodyay rifle range.
4. Hoddy Well.

Beechina Hill.

Beechina Hill is about 4 miles north of Beechina railway station on the main eastern railway, and lies between the railway and the Great Eastern Highway 40 miles from Perth.

It is reported (Matheson, 1942) that bauxite of the composition indicated in the following analyses exists over an area of several hundred acres in the vicinity of Beechina Hill. The samples were taken from light-coloured pisolitic material on the eastern side of the hill and represent a thickness of about two feet. The fourth analysis given below is that of a sample from Werribee, 4 miles north-east from Beechina Hill.

—	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	9.91	14.87	14.72	16.54(*a*)
Al_2O_3, acid-soluble	..	..	48.48	49.93
Al_2O_3, soda-soluble	36.59	40.73	45.51	44.86
Al_2O_3, total	43.26	44.36	..	49.95
Fe_2O_3	20.46	13.30	9.40	5.85
TiO_2	2.67	1.57	0.89	0.49

(*a*) Consists of 15.10 per cent. quartz, 1.44 per cent. combined silica.

Between Midland Junction and Beechina.

Other bauxite localities in the Darling Range to the east of Perth and within 30 miles of the Capital are Sawyers Valley, Glen Forrest or Smith's Mill, Parkerville, and, on the Kalamunda branch railway, Bickley, Guppy's Siding or Walliston, Kalamunda, and Gooseberry Hill. No estimates of the resources in these localities can be made from the present information, but it is reported by R. S. Matheson that many hundreds of thousands of tons of aluminous laterite containing not less than 35 per cent. alumina could be produced in the Darling Range close to Perth.

Many analyses of laterite from these places have been made, and they show the wide range of composition commonly found in laterite profiles.

Analyses of samples from representative localities in the Darling Range within a 30-mile radius of Perth are given below:

No.	1.	2.	3.	4.	5.
Locality	Sawyer's Valley.		Smith's Mill.	Guppy's Siding (Walliston).	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2, quartz	..	16.65	..	..	..
SiO_2, combined	0.47	2.46	11.05	0.51	..
SiO_2, total	16.89(*a*)	..	16.05	3.96(*a*)	17.22
Al_2O_3, acid-soluble ..	..	45.78	..	..	35.44
Al_2O_3, soda-soluble ..	42.01	44.47	..	33.09	..
Al_2O_3, total	47.91(*b*)	..	50.68	43.52(*b*)	..
Fe_2O_3, acid-soluble ..	..	8.06	..	..	25.26
Fe_2O_3, total	9.79	..	7.14	28.52	..
TiO_2	..	0.91	..	..	0.90(*c*)
H_2O, combined	..	25.12	25.95	..	19.34

(*a*) Insoluble matter other than combined silica.
(*b*) Includes acid-soluble TiO_2.
(*c*) Acid-soluble TiO_2 only.

1. Quarry at railway station Sawyer's Valley: bed 3 to 6 feet thick.
2. and 3. Precise locality not stated.
4. Costean in large outcrop 10 chains west of Guppy's Siding.
5. About 20 chains west of Guppy's Siding.

Other Localities in South-West Division.

Localities which are further removed from Perth than those previously mentioned and at which aluminous laterite has been noted are numerous. The relative importance of these occurrences cannot be assessed but it may be mentioned that laterite containing more than 35 per cent. soda-soluble alumina has been reported at Dwellingup, Quindanning, between Roelands and Collie, Greenbushes, Boyup Brook, near Qualeup, and Kojonup. All these localities, with the exception of Quindanning, are close to railways.

A single specimen from between Bindoon and New Norcia on the Perth to Geraldton road yielded on analysis—

	Per cent.
SiO_2, quartz	3.90
SiO_2, combined	7.58
Al_2O_3, acid-soluble	45.15
Al_2O_3, soda-soluble	39.33
Al_2O_3, total	45.43
Fe_2O_3, total	17.50
TiO_2, total	1.25

Other samples from gravel pits in this locality were found to be more siliceous.

MODE OF OCCURRENCE OF THE BAUXITE.

The bauxite occurs as part of a primary laterite which has developed *in situ* on the Darling peneplain. Dissection of the peneplain has divided the sheet of laterite into small outliers which occur over many thousands of square miles.

It is not clear whether the bauxite has been brought into existence by the selective removal of iron in the course of secondary leaching of the laterite with consequent increase in alumina, or whether it represents a normal zone in the laterite profile; if the latter it is probable that the proportion of alumina present is directly related to the nature of the parent rock.

During 1942, R. S. Matheson (1942) collected 25 samples of laterite from various localities ranging from Bindoon to Greenbushes and at the same time noted the character of the underlying parent rock. These samples were submitted to detailed analysis, and although the examples are too few to permit conclusive results to be drawn, they indicated that laterites derived from granitic rocks contain more quartz than those developed over greenstones. The laterites of granitic origin, however, do not necessarily contain less alumina than the greenstone laterites.

A detailed examination of a laterite profile at Parkerville, 25 miles east of Perth, by S. E. Terrill (1950), has demonstrated the passage from laterite to the underlying quartz dolerite, from which it appears to have been developed by a process of removal from the parent rock by meteoric waters of those original constituents now absent from the laterite.

INTRODUCTION.

The first reference to bauxite in the Northern Territory was made by H. Y. L. Brown (1908) early in this century when he so described siliceous pisolitic laterite at Mounts Roe and Bedwell on Cobourg Peninsula.

The writer visited and sampled Brown's deposits in June, 1949, and at the same time requested members of the Northern Territory Coast Patrol Service to collect specimens of pisolitic material from other places along the Arnhem Land coast.

Before the end of 1949 specimens of bauxite containing between 34.6 and 40.8 per cent. of available alumina had been forwarded from Truant Island and the Wessel Islands by Captain F. E. Wells and Seaman F. J. Waalkes, of the Patrol Service.

At the same time geologists of the Bureau staff collected laterite specimens from various inland localities in northern Australia, but all these were too siliceous or too ferruginous to be classed as bauxites.

For various reasons an examination of the island deposits could not be made until October, 1951, two years after the original discovery, and then only a hurried reconnaissance of part of Marchinbar Island, one of the Wessel group, and points on the adjacent mainland coast was made by the writer accompanied by Captain Wells. As a result of this visit the Aluminium Commission decided to prove the deposits on Marchinbar Island, and field work began in May, 1952. Supervision in the field was exercised by J. V. Puckey and A. J. Richardson, geologists, whose services were made available by the British Aluminium Co. Ltd. Australasian Civil Engineering Pty. Ltd., of Sydney, were responsible for the establishment and maintenance of the camp, sinking of test pits, surveys, transport, and communication.

During the course of the work in the Wessel Islands, bauxite was discovered in the vicinity of Melville Harbour (Latitude 12° 14′ S.; Longitude 136° 42′ E.), but so far only preliminary examinations of these deposits have been made.

COBOURG PENINSULA.

Introduction.

Although the laterite on Cobourg Peninsula is of no value as a potential source of aluminium it is of interest in that Brown's description of it directed the writer's attention to the north coast and led to the discovery of substantial deposits of bauxite farther to the east. The Cobourg occurrences are examples of mature laterite development on siliceous sedimentary rocks and for that reason are worthy of brief description.

Cobourg Peninsula is joined to the mainland by a narrow isthmus at Latitude 11° 33′ S., Longitude 132° 42′ E., and extends westerly from this point for a distance of 60 miles to Cape Don.

Mounts Roe and Bedwell form two prominent landmarks on the south coast of the peninsula 120 miles east-north-east from Darwin and 10½ miles south-south-east from the old garrison post—Victoria—on Port Essington.

The peninsula is gently tilted to the north with the result that remnants of the old laterite surface are carried from an elevation of 500 feet at Mount Roe to sea-level on the north shore, and the drowned valleys of Port Essington, Port Bremer, and Raffles Bay present an irregular and deeply embayed northern coastline.

Only rocks of the Mullaman group (Lower Cretaceous) capped with remnants of laterite occur in addition to Recent sand, recemented laterite and raised beach deposits.

The Mullaman group consists of alternating beds of sandstone and shale; the latter is arenaceous in part. Only few remnants of the laterite now remain as areas elevated above the general level.

The Laterite Occurrences.

Mount Roe bears a flat cap of laterite ranging from about 40 feet to a minimum of 15 feet thick and occupying an area of 11 acres. Vertical joints have caused the laterite to fall away in large prismatic blocks leaving vertical faces flanking the cap and littering the steep slopes at the foot of the cliff with fallen blocks. At only two places on the periphery of the laterite body could the underlying parent rock be seen and sampled.

The laterite is surmounted by thin pisolitic material 2 feet to 4.5 feet thick, consisting of light red pisolites, mostly from 4 to 6 millimetres in diameter, embedded in an apparently textureless matrix of similar colour. The pisolites, which show typical concentric structure when broken, constitute about 75 per cent. of the volume of the pisolitic zone.

Massive tubular laterite underlies the pisolites with a sharply defined contact. The tubular laterite is also light red in colour but is dull and dirty to the eye. It contains small rounded nodules of altered but recognizable shale, and, very rarely, grains of milky quartz. The solution channels which give the rock its tubular character are vertical and range in diameter from about 65 to 5 millimetres or less.

The tubular laterite passes with little gradation into a mottled zone of pink and white earth containing thin horizontal plates of ferruginous matter and rounded fragments of soft bleached shale. Below this a zone of fine red earth overlies horizontally-bedded bleached shale.

Analyses of six channels samples representing a complete section are given; reference should also be made to Fig. 6 on Plate 27.

Depth in Feet.		Description.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0	2	Pisolitic laterite	28.7	36.9	13.8	2.7	17.3(1)
2	7	Tubular laterite	34.4	27.7	24.1	1.5	12.0
7	12	Tubular laterite	30.3	25.3	31.1	1.6	11.5
12	17	Tubular laterite	32.0	25.6	28.7	1.85	11.6
17	19	Pink and white earth ..	40.4	30.2	14.7	2.2	12.2
19	20.5	Red earth	41.5	27.7	17.7	2.1	11.3
20.5	24	Obscured	..	..	..	..	..
24	..	Bleached shale	Not sampled				

(1) Contained 17.3 per cent available Al_2O_3. All other samples contained less than 1 per cent. available Al_2O_3. Minor constituents showed the following ranges :—

P_2O_5	0.02 to 0 13 per cent., increasing with depth.
V_2O_5	0.05 to 0.09 per cent., increasing with depth.
Cr_2O_3	Nil to 0.06 per cent., irregularly distributed.

Very similar results were obtained by sampling the capping on nearby Mount Bedwell.

Examination of a thin section of tubular laterite from Mount Roe showed the rock to be composed wholly of apparently isotropic minerals except for a single minute grain of quartz. A large part of the section consisted of white translucent mineral, probably halloysite, and the remainder of the slide was opaque to brown sub-translucent material ranging from hematite or limonite to iron-stained clay. No gibbsite was recognized, and cliachite, if present, could not be distinguished from iron-stained clay minerals.

Wessel Islands.

Introduction.

The Wessel group forms a narrow, slightly arcuate, island chain trending north-easterly to north-north-easterly from Napier Point for a distance of 80 statute miles and dividing the Arafura Sea from the waters of the Gulf of Carpentaria. The northernmost point in the group is Cape Wessel (Latitude 11° 00′S; Longitude 136° 45′E) on a small unnamed island separated from Marchinbar Island by a narrow strait. (*See* Plate 23.)

Marchinbar (or Erimbiga) Island, the largest of the group, is approximately 34 miles in length by a maximum width of 4 miles. The group consists of two other major islands, five small ones each of one or two square miles, and numerous low rocky islets.

Of the three major islands the southern two, separated from Marchinbar by Cumberland Strait and from each other by a narrow cleft called Hole-in-the-Wall, are not named on official maps and charts but are known to local natives as "Kullorunga" and "Irrakulla".

As Marchinbar is the island on which the bauxite reserves have been proved the following remarks about access, distances, and anchorages refer to that island.

The nearest point on the mainland is Margaret Point in Malay-road, 30 miles south of Cumberland Strait and 2 miles north-west of Cape Wilberforce, the north-easterly extremity of Arnhem Land. Two airstrips for light aircraft have been cleared on the island and could be easily and quickly re-established when required. Aerodromes for light aircraft are maintained by mission stations at Milimgimbi and Elcho Islands, and a war-time sealed runway 6,000 feet in length at Gove (Yirrkala), Melville Harbour, is in good condition. Melville Harbour is a nearly enclosed sheet of water forming a southerly extension of Melville Bay.

Distances in statute miles and directions from the northern airstrip on Marchinbar to Darwin and the places mentioned are—

From Marchinbar—	True Bearing.	Distance.
		Miles.
To Gove (Yirrkala)	176°	60
Elcho Island	232°	80
Millimgimbi	242°	110
Darwin	257°	400

Good anchorages for small craft exist along the west coast of the islands, but the east coast is rocky and unprotected except for a large embayment in the coast of Irrakulla. Jensen Bay and Japanese Creek Bay offer good anchorages in close proximity to the groups of bauxite deposits, but both are open to north-westerly and westerly weather.

Access by sea presents no difficulties other than distance and the hazards presented by an unlighted coast to those unfamiliar with it. Distances from Jensen Bay to various points are—

	Nautical miles.
Melville Harbour—via Cumberland Strait	70
via Cape Wessel	95
Thursday Island	350
Darwin	400
Port Moresby	650
Sydney	2,200
Bell Bay, Tasmania	2,730

PHYSIOGRAPHY.

Topography.—The topographic form of Marchinbar Island is a simple reflection of geological structure.

The ideal cross-section of the island is that of a thin wedge rising vertically from the sea on the east coast to a maximum height of 200 feet and sloping gently to sea level in 2 to 3 miles to the west. The surface is the dip-slope of either of two relatively thin quartzite beds which dip north-westerly at about 1½°. This surface is not, however, as regular as this simplified picture suggests; it retains remnants of a former land surface now represented by residual hills of laterite, is somewhat dissected by the drainage system, and in places is buried beneath sand dunes.

The two quartzite beds which constitute the greater part of the present surface are separated by about 60 feet of uncemented sand, shale, and soft to hard siltstone. Where streams have succeeded in cutting through the upper bed they have rapidly widened their valleys to expose large areas of the resistant lower bed.

The valleys have been blocked by sand dunes along the western shores with the fortunate result that useful bodies of fresh water have been impounded.

The drainage pattern is largely controlled by rectangular jointing of the quartzite. Erosion along these joint planes has provided a minor but important striking topographic feature. In many places the bare quartzite surfaces are divided into rectangular blocks by channels ranging from mere cracks to vertically incised water courses as much as 10 feet wide by 15 feet deep.

Climate.—The climate is of a characteristic monsoonal type in which the year is sharply divided into wet and dry seasons. There is an almost complete reversal of wind direction from season to season. North-westerly winds prevail during the wet summer from about December to April, and dry cool south-easterlies blow during the greater part of the remainder of the year. On the Arnhem Land coast the late phases of the north-westerly season in March or as late as April may be marked by violent tropical cyclones. These storms advance on a narrow front and are capable of much destruction.

No climatic records have been kept on the Wessel Islands, but rainfall figures for the three nearest reporting stations are given,[1] It is probable that the figures for Yirrkala (Gove) most nearly indicate the climatic conditions in the Wessel group.

AVERAGE RAINFALL—POINTS.

(100 points = 1 inch.)

Jan	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec	Year
(1) YIRRKALA—8 YEARS.												
913	966	900	950	443	111	64	7	5	8	212	493	5,072
(2) ELCHO ISLAND—8 YEARS.												
955	1,261	902	548	96	35	1	0	11	52	81	892	4,834
(3) MILIMGIMBI ISLAND—19 YEARS.												
1,061	985	1,059	347	68	23	1	0	1	19	167	482	4,213

Monthly average temperatures for Milimgimbi and Groote Eylandt, compiled from records taken for six and nineteen years respectively, range between the following figures:—[1]

Station	Temperature Range Degrees Fahrenheit.
Groote Eylandt—Maximum	91.7 (December) to 79.6 (June)
Minimum	78.3 (December) to 65.8 (August)
Milimgimbi—2.30 p.m.	90.9 (November) to 81.1 (July)
8.30 a.m.	83.9 (November) to 69.6 (July)

Groote Eylandt is approximately 200 miles south of Marchinbar Island.

(1) The climatological figures quoted above have been made available by the courtesy of the Meteorological Branch, Department of the Interior, Melbourne.

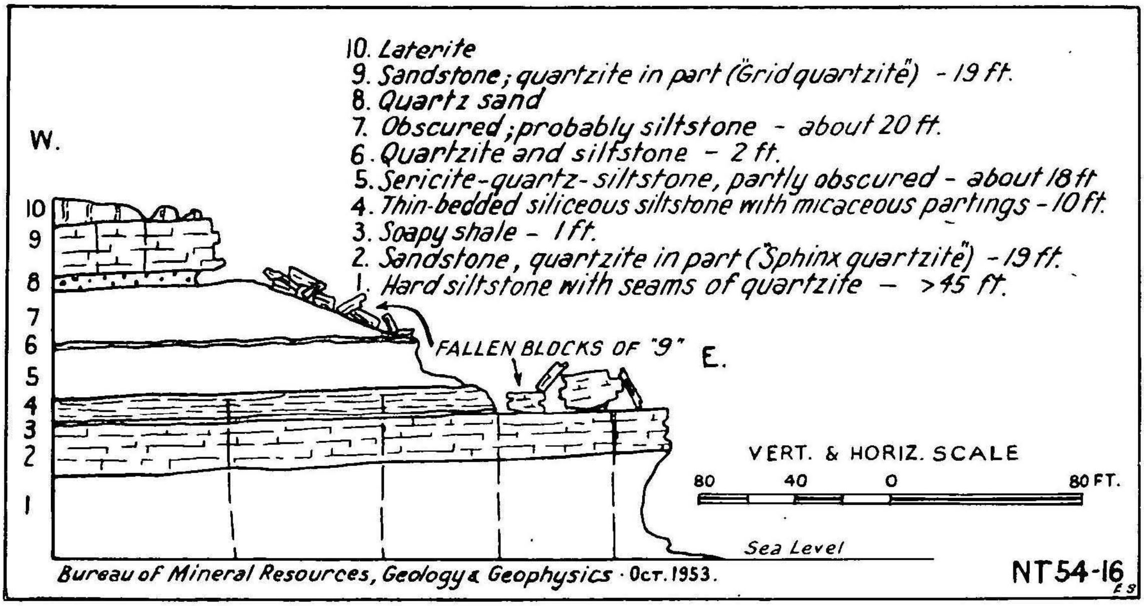


FIG. 14 Section, Philip Cliff, Marchinbar Island, Northern Territory.

[*To face page* 153.]

Vegetation.—Excluding very small areas of coastal mangrove swamp the vegetation on Marchinbar Island may be divided into four types, viz.: (*a*) spinifex, mainly along the cliff-top areas on the east coast, (*b*) light scrub dominated by casuarinas and with coarse tussocks on the said-hills of the west coast, (*c*) dense stunted eucalypt scrub matted with vines on the laterite ridges, and (*d*) limited stands of tall eucalypts (white gums) interspersed with low scrub and grass along water-courses and marginal to fresh-water swamps.

Where the laterite extends to the east coast the characteristic dense scrub thins out fairly abruptly within about ¼ mile of the cliff-top and is replaced by spinifex. Apparently the dense vegetation of the ridges is not able to tolerate salt spray borne on the south-easterly wind. The dense scrub has a very uniform height of about 15 feet, exceeded by 10 feet or so by a few widely distributed white gums. This vegetation gave a great deal of trouble where grid lines had to be cleared through it during the testing campaign. The presence of much dead wood rendered knives or slashers useless, and the scrub proved too green to burn.

Generally satisfactory clearing was performed with a D.4 bulldozer but there were places where the bulldozer could not penetrate, and lines had to be offset or new positions chosen. The chief trouble was caused by vines in which the machine and the uprooted trees, &c., became entangled and brought to a stop.

The white gums mentioned in (*d*) above include many large trees of sound outward appearance but it is not likely that much useful timber could be obtained on the island.

GEOLOGY.

Stratigraphy and Lithology.—The following stratigraphical succession occurs on Marchinbar:—

Recent: Beach and dune sand, stream gravel, talus, shingle, raised beach deposits.

Tertiary: Bauxite and laterite.

Pre-Cambrian (Upper Proterozoic): Quartzite and massive sandstone, sand, siltstone, shale.

Pre-Cambrian.—The beds are high in the Pre-Cambrian and are shallow water deposits of the epi-continental seas which flooded the shield. The most complete exposure seen occurs in Philip Cliff on the east coast 1½ miles north of Sphinx Head (*see* Fig. 14). The total thickness of beds above high water is approximately 140 feet.

The lowest component of the section has not been closely scrutinized. It consists of laminated hard grey siltstone with numerous seams and lenticular bodies of fine brownish quartzite. The quartzite bands are generally a few inches in thickness. The lenticular bodies are short and thick in cross section, their under surface is convex and the top relatively plane. They appear to have considerable length and may represent the infilling with coarser sediment of small gutters or ripple troughs in off-shore silt.

The second member is a strongly cemented sandstone bed 19 feet thick at the locality of the section and very persistent. It was named " Sphinx Quartzite " in the field because this bed forms the prominent " nose " of Sphinx Head. Bedding is well marked by persistent partings formed by films of earthy matter. Near Sphinx Head the top of the bed bears large symmetrical ripple-marks with an amplitude of 2 to 3 inches and a wave-length of 12 inches.

In freshly broken specimens of the rock the fractures usually do not extend through the quartz grains which in almost all instances part from the interstitial cement, but the specimens tested were weathered and it is probable that the unweathered rock is more strongly cemented.

The third bed in the sequence is a band of shale (?) 12 inches thick, weathered to soapy clay-like material. Either this bed has very little lateral extent or it is easily obscured as it was observed at one point only.

The next member consists of 10 feet of thin-bedded quartzite and micaceous quartzite, with micaceous partings. Some ferromagnesian material is also present. The relative abundance of mica has brought about unusual slumping and slipping during compaction with the result that the rock has developed fine foliation with good cleavage parallel to the bedding. Specimens removed from their natural surroundings might be mistaken for products of moderately severe metamorphism.

The fifth unit in the sequence is of particular interest and importance as it is the parent rock from which part of the bauxite is derived. The bed has a total thickness of about 18 feet, but at the place examined the lower half is obscured by soil and talus. The rock is finely laminated, soft, and when damp rather soapy to the touch.

One specimen was sectioned and a duplicate specimen was analysed by R. A. Dunt with the following result:—

	Per cent.
SiO_2	64.6
Al_2O_3	19.3
MgO	1.5
Fe_2O_3	2.5
TiO_2	1.3
K_2O	5.9
Na_2O	0.1
SO_3	0.1
Ignition loss	4.2
	99.5

This analysis suggests that the rock consists of approximately 55 per cent. sericite (including the magnesia and some ferric iron, which appear to be invariable constituents of sericite), 42 per cent. quartz and the balance hydrous titania and limonite. This view is supported by microscopical evidence and the rock is therefore regarded as a sericite-quartz siltstone. Most of the quartz grains in the thin section examined were less than 0.03 mm. in diameter but a few larger grains ranging up to 0.10 by 0.15 mm. were noted.

The siltstone is overlain by the sixth member of the sequence which consists of a band two feet thick occupied by several quartzite seams separated by hard micaceous shale or siltstone and capped by a very persistent band of quartzite 6 to 9 inches thick.

The seventh member is completely obscured by fallen blocks of quartzite, boulders of laterite, finer talus, and sand. From its topographic profile at Philip Cliff and from the evidence of its complete lateritization at Sphinx Head (1½ miles south along the strike and slightly up dip) it is assumed that the hidden bed is shale or siltstone similar to the fifth member.

A bed of loosely coherent white quartz sand slightly iron-stained in places constitutes the eighth unit. This weak bed has caused extensive undermining of the "Grid Quartzite", the ninth member, very large blocks of which have broken off along joint planes and slid down the steep slope to accumulate on the shelf formed by the Sphinx Quartzite.

The "Grid" bed, temporarily so named in the field because it outcropped across the Sphinx Head deposit testing grid with bauxite on either side, has many points in common with the Sphinx bed. It is composed of a dense sandstone in which fractures rarely break the composing quartz grains. At the point measured it is also 19 feet thick. It is persistent and forms the greater part of the present surface of the island.

The grains are of clear glassy quartz, rounded and of fairly uniform size—about 0.5 mm. diameter.

Along the eastern side of the island the overlying formation is now represented by bauxite or ferruginous and siliceous laterite. On the western (down-dip) side of the island the "Grid" quartzite underlies about 50 feet of apparently lateritized beds which are strongly arenaceous near the base.

Tertiary.—Laterite-capped mesas and plateaux occur over very extensive areas of northern Australia, particularly in the region from south of Melville Harbour to the north coast and including the English Company's and Wessel Islands.

The conclusion that these laterite occurrences are contemporaneous in origin is inescapable.

The age cannot be determined with precision but by analogy with laterite in southern Australia and the bauxite at Bintan, Indonesia, it is assumed that the Arnhem Land laterite is of Tertiary age. As it has developed upon Cretaceous sediments at Margaret Bay (2 miles west of Cape Wilberforce) it must be younger than these beds, but there is no stratigraphical evidence by which an upper age limit may be determined. However, the laterite developed to maturity before the breaking up of the peneplain on which it formed, and which is now reduced to relatively small remnants; therefore considerable time must have elapsed since its formation, and it is not unreasonable to ascribe it to early Tertiary time.

Clearly it cannot be a product of the present climatic cycle.

The entire laterite profile has not been observed in any readily accessible position but it may be glimpsed in cliff sections. The lateritic process had no effect upon the quartzite beds and consequently the total thickness of laterite (including leached zones) depended upon the thickness of suitable sediments which remained above the quartzite at the time of lateritization. Towards the western side of the island the present thickness probably exceeds 50 feet, notwithstanding the fact that all the pisolitic zone has been eroded. The greatest thickness observed on the eastern coast is about 30 feet, but in many places the total thickness at no time exceeded about 20 feet. The maximum thickness of pisolitic bauxite encountered in test-pits is 16.5 feet.

Typical partial analyses of material from the upper (concretionary) part of the profile are given. The samples represent a vertical sequence near Sphinx Head, but do not all come from the same place.

Description.	Percentage Composition of Material dried at 105° C.					
	Total SiO_2	SiO_2 as Quartz.	Total Al_2O_3.	Soda-soluble Al_2O_3.	Fe_2O_3.	Ignition Loss
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Pisolitic bauxite(1)	4.5	1.0	51.8	47.5	14.5	25.9
Red tubular bauxite(2)..	2.5	1.3	48.4	47.8	19.6	26.2
Red tubular laterite(2)	6.3	2.4	30.5	25.9	43.7	17.8
Red and black laterite	6.8	3.2	..	24.1	46.1	..
Ferruginous, nodular laterite, quartz grains common and fragments of doubtfully recognizable siltstone present	21.7	..	23.2	15.5	40.9	12.6

(1) A siliceous base to the pisolitic zone occurs in Easy deposit. A typical partial analysis of soft pisolitic material is 21.2% total SiO_2; 0.8% quartz; 17.0% available Al_2O_3

(2) The distinction between "bauxite" and "laterite" is here purely economic.

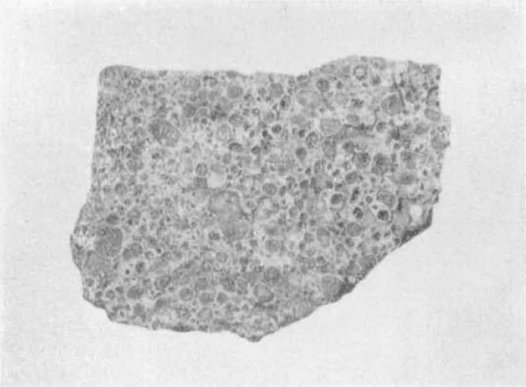
Recent.—Deposits of Recent origin have two important aspects. A thin cover of wind-blown sand, usually only a few inches thick, covers part of the bauxite deposits and has penetrated into the bauxite down joints and spaces between pisolites. In the course of mining operations much of the superficial sand and soil may be removed when vegetation is cleared off the deposits, but extraction of the entrained sand will necessitate screening of the ore.

Penetration by sand is shown by analyses of a sample of pisolitic bauxite which was recovered from a depth of 4 feet to 5 feet 6 inches below the surface.

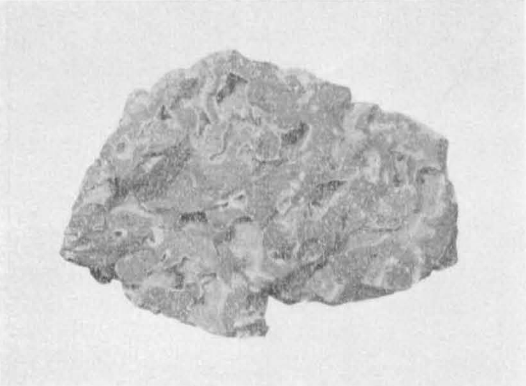
——	Total SiO_2.	SiO_2 as Quartz.	Total Al_2O_3	Fe_2O_3.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
As received	18.7	6.7	43.0	19.7	22.5
Pisolites	1.7	0.5	48.1	21.8	25.6
Fine material	46.0	..	29.9	8.4	13.8

This aspect is further discussed in a later section of this report.

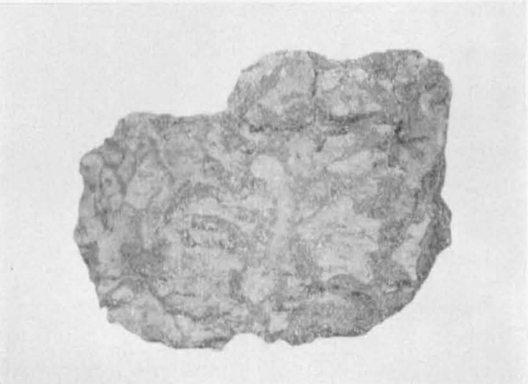
Dune sand driven inshore by north-westerly winds has blocked the mouth of a stream at Jensen Bay, thereby impounding a body of fresh water which is permanent.



Pisolitic bauxite, Marchinbar Island, Northern Territory. Cores of pisolites are red, interstitial material and envelopes of pisolites are light brown.



Tubular (vermicular) bauxite, Marchinbar Island, Northern Territory. Dominant colour is red, linings of tubes are light brown.



Quartzose laterite, Marchinbar Island, Northern Territory. Colour: black and light brown. Dark coloured portions of the rock are speckled by quartz grains.

Structure.—Regional.—The Wessel chain of islands represents the upthrown edge of a narrow fault-block trending north-easterly and gently tilted down to the north-west. Two nearly parallel lines of islands, those extending north-easterly from Elcho Island, and the English Company's Islands, are similar narrow blocks; the structure of the latter area, however, is slightly complicated by cross-faulting and some high dips on Cotton Island.

South-west of Cape Wilberforce near the northern head of Melville Bay, and near Flinders Point, the siltstone-quartzite sequence rests with strong unconformity upon steeply dipping folded sediments which have a northerly trend.

The relationship between the north-easterly submarine stepfault system and the large-scale meridional faulting which can be traced from the north coast in the vicinity of the 136th Meridian to the latitude of Blue Mud Bay is obscure at present.

The north-easterly system of submarine step-faults has developed by tension along the margin of the mainland block, which has been unlifted, probably in late Tertiary time. This uplift has been the cause of the breaking up and rejuvenation of the peneplain and consequent erosion of the laterite. The amount of uplift has been small, a few hundred feet at the most; consequently the throw of the faults is small and the wide stretch of water between the Wessel and the English Company's Islands is shallow (less than 20 fathoms).

Marchinbar Island.—Bedding of the siltstone and the quartzite is nearly horizontal: the highest angle of dip measured is 3° in the vicinity of Jensen Bay, and the average dip is about 1½°, but steeper dips may occur elsewhere. The direction of dip, difficult to measure with any exactness, ranges between 310° and 280° and is commonly 300°.

Two sets of joints are exceedingly prominent and their effect on topographic detail has been mentioned elsewhere. One set trends 315° and the other 40°. On the northern slopes of Sphinx Head the trends of both sets are 5° more easterly. On either side of the Red Cliff—Easy ridge a third system trending 340° is poorly developed. The joints persist vertically through the siltstone and continue to below sea-level.

Very gentle folding, which is perhaps a distant reflection of the disturbance in evidence at Cotton Island, is difficult to discern by eye but may be deduced from small regular changes in strike. Gentle synclinal folding shows in the cliff face south of Sphinx Head. It is probable that the Sphinx Head and Red Cliff Easy ridges are partly structural in origin.

A fault striking north and with downthrow to the east obliquely traverses the northern end of the island.

The laterite dips gently to the north-west; in a distance of 4,400 feet in this direction across Able deposit the base of the economic bauxite falls only 32 feet. The laterite is necessarily less regular than the underlying sedimentary beds, and it is best described as sub-horizontal with a general dip of about half a degree to the north-west, with local variations caused by irregularities in thickness. Such variations are reflections of the type of underlying rock and the relief of the surface on which the laterite developed.

THE BAUXITE DEPOSITS.

Introduction.—Eight bauxite deposits ("deposit" including groups of narrowly separated bodies) have been tested; of these one—Charlie—contained no appreciable quantity of economic bauxite, another—Fox—has been defined by pits on grid lines spaced 1,600 feet apart, and the remaining six have been proved by close testing.

Individual deposits are described in order from north to south.

Baker Deposit.

Baker is the northernmost and smallest of the deposits. It consists of three detached bodies containing:

	Tons.
Body A.	34,000
B.	166,000
C.	15,000
	215,000

With minor exceptions the economic bauxite is confined to the pisolitic zone.

Bodies A and B occupy the crest of a narrow steep-sided ridge which trends north and is covered with dense scrub and jungle. Overburden consists of bauxite rubble mixed with a little sandy topsoil and containing to an average depth of 1.8 feet 83 per cent. of recoverable economic bauxite.

Body C occurs on the cliff edge in clear spinifex country and underlies an area of 54,000 square feet and is covered to an average depth of 1.7 feet by sandy soil and rubble containing 81 per cent. bauxite.

The highest grade ore in the deposit occurs in body C along the cliff edge, where ore 7 feet 6 inches thick averaged 2.8 per cent. total SiO_2, 1.2 per cent. SiO_2 as quartz, and 53.8 per cent. available Al_2O_3.

Salient details of the deposits are summarized in the following tables:—

TABLE 38.—RESERVES.

BAKER DEPOSIT.

Body.	Area.	Number of Pits in Bauxite.	Bauxite Thickness in Feet.		Recovery Factor.
			Range.	Average.	
	Acres.				
A	2.9	3	4 to 6	4.7	98
B	9.85	10	4 to 12	7	94.5
C	1.25	2	2.5 to 7.5	5	93.5

ECONOMIC BAUXITE.

Body.	Long Tons.	Total SiO_2.	SiO_2 as Quartz.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.		Cwt.
A	34,000	9.4	2.6	46.0	1.51
B	166,000	9.0	3.1	47.8	1.35
C	15,000	3.8	1.4	51.7	0.58
Total ..	215,000	8.6	2.8	47.8	1.32

Charlie Deposit.

A few pits were sunk along a low narrow ridge capped with boulders of pisolitic bauxite, and proved the deposit to be very small and consist mainly of residual boulders. No samples were sent for analysis and reserves contained in the deposit have not been assessed. It is possible that a few thousand tons of bauxite could be recovered from Charlie deposit when nearby Baker deposit is being worked.

Sphinx Head Deposit. (*See* Plate 24.)

This deposit consists of five large and two very small bodies which lie on the broad crest of a ridge trending north-westerly from Sphinx Head. The easternmost body (" A " on plate 24) which extends westwards from the cliff edge is separated from the remainder by the " Grid Quartzite ", and is therefore derived from beds which underlie it, while on the other hand the more westerly bauxite bodies are developed upon beds statigraphically above it. This different parentage has not resulted in any significant differences in composition of the bauxite and it is assumed therefore that the parent rocks in each case are similar. It is noteworthy that bodies A and B, although separated by the quartzite, each contain an appreciable amount of red tubular bauxite beneath the pisolitic zone, and in this respect they differ from the remaining six bodies. Because the dividing line between bauxite (whatever its physical form) and uneconomic laterite is an arbitrary one it must not be assumed that the difference between the tubular or massive bauxite and laterite of similar form is necessarily one of minor or insignificant degree; there is not much tubular material which is on the borderline; generally it is well within economic limits or hopelessly without.

The presence of tubular bauxite in bodies which are derived from different, though probably not lithologically dissimilar, beds suggests that more effective local leaching rather than the original constitution of the parent rock is responsible for the high alumina content.

Descriptions of other deposits which follow show that tubular ore occurs at or towards the eastern end of several of them also, and it is reasoned that position in its relation to effective drainage (i.e. juxtaposition to the east coast cliff) is the controlling influence in the development of bauxite below the pisolitic zone. Further, it is considered that this development is a secondary effect brought about by reduction and leaching of iron from what is normally an iron-rich zone.

An important practical aspect of the presence of tubular bauxite is that the sharp boundary between pisolitic and tubular zones cannot be used as an easily recognizable depth limit for quarrying.

Two logs of pits, one from each of bodies A and B, are quoted—

Co-ordinates.	Depth in Feet.		Description.	Total SiO_2.	Quartz.	Available Al_2O_3.	Soda Loss.
	From—	To—					
				Per cent.	Per cent.	Per cent.	Cwt.
NB.6 ..	0	1.5	Bauxite rubble	10.3	6.1	35.4	1.2
	1.5	5.5	Pisolitic bauxite	5.6	2.0	47.2	1.0
	5.5	8.5	Pisolitic bauxite	9.4	3.8	41.3	1.4
	8.5	9.5	Red massive bauxite	3.0	1.2	40.5	0.4
	9.5	..	Black laterite	Not sampled			
NB.7 ..	0	1.5	Sandy rubble	7.0	3.3	29.6	..
	1.5	4	Bauxite rubble	4.4	1.5	34.2	1.0
	4	7	Rubble with boulders of pisolitic bauxite	4.0	1.3	46.0	0.6
	7	10	Red massive bauxite	2.4	0.8	46.8	0.4
	10	..	Massive blue-black laterite ..	Not sampled			

As discussed elsewhere the parent of body "A" is known to be a sericite-quartz siltstone, but the higher bed has not been found yet except in a thoroughly lateritized condition.

The upper part of the bauxite is contaminated with wind-blown sand, but there is no overburden in the ordinary sense of the word. All contaminated samples were screened and recovery factors (percentage of coarse material retained on sieve) for the separate bodies averaged.

The highest grade ore is contained in E which averaged 47.2 per cent. available alumina for 214,000 tons.

Principal details of the deposits and the reserves are contained in the table which follows:—

TABLE 39.

RESERVES—SPHINX HEAD DEPOSIT.

Body.	Area.	Number of Pits in Bauxite.	Bauxite Thickness.		Recovery Factors.
			Range.	Average.	
	Acres.		Feet.	Feet.	Per cent.
A	38.4	28	2.5 to 16.5	5.3	95
B	4.1	3	4 to 8.5	6.6	90
C	9.0	6	3 to 5.5	4	90
D	24.0	15	2.5 to 9	6	92
E	15.1	10	2 to 10	5.8	95
F	0.6	2	2 to 12	7	88
G	1.4	2	4 to 5.5	5	90

Body.	Long Tons (Recoverable Dry Ore).	Total SiO_2.	SiO_2 as Quartz.	Total Al_2O_3	Available Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
A ..	490,000(1)	5.4	2.4	44.1	40.9	23.8	2.7	23.6	0.82
B ..	63,000(2)	5.3	2.0	43.8	39.4	23.9	2.0	24.3	0.90
C ..	84,000	6.8	3.0	45.7	45.2	19.7	2.6	25.2	0.95
D ..	357,000	7.8	2.9	51.2	45.1	10.1	3.1	27.3	1.20
E ..	214,000	6.8	2.0	52.5	47.2	9.9	3.2	27.2	1.08
F ..	10,000	5.4	1.4	47.1	43.5	18.7	2.9	26.4	1.14
G ..	15,000	9.3	2.7	51.6	43.8	10.3	2.9	26.4	1.58
Total ..	1,233,000	6.5	2.5	48.0	43.5	17.0	2.9	25.6	1.00

(1) Includes 160,000 tons of massive and tubular red bauxite underlying the pisolitic zone. This bauxite contains approximately 40.5 per cent. available alumina extractable with soda loss of 0.6 cwt. of Na_2O per ton of alumina.

(2) Includes 13,000 tons of massive red bauxite containing approximately 45.0 per cent. available alumina extractable with soda loss of 0.6 cwt.

Able Deposit. (*See* Plate 25.)

Able deposit is the largest on the island; it occupies an area of 220 acres and contains 4,627,000 long tons of bauxite.

The thickness of the ore included in the reserves ranges from the cut-off figure of 2.5 feet to 16.5 feet and averages approximately 8 feet.

With the exception of 125,000 tons of massive and tubular red bauxite which underlies the pisolitic ore towards the eastern end of the deposit, economic values are confined to the pisolitic zone. The position of the massive ore adjacent to the eastern coast is analogous to that of the similar bodies at Sphinx Head, and this circumstance suggests that conditions of leaching rather than original differences in the parent rock are responsible for its development.

Generally the grade of the pisolitic ore improves slightly below a depth of 4 feet and declines again towards the base, but such distribution is not invariable. The surface impoverishment is caused mainly by entrainment of sandy and clayey soil, but a small part of it may be due to resilication of the bauxite. Results of sampling 4 pits are quoted to illustrate variation of grade with depth.

Depth in Feet.	Total SiO_2.	Quartz.	Available Al_2O_3.	Depth in Feet	Total SiO_2	Quartz.	Available Al_2O_3.
	Per cent.	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.
	PIT H.12.				PIT F.11.		
0– 4 ..	2.8	1.3	48.6	0– 1 S. ..	13.6	9.3	40.3
4– 8 ..	2.5	0.8	51.5	1– 5 ..	3.7	0.9	48.3
8–12 ..	1.4	0.3	49.6	5– 9 ..	3.1	0.7	48.2
12–13 ..	1.6	0.3	43.8	9–13 ..	4.2	0.7	48.4
13– ..		Laterite		13–15 ..	4.5	0.3	40.2
				15–16 L. ..	11.6	0.3	17.9
	PIT Z.7.				PIT E.6.		
0–1.5 S. ..	12.8	8.1	38.6	0– 4 ..	3.4	0.6	50.3
1.5–5.5 ..	3.4	1.1	47.6	4– 6 ..	3.5	0.7	47.9
5.5–7 ..	5.0	1.0	38.2	6–10 ..	4.2	0.6	44.7
7–8 L. ..	12.5	0.9	15.3	10–11 L. ..	8.5	0.7	26.8

S = Soil contamination.
L = Laterite.

On approximately half the area of the deposit, mainly on the eastern side, the surface of the bauxite is contaminated with quartz sand and fine detrital material amounting to 10 to 25 per cent. to depths of 2 and 3 feet. The area free from this contamination lies to the west of grid line 6 and is shown on Plate 25. Overburden of sandy soil a few inches deep occurs in patches on either area.

Dry screening of contaminated samples gave an average recovery factor of 96 per cent. for the whole deposit.

The ore included in the reserves ranges in available alumina content from 31 to 53 per cent., but of 354 samples of economic grade 307 (87 per cent.) contained more than 40 per cent. of available alumina. The lower grade samples generally represent thin bauxite near the margins of the deposit and have little effect on the mean value. The following frequency table shows the distribution of values between the 354 samples:—

Per cent. available Al_2O_3.	Frequency (No. of samples).
30 to 31.9	2
32 „ 33.9	6
34 „ 35.9	9
36 „ 37.9	14
38 „ 39.9	16
40 „ 41.9	30
42 „ 43.9	60
44 „ 45.9	64
46 „ 47.9	72
48 „ 49.9	52
50 „ 51.9	20
52 „ 53.9	9

Total proved reserves amount to 4,627,000 tons of the following average composition:—

Total SiO_2	SiO_2 as Quartz.	Total Al_2O_3.	Available Al_2O_3.	Fe_2O_3.	TiO_2.	Soda Loss
Per cent. 4.1	Per cent. 1.1	Per cent. 51.4	Per cent. 47.1	Per cent. 15.7	Per cent. 3.3	Cwt. 0.71

The total includes 125,000 tons of massive and tubular red bauxite containing 43 per cent. available Al_2O_3 extractable with soda loss of 0.6 cwt.

In addition to determinations of available alumina with small assay samples, autoclave extractions on a larger scale to simulate plant practice more closely were also carried out in the laboratory. Results of the latter tests showed small deviations from the available alumina figures but generally were in close agreement. The averages of available and autoclave figures for samples representing 3,114,000 tons of ore are—

	Per cent.
Available Alumina	48.1
Autoclave Alumina	47.8

Dog Deposit. (*See* Plate 26.)

Dog deposit occupies an area of about 69 acres and contains 1,317,000 tons of economic bauxite the thickness of which ranges to 16.5 feet and averages 7 feet. Tubular and massive red bauxite occurring within and at the base of the pisolitic ore totals 165,000 tons containing 44.3 per cent. available alumina extractable with a soda loss of 0.5 cwt. Na_2O per ton.

The deposit has many features in connexion with Able deposit of which it is an outlier. The remarks descriptive of vertical distribution of values within the latter deposit apply with equal force to Dog.

Contamination of the surface bauxite with sand to a depth that rarely exceeds 2 feet occurs over the central portion and part of the eastern end of the deposit.

The reserves computed from the results of analysis of 129 samples include ore ranging from 33.9 to 53.3 per cent. available alumina; however, 119 (92 per cent.) of the samples yielded results exceeding 40 per cent. available alumina.

Total proved reserves amount to 1,317,000 long tons of the following average composition.

Total SiO_2.	SiO_2 as Quartz.	Total Al_2O_3.	Available Al_2O_3.	Fe_2O_3.	TiO_2.	Soda Loss
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cwt.
5.1	1.1	51.4	47.2	13.2	3.3	0.88

This total includes 165,000 tons of massive red bauxite mentioned above.

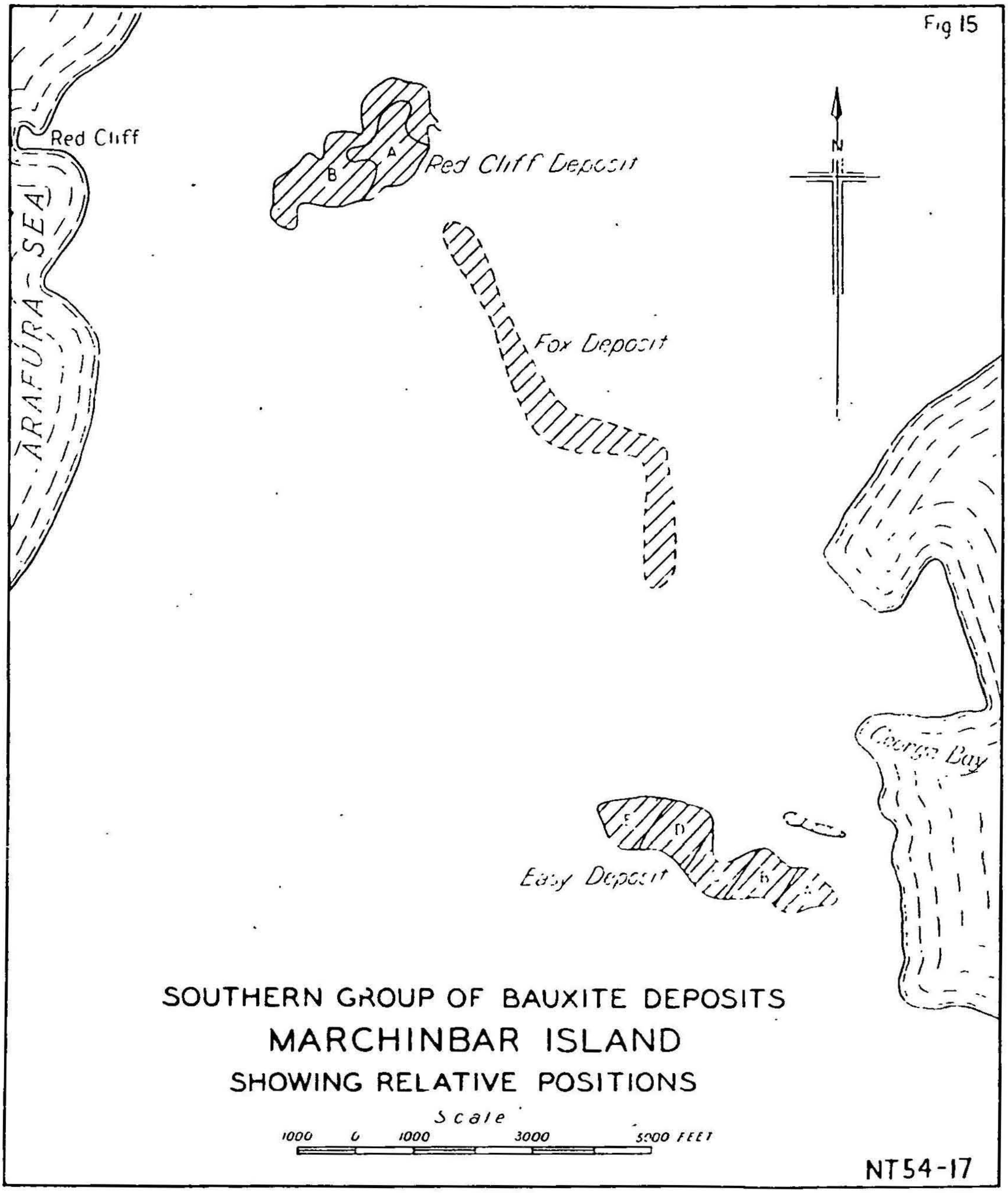
Easy Deposit.

Three deposits, Easy, Fox, and Red Cliff, constitute the southern group, which form a nearly continuous ridge trending north-westerly across the island from a point 9 miles south-south-west from Dog deposit. Relative positions of the deposits are shown in Fig. 15.

All three deposits are thinner and of lower grade than the members of the northern group.

Easy deposit has an area of 71 acres not including small outlying areas and the ore averages 4.9 feet thick with maximum thickness of 11.5 feet. Total reserves which amount to 825,000 tons include about 27,000 tons of tubular red bauxite beneath pisolitic ore at the eastern end of the deposit.

The tonnage and grade of reserves in Easy deposit have been computed from the results of analysis of 78 samples which yielded available alumina ranging between 35.2 and 54.4 per cent. Seventy-two (92 per cent.) of the samples contained more than 40 per cent. available alumina.



[*To face page* 164.]

For convenience the deposit has been divided into five blocks of which details are as follows (*see* also Fig. 11) :—

TABLE 40.—RESERVES : EASY DEPOSIT.

Block.	Area.	Number of Pits in Bauxite.	Bauxite Thickness. Range	Bauxite Thickness. Average.	Recovery Factor.
	Acres.		Feet.	Feet.	Per cent.
A	11.5	8	2 to 11.5	5.4	90.5
B	15.5	9	1 to 8	4.5	92.0
C	11.6	6	2 to 7	4.2	93.5
D	16.4	9	3 to 5.5	4.5	88.7
E	16.1	9	2 to 11	5.9	92.6
	71.1	41	1 to 11.5	4.9	..

——	Long Tons	Total SiO_2.	SiO_2 as Quartz.	Available Al_2O_3	Soda Loss.
		Per cent.	Per cent.	Per cent.	Cwt.
A	143,000*	7.9	2.0	45.6	1.4
B	161,000	9.2	1.9	42.7	1.8
C	123,000	8.3	1.8	42.1	1.5
D	168,000	10.1	3.4	45.4	1.47
E	230,000	6.6	2.0	48.5	1.07
Total ..	825,000	8.3	2.2	45.2	1.40

* Includes 27,000 tons of tubular red bauxite of composition—7.9 per cent. total SiO_2, 0.8 per cent. quartz, 45.6 per cent. available Al_2O_3 with soda loss of 1.76 cwt.

Red Cliff Deposit.

Red Cliff deposit occupies the north-western end of the Easy—Red Cliff ridge adjacent to the west coast of the island. The bauxite is wholly of the pisolitic type and much of the surface is weathered to rubble mixed with more or less sandy soil.

The total area of the deposit is 81 acres, the maximum thickness 8 feet and the average thickness 4.6 feet.

The economic reserves which total 763,000 tons hav been computed from 72 samples which yielded results ranging between 35.6 and 51.2 per cent. available alumina. Of these samples 61 (or 85 per cent.) contained 40 per cent. or more of available alumina.

Reserves have been calculated in a manner that distinguishes between higher grade ore occurring over an irregular area of 25 acres towards the northern end of the area and the lower grade and thinner ore which encloses the former on north, west, and south. The respective areas are shown on Fig. 15 and details are given hereunder.

TABLE 41.

RESERVES: RED CLIFF DEPOSIT.

Block.	Area.	Number of Pits in Bauxite	Bauxite Thickness		Recovery Factor.
			Range	Average.	
	Acres.		Feet.	Feet.	Per cent.
A	25	15	4 to 8	6	80
B	56	32	1.5 to 7	4	

RESERVES.

—	Long Tons.	Total SiO_2	SiO_2 as Quartz.	Available Al_2O_3.	Soda Loss.
		Per cent.	Per cent.	Per cent.	Cwt.
A	348,000	8.3	3.7	46.8	1.10
B	415,000	9.2	3.9	41.6	1.48
Total ..	763,000	8.8	3.8	43.9	1.31

Fox Deposit.

Fox deposit lies along a sinuous flattened ridge, which extends for 8,500 feet between Easy and Red Cliff deposits. The crest of the ridge falls from an elevation of 200 feet above sea level at its south-eastern end to 156 feet at the north-western extremity, where it is separated from Red Cliff deposit by a shallow gap approximately 1,000 feet wide (*see* Fig. 15).

Attempts to clear a base line along the ridge were frustrated by dense scrub which could not be effectively handled by the bulldozer, and the line was off-set in places. Five transverse lines were cleared at intervals of 1,600 feet and the deposit was tested with pits sunk at intervals of 200 feet along them.

This testing disclosed that the bauxite extends along the crest of the ridge as a strip averaging approximately 550 feet wide. The bauxite, which is pisolitic in character, is shallow; it has a maximum thickness of 6.5 feet and the upper 2 to 3 feet is much admixed with sand and fine bauxite rubble.

The average grade indicated by the somewhat limited testing is rather lower than that of either Red Cliff or Easy, but the lower alumina is partly off-set by lower silica content than at either of the other two occurrences.

Reserves, which can be regarded only as indicated rather than proved in the absence of more closely spaced test points, amount to 800,000 tons of the following grade:—

Total SiO_2.	SiO_2 as Quartz.	Available Al_2O_3	Soda Loss.
Per cent.	Per cent.	Per cent.	Cwt.
6.8	2.4	42.8	1.07

This statement does not include small outlying areas, but it is unlikely that additional testing would add or detract materially from these figures.

PETROLOGY OF THE BAUXITE.

The pisolitic bauxite is a reddish-brown rock which breaks cleanly across the closely packed pisolites and cement to yield fairly flat faces. The pisolites, thus seen in section, range between about 1 mm. and 22 mm. in maximum dimension but the great majority of them measure less than 10 mm. across. In shape they may be spherical, oval, reniform, or irregular sub-angular forms.

To the unaided eye the pisolites, which are coated with a thin whitish skin, appear to be composed of homogeneous brown material with a resinous lustre, or of a light brown, pink, or whitish granular substance. Some pisolites have a relatively thick shell of brown resinous material surrounding a granular core.

The cementing material is invariably lighter in colour than the pisolites and forms only a very small proportion of the rock as it incompletely fills the small voids between the more or less spherical concretions.

The tubular bauxite which underlies the pisolitic zone on Able deposit is also a reddish-brown rock with a dull waxy to finely earthy texture on fresh faces. The solution cavities which give the rock the typical appearance of tubular or "vermicular" laterite are lined with a cream-coloured skin about 0.1 to 0.5 mm. thick. Examination of the wet rock with a hand lens reveals that it is composed of pinkish-brown oolites up to 1 mm. diameter set in a darker matrix. The lining of the tubes is also finely oolitic.

Thin sections of two selected specimens were prepared for microscopical examination. Specimens were chosen to represent granular and resinous pisolites, and duplicates were analysed with the following results:—

No.	Total SiO_2	SiO_2 as Quartz.	Total Al_2O_3	Available Al_2O_3	Fe_2O_3.	TiO_2.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1/52	6.6	1.1	58.0	48.2	3.8	3.4	28.3
2/52	9.2	3.7	52.3	48.4	4.8	2.3	27.7

The section of the specimen 1/52, which came from Sphinx Head, showed pisolites from 2.5 to 7 mm. in diameter, oval to circular in form and with a narrow red-brown rim enclosing a coarsely granular core. The rims ranged from 0.1 to nearly 1 mm. wide and were composed of alternating concentric bands of lighter and darker brown isotropic cliachite. The granular core contained rounded grains of a crystalline aggregate of gibbsite; the individual grains measured from 0.2 to 0.4 mm. across. Very narrow (0.01 mm.) veinlets of crystalline gibbsite extended radially across the rims and into the cores.

The matrix between the pisolites was white, isotropic, and oolitic. It contained rare quartz grains partially replaced by gibbsite.

Specimen 2/52 came from the Red Cliff deposit; the section contained white-rimmed pisolites of diameter 1 to 5 mm. with brown cores. The smaller pisolites consisted wholly of concentric shells of isotropic material (cliachite) surrounding a nucleus consisting of a single quartz grain. The larger examples have a core of several or many quartz grains embedded in cliachite and surrounded by a rim of white or light brown cliachite about 0.15 mm. wide. The quartz grains were commonly 0.2 mm. in diameter with a few as large as 0.5 mm. Many of the pisolites were traversed by radial veinlets of gibbsite, and the quartz grains might be replaced by gibbsite or have needles of gibbsite extending into them. In some instances the whole grain retained the original rounded outline but only a central irregular remnant of quartz surrounded by gibbsite remained.

The matrix contained a few quartz grains more or less replaced and embedded in nearly opaque white oolitic cliachite.

Chemical analyses indicate that the bauxite is composed essentially of aluminium hydroxide $Al(OH)_3$ and is a tri-hydrate ore. The probable mineralogical composition calculated from three typical analyses is given below, but it is not possible to distinguish between gibbsite $Al(OH)_3$ and cliachite or "amorphous bauxite" which is essentially $Al(OH)_3$ with more or less hydrated iron oxide intimately associated. The calculations are based on two assumptions, viz: that all combined silica is present as kaolin and that "available alumina" represents all alumina present as hydroxide. In a few instances, as for example the second example below, there is not sufficient combined silica to satisfy the "fixed" alumina, i.e.,. the difference between total and available alumina figures. The discrepancies are small, however, and may be due to vagaries of the laboratory extraction process.

—	Total SiO_2.	SiO_2 as Quartz.	Total Al_2O_3.	Available Al_2O_3.	Fe_2O_3.	TiO_2.	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1. ..	6.1	1.1	48.0	43.5	17.2	2.8	25.8 = 99.9
2. ..	3.8	0.5	49.1	45.0	17.9	3.0	26.4 = 100.2
3. ..	2.4	1.3	45.4	44.3	25.0	2.4	24.9 = 100.1

1 and 2. Pisolitic bauxite. 3 Hard red tubular bauxite.

PROBABLE MINERALOGICAL CONSTITUTION.

—	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Quartz	1.1	0.5	1.3
Kaolin	11.0	7.1	2.5
$Al(OH)_3$ (Cliachite and gibbsite)	66.5	68.8	67.8
Al_2O_3 excess	.	1.3	..
Limonite (mainly goethite)	18.5	19.5	26.1
Titania	2.8	3.0	2.4
	99.9	100.2	100.1

Melville Harbour Area.

Introduction.

Melville Harbour (Latitude 12° 15′ S., Longitude 136° 40′ E) is a southerly and nearly land-locked extension of Melville Bay near the north-eastern extremity of Arnhem Land and 65 nautical miles south of Sphinx Head, Marchinbar Island. It is included in the extreme south-east corner of the area of the locality map shown in Plate 23.

During the war an aerodrome was constructed on the peninsula which separates Melville Harbour from the Gulf of Carpentaria and a short pier was built at Drimmie Head on the eastern side of the harbour. Since then a mission station has been established at Yirrkala on the Gulf coast, 6 miles east of the aerodrome, and the peninsula has been leased by the mission authorities. The war-time name for the aerodrome, "Gove", has been abandoned officially in favour of "Yirrkala" for both the mission and the aerodrome.

At the time of writing only preliminary reconnaissances of the area have been made but bauxite in substantial amount has been observed on Yirrkala peninsula, and another occurrence of doubtful value has been examined in part at about 8 miles south-west of Melville Harbour between Cato and Giddy rivers.

Yirrkala.

At Yirrkala pisolitic bauxite containing up to 50 per cent. alumina has been observed throughout a traverse of 5½ miles easterly from the aerodrome. The bauxite rests upon tubular laterite. Both are developed on sedimentary rocks which are arenaceous in part and overlie coarse garnetiferous granite. On the eastern coast of the peninsula and round the shores of Melville Harbour the granite is lateritized.

Specimens of bauxite and laterite from Yirrkala have been examined at the Aluminium Commission's laboratory with the following results:—

Mark.	Total SiO_2.	SiO_2 as Quartz.	Total Al_2O_3.	Available Al_2O_3.	Fe_2O_3.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
(*a*)	5.5	1.9	52.6	45.3	13.0
A4016	8.9	3.2	..	36.3	..
A4015	5.5	0.7	..	42.4	..
A4013	10.6	2.8	..	43.6	..
A4014	34.9	0.5	..	11.5	..

(*a*) Surface boulder near airstrip.
A4016 Collection of surface boulders north of airstrip.
A4015 Loose pisolitic bauxite, surface to 1.5 feet, north of airstrip.
A4013 Pisolitic bauxite, base of bauxite in shallow quarry north of airstrip.
A4014 Laterite, floor of same quarry.

In general the pisolitic bauxite closely resembles that of Marchinbar Island, but most specimens seen are rather darker in colour, probably because of higher iron content. Quartz grains are visible in some specimens. Some of the ore (A4015 above) is only weakly cemented, and consequently on handling it breaks down into a mass of loose, roughly spherical, pisolites.

The laterite formation of which the pisolitic bauxite forms a part occupies an area of about 25 square miles, and it is very probable that bauxite persists over the greater part of this area, and that systematic testing would indicate very substantial tonnages.

Access to the area is good. The airstrip, 6,000 feet long, is sealed and in excellent condition (1952). The jetty at Drimmie Head, the aerodrome, and the mission are connected by metalled and in part sealed roads.

Cato River.

The following notes, except the analyses and ensuing discussion, are taken from a report to the Aluminium Commission by J. V. Puckey and A. J. Richardson, dated December, 1952.

Laterite with a pisolitic capping forms a plateau about 30 square miles in area. Coarsely pisolitic and tubular laterite generally about 10 feet thick overlies massive laterite which ranges from about 10 to 30 feet in thickness. In places a gradation to lateritized shale can be seen.

The underlying rocks consist of a relatively undisturbed sequence of shales, sandstones, grits, and conglomerates. The lateritized horizon appears to represent a shale bed.

Lack of time and of adequate facilities prevented more than a superficial examination of the eastern side of the plateau and outliers. Sections were measured and samples taken from natural exposures in scarps and at the heads of gullies. An attempt to sink a pit below the depth of 2.5 feet was foiled by the hardness of the pisolitic laterite.

Two typical sections are quoted (with minor modifications) below. Analyses which follow did not become available until after the report had been written.

Depth in Feet.	Description.	*See* Analysis.
	(1) NATURAL EXPOSURE.	
0 to 6	Soft, red, pisolitic laterite with ferruginous tubular concretions ..	1
6 to 14	Soft amorphous laterite with ferruginous concretions	2
14 to 18	Similar to above but probably with higher iron content	3
18 to ?	Coarse pisolitic laterite covered with scree.	
	(2) SHALLOW PIT.	
Surface	Boulder, hard pisolitic bauxite	4
0 to 0.5	Bauxite rubble in top-soil	5
0.5 to 2.5	Hard massive pisolitic bauxite	6

Analyses.

No.	SiO_2	Quartz.	Available Al_2O_3	Ignition Loss.
	Per cent.	Per cent.	Per cent.	Per cent.
1	24.3	0.4	21.3	19.8
2	41.6	0.2	2.5	14.3
3	41.4	0.4	2.6	14.8
4	10.7	1.8	33.6	22.8
5	22.1	11.9	25.0	18.3
6	14.8	1.8	32.8	22.5
5(1)	11.6	..	28.5	20.8

(1) Calculated free from quartz.

These unfavorable results cannot be regarded as conclusive although the outlook is not very encouraging. What sampling has been done is of a random nature and confined to the eastern margin of the plateau and to small outliers. At least 20 square miles of the laterite surface remains untouched, and this area should be explored by sub-surface testing before the potentialities of the occurrence can be gauged.

Truant Island.

A specimen of pisolitic bauxite from Truant Island, 30 nautical miles south-south-east from Sphinx Head, was received from Captain F. E. Wells in August, 1949, and yielded on analysis—

	Per cent.
SiO_2	2.9
Al_2O_3	43.5
Fe_2O_3	26.6
TiO_2	2.3
P_2O_5	0.1
V_2O_5	0.02
Cr_2O_3	0.06
Ignition loss	23.8
	99.28
Available Al_2O_3	40.8

The island is less than one square mile in area, and air photos indicate that only a small part of it is covered with laterite or bauxite. The deposit has not been examined geologically.

CONSTITUTION AND ORIGIN OF BAUXITE.

Introduction.

Australian bauxites are aluminous varieties of laterite which may or may not have been modified by secondary chemical effects. Discussion of the constitution and origin of bauxite cannot, for the sake of completeness, be limited to the alumina enrichments only and therefore a general discussion of laterite, and the processes by which it develops, is involved.

The term "laterite" was first introduced by F. Buchanan in 1807 to describe a ferruginous earthy rock which he had observed when travelling in southern India in 1800-01. This rock was, and still is, extensively quarried and used for building purposes. When freshly excavated the soft rock is cut into blocks, or bricks, which harden on exposure. Buchanan proposed "laterite" (from L. *lateris*, a brick) as a suitable name for this material, which he described in the following words (Buchanan, 1807, pp. 440-1): "It is diffused in immense masses, without any appearance of stratification. It is full of cavities and pores, and contains a very large quantity of iron in the form of red and yellow ochres. In the mass, while excluded from the air, it is so soft that any iron instrument readily cuts it. It very soon after [exposure] becomes hard as a brick".

It is clear to any one with field experience of laterites that this description applies to the tubular (vermicular) portion of a laterite profile, but the term no longer has this restricted meaning and is now applied to all the products of the process known as lateritization. Some workers extend the meaning of the term to cover silicified rocks which conceivably could have received added silica by deposition from solutions developed within a laterite profile, but the practice of calling a siliceous rock a " laterite " cannot be too strongly condemned.

Lateritization is a process of deep weathering by which some constituents leached from rocks are removed in solution and others, chiefly iron and aluminium, are redeposited in the immediate vicinity. The term laterite as used here embraces the zones of ferruginous and aluminous deposition and of leaching. The former, which occurs above the leached material and includes Buchanan's laterite, results from chemical precipitation, and only the leached zone is a residual product.

At this stage the definition of laterite given on page 12 above may be restated with some expansion into a form which owes something to both Fermor (1911) and Lacroix (1913). Laterite is a mixture of oxides of iron, more or less hydrated, aluminium hydroxide with or without basic aluminium oxide, and titanium dioxide; it is formed as a precipitate and a relatively insoluble residue resulting from prolonged sub-aerial leaching of rocks and the oxidation of the leached products. It forms near the surface of a shallow water-table, and possesses a range of composition from relatively pure iron oxide on the one hand to aluminous varieties almost free from iron (i.e. bauxite) on the other. Alkalis, alkaline earths and silica are eliminated, but certain minor constituents, if present in the parent rock, invariably occur in the laterite.

Bauxite may result from lateritization of an aluminous rock which is deficient in iron, or more commonly by the segregation of much of the iron within one restricted part of the profile with consequent proportional increase of alumina in the less ferruginous zones. Secondary changes whereby iron is reduced to the divalent state and removed in solution play an important part in raising the alumina content of laterites.

Although bauxite commonly occurs in the zones of deposition it may occur also as a residual product in the leached portion of the profile where a suitably aluminous rock has been attacked.

Laterites are prominently developed in the tropics, but their occurrence is not limited to low latitudes. In the southern hemisphere laterite occurs in Tasmania as far south as 43°, and in the northern hemisphere at 45° in Oregon, United States of America, and 55° in Antrim, Northern Ireland. Monohydrate bauxite occurs at 59½° north at Tikhvin, near Leningrad, Union of Soviet Socialist Republics, but this deposit is of Palaeozoic age and possibly not of lateritic origin. The prevalence of laterite in tropical regions suggested to many workers that a tropical climate is essential to its formation, but this does not appear to be invariably so. Though the higher mean temperatures of the tropics, moisture, and abundance of decaying vegetation provide active reagents for attack on the rocks, it is noteworthy that all sub-aerial weathering tends towards lateritization, i.e., towards concentration of iron as ferric hydroxide and alumina as hydrated silicate or hydroxide. Given stability and low relief for a sufficient length of time there seems no reason why laterites should not develop to maturity in temperate regions of fairly high rainfall.

PARENT ROCK.

It is an essential factor in the development of commercial bauxite that the parent rock shall contain adequate alumina and be reasonably free from coarse particles of quartz. The presence of alkalis, particularly soda, and alkaline earths is favorable to the process of alteration. The necessary conditions are fulfilled by intermediate and basic igneous rocks and argillaceous and micaceous sediments. Even highly siliceous rocks in which the grain-size of silica particles is small can be converted to bauxite with very low silica content. Three excellent examples are afforded by the bauxites of Bintan, Indonesia, Marchinbar, Northern Territory, and Manus Island, New Guinea.

Salient features of the parent rocks and resulting bauxite at these localities are summarized below:—

Locality	Bintan.		Marchinbar.		Manus.	
Rock .. .	Hornfels.	Bauxite.(1)	Sericite-quartz Siltstone	Bauxite.	Dacite.	Bauxite.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total SiO_2	61	1–3	64	4–8	67	0.36
Quartz . ..	?	..	45	1–4	25	..
Alumina	15	45	19	48–53	14	57

(1) Approximately 60 per cent. gibbsitic nodules ; 40 per cent. clay-like bauxite.
(2) Bauxitic crust adhering to unaltered dacite

Irregular dissemination of iron oxide in the bauxite below the pisolitic zone and abrupt changes in the crystallinity of gibbsite often lend the rock a false fragmental or brecciated appearance. This, taken together with crude horizontal or sub-horizontal layering which simulates bedding, has misled some workers into the belief that laterite (or bauxite) which rests upon massive igenous rock is derived from superincumbent pyroclastic material.

At Tamborine Mountain, Queensland, the derivation of the bauxite from massive basalt and porphyritic andesite is established by tracing the texture upwards from the fresh parent rock. At this locality the earthy bauxite is granular and contains gibbsite pseudomorphs after plagioclase phenocrysts, and blebs of gibbsite(?) which have replaced similarly shaped inclusions of black glass in the parent rock.

Similarly, at Inverell and Moss Vale, in New South Wales, the fine texture of the olivine basalt on which the bauxite rests may be traced continuously into the earthy bauxite. Bauxitization of basalt at Inverell is shown by the following chemical determinations made on a kernel of fresh basalt and successive concentric shells of weathered material which surrounded the core of fresh rock. The specimens were taken from Parish's deposit.

	1. Kernel of Fresh Basalt	2. First Shell 4-in Thick.	3. Second Shell 2-in Thick.	4. Third Shell 2-in. Thick.
	Per cent.	Per cent.	Per cent.	Per cent.
Silica	45.6	45.7	40.6	15.4
Alumina	14.8	16.6	18.4	25.6
Ignition loss	2.4	4.3	12.4	17.6
Available alumina	n.d.	n.d.	n.d.	10.5

Brief megascopic descriptions of these specimens are: 1. Fresh olivine basalt, slightly weathered on outside faces to depth of 3 mm. 2. Incipiently weathered basalt, very hard. Felspars apparently fairly fresh; olivine present. 3. Soft weathered basalt with dull white opaque felspar laths and weathered pyroxenes present. Colour—greenish-grey. 4. Soft light-brown clayey rock with poorly preserved granular texture and small specks of lustrous black mineral (ilmenite ?). Weathered pyroxene doubtfully discernible.

As a means of determining the type of parent rock from which bauxite has derived, petrological examination is limited by the extremely small samples which are submitted to precise examination. However, A. B. Edwards (Appendix 1), when examining a suite of specimens from Parish's deposit, recognized the basaltic texture inherited from the parent.

The Gippsland (Victoria) bauxites which have been described in considerable detail on pages 80-102 are commonly derived from basaltic agglomerate and tuff which orginally consisted of irregular fragments of olivine basalt embedded in fine ash containing minor amounts of detrital minerals, including rare grains of quartz and zircon. An exceptional example occurs at Nahoo where a band of bright red bauxite at the base of the bed has developed from sedimentary clay. Fairly well developed stratification, at the southern end of Napier's No. 1 deposit and at Nahoo particularly, suggests that the parental tuffs may have been laid down under water. Field observations suggest that elsewhere, e.g. the northern part of Napier's No. 1 deposit, and in the eastern side of the field, bauxite has developed from massive basalt, but relict texture has been destroyed to such an extent by the chemical vicissitudes that the rock has undergone that the evidence is inconclusive.

Tasmanian bauxites are derived from either dolerite or basalt; the former variety is typically developed at Ouse and St. Leonards, and examples of the basaltic type occur near Myalla and Campbell Town.

The high degree to which a fragmental appearance may be developed in coarsely pisolitic bauxite derived from massive dolerite is mentioned in the following paragraphs which show how deceptive abrupt textural changes may be. The rock at Ouse consists of angular and sub-angular nodules of earthy or dolerite bauxite surrounded by rims of amorphous limonite or cliachite and embedded in a matrix of earthy or textureless ferruginous material. Nodules with earthy cores may lie in close juxtaposition with those of a coarse doleritic texture. The differences of texture are heightened by variegation of colour which results from a fairly wide range in the content and staining power of iron in nodules in close proximity to each other. For example, a single hand specimen may contain buff, pale-brown, red-brown, and dark-brown nodules.

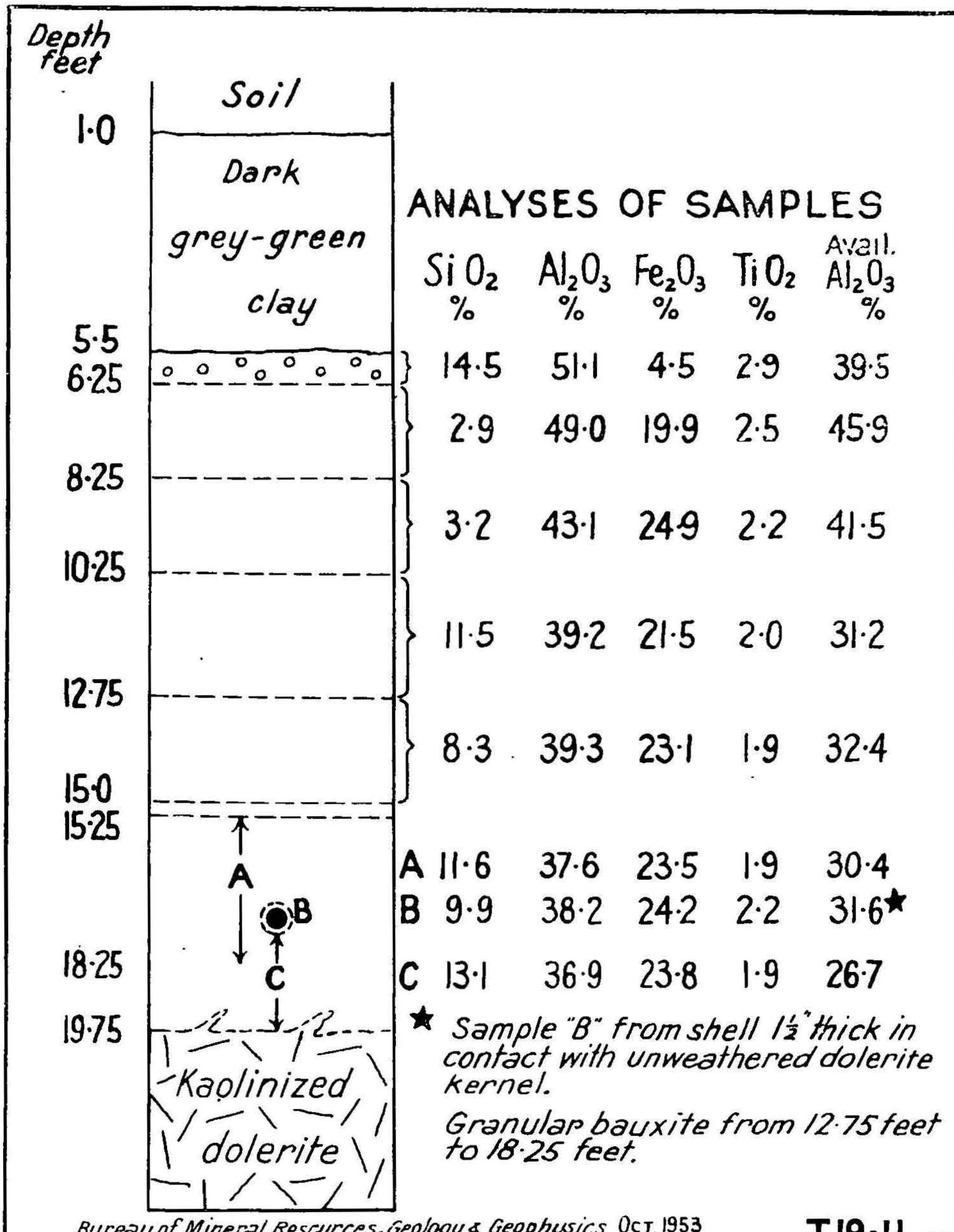


FIG. 16. Shaft M.D.1, St. Leonards, No.1 area, Tasmania.

Suggestions that the bauxite at Ouse had developed by alteration of water-sorted tuffs which still displayed traces of bedding were disproved by careful observation over a period of several months during which the testing campaign continued. No evidence of stratification was found in the many shafts examined, but a somewhat ill-defined division into horizontal zones characteristic of laterite, and less commonly, nearly horizontal streaks of limonite and clay, were noted. Shafts which penetrated well into kaolinized dolerite, or, as at St. Leonards, encountered fresh dolerite, afforded many opportunities of tracing the rock texture and joint system into the bauxite. A section revealed by such a shaft at St. Leonards showing the sample channels and analyses of bauxite is given in figure 16.

The false brecciated appearance of much of the Tasmanian doleritic bauxite is due to the fact that attack on the parent rock, beginning in the joint planes, advances normally from the joints and carries forward recognizable traces of the angular outlines of the original polyhedral joint blocks.

Analyses of examples of Tasmanian dolerite and basalt will be found in Appendix 2.

The aluminous laterites of the Darling Range, and elsewhere in Western Australia, have developed on a wide variety of rocks of Pre-Cambrian age. The parent rocks include acid and intermediate igneous rocks and metamorphosed sediments. The laterites which overlie granitic bedrock contain more quartz than those which are derived from greenstones or meta-sediments. Terrill (1950) traced the passage from quartz dolerite to laterite at Parkerville in the Darling Range, and Matheson (1942) related variation in the composition of laterite to difference in the bedrock. No bauxite attributable to lateritization of basic volcanics has yet been reported in Western Australia.

The bauxite on Marchinbar Island, Wessel group, Northern Territory, is unusual in that it is derived by lateritization of sericite-quartz siltstone. Arenaceous sediments have yielded siliceous laterite, but the finely divided quartz contained in the siltstone has been almost completely removed.

Chemical analysis and microscopical examination indicate that the Marchinbar siltstone consists of slightly more than 50 per cent. sericite, which includes small quantities of magnesia and ferric iron, and the remainder quartz. The composition of one specimen of the rock, determined by the Aluminium Commission laboratory, is as follows:—

	Per cent.
SiO_2	64.6
Al_2O_3	19.3
MgO	1.5
Fe_2O_3	2.5
TiO_2	1.3
K_2O	5.9
Na_2O	0.1
SO_3	0.1
Ignition loss	4.2
	99.5

The majority of the quartz grains in the thin section examined were less than 0.03 mm. in diameter, but a few larger grains ranged up to 0.10 by 0.15 mm,

FORM OF THE DEPOSITS.

Primary laterite, whether aluminous or not, occurs as a superficial deposit upon its parent rock. The complete laterite profile, including zones of deposition and of leaching, may exceed 50 feet thick but commonly is not more than 20 feet.

Mechanical erosion and surface drainage must be at a minimum to enable the precipitated products of lateritic weathering to accumulate in the upper zones of the profile. Therefore, laterite occurrences usually develop with great lateral extent and lie on surfaces of gentle relief.

The bauxite and laterite deposits now remain as relatively small residuals capping flat-topped hills as at Kingaroy, Queensland, and Moss Vale, New South Wales, or as irregular bodies overlain by younger sediments or basalt flows. The two largest bauxite bodies known in Australia are those at Parish's farm, near Inverell, and Able deposit on Marchinbar Island. These average 14 feet and 8 feet thick and occupy areas of 150 and 220 acres respectively. Part of Parish's deposit is overlain by basalt and it is probable that concealed bauxite occurs over an area of some 100 acres besides the 150 acres which has been proved.

In Victoria all the bodies are small and usually terminate against rising bedrock and hence have a lenticular cross-section. Many of the Victorian bauxite deposits, like those near Launceston, Tasmania, occupy shallow depressions in the bedrock surface and are wholly or mostly surrounded by unlateritized bedrock at higher elevation than the bauxite. The largest single body in Victoria, Watkin's deposit, has an area of about 14 acres with average thickness of 10 feet and maximum of 27 feet.

Western Australian bauxites are merely alumina-enriched patches within remnants of a vast sheet of laterite. At present little is known of their extent and thickness, which can be determined only by systematic sampling.

Bauxite on Marchinbar Island and the nearby mainland is, with minor exceptions, confined to a relatively thin horizontal pisolitic capping on a mature laterite derived from very gently inclined micaceous sedimentary rocks. This pisolitic bauxite covers large areas, probably several square miles, in the vicinity of Melville Harbour, and in the areas tested on the island reaches a maximum thickness of 16.5 feet.

Numerous plans and sections which accompany this Bulletin, and the descriptions of the individual deposits, provide information regarding the form and attitude of the orebodies and their relationship to overburden in complete detail. It may be noted, however, that commonly the upper surfaces of deposits are nearly plane while the base is less regular. Irregularities of the top may usually be attributed to the effects of erosion or resilication. The lower surface, unless coincident with a well-defined zone boundary in the profile, may be very irregular. In Victoria, pillars of floor clay may rise steeply to heights of 6 or 10 feet above the general level of the floor. These are believed to represent original irregularities of the weathered basalt surface on which the parental tuff and agglomerate was laid down. Figure 17 (page 183) shows irregularities of the surfaces of dolerite bauxite at Ouse, Tasmania, where incomplete bauxitization, resilication, and erosion have operated to produce the irregular surfaces.

The horizontal limits of the sheet-like deposits are usually determined by erosion or less commonly by faulting. The margins of unburied occurrences are characterized by near-vertical scarps, commonly between 5 and 15 feet high, or steep slopes. Smaller bodies which terminate against rising bedrock have been mentioned. An unusual boundary occurs at Sphinx Head, Marchinbar Island, where the bauxite transgresses the gently inclined bedding of a succession of siltstones, sandstones, and quartzites. A bed of quartzite crops out through the laterite and bauxite, which terminate abruptly against it on either side.

The mode of occurrence of most bauxite deposits renders them particularly amenable to cheap open-cut mining, as the overburden may consist of only a few feet of lateritic soil. The buried deposits of Victoria and Tasmania underlie beds of sand, clay, and lignite, which present no difficulty to earth-moving equipment.

Internal Structure.

Lateritization proceeds in several concurrent or overlapping stages which produce distinguishable products that may be recognized as zones within the profile. Lacroix (1913) divided the profile into two zones, viz., the upper or concretionary, and the lower or leached zone. The former results from the redeposition of iron and aluminium from solution, and being composed of a chemical precipitate does not usually retain any trace of the texture of the original rock; the bleached zone is the residual matter from which alkalis, alkaline earths, and silica, and to a greater or lesser extent iron, have been removed.

J. Walther (1915) renamed and further subdivided the profile by introducing an intermediate stage where leaching and deposition alternate with fluctuations of the water table. The three zones then became, in descending order, (*a*) Ferruginous, (*b*) Mottled (Fleckenzone), and (*c*) Pallid (Bleichzone). The last term was no doubt made in recognition of the usual lack of colour in the lowest part of the laterite profile, but is something of a misnomer in respect of laterite developed on basic rocks where the "pallid zone" is often deeply and brightly coloured. This division is widely used in Australia and for most purposes is quite adequate, but the author has found it convenient and desirable to divide further as shown in the following Table, which sets out five zones commonly recognizable in Australian bauxite occurrences. The ideal section in which all zones are well developed and easily observed is extremely rare, but there is little doubt that close scrutiny of any bauxite section would reveal some evidence of all zones unless destroyed by denudation or extreme secondary changes.

Perusal of Table 42 will show that the lithomarge zone mentioned by Fox (1932, p. 65) or the equivalent "billy" of northern Australia (Noakes, 1949, p. 30) is not present. The partial analyses of typical representatives of each zone show that although there is general increase in silica content with depth, zones are characterized by physical rather than chemical differences.

TABLE 42.—ZONES IN THE LATERITE PROFILE.

Zones.			Common Thickness.	Number.	Typical Composition.				Derivation see note (5).
Lacroix.	Walther.	Ideal Bauxite Section.			SiO_2.	Al_2O_3.	Fe_2O_3.	Free Al_2O_3.	
			Feet.		Per cent.	Per cent.	Per cent.	Per cent.	
..	..	Derived soil	1 to 5	1	4.0	35.5	35.2	29.8	BT
				2	9.3	31.3	34.1	21.0	BI
Concretionary (Zone de concretion)	Ferruginous.	*Pisolitic* .. .. *see* note (1)	4 to 20	3	3.3	52.4	13.8	49.7	SW
				4	2.5	42.7	31.6	33.7	BI
				5	3.6	38.5	36.4	27.9	BM
				6	2.9	28.0	50.0	..	BT
		Tubular and *massive* .. *see* note (2)	4 to 8	7	2.5	48.4	19.6	47.8	SW
				8	4.6	34.2	36.9	32.4	BM
				9	1.3	26.7	47.1	25.8	BM
				10	3.4	38.7	33.2	36.5	DO
Leached (Zone de départ)	Mottled (Fleckenzone)	*Earthy*: with or without poorly preserved relict texture, variegated; *OR*	10 to 20	11	3.9	37.9	32.1	32.3	BM
				12	3.8	55.3	4.2	50.3	BM
				13	2.4	44.9	24.7	42.7	DO
		Nodular: hard gibbsitic nodules in soft clayey matrix *see* note (3)		14	8.0	38.7	27.0	32.7	BT
				15	9.1	36.9	28.5	29.6	BK
				16	11.1	48.3	13.5	37.8	DO
				17	9.7	40.4	23.8	30.1	DL
	Pallid (Bleichzone)	*Granular*: relict texture well preserved	5 to 10	18	18.3	25.5	39.9	7.2	BM
				19	3.7	43.8	26.5	40.6	DL
				20	12.8	39.2	22.4	28.1	DL
		Clay zone	0.5 to 40	21	30.5	35.5	12.5	11.2	BM
				22	24.0	23.2	34.2	..	DL
				23	30.3	28.7	23.7	..	DL
		Parent rock .. .. *see* note (4)	..	24	64.6	19.3	2.5	..	SW
				25	45.6	14.8	11.7	..	BI
				26	53.4	14.7	10.3	..	DL
				27	54.8	14.5	11.3	..	DO

(1) Analysis 4 represents 24 feet of pisolitic laterite at Emmaville, New South Wales. The pisolitic zone in Wessel Islands ranges up to 16.5 feet thick.

(2) Tubular laterite is not well developed in Tasmania. Sample No. 10 is a massive ferruginous bauxite containing a few poorly developed pisolites with earthy cores.

(3) Nodular zones are uncommon and poorly developed in Australia.

(4) Total iron in these rocks is expressed as Fe_2O_3.

(5) Explanation of letter symbols B—basalt; D—dolerite; S—micaceous siltstone: I—Inverell area, New South Wales; K—Kingaroy, Queensland; L—St Leonards, Tasmania; M—Moss Vale, New South Wales; O—Ouse, Tasmania; T—Midlands, Tasmania; W—Wessel Islands, Northern Territory.

Both pisolitic and massive zones are formed under strongly oxidizing conditions which fix the iron as ferric oxide or hydroxide. There is usually only little difference in composition between these two zones in any one locality, but the megascopic appearance is markedly different, and commonly the boundary between the two zones is sharp. Commonly the upper zone is occupied wholly by pisolites which are roughly spherical and range between 5 and 10 mm. in diameter. They consist of concentric shells of cliachite built upon a nucleus which may consist of a minute grain of quartz, a crystal of gibbsite, or a small mass of granular bauxite. In some instances the nucleus of granular bauxite constitutes half or more of the total mass of the pisolite and the core may then retain clear evidence of the parent rock texture. The pisolites may be loose without interstitial cement, loosely held together by earthy or oolitic matter, or firmly cemented in a tough matrix of cliachite.

The tubular material presents a very different appearance. The rock is usually fairly hard, red or dark-brown to nearly black, and is penetrated by solution channels which are roughly circular or elliptical in cross-section and generally 10 to 30 mm. in diameter. These channels, branching and anastomosing, have no common orientation but are mostly vertical or steeply inclined. Although the passage from pisolitic to tubular laterite is sharp a gradation may be noticed in a few places, where locally cemented pisolite material may enclose small masses of tubular laterite. The converse also holds true and partially developed pisolites may be formed upon the walls of the tubes of the lower zone.

Earthy material in the mottled zone is textureless, soft, and usually lighter in colour than the material above it. The colour, commonly light brown, buff, or pinkish-brown, is irregularly distributed, and red ferruginous patches give the zone the variegated or coarsely mottled appearance from which the name has been derived. Earthy bauxite at Ellsmore, Moss Vale area, is uniformly deep red.

Nodular bauxite consists of unevenly distributed nodules of hard bauxite (mainly gibbsite) embedded in a matrix of buff, brown, or light red siliceous clay. The nodules may constitute from about 10 to 50 per cent. or more of the material, which owes its economic value to the high alumina content of the nodules and the ease with which they may be separated from the matrix by washing and screening. The nodules, which may be as large as a man's fist, range from nearly spherical to irregular shapes and possess a smooth outer surface. Some are wholly concretionary, others display relict parental texture internally.

The mottled zone passes gradually into the pallid zone by diminution of the gibbsitic nodules or ferruginous patches.

Granular bauxite occurs near the base of the profile and constitutes a part of the pallid zone. Its principal characteristic is excellent preservation of the texture of the parent rock, particularly if that rock is a medium-grained igneous type. Examples of altered basalt, dolerite, and diorite (the latter extra-Australian) which appear to be normally weathered rocks but are in fact almost wholly gibbsite are known to the writer. Such rocks retain not only the original texture, but also the original grain size, which indicates that little shrinkage or compaction has accompanied the replacement of complex silicates by aluminium hydroxide.

The clay zone needs little description—it consists of the residual product of kaolinitic weathering of the bedrock and usually retains traces of the original rock texture. Analyses usually show the material constituting this zone to be a ferruginous clay containing a few per cent. of free alumina. An anomalous example was observed at one point at St. Leonards, Tasmania, where a six-inch band, described in the field as "light brown clay" and underlying 4 feet of pisolitic, nodular, and granular bauxite, was found to contain 2.9 per cent. SiO_2, 51.2 per cent. Al_2O_3 and 49.6 per cent. available Al_2O_3.

Chemical and Mineralogical Composition of Bauxite.

Introduction.

The lateritic process effects a separation of the chemical elements originally present in the more or less complex parent rock. This separation is brought about partly by selective leaching and partly by selective precipitation of some of the dissolved substances. The elements which remain to constitute laterite or bauxite have been called the "lateritic constituents" and it follows that laterite consists essentially of a mixture of compounds of such elements together with small amounts of non-lateritic constituents which have not been eliminated from the parent rock completely. Distribution of the major constituents in typical examples of laterite is shown graphically in Plate 27.

The principal lateritic elements are iron (almost wholly trivalent in laterite), aluminium, and titanium, but elements of minor importance that may be included in the category are vanadium, trivalent chromium, which is analogous to ferric iron and aluminium, and probably gallium, a homologue of aluminium. There are also other elements commonly found in small amounts in Australian laterites but the relatively few analytical results for these minor constituents are rather inconsistent. On the whole they tend to show that phosphorus and, perhaps, chromium accumulate in the leached zones of the profile but diminish in the zones of concretionary deposition unless these zones are richly ferruginous.

Only a few determinations of manganese in Australian bauxites and parent rocks have been made; these indicate that manganese does not accumulate in the Tasmanian bauxites but may have done so to a slight extent at Inverell. As far as it goes the evidence favours the exclusion of manganese from among the ranks of the lateritic elements.

The components which are removed on break-down of the original rock are silica (unless present as coarse grains of quartz), alkalis, alkaline earths, and metals which form strongly basic oxides. On this reasoning it might be expected that zinc, lead, tungsten, molybdenum, and uranium would be concentrated or at least partly retained in laterites.

According to Prescott and Pendleton (1952, page 22) their work in a field restricted to "ironstone gravels" suggests that cobalt, nickel, manganese, and copper are not concentrated with iron in laterites and ironstone gravels. As far as nickel is concerned this view can be reconciled with the superficial nickelliferous ironstone bodies of New Caledonia only by the unlikely assumption that the metal is concentrated exclusively within the leached portions of the profile.

Such conclusions as may be drawn from these observations and from the evidence presented under the sub-heading "Minor Constituents" below, where the relatively few and scattered laboratory determinations of minor constituents are set out, make it appear that chromium and phosphorus are only partially precipitated in the concretionary zones. The relative distribution of other elements of economic value may follow a similar pattern.

It is believed that these observations are of profound significance in the field of geochemical prospecting on laterites that overlie potentially metalliferous rocks. The inconsistencies and doubts which exist at this stage should be cleared up by a systematic investigation of the distribution of the minor constituents of laterite.

The probable mineral composition of the bauxite has been calculated on the assumptions that "available alumina" is present as hydroxide and that silica present in bauxites of basaltic and doleritic origin is present as clay corresponding to $Al_2O_3.2SiO_2.2H_2O$ and does not include appreciable quantities of quartz.

The first assumption is open to the objection that digestion with alkali containing 200 grams Na_2O per litre may attack clay minerals and boehmite. Apparently clay minerals are little affected and increased alumina from this source is offset by loss as insoluble sodium aluminium silicate. Experience with partly dehydrated ores taken from close proximity to basalt contacts at Inverell has shown that increased time of digestion and augmented strength of solution to 300 gr/l Na_2O is necessary to affect "monohydrate" ore.

Any combined water remaining after satisfaction of gibbsite, boehmite, and kaolin is allotted to ferric oxide, but in practice it is found that usually very little water remains after all alumina minerals are satisfied.

Aluminium.

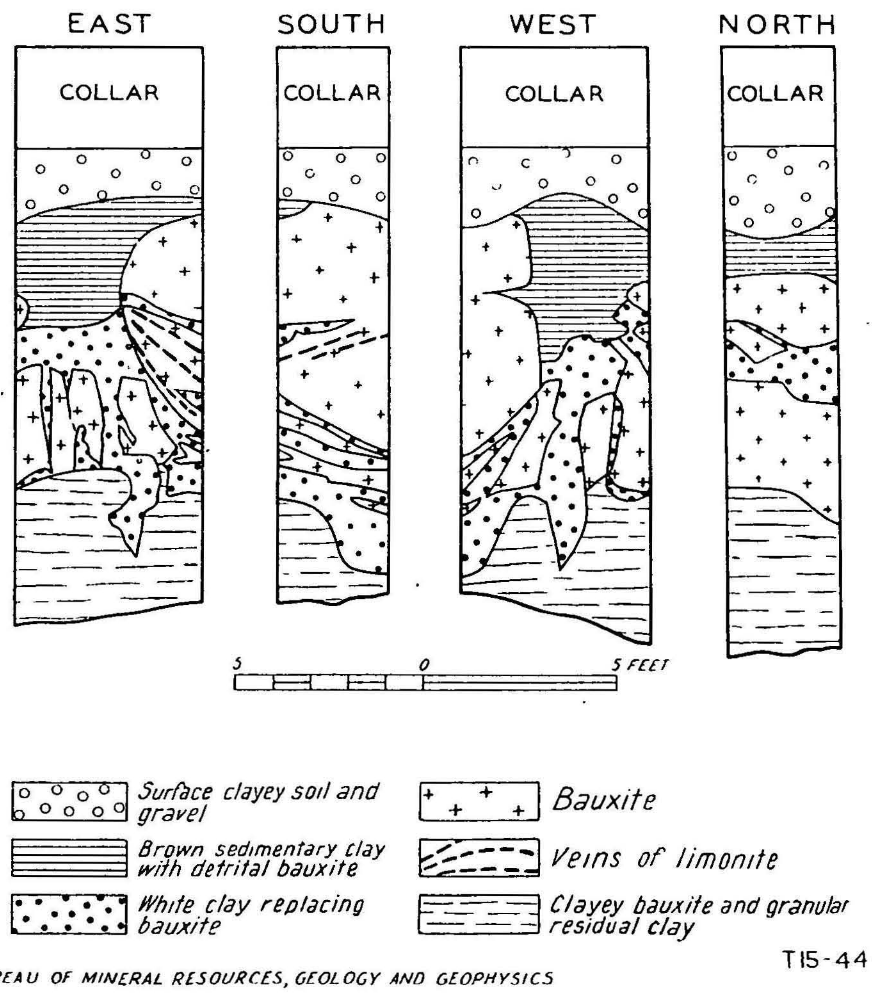
The principal aluminous constituent is hydroxide, $Al(OH)_3$, known to alumina technologists as "trihydrate" from the supposed formula $Al_2O_3.3H_2O$. The hydroxide is stable at temperatures below 150° C.; above that point transition to the basic oxide AlO.OH begins. It is probable that transition from $Al(OH)_3$ to AlO.OH also takes place under the influence of pressure; hence bauxites which have been subject to mild thermal effects of igneous contacts or to load imposed by deep burial contain both compounds.

The hydroxide occurs as the monoclinic mineral gibbsite, usually in aggregates of minute crystals, or as an amorphous gel-like form, more or less iron-stained and known as cliachite. Cliachite commonly occurs as concretions or colloform masses. The presence of the basic oxide—boehmite—is difficult to detect and is usually indicated by an insufficiency of the combined-water content to satisfy the hydroxide molecule. Stillwell (1952) has demonstrated the presence of the mineral in bauxite from Mirboo North, Gippsland, Victoria, and it may be inferred from chemical analyses of bauxite samples from most other Australian localities, particularly Inverell, New South Wales, where the bauxite has been directly covered by basic lava flows.

Boehmite becomes unstable at about 300° C. and changes to the isomeric mixed oxide diaspore, $HAlO_2$, above this temperature. The presence of diaspore in lateritic bauxite is regarded as highly improbable. Bauxites which consist largely of boehmite or diaspore are known as "monohydrate" ores.

FIG.17

SCALE DRAWING OF WALLS OF NO. 26 SHAFT, NO. 2 AREA, OUSE, SHOWING REPLACEMENT OF BAUXITE BY KAOLIN



Invariably some aluminium is present as hydrous silicate as kaolin, halloysite, or other clay minerals. The clay minerals occur either as residual clay derived from the parent rock or as halloysite and kaolin which have developed at the expense of gibbsite and cliachite by introduction of silica from overlying material.

Resilication of bauxite by introduced silica is shown in Fig. 17, which is a scale drawing of the four walls of a test pit at Ouse, Tasmania. The white clay at this point has penetrated the bauxite from above and has originated from silica introduced from the overlying Derwent Lake beds, which have now been eroded from the immediate locality. These beds consist mainly of clays with thin seams of lignite and lignitic clay—a combination which seems to be peculiarly favorable to the development of silica solutions. An exactly parallel example in Arkansas is mentioned by Goldman and Tracy (1946).

Similar conditions have brought about resilication of gibbsite in Victoria, where bauxite has been replaced irregularly by white and pale-blue halloysite.

In both Tasmania, at St. Leonards, and Victoria, at Jeeralang, introduced silica has attacked the pisolitic zone and replaced the originally ferruginous matrix, thus leaving pisolites of high-grade bauxite embedded in grey clay. The following analyses from the Victorian example are interesting. The first is of a channel sample containing the natural proportions of pisolites and clay; the second is of pisolites washed free from clay:—

—	1	2.
	Per cent.	Per cent.
SiO_2	16.8	2.2
Al_2O_3	49.0	57.3
Fe_2O_3	5.2	4.9
TiO_2	4.7	4.2
Loss on Ignition	24.3	31.2
Available Al_2O_3	35.0	55.6

The probable mineralogical compositions of these two examples are—

—	1	2.
	Per cent.	Per cent.
Free silica	Nil	Nil
Clay, $Al_2O_3.2SiO_2.2H_2O$	35.8	4.3
Gibbsite, $Al(OH)_3$	53.5	85.0
Limonite(1), $Fe_2O_3.xH_2O$	6.0	6.3
Leucoxene? TiO_2	4.7	4.2

(1) Limonite is used loosely to signify ferric oxide with more or less water (see below).

Iron.

Generally the degree of hydration of the ferric oxide is low; analyses usually disclose barely sufficient combined water to satisfy the aluminium when available alumina is calculated to hydroxide and the remainder to kaolin. Iron oxide is intimately mixed with aluminium hydroxide in the amorphous substance cliachite and no definite ferric iron minerals such as hematite, goethite, or lepidocrocite have been recognized. Highly ferruginous portions of the bauxites are dark-brown or red and lack the characteristic bright resinous lustre of limonite. The iron is probably present as metacolloidal ferric oxide with adsorbed water, or turgite.

Highly ferruginous pisolitic ore is commonly magnetic: analyses of such material from Moss Vale area have yielded as much as 2.7 per cent. ferrous oxide in ore that has a total iron content of 21.6 per cent. Fe, but no magnetite has been identified, and in fact any crystalline minerals other than gibbsite and residual minerals are exceedingly uncommon.

In thin section many ferruginous pisolites show concentric shells of differing intensity of colour, which indicates a greater or lesser proportion of admixed amorphous alumina.

Ferrous carbonate (siderite) occurs as a result of secondary changes that take place in buried laterite under the influence of reducing conditions below the water-table. Such conditions have operated at Ouse, Tasmania, and Budgeree, Victoria, where lignite in the overburden has removed available oxygen from percolating ground water and added organic matter, which has reduced the ferric iron to the divalent state.

At Budgeree ferrous carbonate has developed in appreciable quantities: 18 per cent. of one sample consisted of coarsely crystalline siderite. Mead (1915) records similar development of siderite in bauxite in Arkansas, where the overburden also contains lignite.

The greenish tint noticed in basaltic laterite at Campbell Town, Tasmania, is probably due to the presence of ferrous iron as a silicate mineral.

Titanium.

Except under conditions of good drainage titanium is not removed during lateritization but becomes more or less evenly distributed through the profile. Reference to Plate 27 will show that the titanium compounds are very stable and the metal shows less variation within the profile than any other element. It commonly amounts to a significant percentage, which is usually about double or treble the proportion contained in the original rock. The mineral form in which titanium occurs in bauxite is not known, but it is probable that it is present as dioxide derived by alteration of ilmenite ($FeTiO_3$). In bauxites of basaltic origin the titanium has been derived largely from titanaugite and consequently it is widely dispersed and masked by iron. Remnants of ilmenite may be seen occasionally in thin section and in hand specimens taken from low in the profile. Under the microscope alteration of ilmenite to leucoxene is sometimes apparent.

Silica.

In combination with alumina and water, silica is present as clay minerals which have been discussed above.

Free silica may be present as relatively large grains of quartz, which are discernible by the unaided eye, or as a dispersed colloid distributed throughout residual clay. In the former case, of which good examples occur in the Moss Vale area, New South Wales, and on Marchinbar Island, quartz grains have gained access to the bauxite in any of three ways: first, at Moss Vale, quartz grains or groups of grains, which cannot have come from the basaltic parent, form nuclei of pisolites and are apparently derived from soil in which the iron-alumina hydroxides were precipitated to constitute the concretionary zones; secondly in the Northern Territory, the quartz is residual from an arenaceous parent rock and also forms nuclei of pisolites; and thirdly, loose sand, mainly of wind-blown origin, is at present being introduced by way of open joints and crevices to the upper few feet of outcropping bauxite on Marchinbar Island.

Minor Constituents.

Except in a very few instances chemical determinations of minor constituents were not made until the sampling campaign in the eastern States was nearing completion and consequently figures for phosphorus, vanadium, &c., are available for New South Wales and some Northern Territory bauxite only. Generally these determinations were made on composite samples which represented considerable tonnage of bauxite, but phosphorus and vanadium were determined in several individual channel samples from shafts in the Moss Vale area and on Marchinbar Island. Results of these examinations are presented below, and they throw some light on the movement of the minor elements within the profile. Analyses in the first group are averages of channel samples of pisolitic laterite and underlying basaltic clays from Ellsmore deposits, Moss Vale area, New South Wales.

—	Average.	Range
	Per cent.	Per cent.
	Pisolitic Laterite—Seven Samples.	
SiO_2	6.1	3.7 to 10.6
Al_2O_3	38.3	34.7 to 42.1
Fe_2O_3(1)	32.6	28.4 to 37.3
TiO_2	4.7	3.8 to 5.6
P_2O_5	0.19	0.06 to 0.29
V_2O_5	0.053	0.04 to 0.07
Cr_2O_3	0.07	0.04 to 0.08
	Basaltic Clay—Nine Samples.	
SiO_2	31.1	29.4 to 33.0
Al_2O_3	28.8	28.4 to 29.5
Fe_2O_3	22.7	21.1 to 25.5
TiO_2	3.2	2.3 to 4.1
P_2O_5	0.18	0.15 to 0.22
V_2O_5	0.017	0.01 to 0.04
Cr_2O_3	0.07	0.04 to 0.12

(1) Contains FeO up to 2 per cent.

Averaged analyses of composite samples from Wingello deposit, Moss Vale area, show virtually no difference between pisolitic and tubular zones for P, V, and Cr. They are however set out below.

—	Average.	Range.
	Per cent.	Per cent.
PISOLITIC ORE—FIVE COMPOSITE SAMPLES.		
SiO_2	7.1	4.2 to 10.0
Al_2O_3	36.5	33.2 to 40.8
Fe_2O_3(1)	33.1	29.6 to 36.0
TiO_2	3.8	3.7 to 4.3
P_2O_5	0.30	0.09 to 0.46
V_2O_5	0.06	0.04 to 0.07
Cr_2O_3	Trace	Trace to 0.06
MASSIVE TUBULAR AND NODULAR ORE—TEN COMPOSITE SAMPLES.		
SiO_2	4.6	3.4 to 8.9
Al_2O_3	34.4	32.6 to 36.5
Fe_2O_3	34.5	30.8 to 37.9
TiO_2	4.3	3.6 to 5.0
P_2O_5	0.30	0.12 to 0.59
V_2O_5	0.067	0.06 to 0.09
Cr_2O_3	Trace	Trace
MASSIVE FERRUGINOUS ORE—TWO CHANNEL SAMPLES.		
	(a)	(b)
SiO_3	1.3	1.6
Al_2O_3	26.7	22.1
Fe_2O_3	47.1	53.5
TiO_2	7.7	8.7
P_2O_5	0.25	0.31
V_2O_5	0.06	0.07
Cr_2O_3	n.d.	n.d.
SUTTON FOREST, MOSS VALE AREA. HIGH-GRADE BAUXITE UNDERLYING RICHLY FERRUGINOUS CONCRETIONARY ZONES—TWO CHANNEL SAMPLES.		
SiO_3	4.6	3.8
Al_2O_3	55.3	55.3
Fe_2O_3	3.3	4.2
TiO_2	5.8	6.7
P_2O_5	0.06	0.06
V_2O_5	Trace	Trace
Cr_2O_3	Trace	Trace

(1) Contains FeO ranging up to 2 per cent.

(a) Hard ore. (b) Soft clay-like material underlying (a).

No analyses of parent basalt are available for comparison, but at Inverell, where two analyses of basalt gave 0.55 and 0.37 per cent. P_2O_5, trace and 0.01 per cent. V_2O_5, and traces of Cr_2O_3, thirteen composite samples representing more than 4,000,000 tons of low-grade bauxite in Parish's deposit yielded the following figures:—

—	Average.	Range.
	Per cent.	Per cent.
SiO_2	3.4	2.4 to 4.6
Al_2O_3	38.5	37.3 to 40.5
Fe_2O_3	29.4	27.9 to 31.0
TiO_2	5.0	4.3 to 5.5
P_2O_5	0.41	0.28 to 0.53
V_2O_5	0.06	0.04 to 0.08
Cr_2O_3	0.046	0.02 to 0.07
MnO	0.40	0.27 to 0.50
MgO	0.29	0.16 to 0.42
CaO	0.09	0.07 to 0.13

As laterite of basaltic origin results from the elimination of 60 to 65 per cent. of the original rock, partly offset by addition of combined water and oxygen, it will be seen that at Inverell substantial loss of phosphorus has taken place, and at Ellsmore loss of both phosphorus and chromium has occurred during formation of the pisolitic zone.

Two composite samples, composed of siliceous bauxite representing a lower part of the profile at Parish's deposit than the thirteen composite samples mentioned above contained somewhat more chromium but less phosphorus:—

—	Block G (590,000 tons.)	Block M (88,000 tons.)
	Siliceous Bauxite—Two Samples.	
	Per cent.	Per cent.
SiO_2	17.7	9.9
Al_2O_3	30.8	34.9
Fe_2O_3	25.9	28.7
TiO_2	4.3	4.8
P_2O_5	0.36	0.37
V_2O_5	0.06	0.06
Cr_2O_3	0.13	0.09
MgO	1.9	1.1
CaO	1.1	1.1

The manganese content of parental basalt at Inverell is not known but the figures above probably indicate an accumulation of manganese in the laterite. On the other hand the very few complete analyses of Tasmanian bauxite and parental dolerite that are available show a loss of about half of the manganese, as the following figures indicate:—

—	Dolerite.	Doleritic Bauxite.
	Per cent.	Per cent.
MnO	0.07 to 0.17	0.08 to 0.09

No mineral species representative of the minor constituents have been recognized but bluish stains on joint faces of ferruginous laterite have been noted. These stains are probably composed of vivianite, hydrated ferrous phosphate.

AGE.

The question of the ages of Australian mature laterites (including bauxites) is a vexed one which cannot be answered satisfactorily without further investigation. Although the great majority of, if not all, mature laterites may be assigned to the earlier part of the Tertiary Period, there is little direct evidence from which the ages can be determined within narrower limits. In most instances the laterites occupy the present land surface with no overlying younger formations, and where superincumbent beds do exist they do not contain good diagnostic fossils. Parent rocks from which the laterites are derived are commonly igneous and of ages which are still matters of some dispute.

Evidence which bears on the age of lateritization is summarized below in Table 43.

TABLE 43.—STRATIGRAPHY OF AUSTRALIAN MATURE LATERITES AND BAUXITES.

Locality.	Parent Rock		Overlying Beds.	
	Type.	Age.	Formal Name or Type	Age.
		VICTORIA.		
Co. Buln Buln ..	Basalt and tuff ..	Eocene ..	Yallourn Formation; clay, lignite, &c.	Eocene to mid-Miocene
		TASMANIA.		
Ouse	Dolerite ..	Jurassic ..	Derwent beds..	Eocene ?
St. Leonards ..	Dolerite ..	Jurassic ..	Launceston beds	Eocene ?
Campbell Town ..	Basalt	Eocene ? ..	..	..
Myalla	Basalt	Miocene ? ..	..	..
		NEW SOUTH WALES.		
Inverell	Basalt	Lower ? Tertiary	Basalt, lignitic clay, diatomaceous clay	Lower ? Pliocene
Moss Vale ..	Basalt	Lower Tertiary ..	..	..
		QUEENSLAND.		
Tamborine Mountain	Basalt	Lower ? Tertiary	..	..
		WESTERN AUSTRALIA.		
Darling Range, &c.	Granitic and metamorphic	Archaeozoic ..	..	..
	Sediments ..	Tertiary ..	..	..
		NORTHERN TERRITORY.		
Cobourg Peninsula	Shale .. Sandstone ..	Lower Cretaceous	..	..
Margaret Bay ..	Sandy clay ..	Lower Cretaceous	..	..
Wessel Islands ..	Siltstone ..	Proterozoic ..	..	..

Tasmania and Victoria afford good starting points because lateritic bauxites in these States underlie Tertiary formations which have been studied in greater or lesser detail.

The precise ages within the Tertiary Period to which the laterites and covering beds should be assigned have not been determined with accuracy. It is possible that in Victoria the extrusion of the Older Basalts began before the close of the Cretaceous Period and continued into middle Eocene (Keble, 1950, page 30). Until recently it was believed that the Yallourn Formation occupied a position fairly low in the middle Miocene (Singleton, 1941; Crespin, 1943), but further investigation by Miss Crespin, as mentioned earlier in this Bulletin, suggests that coal deposition in the Formation continued from about middle Eocene into the Oligocene Epoch.

These determinations impose fairly narrow upper and lower limits on the age of the bauxite, which accordingly must have developed in middle or lower Eocene time.

In Tasmania the Derwent Lake lignitic beds have been ascribed to the Eocene by analogy with the similar lignites of the Yallourn Formation.

Incidentally, the sequence in Victoria has a parallel in the well-known bauxite deposits of Arkansas, where bauxite derived from Cretaceous nepheline syenite is overlain disconformably by sands, clays, and lignites of the Wilcox (lower Eocene) beds. Where the Arkansas bauxite has been transported and re-deposited it overlies Palaeocene clays and limestone of the Midway Group.

At Moss Vale, New South Wales, the youngest rock overlain by the lateritized basalt is a sandstone containing leaf impressions and woody plant fragments which indicate Tertiary, probably early Tertiary, age (Jaquet, 1901). On this evidence the basalt is not likely to be younger than Oligocene.

At Inverell the parental basalt lies upon carboniferous sediments and again there is no direct evidence of its age. The laterite that is developed on this basalt is directly overlain by younger basalt flows which include thin intercalated lenses of lignitic and sandy clays. A specimen of lignitic clay submitted to Miss Crespin contained diatom fragments and has been tentatively classified as lower Pliocene (private communication). The laterite had been subjected to considerable erosion, and gullies of fairly mature cross-section had been carved into and through the profile before the younger basalts were extruded. It is apparent that the laterite must at least be considerably older than Pliocene.

The bauxite at Tamborine Mountain is derived from lavas which Richards (1916, pages 125 and 131) believes were extruded over a long period of time probably beginning in Lower Cainozoic and concluding in Upper Cainozoic time. Richards implies that the lateritized basalts at Tamborine belong to the top of the sequence and he correlates them with the Plioene basalt at Inverell. The writer was the first to demonstrate two major periods of vulcanicity at Inverell, separated by a considerable time interval, and to show that the lateritized basalt there is much older than Pliocene. Correlation of the lateritized volcanic rocks at Inverell and Tamborine appears reasonably sound and is supported by the wide distribution of similar laterite between the two localities. It therefore appears that the Tamborine basalt originated in fairly early Tertiary time.

Laterite in Western Australia, although commonly developed on Archaeozoic rocks, does occur on Mesozoic and Tertiary sediments according to Matheson (1942). In the Northern Territory the youngest formations known to be lateritized are Cretaceous.

Assignment of an early Tertiary age to many laterites where stratigraphical evidence is lacking, particularly those of southern Queensland, Moss Vale area, and Arnhem Land, gains support from the enormous amount of erosion which has taken place since the breaking up of the laterite surface. Widespread areas have been reduced to relatively small residuals, and the excavation of gorges exceeding 1,000 feet in depth at Tamborine Mountain and Bungonia (Moss Vale) must have occupied a very considerable time.

At the present state of investigation it is profitless to attempt correlation of mature laterites throughout Australia; and, indeed, it is improbable that all developed simultaneously. It is now known that under particularly favorable conditions complete lateritization can and does occur at the present day (*see*, for instance, Appendix III.), and it seems probable that similar conditions arose at various times and places in the past. For example, the gently sloping lava field at Myalla, Tasmania, given adequate rainfall and vegetation, would provide a suitable locus for rapid lateritization, and it is highly probable that the bauxite here is, in fact, younger than Miocene while the other occurrences in the State are much older—probably Eocene.

On the whole, however, the evidence indicates that lateritization became general in Australia early in the Tertiary Period, and recurred from place to place as conditions permitted perhaps into the Pliocene Epoch.

The writer does not know of any locality in Australia where lateritization has proceeded to completion during the Quaternary Period.

The Formation of Laterite and Bauxite.

Theories on the origin of laterite and bauxite have been much influenced by suggestions put forward during last century by European workers who, although probably familiar with the Mediterranean *terra rossa* bauxite, had no first-hand experience of the tropics. It was suggested that thermal waters containing aluminium and iron in solution precipitated these metals as hydroxides on coming into contact with calcareous rocks.

Later workers, notably Harrassowitz and Marbut, who persisted along these lines and issued hypothetical pronouncements based solely on observations made at the laboratory bench, have been strongly castigated by R. L. Pendleton (1941, pp. 65-67) who dubs them "arm-chair travellers" who failed to place the correct interpretation on the data available.

The hypothesis of precipitation from heated waters was, with modification to suit local conditions, applied to other bauxites, notably by C. W. Hayes (1901), who described the Arkansas bauxite, and other American geologists in later years writing of the bauxite deposits of the southern Appalachian region and Alabama (Nelson, 1923; Jones, 1929).

Later observations of the European *terra rossa* bauxites led to the view that the material represents the insoluble residue left by the solution of large volumes of limestone, and that in some instances the residue may have accumulated in a shallow littoral environment (Fox, 1932, pp. ii, 9, 21).

This theory has been modified by Russian geologists who apparently ascribe all bauxite deposits to chemical sedimentation under shallow marine or lacustrine conditions. They suggest that solutions containing iron and aluminium derived from the weathering of various rocks find their way to shallow protected waters where precipitation of the iron and aluminium takes place, largely under the influence of calcareous rocks on the sea or lake floor. The views of several Russian workers, particularly A. D. Arkhangelsky and N. A. Karjavin, are summarized in a publication of the Academy of Science U.S.S.R. (1943).

J. Morrow Campbell (1917), after an exhaustive study of laterites, published a paper which has not received the attention it deserves and which leaves little more to be contributed to the subject. He pointed out that laterite forms in two major zones, the lower where the rock is permanently saturated, and an upper zone of ground-water fluctuation where ferrous iron is oxidized and thrown down. These zones correspond with the zones of leaching and deposition which were postulated by Lacroix in 1913.

The hypotheses of transport followed by chemical precipitation and aqueous sedimentation cannot be applied to any of the Australian laterite and bauxite deposits seen by the writer. There is abundant evidence that the origin of the Australian occurrences must be ascribed to weathering *in situ* with accumulation of the insoluble oxides and hydroxides of the lateritic constituents, principally iron, aluminium, and titanium. Conclusive evidence of the derivation of bauxite by alteration *in situ* of the parent rock is afforded by the persistence of the parental rock texture to high in the profile and, particularly on dolerite in Tasmania, by the preservation of joint planes which, at favorable places, may be traced continuously from the parent rock to the base of the concretionary zone. At Ouse, where lack of exposure in depth prevented observation of the passage of joint planes from bauxite to parent, Gardner noticed a similarity between the joint patterns of both rocks with common orientation of the major joint planes.

Some workers contend on physico-chemical grounds that bauxite (gibbsite) can be formed by direct alteration of primary silicates only and that clay products of sub-aerial weathering are themselves an end product which cannot undergo further alteration and consequently cannot be converted to gibbsite.

The presence of clay minerals of later genesis within the bauxite has encouraged these observers to suggest that all clay associated with a bauxite profile is the product of secondary resilication by silica introduced into the bauxite from above and from the parent rock below. Alternatively the clay zone is supposed to have formed by kaolinization of the fresh rock below the bauxite when changed conditions have brought the formation of bauxite to a stop and initiated kaolinitic weathering.

Without going deeply into the arguments put forward by these workers it is sufficient to point out that their contentions gain some support from the presence in the bauxite of clay of undoubted secondary origin, which has grown at the expense of gibbsite, and from the apparently sharp contact between bauxite and nearly fresh parent rock at some localities.

Dealing with the first point it is worth noting that the secondary clay observed by the writer in Tasmania and Victoria is plainly distinguishable from the floor clay of the clay zone which it may penetrate (*see* Fig. 17).

In Victoria the secondary clay is a white or pale blue, hard, hydrous clay, probably halloysite, which is mainly developed along fractures as veins and irregular masses, while the floor clay is plastic and speckled with the relict texture of the parent.

Regarding the second point it is noteworthy that as a general rule all bauxites are underlain by a zone of residual clay, usually of considerable thickness. Where the clay zone is inconspicuous and bauxite appears to be in immediate contact with unaltered igneous rock, analyses of samples representing thin layers above the parent rock show a transition through kaolin to bauxite. This evidence may not be conclusive, but the development of laterite containing some free alumina on argillaceous shale at Cobourg Peninsula, Northern Territory, and of high-grade bauxite on clay shale at Mount Ejuanema in the Gold Coast colony (Cooper, 1936, p. 17) afford powerful support to this contention. E. C. Harder (1949) and V. A. Eyles (1952, pp. 6, 7) consider that field evidence in Arkansas and Northern Ireland respectively strongly indicates that $Al(OH)_3$ develops from clay minerals which are formed as an intermediate step in the break-down of felspars to aluminium hydroxide.

The following table—44—shows the passage from parent rock to low-grade bauxite in places where the clay zone is poorly developed :—

TABLE 44.—ANALYSES SHOWING PASSAGE TO BAUXITE WHERE CLAY ZONE IS INCONSPICUOUS.

Derivation	Basalt			Dolerite.				
Locality	Inverell, New South Wales.			St. Leonards, Tasmania.				
Number	4F.	6W	8R.	1–1.	1–2.	7–1	7–2.	7–3.
Description	Incipiently weathered shell surrounding kernel of fresh basalt. Hard, with apparently fresh felspars.	Soft weathered basalt from shell surrounding 4F. Felspars dull and opaque.	Soft light-brown rock with granular texture Shell surrounding 6W.	Soft granular bauxite Shell 1½ inches thick in immediate contact with fresh dolerite.	Soft granular bauxite surrounding 1–1.	Shell, 1 inch thick surrounding kernel of fresh dolerite.	Shell, 1½ inches thick surrounding 7–1	Brown granular bauxite surrounding 7–2.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2 ..	45.7	40.6	15.4	9.9	11.6	48.4	24.6	10.0
Al_2O_3 ..	16.6	18.4	25.6	38.2	37.6	22.9	33.0	40.4
Total Fe expressed as Fe_2O_3 ..	10.7	11.0	32.0	24.2	23.5	11.1	19.4	23.5
TiO_2 ..	2.2	3.7	4.8	2.2	1.9	1.4	1.7	2.1
CaO ..	10.5	4.40	1.40	..	..	..	..	..
MgO ..	5.70	4.58	1.84	Pres.	Pres.	1.7	Pres.	..
Na_2O ..	2.72	1.21	0.12	..	..	0.6	..	..
K_2O ..	1.69	2.00	0.64		..	Trace	..	..
P_2O_5 ..	0.45	1.17	0.56		..	0.1	..	..
Ignition loss ..	4.3	12.4	17.6	23.3	22.6	9.7	18.1	24.2
Available Al_2O_3	..	..	10.5	31.6	30.4	..	21.2	37.1

All analyses by R. A. Dunt, except 7–3 which is by W. St. C. Manson

The calculated percentages of aluminium hydroxide and kaolin in samples 8R, 1–1, 1–2, 7–2, and 7–3 are—

Sample.	8R.	1–1.	1–2.	7–2.	7–3.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Free silica	Nil	2.0	3.0	10.6	6.1
Kaolin	33.1	16.9	18.4	29.4	8.2
$Al(OH)_3$	16.0	48.1	46.5	32.4	56.7
$Fe_2O_3.xH_2O$	36.6	28.6	27.4	22.7	27.1

Waters of acidity greater than pH5 may attack aluminous silicate rocks to yield aluminium hydroxide directly. Kaolin, if formed, is decomposed and removed immediately. The author has observed this process in operation recently in tropical rain forest on Manus Island, New Guinea, where, at 5 feet below the surface, an exceedingly fine-grained dacite is undergoing alteration to bauxite with very low silica content. Unfortunately the acidity of the ground water could not be measured, but the abundance of decaying vegetation on the surface and the slight discolouration and foetid odour of the ground water bear ample testimony to its high degree of organic contamination. Pits sunk to a depth of 20 feet at Nabobi, Manus Island, were found, after being unattended for a week, to contain sufficient CO_2 in the bottom 3 or 4 feet to extinguish a kerosene lamp, but the CO_2 dispersed during the one night that was spent in the locality and it is not known whether accumulation of the gas recurred the following day. Analyses of parent dacite and bauxite in immediate contact with the fresh rock are—

—	Dacite.	Bauxite.
	Per cent.	Per cent.
SiO_2	67.31	0.36
Al_2O_3	14.22	56.71
Fe_2O_3	0.90	10.78
FeO	4.68	0.06
TiO_2	0.53	1.09
CaO	4.30	Not detected
MgO	2.55	Not detected
Na_2O	2.70	Not detected
K_2O	2.80	Not detected
H_2O –	Nil	..
H_2O + ...	Nil	31.19
MnO	0.28	0.006
	100.27	100.196

(Analysts—Avery and Anderson.)

The prevalence of laterite and bauxite within the tropics suggests that tropical conditions of weathering are necessary for its formation. Undoubtedly high mean temperatures, copious rainfall, and abundant supply of organic acids from vegetable debris are very important conditions necessary for the development of laterite with sufficient rapidity to ensure its preservation, and its presence well outside the tropics, e.g., in Tasmania, Oregon, Northern Ireland, suggests that warm conditions and dense vegetation may have existed in early Tertiary time at higher latitudes than at the present day.

Gentle topographic relief, which implies sluggish surface and underground drainage, is also a controlling factor in the development of laterite.

The key to an understanding of the process of laterite formation lies in the simple fact that not only alkalis, alkaline earths, and to a greater or lesser degree silica, but also iron and aluminium are soluble in acid ground water, the former, in the absence of oxygen, as ferrous bicarbonate. On dilution of the ground water with oxygen-bearing meteoric water the iron is thrown down as ferric hydroxide and the alumina as hydroxide, either as a gel or crystallizing as gibbsite, and the other constituents remain in solution. The necessary variations in chemical composition of the ground water may be brought about by seasonal fluctuations of rainfall, and, although the importance of the part played by alternating wet and dry seasons and a consequent fluctuation in ground-water level is now somewhat discredited (Prescott and Pendleton, 1952, page 31), the author considers that such changes play a large part in the formation of laterites that possess a pisolitic capping. It is possible that localities with uniformly distributed rainfall do not produce pisolitic laterites.

The process is envisaged as follows:—Reverting to the five zones shown in Table 42 it is believed that the pisolitic zone forms within the range of rise and fall of the water-table and the effect of capillarity. The massive and tubular zone, also a zone of precipitation, forms in permanently or nearly permanently saturated ground where the water still retains available oxygen. The next deeper part—the mottled zone—results from an irregular and impoverished supply of oxygen. Below the mottled zone anaerobic conditions and permanent saturation prevail. It is in this zone that the main leaching takes place. The leaching is somewhat selective: soda and lime are first removed, followed by magnesia, potash, and much of the silica that has been set free by the breakdown of felspars and ferromagnesian silicates.

Silica set free from clay at a later stage is not always removed immediately: in some instances the base of the profile is occupied by clay which contains much more silica than is required to satisfy the kaolin molecule, but generally there is excess of alumina indicating more immediate removal of silica.

That pisolites grow from intermittent supplies of material delivered in solutions of varying strength and composition is evidenced by the following description of the successive shells of a pisolite in bauxite from Marchinbar Island. In section the shells to be described are distinguishable by the unaided eye and have sharp boundaries, but within these boundaries each shell, which appears as a curved band in thin section, contains numerous microscopic bands partly obscured by iron-staining. The pisolite chosen for examination is roughly circular and has a diameter of 7.1 mm. It contains a core 3.5 mm. in diameter surrounded by concentric shells that in thin section were resolved under low magnification into distinct bands ranging in width from 0.01 to 0.40 mm. The core consists of rounded blebs of aggregated gibbsite crystals (replacing quartz) embedded in a matrix of light brown isotropic cliachite. The matrix is traversed by veinlets of gibbsite with maximum width of 0.015 mm. These veinlets connect the blebs of gibbsite with each other and less commonly traverse the banded rim of the pisolite. Proceeding radially outwards from the outer edge of the core the successive bands are described as follows: after the width is given, the colour by reflected light is mentioned, and then the characteristics observed by transmitted light—

1. 0.28 mm.—Reddish-brown; dark brown to opaque with faint banding; isotropic.
2. 0.40 mm.—Cream to pale brown, with irregular reddish-brown streaks; greyish-brown with faint concentric banding; isotropic.
3. 0.10 mm.—Pale reddish-brown; opaque.
4. 0.27 mm.—Deep orange-brown; red brown with grains of gibbsite aggregates similar to replaced grains in the core.
5. 0.10 mm.—Pale brown; greyish-brown; isotropic.
6. 0.10 mm.—As above but slightly darker. Separated from band 5 by a narrow red line almost invisible by transmitted light.
7. 0.01 to 0.05 mm. Faintly visible by reflected light as pale brown stain; dark brown nearly opaque. Pinches and swells regularly in field examined but when followed round pisolite diminishes to an irregularly sinuous hair-line.

8. 0.10 mm.—Cream coloured; light brown with line of dark brown specks along middle of band; isotropic.
9. 0.11 mm.—Reddish-brown; dark brown with irregular dark brown nearly opaque line; contains minute grains of quartz otherwise isotropic.
10. 0.02 mm.—Pale brown; discontinuous dark brown line may be traced around pisolite swelling in one place to band similar to matrix of band 4 and 0.2 mm. wide.
11. 0.12 mm.—Pale brown; brown with spots of darker brown; isotropic.
12. 0.14 mm.—Deep red-brown; dark brown to opaque with narrow sub-translucent streaks.
13. 0.04 mm.—White; white, sub-translucent; isotropic. Similar to the oolitic material which fills space between the pisolites.

It is necessary to postulate a mechanism by which the supply of dissolved material to the growing pisolite may be interrupted from time to time. At first sight seasonal fluctuations of the water table appears to be all that is required, but it may be argued that while addition of vadose water by downward percolation will raise the *level* of the ground water, such additions cannot raise the mineral-bearing water of the previous season but will merely float upon it.

There is, however, some commingling of the waters. At the end of the dry season when the water table has receded to its lowest level the capillary fringe may extend several feet above the ground-water surface (Meinzer, 1923, pages 34-35). This capillary water and pellicular water left behind by the retreating ground water will be charged with dissolved mineral matter (mainly iron) and will become mixed with the fresh supplies of oxygen-bearing vadose water after the onset of the next rainy season. Also, in the following dry period when no further additions are being made to the ground water, the body of water will recede as a whole with comparatively quiescent internal conditions, and it is probable that further mingling of solutions will take place by diffusion. Again, as laterites form most readily in densely vegetated areas with a shallow water table, it is certain that considerable upward flow of ground water and consequent mixing are effected by transpiration. Evolution of CO_2 from organic matter and ferrous bicarbonate might also assist mixing.

Concretionary zones, or particularly pisolitic zones, of a laterite are not limited in thickness to the height of the capillary fringe but rather to the range of water-table fluctuation plus the capillary fringe.

Much re-solution and re-precipitation of alumina takes place. In the zone of leaching, alumina is probably taken into solution as an alkali aluminate and precipitated in the presence of CO_2 without having moved from the lower zones of the profile. In this way complete replacement of felspar laths by aluminium hydroxide takes place. At higher levels alumina is maintained in solution in an acid medium that, under favorable circumstances, is capable of attacking clay minerals. On dilution this alumina is precipitated in the concretionary zones largely as cliachite. Gibbsite in the pisolitic and massive zones is of encrusting habit or fills fine cracks and is clearly of secondary origin.

Iron in the ferrous state is very mobile but it is readily precipitated as ferric hydroxide on contact with oxygen even in fairly acid solutions. Ferric iron is also precipitated by gallic and tannic acids which are extracted from decaying vegetation by rainwater and carried into the ground water.

It has been pointed out that the apparent precipitation of iron and aluminium is brought about by different chemical mechanisms; that of the former by oxidation and that of the latter slowly by dilution of acid solutions and neutralization by CO_2 of alkaline media. It is therefore to be expected that under conditions of changing chemical composition of ground water effected by varying intensity of rainfall either seasonal or at shorter and longer periods, some separation of iron and aluminium will take place. This in fact happens and consequently any agreement between iron/alumina ratios in laterite and parent rock is wholly fortuitous and of no value in relating one to the other, for which purpose other evidence must be sought. Commonly iron segregates in the upper part of the profile where oxidizing conditions are best developed; consequently much of the world's lateritic bauxite is recovered from beneath a strong ferruginous cover. This does not apply to such an extent in Australia where, because of the low standard used, "bauxite" includes pisolitic ore containing 30 per cent. of ferric oxide, or where secondary leaching has removed iron from the concretionary zones. However, the high-grade bauxite at Sutton Forest and lower-quality material at Emmaville and Tamborine Mountain underlie richly ferruginous pisolitic and concretionary laterite. On Marchinbar Island the reverse holds true; pisolitic bauxite containing 50 per cent. alumina and from 7 to 20 per cent. ferric oxide overlies tubular and massive laterite that contains 27 to 54 per cent. ferric oxide. It is apparent that very strongly oxidizing conditions penetrated to an unusual depth, fixing the greater part of the iron before it could migrate to the pisolitic zone with the bulk of the alumina in the rising water table.

Laterite cannot develop to maturity unless certain physical conditions of environment are present. The land surface must be one of subdued or moderate relief and the water table must lie at a shallow depth. The former condition ensures that mechanical erosion of the surface is at a minimum, and shallow depth to the ground-water surface permits access of oxygen. Provided other conditions are very favorable the flat area need not be large; on Manus Island bauxite alteration, par excellence, is taking place within an area of 40 acres flanked by steep-walled gullies.

LATERITE AND PENEPLANATION.

Widespread occurrence of laterite within a region is generally accepted as evidence of peneplanation, but this view is not always correct.

By definition the perfect peneplain is a land surface of extreme maturity, everywhere reduced to base level irrespctive of the type and structure of the underlying rocks. This is a theoretical concept never completely attained in nature; the most senile land surfaces are never devoid of relief and, locally, areas of resistant rock may stand well above the general level. Mechanical erosion is, however, at a minimum, and continued lowering of the surface is effected almost wholly by chemical attack and solution of some of the products of rock decomposition.

Such surfaces, unless developed by denudation of a hard flat bed, present a horizontal geological section and may be composed of rocks of a great diversity of types and ages. If such a land surface be lateritized, the resulting laterite will develop to a greater or lesser degree on all rock types (except perhaps massive quartzite) and its differing origin will be apparent from inherited characteristics. Therefore, if laterite from a region occupied by different rock types is confined to one parent rock only the case for peneplanation is greatly weakened or destroyed.

It is beyond doubt that laterite of the Darling Plateau, Western Australia, and of Arnhem Land, Northern Territory, developed on sensibly flat areas of several thousand square miles, i.e. peneplains. In the latter region the rocks which bear a mantle of derived laterite constitute an impressive catalogue which include, as extremes, Pre-Cambrian phyllite with intrusive granite and Cretaceous unconsolidated sand and clay. On the other hand in Tasmania laterite is restricted to basalt and dolerite and has not been observed on other amenable rocks, such as the Triassic "Felspathic Sandstones" and the Permian mudstones. At Myalla bauxite has developed on the gently sloping surface of a lava field, and at Ouse, where aluminous laterite occurs exclusively on dolerite, it is probable that it developed relatively quickly on the exposed parts of a flat sill from which the cover of Triassic sandstone had been stripped. It is noteworthy that at Ouse sandstone adjacent to, and now at comparable levels with, the bauxite shows no evidence of lateritic alteration. The hypothesis of peneplanation can scarcely account for these facts.

The discussion earlier in this Bulletin regarding the development of laterite on an uneroded lava field near Inverell, New South Wales, applies also to the Moss Vale area, where it is probable however that the basalt was poured out on a surface of low relief which was, in part at least, a structural plain developed on horizontal Triassic strata. Reference to Fig. 4 will show that the laterite bodies at Moss Vale occur in three groups—Ellsmore, Sutton Forest, and Wingello (or four including the isolated occurrence at Freestone Trig) and each group lies on a surface which dips to the south-west, at about 100, 60, and 50 feet per mile respectively. The Sutton Forest group is 3 miles south-east (i.e. along the strike) from Ellsmore but is 150 feet lower. No really useful inference may be drawn from these observations, but it is apparent that the laterite formed on a gently undulating surface with regional fall to the south or south-south-east and that the surviving, and therefore presumably thicker, laterite developed on local south-westerly slopes.

A field occupied by basic or intermediate lavas affords very favorable conditions for rapid lateritization given an appropriate climate. Lava fields possess large areas of moderate to low topographic relief, and are composed of chemically unstable and often porous rocks that contain abundant "lateritic constituents" and alkalis, and little or no free silica, and are, therefore, particularly amenable to rapid lateritization.

FORMATION OF BAUXITE FROM LATERITE BY SECONDARY CHANGES.

As laterite is the end product of a process of leaching and oxidation further chemical alteration cannot take place without a change in external conditions which upsets the equilibrium; and consequently the burial of bauxite beneath a sufficient depth of younger sediments to deny access by oxygen brings about important secondary changes, particularly if the superincumbent formations contain organic matter. The principal secondary changes that take place under cover are removal of iron or addition of silica or both.

Re-silication of bauxite in Tasmania and Victoria has been discussed in a preceding section of this part of the Bulletin and brief mention has also been made of the development of siderite in buried bauxites.

The removal of iron from the normally very ferruginous concretionary zones may proceed to the point where good-quality bauxite is developed from ferruginous ore merely by abstraction of iron. The following analyses of channel samples from shafts at St. Leonards illustrate the removal of iron from the top of the pisolite zone and include an example from the same locality where the laterite has been unaffected by secondary changes.

Depth in Feet.		Description.	SiO_2	Al_2O_3.	Fe_2O_3.	TiO_2	Available Al_2O_3.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		No. 1 DEPOSIT.—SHAFT M.D.1.					
0	1	Soil	..	..	..	..	..
1	5	Dark grey-green clay	..	..	..	..	..
5	6	Pale brown pisolites in grey clay-like matrix	14.5	51.1	4.5	2.9	39.5
6	8	Pale brown pisolites passing to earthy bauxite	2.9	49.0	19.9	2.5	45.9
8	10	Brown earthy bauxite	3.2	43.1	24.9	2.2	41.5
10	12.5	Brown clayey bauxite	11.5	39.2	21.5	2.0	31.2
12.5	15	Soft granular bauxite	8.3	39.3	23.1	1.9	32.4
15	18.25	Soft granular bauxite	11.6	37.6	23.5	1.9	30.4
18.25	23.5	Soft granular bauxite with veins of clay, passing to kaolinized dolerite	..	..	..	..	..
		No. 3 DEPOSIT.—SHAFT 33.					
0	5	Clay, sandy clay	..	..	..	..	..
5	7.5	Clay and quartzite pebbles ..	..	..	..	..	..
7.5	10.5	Dolerite boulders in hard clay ..	..	..	..	..	..
10.5	12.5	Pisolites of earthy bauxite in clay-like matrix	9.9	50.6	9.8	2.4	42.2
12.5	15	Hard ferruginous bauxite passing to soft earthy bauxite	5.6	32.8	39.2	1.6	28.2
15	18	Soft granular (doleritic) bauxite ..	8.7	44.0	20.7	1.7	39.3
18	22	Soft granular (doleritic) bauxite and pale brown clay	11.2	34.9	29.4	1.7	26.1
22	25	Brown granular and compact clay ..	17.7	32.1	28.0	1.8	19.1
25	29.5	Brown granular clay	..	..	..	..	..

Depth in Feet.		Description	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Available Al_2O_3.
From—	To—						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
		No. 3 Deposit.—Shaft 21.					
0	1	Soil	..	..	..	..	..
1	2.5	Grey clay	..	..	..	..	..
2.5	3.5	Brown pisolites					
3.5	4.2	Brown pisolites in grey-green matrix	4.7	35.3	34.3	2.3	33.0
4.2	5.5	Brown pisolites in grey-green matrix with ferruginous concretions ..					
5.5	8	Brown pisolites in dark grey matrix	7.1	34.2	32.9	2.8	28.1
8	11	Brown pisolites passing to brown earth with ferruginous concretions	4.8	32.9	35.2	2.2	29.8
11	14	Friable granular bauxite with few ferruginous concretions at top ..	6.9	38.9	26.7	2.2	33.9
14	17.5	Soft brown granular bauxite ..	12.9	37.8	24.2	1.9	27.1
17.5	20.5	Pale brown clay	..	..	..	..	..
20.5	21	Weathered dolerite	..	..	..	..	..

Commercial bauxites which have developed from more or less ferruginous laterites by secondary reduction and removal of iron are not readily recognizable as laterites. This is especially true if the laterite had not developed a pisolitic capping or had lost it by erosion before burial, as no other structure characteristic of laterite is likely to be preserved. In Victoria, where the origin of the bauxites has been a matter of dispute, the pisolitic zone in a bleached and partly re-silicated form has been preserved at Jeeralang.

The chemical mechanism by which iron is removed from a laterite is relatively simple. Trivalent iron is reduced to the ferrous form, in which state it is extremely mobile either as a hydroxide or bicarbonate. In the absence of free oxygen ferrous hydroxide is not precipitated from solutions with an alkalinity of less than pH 8.1 (Prescott & Pendleton, *op. cit.*). Some of the iron so leached is carried to lower levels of the laterite and precipitated as siderite.

Partial dehydration of gibbsite to yield boehmite has been effected at Parish's deposit, Inverell, near contacts with the overlying Pliocene basalt, but development of boehmite at Napier's No. 1 deposit, South Gippsland, cannot be attributed to thermal effects and presumably is caused by pressure of superimposed sediments.

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APPENDIX I.

MINERAGRAPHIC INVESTIGATIONS OF THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

Report No. 295.

University of Melbourne.
5th November, 1948.

FERRUGINOUS BAUXITE FROM INVERELL, NEW SOUTH WALES.

A series of nine specimens from the ferruginous bauxite deposit on portion 114, Parish of Byron, County of Arrawatta, 10 miles NW. of Inverell, New South Wales, has been submitted by the Australian Aluminium Production Commission for examination with reference to their mineral composition.

The localities from which the specimens were taken are as follows:—

1. Typical outcropping bauxite, from approximately 500′N./1100′W.
2. Sample at 3-ft. depth, from shaft at 200′S./300′W., from near the contact of later basalt.
3. Sample of hard brown bauxite at 6.5-ft. depth, same shaft as No. 2.
4. Sample of softer brown bauxite at 8.5 feet, same shaft as No. 2.
5. Sample of brown bauxite at 11 feet, same shaft as No. 2.
6. Hard lumps from bore core, at depth of 10 to 12.5 feet, in bore at 2600′S./2300′W.
7. Hard lumps from same bore core, at depth of 12.5 to 15 feet.
8. Hard lumps from same bore core at depth of 15 to 17.5 feet.
9. Parent basalt from outcrop at 2200′S./1600′E.

Analyses of the bauxite specimens were provided by Mr. R. A. Dunt, Chief Chemist of the Australian Aluminium Production Commission, and are as follows:—

——	1.	2.	3	4	5	6.	7.	8.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	2.5	23.5	2.9	3.5	3.6	15.4	8.2	6 2
Al_2O_3	44.7	29.9	44.4	39.6	38.5	37.2.	42.2	39 8
Fe_2O_3	23.1	22.1	23.6	28.9	30.3	25.6	28.0	28 5
TiO_2	3.1	5.0	3.1	3.3	2.7	4.7	5.2	4 9
Ignition loss	26.2	18.4	26.0	24.0	23.2	15.3	15.1	20.0
P_2O_5	0.27	0.17	0.18	0.25	0.24	0.28	0.34	0.35
V_2O_5	0.05	0.07	0.05	0.04	0.04	0.07	0.07	0.06
Cr_2O_3	0.04	0.05	0.04	0.04	0.06	0.03	0.05	0.05
	99.96	99.19	100.27	99.63	98.64	98 58	99.16	99.86
Available Al_2O_3 ..	40.5	8.4	40.4	34.0	33.7	16.7	28.1	28.1
Na_2O loss in cwt./ton of Al_2O_3 extracted ..	0.69	..	0.65	1.01	0.77	8.35	2.73	1.71

Examination of thin sections of the specimens reveals that they are derived from olivine-basalt, or related tuffs; and that they consist essentially of gibbsite, cliachite,* limonite, and clay minerals, in varying proportions, with minor amounts of ilmenite, leucoxene and (?) iddingsite (Fe_2O_3. MgO. $3SiO_2$. $4H_2O$).

* The term *Cliachite* is used here in the sense of Rogers and Kerr, *Optical Mineralogy*, McGraw-Hill, 1942, to indicate an amorphous form of hydrated alumina. Much of it is light coloured, when it probably approximates to gibbsite in composition, but some contains a variable proportion of iron oxide and appears brownish or reddish.

It seems likely that there is a complete gradation from alumina-gel to ferric hydrate-gel

The term *Cliachite* is intended to specify the material in which alumina predominates over iron oxide. It corresponds to the "amorphous bauxite" of some authors.

Gibbsite is the main aluminous mineral present. Much of it occurs as microcrystaline grains intermixed with limonite, with the individual crystals not more than 10 to 15 microns across. In places, however, the gibbsite is concentrated into relatively iron-free areas, 2 to 3 mm. across, where it occurs as clusters of spherulites, with individual spherulites up to 0.1 mm. across. It also tends to occur as relatively coarse crystals lining open spaces that are encrusted by the limonite. It is readily distinguished by its low polarization colours, positive interference figure, and small optic axial angle. Its refractive index is about 1.535, and the coarser grains show a prominent cleavage, and in some instances lamellar twinning, with oblique extinction.

It occurs in part as pseudomorphs after felspar laths, and after olivine, the original minerals being replaced by a mosaic of fine crystals of gibbsite. The outline of the original mineral is commonly preserved by a narrow rim of limonite.

The clay, which is presumed to be a kaolin, is not easily recognized in some sections, and is generally a minor constituent, except in Specimen No. 2, in which it comprises the bulk of the rock. In Specimen No. 6, which has a pronounced relict basaltic texture, coupled with high silica and low available alumina, the clay mineral can be observed as occasional patches up to 0.1 mm. across and as innumerable minute greyish particles, a few microns across, dispersed through the areas of fine-grained gibbsite, giving it a dusty appearance. In Specimen No. 8, which has much the same preservation of basaltic texture, the clay is not so readily detected, which conforms with the lower silica and higher though still low available alumina content of this rock. Specimen No. 7 though chemically similar to No. 8, has much less relict texture, and in it the gibbsite tends to occur in clusters of clear spherulites, up to 3.0 mm. across. The original form of the olivine phenocrysts, which were 0.5 to 1.5 mm. across, can still be distinguished, but much of the rock has been converted to cliachite or to areas of reddish brown limonite with cores of cryptocrystalline gibbsite. In No. 5 a clot of clay about 1.0 mm. across occurs as a pseudomorph after a felspar phenocryst. In Nos. 6 and 8 the original ilmenite of the basalt is retained as numerous lath-shaped crystals about 0.2 x 0.02 mm., but in No. 7 a proportion of the ilmenite has been altered to leucoxene. The leucoxene tends to occur partly as distinct grains, and partly as a fine dust dispersed through a cloudy grey area that apparently marks the position of a grain of titaniferous pyroxene.

Cliachite occurs chiefly in the rocks which have lost their original basaltic texture, and tends to be associated with areas of brownish limonite, which may be aluminous, and commonly shows colloform textures. It is more abundant in Specimens 3, 4, and 5 from the shaft than in Specimens 6, 7, and 8 from the bore.

The limonite in the bauxite varies considerably in colour, presumably as a result of varying degrees of hydration. Much of it is reddish-brown to golden-brown and isotropic. Such limonite commonly shows colloform textures, and shrinkage cracks, and is evidently a gel. Some of its shows anomalous polarization colours, indicating dehydration, and crystallization as either geothite or lepidocrocite. The golden-yellow limonite showing these features probably approximates to lepidocrocite; the reddish-brown limonite that is anisotropic approximates to goethite.

The limonite forming the rims of the altered olivine crystals is severely dehydrated. Some of it takes a good polish, and is isotropic. Much of the limonite replacing the olivine phenocrysts, and also the small olivine crystals 0.55 to 0.1 mm. across originally present in the groundmass of the basalt, is pleochroic and anisotropic, and bears considerable resemblance to iddingsite, In some instances it forms the whole of the pseudomorph; in others it occurs as a replacement of a fibrous alteration product (serpentine) that developed in the original olivine along cross fractures. Some of this material has quite high polarization colours, and appears to have a relatively low refractive index, so that it may be iddingsite. However, much of the limonite-gel in the bauxite also has a relatively low refractive index. In view of the fact that iddingsite is known to form as a deuteric mineral, and not as a weathering product of olivine in basalts, it is thought that this mineral is an anisotropic form of limonite, rather than iddingsite; but it must be a hydrated mineral, and it probably contains some magnesium, because an occasional olivine grain retains a residual core of olivine.

Specimen No. 2 differs from the others in the suite in that it appears to consist essentially of clay, with some dispersed microcrystalline gibbsite, and fine-grained quartz through which are scattered occasional sharply defined fragments of bauxite, consisting of gibbsite and limonite, and showing typical relict basaltic texture. The extremely high silica, low total alumina, and very low available alumina correspond well with the mineralogical appearance. The high titania is not readily explicable, however. The titania must occur as finely divided leucoxene, masked by the clay minerals, or absorbed into the clay.

(Sgd.) AUSTIN EDWARDS.

8th November, 1948.

APPENDIX II.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION.

Extracts from

The Petrology of the Bauxite of Tasmania.

By A. B. Edwards.

Mineragraphic Section,
Geology Department,
University of Melbourne.
15th October, 1947.

INTRODUCTION.

The petrological study was made as a supplement to the general survey of the deposits which had been made by H. B. Owen and D. E. Gardner, geologists of the Bureau of Mineral Resources, on behalf of the Australian Aluminium Production Commission during the preceding twelve months. Their investigation involved a geological survey of the bauxite deposits, and their testing by drilling and shaft-sinking, coupled with extensive analysis of the samples obtained. Most of the analysis of the samples were made by Mr. W. St.C. Manson, Chief Chemist and Metallurgist of the Tasmanian Department of Mines, and his staff. Some were made by Mr. R. A. Dunt, Chief Chemist of the Aluminium Commission.

THE DOLERITE.*

Dolerite of Jurassic age is the most widely outcropping igneous rock in Tasmania. It occurs chiefly in the form of flat-lying sills, up to 1,000 feet thick, and of dyke-like intrusions, up to 1 mile across and 6 miles long. The bauxite deposits so far discovered in association with the dolerite occur on the eroded surfaces of sills. The dolerite at the time of intrusion was more or less completely liquid, and had the composition of a saturated or tholeiitic basalt (Table 1, No. 1).

* A. B. Edwards, Differentiation of the Dolerites of Tasmania, *J. Geol.*, 50, 451–480, 579–610, 1942.

The magma underwent differentiation *in situ* after emplacement, giving rise in extreme instances to rocks aproaching andesites in composition. All these rocks consist essentially of basic plagioclase and pyroxenes, and apart from chilled margins, have a coarse to medium-grained, ophitic to sub-ophitic texture. The more acid variations tend to have a duplex texture, in which the sub-ophitic to ophitic texture is associated with patches of finer texture, frequently with radial intergrowths of alkali felspar and minute crystals of pyroxene. The dolerites are readily distinguished in thin section from the Tertiary basalts by their texture and their general lack of olivine phenocrysts.

The range in chemical composition of the dolerites is indicated by Table 1. Analyses Nos. 6 and 7 of dolerites underlying the major deposits at Ouse (No. 2 deposit) and St. Leonards, show that there is no preferred relationship between bauxite and dolerite of a particular composition.

TABLE 1.—COMPOSITION OF SOME TASMANIAN DOLERITES.

—	1	2.	3	4	5.	6.	7.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	52.65	52.49	57.05	54.74	54.04	54.76	53.40
Al_2O_3	16.23	16.44	16.95	19.56	16.78	14.49	14.68
Fe_2O_3 ..	0.51	2.60	0.60	1.27	2.69	2 76	1.04
FeO	8.21	5.30	8.64	8.13	8.29	7 72	8.36
MgO	6 64	6.18	1.77	2.34	3.93	4 85	7.50
CaO	11 34	11.71	8.60	10.98	9.37	8 50	10.40
Na_2O ..	1 58	2.06	2.09	2.15	2.15	1.71	1.77
K_2O	0 90	1.09	1.56	1.47	0.93	1.06	0.77
H_2O+ ..	0.48	0.15	0.12	0.23	1.72	2.64	1.21
H_2O- ..	0 85	1.42	0.24	0.31	0.16	0.72	0.10
CO_2	Nil	..	Nil	Nil	Trace	Trace	Trace
TiO_2	0 58	0.62	0.75	0.66	0.80	0.80	0 63
P_2O_5	0 01	Trace	0.10	0.05	0.11	0.11	0.15
MnO	0.15	Trace	0.10	0.15	0.12	0.17	0.07
	100.13	100.06	100.57	100.04	100.09	100.29	100.08

1. Average composition of undifferentiated Tasmanian dolerite (average of six analyses of chilled margins) (Edwards *J. Geol.*, 1942).
2. Dolerite of Cataract Gorge, Launceston (*idem, ibid.*).
3. Dolerite, summit of Mount Wellington, most differentiated phase in Mount Wellington sill (*idem, ibid.*).
4. Dolerite, summit of Gunning's Sugarloaf, most differentiated phase in Gunning's Sugarloaf dyke-like intrusion (*idem, ibid.*).
5. Dolerite, core of boulder, at west end of Rosedale No. 1 bauxite deposit, Campbell Town District. *Analyst:* W. St. C. Manson.
6. Dolerite, incipiently weathered, top of scarp facing Kenmere Rivulet, west end of Ouse No. 2 bauxite deposit. *Analyst:* W St. C. Manson.
7. Dolerite from core of boulder enclosed in doleritic bauxite. St Leonards No. 7 bauxite deposit *Analyst*. W St. C. Manson.

THE BAUXITE AT OUSE.

The bauxite in the several deposits at Ouse is generally similar in character and invariably hardens on exposure and dehydration. In most of the deposits three distinct horizons can be recognized (except where the upper horizons have been removed by erosion) :—

(1) An upper horizon with a pisolitic or nodular (pseudo-fragmental) texture;

(2) An intermediate horizon of massive, structureless bauxite, generally yellow or brown, in places pink or red;

(3) A lower horizon of massive bauxite, generally yellow, and often finely porous, with a texture suggestive of weathered dolerite.

These three varieties will be referred to below as pisolitic bauxite, earthy bauxite, and doleritic bauxite, respectively. Associated with them are irregular bands, lenses, and veins of clay and ironstone.

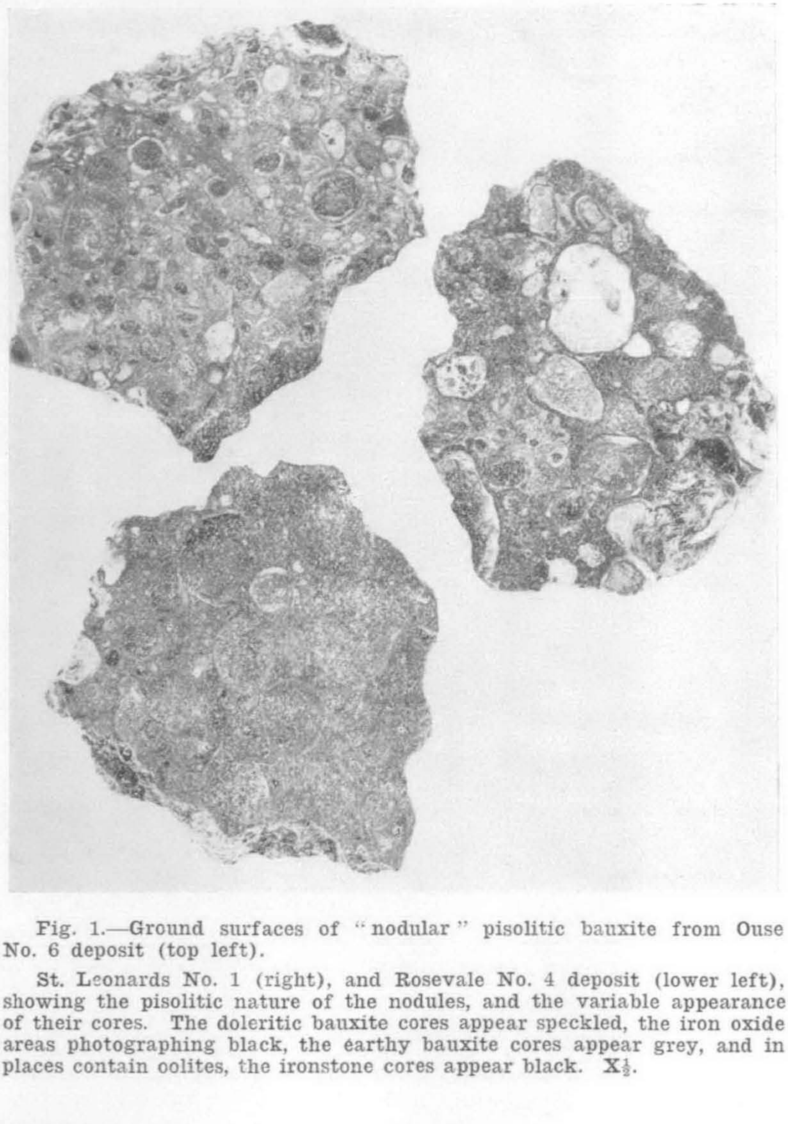

Fig. 1.—Ground surfaces of "nodular" pisolitic bauxite from Ouse No. 6 deposit (top left).

St. Leonards No. 1 (right), and Rosevale No. 4 deposit (lower left), showing the pisolitic nature of the nodules, and the variable appearance of their cores. The doleritic bauxite cores appear speckled, the iron oxide areas photographing black, the earthy bauxite cores appear grey, and in places contain oolites, the ironstone cores appear black. X½.

THIN SECTIONS.

The pisolitic bauxite consists essentially of pisolites and nodules, and in some instances fragments, or even blocks, of doleritic or earthy bauxite, in a dense iron-stained matrix, which is often oolitic. The relative proportion of the pisolites and nodules varies from place to place, even within the same deposit, and the nature of the individual pisolites or nodules varies within the same hand specimen. In general they are ovoid or spherical, though some have irregular or angular shape. They range in size from about 2.0 mm. up to 5.0 cm. in diameter, with occasional fragments or blocks up to 10.0 cm. across. The smaller pisolites consist generally of limonite or aluminous limonite, and may be more or less structureless, or show concentric zoning, in slightly different colours indicating varying alumina and iron content or different degrees of hydration in successive shells.

The larger pisolites or nodules generally have a large core of porous doleritic bauxite, earthy bauxite, or limonite enclosed by several narrow concentric shells of aluminous limonite. The colour of the core ranges from pale pinkish-brown to brown or reddish-brown, according to the amount of iron oxide that has penetrated it prior to the deposition of the enclosing shells, and the porosity of the core varies inversely as the iron content.

Thin sections reveal that the minerals present are gibbsite, cliachite,(1) kaolin, limonite,(2) leucoxene, and magnetite.

In the lighter-coloured cores of doleritic bauxite, the microtexture of the original dolerite is apparent, the outline of many of the coarse stumpy laths of plagioclase being preserved by aggregates of micro-crystalline or crypto-crystalline gibbsite, or less frequently by coarse crystals of gibbsite, up to 0.2 mm. long, showing a characteristic positive, nearly uniaxial, figure and low birefringence. Other felspar areas are outlined by areas of colourless, somewhat cloudy, kaolin, which appears isotropic. The laths are further outlined by staining with golden brown limonite along grain boundaries. The cores are porous, and the numerous cavities are commonly lined with similar limonite, in places showing colloform banding. Irregular, somewhat diffuse areas of dense reddish to brown limonite, commonly enclosing small cubes and octahedra of magnetite, mark the position of the original pyroxene crystals. The margin of such a pisolite or nodule frequently consists of an inner shell of light coloured greenish-yellow or brownish-yellow cliachite, with a fine "crackled" texture, indicative of its gel-origin, enclosed by a shell of buff-brown aluminous limonite, with an outer shell of reddish-brown limonite.

Darker coloured cores of doleritic bauxite preserve the doleritic texture also, but in them there is a sharp contrast between areas of colourless coarse-grained or cryptocrystalline gibbsite, in places ramified by dark films of limonite, and areas of dense limonite. The light yellowish cliachite tends to be absent from such cores.

Cores of earthy bauxite are somewhat less porous, and lack the granular texture of the doleritic bauxite cores, so that they give the impression of being derived from a finer-textured rock. Thin, prominent, isolated patches exhibit doleritic texture. The felspars in these earthy cores are replaced in part by yellowish-brown cliachite, somewhat iron-stained, and in part by cryptocrystalline gibbsite. Where adjacent felspar crystals have been replaced by cliachite of slightly different colour (iron content) and by gibbsite, respectively, with a cement of limonite in the grain boundaries, the appearance of the thin section simulates a micro-breccia. The position of the pyroxene crystals of the original dolerite is indicated by areas of dense brown limonite, which commonly enclose small cubes and octahedra, 0.1 to 0.2 mm. across, of typical magnetite-ilmenite intergrowth, in which the ilmenite is now largely altered to greyish leucoxene. These leucoxene-magnetite lattice intergrowths, with their idiomorphic outlines, are characteristic of most samples of bauxite derived from dolerite, just as the primary magnetite-ilmenite intergrowths are characteristic of the fresh dolerite. In places the enclosing limonite, which ranges in colour from yellow to foxy brown, shows prominent concentric colloform banding.

(1) The term *Cliachite* is used here in the sense of Rogers and Kerr, *Optical Mineralogy*, McGraw-Hill, 1942, to indicate an amorphous form of hydrated alumina. Much of it is light coloured, when it probably approximates to gibbsite in composition, but some contains a variable proportion of iron oxide and appears brownish or reddish.
It seems likely that there is a complete gradation from alumina-gel to ferric-hydrate-gel. The term *Cliachite* is intended to specify the material in which alumina predominates over iron oxide. It corresponds to the "amorphous bauxite" of some authors.

(2) The term limonite covers red, brown, and golden-brown substances, which may include lepidocrocite and goethite. Much of the limonite in the bauxites is probably aluminous, but the ferric hydrate is the predominant constituent.

Some of the cores of earthy bauxite enclose small oolites, many of which are zoned in the manner of those from outcrop at St. Leonards No. 3. Some have a core of brown amorphous material (ferriferous cliachite) with a thin outer shell of lighter colour (cliachite). Others show ill-defined zoning with alternating zones of darker and lighter brown. These oolites are up to 0.5 mm. in diameter.

The most dense cores are composed simply of an aggregate of oolites, ranging in size from 0.05 mm. to 2.0 mm. diameter, cemented together either by limonite or ferriferous cliachite, and enclosed by thin concentric shells of cliachite and limonite. The individual oolites within the cores vary considerably in texture. Some consist of a core of brown limonite, with shrinkage cracks filled with gibbsite, or have a gibbsite crystal as a nucleus, all enclosed by concentric shells of ferriferous cliachite. Some of the larger oolites making up the core are themselves aggregates of smaller oolites. Others again have cores of doleritic bauxite. Yet others have a core of dense blackish-brown limonite, with a rim of cliachite.

The matrix to these varied pisolites is highly oolitic. In some sections it consists of light greenish-yellow cliachite, occurring as small oolites, crowded together, with a cement of limonite. Associated with the oolites are interstitial areas filled with cryptocrystalline gibbsite, or occasionally by large individual crystals of gibbsite. Some of the larger cliachite oolites have the crackled texture observed in larger areas of this substance and some have cores of dark brown limonite. In some instances minute oolites of cliachite occur within such limonite cores, and in others the oolite is composed of a cluster of smaller oolites of varying size in a matrix of similar cliachite, with a thin margin of browner material.

In other sections the highly oolitic matrix is more ferruginous, and the crowded oolites have brown cores with pale rims. The cores of many show shrinkage cracks, now filled with cryptocrystalline gibbsite. In some instances, groups of associated oolites show repeated zoning, the narrow concentric zones being differentiated by slight variations in colour, in pale brown or greenish-yellow. It is thus apparent that the matrices to the pisolites and nodules repeat the textures of the pisolites in miniature.

The most iron-rich pisolites and limonite shells about the nodules tend to be magnetic, and adhere to a small horseshoe magnet. This tendency is stronger in proportion as the material is naturally dehydrated. It indicates that the Fe_2O_3 of the pisolites occurs as the γ form; and in this respect the pisolites resemble the pisolitic limonite of "buckshot" gravel. The buckshot gravel, which is comparably magnetic, is found associated with ironstone "duricrust" and lateritic cappings in Western Australia,[1] and with soils derived from Pliocene or younger basalts in Victoria.

The earthy bauxite owes its distinctive appearance to the presence in it of irregular light-brown or pinkish patches of cryptocrystalline gibbsite, flecked throughout with finely dispersed minute brownish-yellow spots and specks suggestive of gelatinous ferric hydroxide. In many instances these patches show colloform markings, indicating that they represent patches of ferriferous cliachite at an incipient stage of recrystallization, where the recrystallization has not progressed sufficiently to enable the predominant gibbsite to clear itself of iron oxide, as appears to have happened where the crystallization has been more advanced.

(1) J. A. Prescott. The Composition of Some Ironstone Gravels from Australian Soils. *Trans, roy. Soc. S. Aust.*, 58. 10. 1934.

J. A Prescott and A. C. Oertel. A Spectrochemical Examination of some Ironstone Gravels from Australian Soils. *Ibid.*, 68, 173, 1944.

The transition from pisolitic bauxite to earthy bauxite is marked by a sudden increase in the proportion of this incipiently crystallized cliachite, with a corresponding obliteration of other textures. In the extreme, the earthy bauxite consists almost solely of this constituent, but more commonly it is present in shreds and patches from 1 mm. to 5 cm. across, with varying proportions of interstitial material that preserves something of the texture of the underlying doleritic bauxite. The transition to the doleritic bauxite below is marked by a decrease in the proportion of this "earthy" material relative to the interstitial doleritic bauxite.

Scattered through the earthy bauxite are occasional coarse prismatic crystals of gibbsite, up to 0.2 mm. long. They are colourless, with a good cleavage parallel to their length. Some crystals show straight extinction, but an equal number show oblique extinction, with extinction angles up to 40° relative to the cleavage. The gibbsite is further distinguished by its refractive index, which is similar to that of the adjacent microcrystalline gibbsite, and by being optically positive, with a 2V so small that it approximates to a uniaxial figure. The birefringence is about 0.015. In places, clusters of smaller prismatic crystals, up to 0.1 mm. long, but generally smaller, occur in place of the more usual aggregates of microcrystalline gibbsite.

Throughout the earthy bauxite, the characteristic pseudomorphs of leucoxene after idiomorphic crystals of intergrown magnetite and ilmenite blades are present; and even when the alteration to leucoxene has been complete, the lattice texture of the original ex-solution intergrowth can be discerned. In some instances the pseudomorph is an open lattice work, marking only the position of the ilmenite blades of the original intergrowth.

Kaolin is present in this bauxite, but it cannot be identified as such microscopically. Its presence is indicated, however, by the silica content of the bauxite. No quartz has been observed, so that this silica must occur either as finely dispersed amorphous silica, or more probably as a clay mineral. If the combined water content (ignition loss) of the analyses is apportioned to alumina in the proportions required for gibbsite, the excess alumina is generally such as to balance the silica present in the proportions necessary to form kaolin.

The doleritic bauxite (the "granular bauxite" of H. B. Owen) consists in the main of felspar areas replaced by cryptocrystalline or microcrystalline gibbsite, in places showing colloform texture, interspersed with areas containing abundant limonite, commonly with colloform textures, marking the original pyroxene areas. The fresh dolerite at Ouse from immediately below the bauxites shows a duplex texture, found chiefly in the magnesia-impoverished differentiates of dolerite sills, namely patches of coarse sub-ophitically intergrown felspar laths and irregular pyroxene grains, intimately associated with fine-grained patches consisting of fine laths and needles of plagioclase and pyroxene, together with fine granules of iron ore, set in a cloudy base of alkali felspar. The alkali felspar and the pyroxene needles show a tendency to form acicular or radial growths. Both textures are faithfully preserved in the doleritic bauxite near the base of the Ouse deposits.

In other specimens, chiefly those higher in the doleritic bauxite horizon, the details of the texture of the source rock are largely obliterated, and only the areas of distribution of the felspars and pyroxenes are preserved, as areas of microcrystalline gibbsite and areas of dense limonite respectively. In places the forms of the individual felspar laths are outlined by films of limonite occupying original grain boundaries and cleavage planes.

Grains of leocoxene, pseudomorphic after original idiomorphic crystals of ilmenite-magnetite intergrowths, characterise the doleritic bauxite throughout. In those crystals in which alteration to leucoxene is complete, the original lattice intergrowth texture is marked by bars of slightly different colour crossing the pseudomorph.

Kaolin is present in most samples, but is not always easy to detect microscopically. In places, however, it can be distinguished by its clouded appearance in reflected light and its isotropism. It generally occurs as a partial replacement of the felspar, but some kaolin may well be present in the limonitic areas.

If samples of the doleritic bauxite are crushed and digested with sulphuric acid, the residue reveals a minute proportion of fresh felspar in some instances, together with residual kaolin and leucoxene.

Dehydration tests, described in a subsequent section, suggest the presence of some amorphous silica.

St. Leonards Bauxite.

The nine bauxite deposits that have been investigated at St. Leonards, south of Launceston, on the east bank of the North Esk River, have much in common with the Ouse deposits, both as regards the mode of occurrence and the general characters of the bauxites. The largest of them, the No. 1 deposit, forms a narrow terrace trending north-south along the west side of a valley tributary to the North Esk, and has a length of about 3,000 feet. The deposit is flat-lying, and the ends of the deposit follow round the contour for about 1,100 feet at the southern end, and for several hundred feet round the head of the valley at the northern end. The other deposits, which are smaller, are situated at a generally similar level, and their outcrops also tend to follow round the contour, in several instances forming narrow terraces. They give the impression that all are residuals of a much larger sheet-like deposit.

In each instance the bauxites rest directly on a flat-lying surface of dolerite. In places a transition into weathered dolerite is apparent, and in places the characteristic jointing of the dolerite is preserved in the bauxite. In other places there is an abrupt downward change to fresh dolerite. An analysis of dolerite from the No. 7 deposit (Table 1, No. 7) shows that it is a little differentiated, but somewhat basic, phase, with 7.50 per cent. magnesia.

In most of the deposits the bauxite passes beneath Tertiary sands of the Launceston Basin, in which ironstone concretions with poorly preserved leaf remains can be found, and these in turn underlie flat-topped areas of Tertiary olivine basalt, presumably of Pliocene age.

In several of the deposits, and notably in No. 1, the outer edge of the bauxite sheet ends abruptly in a small "cliff" from 3 to 10 feet high, which provides a profile of the deposit. There is in most places a pisolitic to nodular, brown and commonly ferruginous hard capping, several feet thick, grading downwards fairly sharply into a layer of earthy bauxite, often with dispersed pisolites of ironstone through it. Below this is a variable thickness of yellowish bauxite, commonly with speckled appearance from the presence of white stumpy lath-like areas, about 1 mm. long or smaller, and reddish-brown granules of limonite and with a rough finely "pocked" surface, resulting from the leaching out of the cores of many of the iron oxide granules. This lowest zone of bauxite corresponds closely in general appearance with the doleritic bauxite at the base of the Ouse deposits. In a number of places, when followed down to the underlying dolerite it was found to become increasingly doleritic in appearance and composition, and progressively poorer in grade. In a few instances it was found to enclose residual boulders of dolerite.

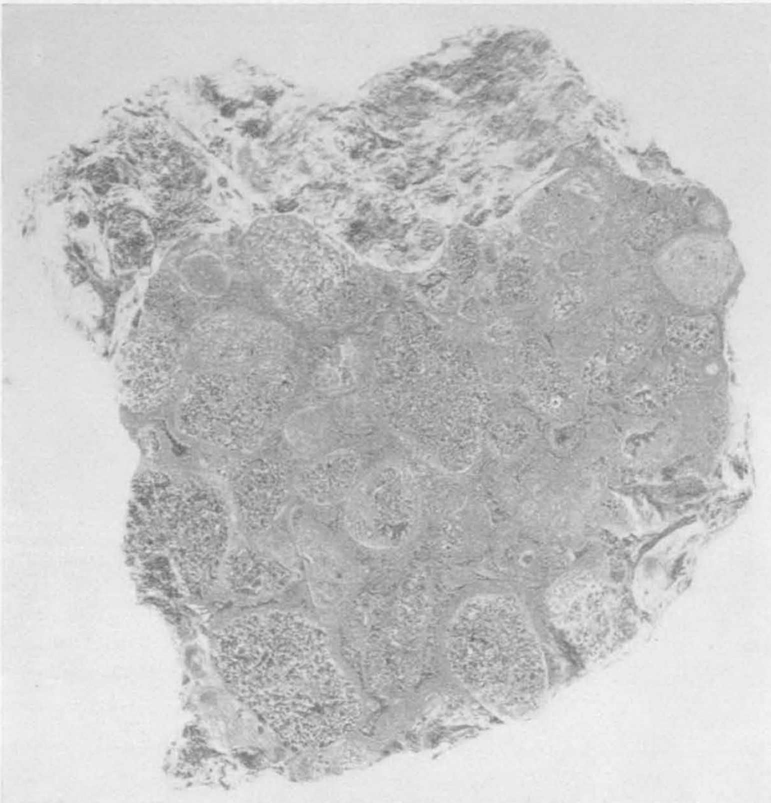

Fig. 2.—"Nodular" pisolitic ferruginous bauxite, upper horizon St. Leonards No. 1 deposit, showing cores of doleritic bauxite, and less commonly of earthy bauxite in nodules with intersecting rims of limonite. X$\frac{3}{4}$.

In many of the bores and shafts the pisolitic upper zone is found to consist of two horizons. The uppermost foot or so consists of ferruginous and aluminous pisolites, with or without nodules of the doleritic bauxite, set in a structureless grey matrix. This grades downwards into a more ferruginous layer which is also more strongly pisolitic or nodular. The grey layer is largely eroded from the outcrops, which consist mostly of highly ferruginous pisolitic and often nodular bauxite, but occasional patches of the grey layer are preserved. The nodules in both horizons consist of a core of doleritic or earthy bauxite, enclosed by several thin concentric shells of limonite and cliachite, so that the nodules can be regarded simply as pisolites with unusually large nuclei.

The *earthy bauxite* occasionally consists of massive structureless material, either creamy, pinkish or yellow in colour, when it is relatively rich in alumina (50 per cent. or more Al_2O_3) compared with the remainder of the bauxite, except some of the grey pisolitic capping. More commonly, however, the amorphous alumina that gives this layer its earthy appearance is irregularly distributed throughout the "earthy" layer, and there is a sensible transition upwards into the pisolitic layer and downwards into the layer of doleritic bauxite. In many bores it is not greatly different in composition from the pisolitic horizon above, but in as many others it contains upwards of 5 per cent. more alumina than the pisolitic bauxite, and correspondingly less ferric oxide. The silica content tends to be rather higher than in the ferruginous pisolitic zone, and approximates to that of the grey pisolitic zone, except that, in general, the higher the alumina content the lower the silica content, which does not apply in the grey pisolitic bauxite. Correspondingly the available alumina in the earthy bauxite tends to be higher than in the pisolitic capping.

The transition to the *doleritic bauxite* is marked by a decrease in alumina content, without much change in ferric oxide content, and a notable rise in silica content marking a considerable increase in the proportion of kaolin in the bauxite. With this goes a decrease in the proportion of the available alumina, and, as the silica content rises, a decrease in ignition loss, corresponding to a reduction in the amount of gibbsite and cliachite present. The doleritic bauxite, though it closely resembles the doleritic bauxite at Ouse in appearance, has a distinctly lower ferric oxide content, the ratio of Al_2O_3/Fe_2O_3 tending to be 3 : 2 for the St. Leonards doleritic bauxite, as against 3 : 3 for the Ouse doleritic bauxite. In this respect the St. Leonards doleritic bauxite parallels the unweathered dolerite from which it is derived (Table 1, No. 7).

THIN SECTIONS.

The *grey alumina-rich pisolitic bauxite* that caps the pisolitic layer in the St. Leonards deposits consists largely of repeatedly zoned oolites of cliachite, from 0.05 mm. to 0.2 mm. in diameter, embedded in a matrix of cliachite or in limonite. The patches with the oolites embedded in limonite are isolated through the specimen, and have a "truncated" appearance, suggesting that they are isolated residuals, and that an original limonitic cement is being leached out and replaced by cliachite.

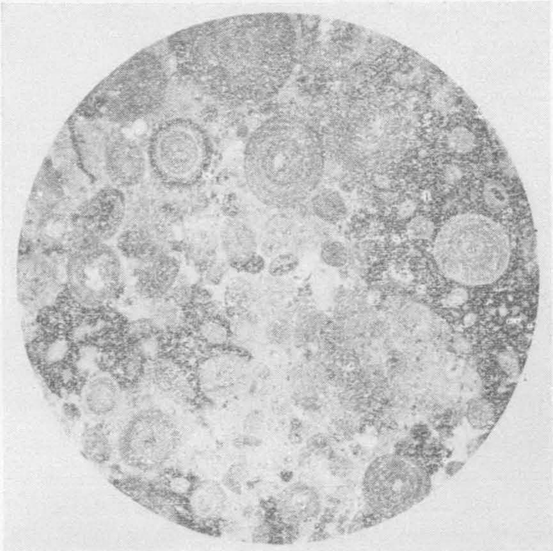

Fig. 3.—Grey pisolitic bauxite from outcrop, St. Leonards No. 3 deposit, showing cliachite oolites in a base of cliachite (grey) and limonite (black). The areas of limonite cement are thought to be residuals of more extensive limonitic cement. X 22.

Occasional grains of gibbsite are present, in places as the nucleus of an oolite, and small pseudormorphs of leucoxene occur from place to place in the sections. In addition to the oolites, there are occasional " nodules ", composed essentially of aggregates of microcrystalline gibbsite and patches of reddish-brown limonite. which in places preserve a suggestion of doleritic texture.

The *ferruginous pisolitic bauxite* differs but little from the pisolitic bauxite at Ouse, except that in places, as at the north end of the No. 1 deposit, large nodules up to 3.0 cm. diameter are crowded together, separated by little more than a skin of limonite, about 2.0 mm. thick, that encloses them. At other localities nodules are few, and pisolites up to 1 cm. diameter prevail. Thin sections of the nodules show that they are derived from dolerite, and preserve the texture of the source rocks in the same way as in the Ouse nodules. They tend, however, to be more strongly impregnated with limonite. There is commonly a sharp demarcation between the clear areas of microcrystalline gibbsite that outline the felspar areas, and the dense reddish to black limonite outlining the pyroxene areas. Leucoxene pseudomorphs are dispersed through the limonite. In some sections the limonite areas have a dark opaque core surrounded by reddish-brown translucent limonite, and the lath-like shape of the original felspar crystals is sometimes apparent in these translucent areas.

The gibbsite mostly occurs as aggregates of microcrystalline crystals, but occasionally it has crystallized more coarsely in clusters of minute prisms. An occasional nodule contains an abundance of a pleochroic green mineral, which closely resembles chlorite, and occurs as clusters of minute crystals, commonly on the fringe of limonitic areas.

The matrix to the pisolites and nodules, as in the Ouse bauxites, consists of minute oolites set in a dense structureless matrix. Associated with the oolites are occasional relatively large crystals of gibbsite, and grains of magnetite or leucoxene. The oolites are generally strongly zoned, and both they and the matrix tend to be reddish-brown, in contrast with the pale colour of the cliachite oolites in the grey pisolitic bauxite, and the pale brownish-yellow to greenish-yellow oolites that form the base of the Ouse pisolitic bauxite. This difference is in keeping with the rather more ferruginous character of much of the St. Leonards bauxite.

The *earthy bauxite* at St. Leonards is markedly softer than the ferruginous pisolitic bauxite, but does not differ essentially from the earthy bauxite at Ouse. In places it forms seams up to 12 inches thick of massive material devoid of texture, both in hand specimen and thin section, associated with doleritic bauxite and these bands are in places rich in clay minerals, as indicated by a high silica content (up to 20 per cent. SiO_2). More commonly it consists of irregular patches of cliachite or incipiently crystallized gibbsite, some of which show colloform banding distributed through a matrix of doleritic bauxite. In places such earthy bauxite has the appearance of a fragmental rock; in others, where the patches are smaller, it has something of the appearance of an altered porphyry. Where the cliachite areas tend to have a parallel elongation, parallel to jointing or the like, an appearance suggestive of bedding is given.

The *doleritic bauxite* also bears a general resemblance in thin section to that of the Ouse deposits, but in some specimens which represent a passage from bauxite to weathered dolerite, there is an abundance of yellowish-green chlorite intergrown with, and fringing, the areas of dull brown limonite that mark the original pyroxene grains. This chlorite closely resembles that found occasionally in the cores of nodules in the pisolitic zone. Some specimens of the doleritic bauxite contain coarse crystals of gibbsite, up to 0.3 mm. across, sporadically distributed through them. Characteristic grains of magnetite-ilmenite intergrowth, commonly only slightly altered to leucoxene, are present in most sections.

CONNAUGHT CRESCENT, LAUNCESTON.

A bauxite deposit is exposed in a road cutting in Connaught crescent. This lies directly on dolerite, near the margin of an old valley in the dolerite. It is pisolitic in its upper few feet, with well defined nodules and blocks of bauxitized dolerite that preserve the texture of the original rock. The pisolitic bauxite shows downward passage through irregularly distributed seams and lenses of earthy bauxite, into doleritic bauxite. Thin sections reveal that the iron oxide areas in some of the doleritic bauxite have a pronounced tendency to collect into limonite oolites, presumably representing an early stage in the formation of a pisolitic horizon. It also contains beautiful leucoxene pseudomorphs after magnetite-ilmenite lattice intergrowths.

THE BASALTS.

The Tertiary olivine-basalts are the second most widespread of the outcropping igneous rocks of Tasmania. Some were extruded in the middle or early Tertiary,[1] but most of the flows now exposed are of Pliocene or younger age. They occur as flat-lying lava flows, up to 100 feet thick, which in some areas are restricted to valleys which they failed to fill, whereas in other areas they overflowed the pre-basaltic valleys and formed wide lava plains. In some areas only a single lava flow is present, but in others as many as three separate flows are superimposed one on the other, with or without intercalated tuff and ash beds, or interbasaltic sands. In some areas, as near Campbell Town and Fordon, the points of eruption from which the basalts issued are preserved in some degree. In other areas, the basalts have undergone severe erosion, and occur only as flat-topped residuals, perched above the level of the surrounding country, as at Ouse.

The rocks are all undersaturated olivine basalts or their basic differentiates, such as limburgites, basanites or olivine nephelinites.[2] They are distinct from the dolerites both in chemical composition—as may be seen by comparing Table 2, which contains the available analyses of Tasmanian basalts, with Table 1, showing the composition of the dolerites—and in texture. The basalts have a fine intergranular to intersertal texture with abundant olivine phenocrysts, which permits ready distinction from the coarser-grained dolerites in which olivine is a most unusual mineral.

THE RICCARTON DEPOSITS, NEAR CAMPBELL TOWN.

The several Riccarton deposits lie east of Campbell Town, immediately to the east and north of the town boundary. They occur as cappings at intervals along a low nearly flat-topped ridge that slopes gently to the west, and several smaller deposits cap adjoining hills, all the bauxite deposits being at about the same absolute level. The main deposits (Nos. 13, 14, and 15) are thickest along the eastern edge of the ridge, where they stand up as low walls, three to ten feet high.

The bauxites are resting directly on the residuals of the basalt flow or tuff bed that formed an interfluve of the former Elizabeth Creek, and the sands simply abut this ridge and the bauxite. The bauxite deposits are isolated residuals on the surface of this now largely eroded basalt flow. The small deposits of bauxite on the low hills between the main ridge and Campbell Town lie directly upon little-decomposed basalt, or upon thin reddish clays, interpreted as ash beds, which overlie the basalt, without any intervening sands.

(1) P. B. Nye and F. Blake. Geology and Mineral Resources of Tasmania, *Bull. geol. Surv. Tasm.*, No. 44, 1938
(2) Edwards, A. B. The petrology of the Cainozoic basaltic rocks of Tasmania. *Proc. roy. Soc. Vict.*, N.S. 62 (1950), 97–120.

TABLE 2.—COMPOSITION OF TASMANIAN BASALTS.

——	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
SiO_2	39.12	42.44	45.59	46.64	44.12	45.44	43.76	44.48	43.68	51.48
Al_2O_3 ..	10.29	10.24	12.48	13.22	13.94	14.52	13.55	20.60	21.18	14.32
Fe_2O_3 ..	6.03	4.38	9.93	9.81	2.60	1.27	3.90	5.98	1.42	2.17
FeO	8.44	8.79	2.84	4.16	8.98	10.68	7.20	7.38	11.35	8.98
MgO ..	14.03	14.25	4.71	7.01	11.43	11.12	10.24	3.76	3.90	8.02
CaO	10.40	7.75	8.26	7.33	9.40	8.23	8.28	8.10	8.85	8.33
Na_2O ..	3.33	4.18	5.51	4.11	2.83	2.95	1.70	2.67	2.51	2.48
K_2O ..	1.23	1.83	3.16	1.35	1.99*	1.14	0.47	2.01	1.71	0.61
H_2O ..	0.88	0.18	1.64	0.52	0.10	0.32	6.68	} 1.56	1.70	0.58
H_2O- ..	2.46	1.32	1.73	2.14	1.94	2.62	2.06			1.54
CO_2	Trace	0.26	Nil	Trace	Trace	Trace	Trace	..	..	0.05
TiO_2 ..	2.73	2.50	2.10	2.50	2.30	1.83	1.63	1.80	1.80	1.45
P_2O_5 ..	1.25	1.61	1.65	1.00	0.55	0.40	0.35	0.51	0.44	0.21
MnO ..	0.18	0.18	0.16	0.19	0.14	0.14	0.12	0.91	2.04	0.14
Cl	Nil	Nil	0.16	Trace	Nil	Nil	Trace	..	..	Nil
SO_3	Trace	Trace	..	Nil	Nil	Nil	0.15	..	..	Nil
	100.37	100.01	100.06*	99.98	100.32	100.56	100.09	99.76	100.68	100.16

* ZrO_2 nil, Cr_2O_3 nil, BaO 0.05.

1. Olivine nephelinite, top flow, Derby (No. 18).
2. Limburgite, Llewellyn, 8 m.W. of Avoca (No. 23).
3. Nepheline basanite, One Tree Point, Sandy Bay. (Iddingsitized) (Aurousseau, *Proc. Linn. Soc. N.S.W.*, 51,615, 1926).
4. Iddingsite basalt, between Rokeby and Bellerive (No. 45).
5. Titanaugite basalt, coarse phenocrysts, point of eruption east of Emu Bay railway line, just north of Hampshire (No. 119).
6. Olivine-titanaugite basalt, cutting above Burnie Park, Burnie (No. 117).
7. Olivine-titanaugite basalt (incipiently weathered), road cutting, sharp bend on main road, midway between Deloraine and Elizabeth-town.
8. Olivine-titanaugite-felspar basalt, Myrtle Hill, Smithton, bottom of third flow, S.129 (No. 81).
9. Olivine-titanaugite-felspar basalt, Lileah, top of third flow. S.142 (No. 83).
10. Glassy olivine basalt, Ouse (No. 15).

In these deposits the upper three to five feet consists of hard ferruginous pisolitic bauxite, with iron oxide in excess of alumina. In places it contains numerous fragments or nodules of bauxitized basalt, and this emphasizes its general resemblance to the pisolitic cappings that characterize so many of the deposits associated with dolerite.

Underlying the pisolitic capping is a comparable thickness of softer, less ferruginous, sometimes grey, bauxite, with a higher alumina content. This contains scattered pisolites, but approximates in many respects to the earthy bauxite of the doleritic areas. Nothing comparable with the doleritic bauxite was observed in the base of the " cliff " outcrops or in the material from shafts.

At the southern end of the main line of deposits the bauxite is highly ferruginous, with seams of non-magnetic lustrous blackish-brown limonite traversing it, presumably along old joints, which in places are coated with films of blue vivianite.

Thin sections reveal that the abundant pisolites of ironstone in the hard cap rock average between 1 and 3 mm. diameter, and are generally zoned, with a black opaque core that is traversed by cracks infilled with a brown limonitic material similar to that forming the narrow concentric shells that enclose the core. These pisolites are strongly magnetic. The matrix enclosing them consists of crowded minute oolites of brown limonite set in a porous base of yellow to yellow-brown cliachite and gibbsite. The gibbsite occurs chiefly as thin encrustations coating the pore spaces. The general texture is much like that as found at Trevallyn. In one section the magnetic pisolites are set in a matrix of opaque brownish-grey substance. The many pore spaces are lined with coarsely microcrystalline gibbsite, and more or less completely filled with a brownish-yellow gel—presumably a ferriferous cliachite—with prominent colloform handling.

The nodules in the pisolitic ore commonly consist of ironstone, and appear structureless, except for small irregular patches where aggregates of micro-crystalline gibbsite preserve the outlines of felspar laths arranged as in a basalt. Some nodules, however, are less ferruginous, and have a well preserved basaltic texture.

The softer greyish bauxite below the pisolitic capping appears in thin section as angular fragments of opaque yellowish-grey cliachite, with prominent shrinkage cracks, cemented together by a brown opaque substance. There are also present occasional areas of limonite, some of which show a suggestion of relict basaltic texture. Films of micro-crystalline gibbsite occur filling cracks in the fragments, and encrusting open pore spaces.

A specimen from No. 13 deposit, with the appearance in the hand specimen of tuff, consisting of greyish fragments in an ironstone matrix, appears in thin section as patches of opaque grey cliachite in a yellowish cement. Some ironstone fragments are present, ramified by fractures filled with gibbsite or cliachite, but none of the fragments shows basaltic textures. The ironstone fragments bear a general resemblance to the altered band of red ash at the base of the No. 12 deposit.

A noteworthy feature of all the sections examined is the complete absence of the coarse grains of leucoxene with triangular lattice pattern that characterize the bauxites associated with dolerite. The titania in these bauxites occurs, presumably, as leucoxene too finely divided to be detected. In bauxite showing basaltic texture it appears to occur largely as small black laths with the form of the ilmenite laths that characterize the adjacent basalts.

Campbell Town Deposits.

Two small deposits of bauxite outcrop to the east of the railway, along the road leading out to the Riccarton deposits from the northern end of Campbell Town. One (Campbell Town No. 1) consists of an exposure in a shallow road cutting of white to bluish material, ramified by thin veins of limonite. A thin section indicates that the bluish-white material is colourless cliachite, showing incipient crystallization. In several places in the slide small areas of basaltic texture are apparent from yellow staining in the cliachite.

The second deposit (Campbell Town No. 2) occurs on the top of the hill to the east of the first. It consists of massive brownish to ferruginous bauxite, which in thin section shows prominent relict basaltic texture, and appears to be derived from massive basalt.

Rosedale-Meadowbank Deposits, Campbell Town.

A group of eight low-grade deposits of ferruginous bauxite (laterite) occurs in the Rosedale and Meadowbank Estates, to the north-west of Campbell Town. The deposits occur as cappings along a long ridge of basalt and basaltic tuff that overlies dolerite. The tuff is best exposed at the northern ends of the No. 1 and No. 3 deposits on Rosedale Estate. The sequence exposed at these localities is as follows:—

5. Ferruginous bauxite (laterite) and bauxitized tuff with boulders up to 2 feet across. Thickness 3 to 5 feet.

4. Fragmental tuff and scoriaceous basalt, 3 feet.

3. Yellow clayey volcanic ash, with abundant fragments of basalt, up to 20 feet thick.

2. Finely bedded bright red ash beds, without fragments, up to 10 feet thick.

1. Deeply weathered dolerite, with isolated cores of fresh rock, surrounded by concentric shells of weathered rock.

The bauxite immediately overlying the fragmental tuff and scoriaceous basalt gives the impression that it is derived from this material, and much of the texture of the original rock is preserved. At a somewhat higher level in the bauxite the texture of the original rock is almost completely destroyed, except that in places there are numerous bauxitized fragments that resemble altered basalt. There is very little development of pisolitic bauxite, and that only locally.

In thin section the bauxite is so impregnated with limonite as commonly to appear structureless, but occasional sections reveal the basaltic origin of the bauxite by the presence of fine residual needles or laths of ilmenite dispersed through the ironstone as in the adjacent olivine basalts. In places, with intense lumination, traces of the felspar laths of the basalt can be discerned sufficiently well to place beyond doubt the basaltic nature of the parent rock.

A section from an outcrop in the Meadowbank Estate shows a well-preserved asaltic texture, with the felspars, now altered to aggregates of micro-crystalline gibbsite, embedded in or outlined by reddish-brown limonite.

Myalla Deposits, near Wynyard.

Several small deposits of bauxite occur near Myalla, west of Wynyard, close to the Sisters Range. The two main deposits are known as Wells deposit, and Bramich and Dowling's deposit. The Wells deposit occurs as the capping to a small hill on the basalt ridge west of the Myalla road, after its turn-off from the main Wynyard-Smithton road. It had been penetrated by two shafts. No. 1 shaft exposed a thickness of basaltic-looking material, traversed by irregular veinlets of gibbsite, from ½ inch to 1 inch thick; and with blebs of gibbsite dispersed through the rock as a whole. Some of the rock showed a structure suggestive of spheroidal weathering, with veinlets or seams of gibbsite in the joint planes. At the bottom of the shaft the basalt appears to give way to sand, and there is a marked rise in silica content of the analyses.

The No. 2 shaft passed through 5 feet of basaltic soil and pebbles at the surface, and beneath this encountered a tuffaceous-looking material with rounded fragments of altered basalt and gibbsite. Specimens on the dump indicate that underlying this material there are quartz sands.

The deposits lie at the top of a hill which is well above the level of the surrounding basalts, and the impression was gained that it represented the altered remnant of either a higher flow of basalt, or more probably of basaltic tuff overlying interbasaltic sands, the bulk of which had now been eroded.

Bramich and Dowling's deposit also occurs on the top of a basaltic hill, almost north of the road junction of the Myalla road with the main Wynyard-Smithton road. Highly decomposed basalt is exposed in road cuttings at the road junction. Floaters of fresh basalt and of bauxite were strewn over the top of the hill, and the bauxite appears from thin sections to be largely derived from massive basalt rather than from fragmental material. The thickness and grade of the bauxite are both uneven. The bauxite contains numerous nodules of altered basalt with spheroidal weathering shells that closely resemble the weathered basalt at the cross-roads.

THIN SECTION (MYALLA).

Thin sections reveal that the Wells deposit was formed, at least, in part, from basaltic tuff. A sample of the greenish-grey fragmental-looking bauxite, containing isolated rounded pebbles about 5 cm. across, near the base of the No. 2 shaft, was found to consist of rounded and sub-angular grains of reef quartz, up to 2 mm. across, and angular fragments of bauxitized olivine basalt, together with irregular areas of structureless or incipiently crystallized cliachite, in a matrix of structureless cliachite. At least two varieties of bauxitized basalt fragments are present. Some fragments have a medium-grained intergranular texture, comparable with that of the basalt outcropping in the vicinity, others have a much finer texture, and are speckled with minute granules of magnetite, so that they resemble a rapidly chilled basalt. The irregular areas or "fragments" of cliachite appear in some instances to have replaced a fine-grained rock. Some of the patches have a cloudy, kaolinized look, others show a suggestion of former bedding.

The pebbles consist of bauxitized olivine basalt of medium grain size, in which the texture of the original basalt is faithfully preserved. The felspar laths have been converted to mosaics of microcrystalline gibbsite. Iron oxide (limonite) pervades the whole rock along cracks and cleavages, outlining the grain boundaries, and tends to form pseudomorphs often hollow, after the original pyroxene and the olivine phenocrysts. The characteristic lath-like rods of ilmenite of the basalt remain unaltered.

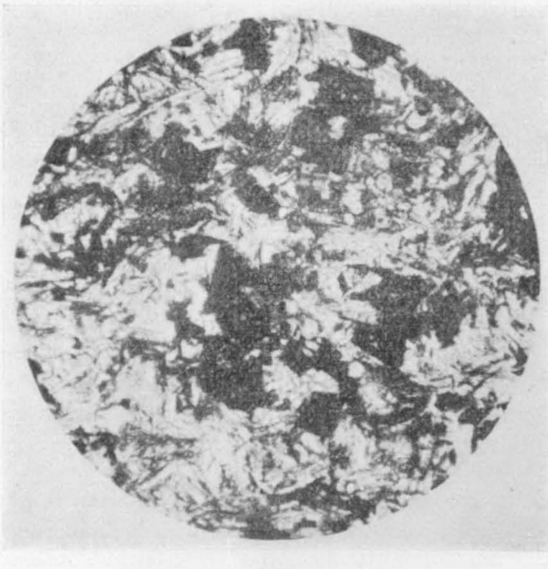

Fig. 4.—Typical field view of olivine basalt, Myalla. Nicols half crossed, X22, showing felspar laths, pyroxene phenocrysts (grey), olivine phenocrysts (white), and iron ore laths (black).

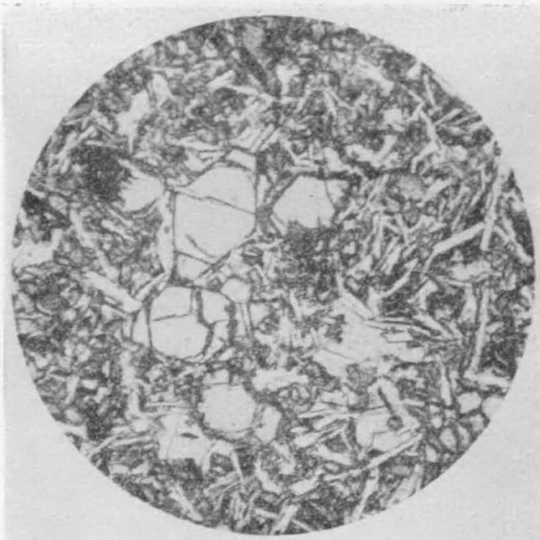

Fig. 5.—Typical field of view of bauxite derived from olivine basalt, Myalla. (Wells deposit No. 1 shaft.) Ordinary light X22. Gibbsite (white) preserving outline of felspar laths, limonite (black) phenocrysts and pyroxene.

A specimen from near the surface in No. 2 shaft consists of fragments of bauxitized olivine basalt up to 1 cm. across, with occasional small grains of quartz, set in an abundant base of yellow cliachite, showing characteristic shrinkage cracks.

A section of a hard porous creamy nodule in the red and green clay at mid depth was found to consist of completely bauxitized olivine basalt, with well preserved porphyritic texture. The olivine and pyroxenes are preserved as limonite pseudomorphs, with some gibbsite, the felspars as microcrystalline gibbsite pseudomorphs. Only the lath-like ilmenite crystals of the original basalt remain unchanged. Nodules of this character contain about 53 per cent. alumina.

At the No. 1 shaft the bauxite appears to be derived from massive basalt rather than from basaltic tuff. It is richer in iron, and much browner, than the light coloured bauxite of the No. 2 shaft. Thin sections of the hard seams and of the irregular "pebbles" of hard bauxite in the softer earthy bauxite, show them to consist of gibbsite and finely dispersed limonite, in which the texture of the original olivine basalt is preserved in detail. The limonite forms pseudomorphs after the olivine phenocrysts and the pyroxene grains, and aggregates of microcrystalline gibbsite form pseudomorphs after the felspar laths. The predominantly rod-like crystals of iron ore (ilmenite) are scarcely altered.

Irregular veins of a creamy to yellow substance up to an inch thick traverse the bauxite, filling joints and fractures. Thin sections reveal that they consist of cryptocrystalline gibbsite, and some specimens show prominent colloform markings, which correspond to zonal alterations in iron oxide content in the original gel. Cavities and early-formed shrinkage cracks are lined with concentric colloform bands of microcrystalline gibbsite in columnar growths. Later fractures are cemented with limonite.

Bramich and Dowling's bauxite deposit shows similar features under the microscope. Specimens from near the margin of the deposit appear as little altered basalt, except that the felspar is completely replaced by gibbsite, and the ferromagnesians by varying proportions of chloritic material and limonite. Other specimens consist of cryptocrystalline gibbsite with numerous minute angular fragments of limonitic material dispersed through it, but no trace of basaltic texture. They are possibly derived from basaltic ash. Yet another specimen consists of angular fragments of intensely bauxitized basalt, together with fragments of structureless cliachite, cemented together by coarsely crystalline gibbsite, occurring as encrustations up to 0.2 mm. thick, of columnar crystals, grown at right angles to the encrusted surface. This specimen presents the coarsest crystals of gibbsite encountered.

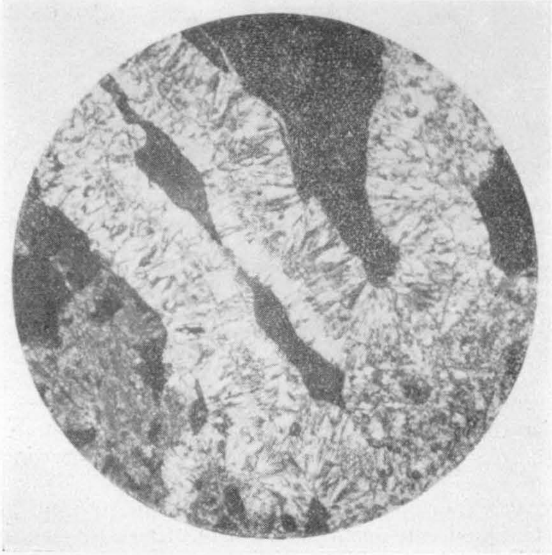

Fig. 6.—Coarse encrustations of gibbsite cementing together fragments of bauxitized olivine basalt. Bramich and Dowling's Deposit—Myalla. X22.

Yet another specimen consists of fragments of massive blue-grey to brownish cliachite, showing incipient crystallization to gibbsite, and stained by limonite along fractures and shrinkage cracks. The cliachite is studded with minute granules of (?) magnetite and occasional needles of ilmenite, some of which show partial alteration to leucoxene. These iron ore grains are much finer than those normal to the basalt, giving the impression that the original rock was a basaltic ash, or glassy basalt.

APPENDIX III.

Bauxite on Manus Island, Territory of Papua and New Guinea.

Summary.

Bauxite was found on Manus Island in 1952 by J. E. Thompson, Senior Resident Geologist, Territory of Papua and New Guinea, at three separate localities.

At Lepatuan a dacite flow overlies bedded tuffs and both have been bauxitized. The former parent rock yields a porous granular bauxite containing about 1 per cent silica, 55 per cent. alumina, 10-13 per cent. ferric oxide and 1 per cent titania. Bauxite developed on the tuffs is nodular in character, and consists of gibbsite nodules embedded in soft clay-like bauxite. The composition of one sample of this bauxite is 11.7 per cent. silica, 51 per cent alumina, 10.8 per cent. ferric oxide and 1 per cent. titania.

The bauxite is forming at the present day by direct alteration of the dacite without an intervening clay zone, but the tuffs are kaolinized in the first stage of alteration. It is of high significance that bauxite can develop on small flat elevated areas (50 acres at Lepatuan) during the present weathering cycle. Essential conditions for bauxitic alteration to take place appear to be—(*a*) high mean temperature, high rainfall and dense vegetation, (*b*) relatively flat terrain, and (*c*) elevation above immediate surroundings to ensure adequate ground-water movement.

Total resources of bauxite at Lepatuan are about 600,000 tons, and possible reserves are negligible at the other localities. Difficulties of access and distance from markets militate against commercial exploitation of the deposit, but prospects of finding more bauxite in the islands of the volcanic arcs of Bismarck Archipelago cannot be lightly dismissed.

Introduction.

A rumour of obscure origin to the effect that bauxite occurred on Manus Island reached the Australian Aluminium Production Commission during 1947. The then Senior Geologist at Port Moresby was subsequently instructed to make a reconnaissance survey of the island. Before this could be done the Senior Geologist (A. K. M. Edwards) met his death in an accident and it was not until 1952 that his successor (J. E. Thompson) could undertake the investigation.

Nodules of high-grade bauxite were found by Thompson at three localities on the island, and the writer was instructed to join forces with him and visit the localities for a more detailed investigation. The examination was made during March-April, 1953; in the meantime Thompson had returned to Manus and engaged native labour to sink test pits. All arrangements were carried through without a hitch for which the writer is very grateful to his colleague's organizing ability and knowledge of local customs and procedure.

Manus Island, the largest island of the Admiralty Group, is within the United Nations Trust Territory of New Guinea which is administered as part of the joint Territory of Papua and New Guinea. The island, including Los Negros Island, which is narrowly separated from the eastern end of Manus by Loniu Passage, is approximately 67 miles long from east to west and up to 20 miles wide. It is enclosed by Latitudes 1° 55′ S. and 2° 15′ S. and Longitudes 146° 30′ E. and 147° 30′ E.

European and inland native populations are concentrated towards the eastern end of Manus and on Los Negros. Navy and Air Force maintain establishments at Lombrom and Momote respectively, and the civil administrative headquarters are at Lorengau on the north-east coast of the main island. Total white population of Lorengau is about 30 persons.

Communications are difficult and slow. Seventeen miles of poor motor road, which crosses decayed and dangerous wooden bridges, connect Lorengau with Momote aerodrome and Lombrom, and short motor roads radiate from Lorengau to former United States military establishments. The eastern third of the island is fairly well served with native tracks but the remainder is sparsely populated and mountainous and movement is difficult on overgrown tracks or through trackless rain forest.

The entire island is covered with dense rain forest and there is little game.

Temperature and humidity are uniformly high throughout the year, and mean maximum and minimum temperatures at Lorengau are 90° F. and 72° F. respectively. Annual rainfall on the coast ranges between 130 and 150 inches but is much greater inland, particularly in the mountainous central area.

GENERAL GEOLOGY.

During August-September, 1952, J. E. Thompson visited Manus and made four traverses on foot across the island in a successful search for bauxite. He incorporated his observations in a report (1952) which has been consulted by the writer and from which, with some additions, the following brief notes have been taken.

The sequence of deposition as interpreted from scattered observations in 1952, and confirmed by a second visit in 1953, is simple. Tertiary and younger sediments have been laid upon a basement of plutonic rock of intermediate composition.

The complete sequence probably is—

Quaternary	Recent	.. Raised coral.
	Recent to Pleistocene	.. Volcanic tuffs and flows.
Tertiary	Miocene	.. Marine tuffaceous sediments.
	lower Miocene ..	.. Hinterland limestone.
Palaeozoic(?) ..	.. ..	.. Plutonic basement.

Basement.

Basement rocks have not been seen *in situ* but gravels of the Harlu and Watani Rivers, which drain from the highest peaks, contain igneous pebbles and boulders from a medium acid suite. One typical boulder from the bed of the Watani River submitted to petrological examination consisted of quartz diorite.

Hinterland Limestone.

This limestone is a dense crystalline rock which has brought about a karst topography in the north-central part of the island. It is much obscured by overlying tuffaceous sediments and is exposed in stream channels. Lithologically the rock is similar to the Miocene Limestone of New Britain and New Guinea mainland. It is believed to represent marginal reefs formed on the coasts (particularly north-east to south-east coasts) of a pre-Tertiary island composed of igneous basement rocks.

Marine Tuffaceous Sediments.

The sediments range from agglomerates to fine siltstones and in places are richly foraminiferal. They are well bedded and dip seaward at angles up to 30 degrees. They are exposed at Lorengau, and on the road to Momote, at numerous places along No. 1 road between Kawaliap and Lorengau, and at Droli on the south coast.

Volcanic Tuffs and Flows.—Comparatively recent vulcanism, renewed as late as June 1953 at Lou Island 20 miles south of Manus, has spread basaltic and acid flows and tuffs over large areas of the island. These formations are sub-horizontal and unconformably overlie the Miocene marine sediments. They are generally covered with a clay mantle which contains highly aluminous nodules in some localities; at Lepatuan dacite is weathering directly to bauxite of very low silica content.

BAUXITE LOCALITIES.

Aluminous enrichments have been observed at (1) one mile south of Lorengau, (2) Nabobi, about ½ mile east of Kawaliap on No. 1 Road, (3) Lepatuan, near the western edge of Manus and (4) a few points along No. 1 Road between Nabobi and Lundret. Of these localities, all of which are shown on the locality map, Lepatuan is the most important.

1. *Lorengau.*

Tabular nodules of bauxitic composition occur in narrow bands in red residual clay and are exposed in road excavations about 1 mile south of the town. The nodules appear to have formed by the selective bauxitization of thin seams of coarse tuff. Some greyish nodules show faint lath-like relict textures of a coarse-grained rock. Pale brown nodules are more uniform and relict textures are absent or indistinct. Analyses of both types of nodules are given; the first is of grey nodules and the second of pale brown textureless specimens:—

Lab No.	8441.	8442.
	Per cent.	Per cent.
SiO_2	10.7	12.1
Al_2O_3	55.9	55.0
Fe_2O_3	5.0	5.0
TiO_2	0.7	0.8
Ignition loss	26.8	26.1
Available Al_2O_3 (1)	44.3	42.3

(1) Extracted by alkaline solution under pressure.

Analyses by Australian Aluminium Production Commission.—On the assumption that all SiO_2 is present in clay minerals, which is supported by the low available alumina figure, the probable mineralogical compositions are—

—	8441.	8442.
	Per cent.	Per cent.
Halloysite or Kaolin	23	26
Gibbsite (*a*)	66	63
Boehmite	4	4
Hematite	5	5
Titania	0.7	0.8

(*a*) In this context throughout "gibbsite" includes amorphous aluminium hydroxide—$Al(OH)_3$.

The nodules are sparsely distributed and the deposit does not constitute a potential source of commercial bauxite.

2. *Nabobi.*

Nabobi is a deserted village and mission station on No. 1 road in close proximity to the village of Kawaliap ("liap" is dropped locally and the village is known to natives and Europeans simpy as Kawa). Nodules and fragments of spherical bauxite shells are exposed at the surface of the cleared area of the old village and along the native tracks. The surface nodules represent a residual accumulation formed by removal of the clay by rain. The nodules and fragments include varieties composed largely of white vesicular gibbsite or of altered granular rock not obviously bauxitic. Analyses of three collections of surface specimens, and probable mineral compositions, are—

A.A.P.C. Lab. No.	8438.	8437	8440.
	Per cent.	Per cent.	Per cent.
Total SiO_2	3.7	3.6	15.8
Quartz	..	..	..
Al_2O_3	52.3	54.4	42.9
Fe_2O_3	13.7	12.3	16.0
TiO_2	0.8	1.2	1.5
Ignition loss	28.5	27.8	23.2
Available Al_2O_3	47.7	50.6	38.1
Halloysite or Kaolin	8	8	11
Quartz	..	..	10.5
Gibbsite	75	77	58
Boehmite	(a)	1.5	(a)
Goethite / Hematite	14.5	12.3	17.5
Titania	0.8	1.2	1.5

(a) Boehmite probably present in small amounts.

Notes descriptive of the megascopic appearance of these nodules are—

No. 8438.—Hard vesicular gibbsitic nodules and softer white nodules coated with yellow clay. No distinct relict texture.

No. 8439.—Crustiform fragments with texture suggestive of altered medium to coarse-grained tuff. Platy inclusions may be mica.

No. 8440.—Rounded nodules of altered, originally felspathic, rock with coating of brown clay.

Similar nodules are scattered over a moderately flat area roughly 600 feet feet from north to south by a width of about 400 feet. Shafts were sunk at two points 400 feet apart on a north-south line within this area. Logs of these shafts are—

SOUTHERN SHAFT AT NABOBI.

Depth.	
Surface to 9′ 10″ ..	Brown clay with purplish tinge in patches, thin reddish stains and few small patches of blue kaolinized tuff. No bauxite nodules.
9′ 10″ to 21′ 0″ ..	Brown and blue mottled kaolinized tuff.
21′ 0″ to 27′ 6″ ..	Blue clay with brown patches and rare harder nodules of greyish-brown clay. Concentric weathering shells discernible.

The sparse distribution of the nodules was aptly described by a native assistant as " one fella—one fella ". No samples were taken from this shaft.

(On arrival at Nabobi at noon on 2nd April, this shaft was found to be filled with CO_2 to a depth of 3 or 4 feet in sufficient strength to extinguish a kerosene lamp immediately. The gas dispersed overnight.)

NORTHERN SHAFT AT NABOBI.

Surface to 7′ 8″ ..	Brown and red variegated clay with few small (up to 1 inch) nodules of bauxite and patches and fragments of kaolinized tuff between surface and 5 feet. Larger nodules (up to 6 inches) at 5 feet, one with soft kaolin (?) core surrounded by ¼-inch shell of bauxite. Yellow patches at 6 feet and purplish tinge towards base. Merging into—
7′ 8″ to 20′ 0″ ..	Purplish kaolinized tuff, red and yellow irregular bands which tend to dip north at 10 to 20 degrees. Granular texture well displayed. One bauxite nodule at 11 feet. Some yellow patches have sharp straight boundaries, which presumably represent joints.

Two samples were taken, viz. (*a*) 0-7′ 8″ and (*b*) 7′ 8″ to 20′. The first sample was divided; one portion was submitted to analysis in its natural state and the nodules from the other portion, which constituted about 20 per cent. of the sample, were examined separately. The analytical work was carried out by the Tasmanian Department of Mines Laboratory, Launceston.

Sample No.	14.	15. (Nodules only.)	16.
Depth	0 ft. to 7 ft. 8 in.	0 ft. to 7 ft. 8 in.	7 ft. 8 in. to 20 ft.
	Per cent.	Per cent.	Per cent.
Insoluble matter	25.5	7.3	..
Al_2O_3	38.0	56.5	..
Fe_2O_3	16.4	7.7	..
TiO_2	1.6	0.6	..
Ignition loss	18.2	27.9	14.3
Soda soluble—			
Al_2O_3	23.9	53.9	14.8
SiO_2	7.9	3.6	9.9

The low ignition loss (combined water) in sample 15 suggests that the nodules contain an appreciable quantity of boehmite but the proportions cannot be computed reliably from the data available.

Plainly the deposit is of no commercial value.

3. *Lepatuan.*

The name Lepatuan is applied by natives to the small relatively flat area on which bauxite has been found towards the western end of Manus. There is no village of that, or any other, name in the vicinity.

Locality and Access.—The area is traversed by a little-used native track between the north coast opposite the island village of Saboi and Droli on the south coast. Respective distances from Lepatuan to north and south coasts are approximately 5 and 4 miles. Lepatuan is at an elevation of about 950 feet and is the widest part of the crest of a narrow ridge which extends from the south coast for the greater part of the width of the island.

Mangrove swamps at either coast would present difficulties to the construction of access roads and dense rain forest on the route and on the bauxite deposits would be difficult to clear.

Geology.—The surface is much obscured by a carpet of decaying vegetation lying on black clay-like soil. A few residual boulders of dark-grey aphanitic dacite show through the soil in places, particularly near the margins of the central and northern bauxite bodies, and nodules and small pellets of bauxite have accumulated on the bare and eroded surface of the narrow native track which traverses the length of the area.

The surface is deeply dissected by streams on either side (east and west) of the bauxite-bearing areas, and fine bedded tuffs, deeply weathered, are exposed in the stream channels and were penetrated in test pits 2 and 2A near the southern end of the area. The tuffs have a low regional dip to the north.

The tuffs are overlain by dacite flows of unknown thickness, but probably exceeding 100 feet at the northern edge of the area and also probably enclosing relatively thin beds and lenses of tuff.

The dacite is a dark grey to nearly black dense rock of sub-vitreous lustre containing minute vesicles. No granular texture is resolvable by naked eye or hand lens. Two largest observed vesicles on one fresh face measured 0.7 by 0.4 and

0.25 by 0.15 millimetres. Vesicles are elongated in the direction of flow and tend to occur in thin sheets which alternate with bands of denser rock. This characteristic is revealed only in weathered specimens, which, by preferential weathering of the more vesicular zones, may acquire a banded aspect.

The widely banded appearance of the rock may be replaced by, or have superimposed on it, a finely honeycombed surface caused by enlargement of the vesicles by weathering. Specimens recovered from within the bauxite profile, when cleaned of bauxite, possess a light grey skin commonly less than 0.01 millimetre thick, and to the eye have a striking resemblance to pumice. Such specimens have an extremely rough surface with small sharp projections which are very harsh to the touch and easily lacerate the skin. Surface boulders have lost the finer detail of this fretted surface but nonetheless may be deeply pitted.

An analysis of the fresh rock is given in the discussion on the origin of the bauxite.

Description of the Bauxite.—The approximate area over which bauxite nodules have been observed totals about 50 acres of which the marginal areas are of doubtful value. Several varieties of nodule were noticed:—

(1) Reddish-brown, vesicular and reddish-brown, crustiform.
(2) Dense greyish-pink and dense pale reddish-purple; both varieties are fine-grained and tough.
(3) White, very rough surface and irregular shape.

Analyses of specimens of the nodules by the Aluminium Commission returned very favorable results and led to sub-surface prospecting of the area. The initial analyses are—

NODULES FROM LEPATUAN.

Lab. No.	8435.	8437.	8436.
Type	Fine-grained dull red and white. bauxite. Tubular cavities. Smooth chocolate-brown skin	Pinkish-grey dense fine-grained bauxite, smooth surface.	Soft greyish white concretionary bauxite with irregular grains of waxy gibbsite Very rough surface
	Per cent.	Per cent.	Per cent.
SiO_2	3.2	4.5	2.2
Al_2O_3	54.8	60.0	58.1
Fe_2O_3	11.1	4.2	7.4
TiO_2	0.9	0.4	0.9
Ignition loss	29.0	30.1	30.5
Available Al_2O_3	51.3	56.2	54.8

Assumed mineralogical composition of the specimens are—

PITS AT LEPATUAN.

PIT NO. 2.

Depth.	Sample No.	——
Ft. in. Ft. in.		
0 0 to 4 0	1	Clay with dense pink bauxite nodules
4 0 „ 10 0	3	Brown clay with sparse nodules

Sample 2.—Nodules only, picked free from clay matrix and comprising approximately 33 per cent of the original sample.

Sample No.	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Insoluble matter	11.7	4.3	..
Al_2O_3	51.0	62.0	..
Fe_2O_3	10.8	3.8	..
TiO_2	1.0	0.3	..
Ignition loss	26.0	30.1	16.7
Soda soluble—			
Al_2O_3	43.8	60.9	19.6
SiO_2	2.9	2.5	7.4

PIT NO. 2A.

Depth	Sample No.	——
Ft. in. Ft. in.		
0 0 to 12 0	..	Clay with nodules. Very thin tubular bauxite fragments in kaolinized tuff below 5 feet. No samples analysed

PIT NO. 3.

Depth	Sample No.	——
Ft. in. Ft. in.		
0 3 to 2 4	4	Soft yellow-brown clay-like bauxite with nodules.
2 4 ,, 3 6		Hard red clay-like bauxite
3 6 ,, 8 0	5	Gritty soft earthy bauxite with tubular fragments of hard bauxite. Brown.
8 0 ,, 12 0	6	Gritty soft earthy bauxite with tubular fragments of hard bauxite with purplish tinge
12 0 ,, 15 0	7	Purplish and grey mottled clay with hard nodules

Sample No.	4.	5.	6.	7.
	Per cent.	Per cent.	Per cent.	Per cent.
Insoluble matter	1.5	1.1	..	..
Al_2O_3	51.3	53.4	..	..
Fe_2O_3	17.4	15.3	..	..
TiO_2	2.0	1.6	..	..
Ignition loss	28.2	28.6	28.6	23.7
Soda soluble—				
Al_2O_3	50.8	52.8	53.4	40.5
SiO_2	1.4	1.0	2.3	4.0

Pit No. 4.

Depth.	Sample No.	—
Ft. in. Ft. in.		
0 0 to 2 6	8	Soft brown clay-like bauxite with very sparse hard nodules, hardening slightly with depth and merging into—
2 6 ,, 4 6	9	Few nodules of hard bauxite dispersed through soft red-brown earthy bauxite. Seam of yellow clay.
4 6 ,, 6 6	10	Dark brown granular bauxite containing residual fragments and boulders of fresh dacite (latter removed from sample)
6 6 ,, 8 6	11	As above, lighter colour, but no unaltered rock on side of pit from which sample was taken
8 6 ,, 11 6	12	As above, lighter colour, no unaltered dacite
11 6 ,, 13 0	13	Red brown bauxitic clay

Sample No.	8.	9.	10.	11.	12.	13.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Insoluble matter	1.9	0.6	0.6	1.1	1.1	..
Al_2O_3	45.7	51.7	55.4	55.8	56.4	..
Fe_2O_3	22.7	17.0	13.1	12.3	11.5	..
TiO_2	2.2	1.9	1.2	1.1	1.1	..
Ignition loss	27.3	28.7	29.8	29.4	30.0	25.9
Soda-soluble—						
Al_2O_3	43.7	50.8	54.8	55.0	55.9	48.2
SiO_2	1.6	0.6	0.6	1.0	1.1	4.4

Assumed mineralogical compositions are—

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Halloysite or Kaolin ..	4.1	1.3	1.4	2.2	1.3
Quartz	Nil	Nil	Nil	Trace	0.5
Gibbsite	66.8	77.7	83.9	84.1	85.5
Boehmite	0.5	0.5	Trace	Nil	Nil
Goethite } Hematite }	26.3	18.4	13.9	12.3	17.7
Titania	2.2	1.9	1.2	1.1	1.1

Pit No. 5.

Depth.	Sample No.	—
Ft. in. Ft. in.		
0 0 to 2 6	..	Variegated yellow and red clay
2 6 ,, 7 6	..	Red clay with few hard nodules

Pit No. 6.

This pit filled with water to within 2 or 3 feet of the surface and could not be examined. The visible portion consisted of variegated yellow, red, and light-brown clay. The spoil dump contained red clay with very few hard red nodules of ferruginous bauxite.

Quantity of Bauxite.—Only a very rough estimate of the total volume of bauxite at Lepatuan can be made as the margins of the deposits could not be determined without a considerable amount of excavation which was beyond the resources available. The boundaries on the sketch map are based mainly on topographical evidence but the limits of the central (i.e., the largest) body have been sketched in by tape or pacing, and compass traverses to several points beyond which no nodules could be found in the soil and where downward slopes became steeper.

Bauxite in the central area may occupy an area of 40 acres with an average thickness of 6 feet; this is equivalent to roughly 500,000 tons, but the commercial value of the bauxite is much diminished by the presence (Pit No. 4) of blocks and fragments of unaltered rock.

The limits of the southern body are known with even less exactness, but the narrowness of the ridge and limited depth of bauxite (Pit No. 2) indicate a much lower tonnage, probably less than 100,000 tons.

Quantities in the northern body are for all practical purposes negligible. Pits 5 and 6 sunk in the most favorable positions revealed only variegated clays with very sparsely distributed nodules.

4. *Between Nabobi and Lundret.*

Native villages along No. 1 road are built on hill tops or on the gently rounded but narrow crests of ridges. On the cleared and worn ground surfaces of some village squares, a few pellets of hard kaolinized (halloysitic?) tuff and, less commonly, of bauxitic material may be picked up. Fragments of obsidian and other humanly transported rocks may also be found but is unlikely that the bauxitic pellets would have been carried into the villages.

The rarity of the bauxite nodules, when compared with their comparative abundance at the three principal localities mentioned, does not hold out much promise of useful deposits existing beneath the villages. However, the existence of clay-like bauxite with a few or no nodules is a possibility which could be easily overlooked.

Origin of the Bauxite.

Parent Rock.

Three types of bauxite occur at Lepatuan, viz.:—

(*a*) Tabular nodules, up to 1 inch thick, of dense pink or greyish pink bauxite embedded in a matrix of bauxitic (i.e. highly aluminous) clay passing downwards to recognizable kaolinized tuff. The nodules contain about 4 per cent. SiO_2, 60 or more per cent. Al_2O_3 and 4 per cent. Fe_2O_3. The matrix contains approximately 15 per cent. SiO_2, 45 per cent. Al_2O_3, and 14 per cent. Fe_2O_3.

(*b*) Rounded and irregular greyish white, also brown and red, nodules in a light-brown clay-like matrix. Such bauxite contains about 2 per cent. SiO_2, 45 to 51 per cent. Al_2O_3, and 17 to 23 per cent. Fe_2O_3. Separated nodules may contain about 55 to 58 per cent. Al_2O_3.

(*c*) Gritty earthy brown bauxite underlying type (*b*) and in direct contact with unaltered parent dacite. Composition ranges between 0.4 to 1.5 per cent. SiO_2, 51 to 56 per cent. Al_2O_3, and 11 to 23 per cent. Fe_2O_3.

Type (*a*) is derived from medium to coarse finely bedded tuff which has been seen only in small weathered outcrops in stream courses and, thoroughly kaolinized, in the test pits.

The derivation of type (*b*) is somewhat obscure, but it probably represents a residual accumulation of bauxitic material derived from tuffaceous beds overlying or intercalated with the dacite. The boundary between types (*b*) and (*c*) is sharp.

The third type (c) results from the direct alteration of dacite. The two analyses which follow are of the fresh parent rock and of bauxite crusts adhering thereto:—

—	Dacite.	Bauxite Crust.
	Per cent.	Per cent.
SiO_2	67.21	0.36
Al_2O_3	14.22	56.71
Fe_2O_3	0.90	10.78
FeO	4.68	0.06
MgO	2.55	(a)
CaO	4.30	(a)
Na_2O	2.70	(a)
K_2O	2.80	(a)
H_2O+	Nil	Nil (b)
H_2O-	Nil	31.19
TiO_2	0.53	1.09
MnO	0.28	0.006
	100.27	100.196

(a) Not detected. (b) Moisture 1.03 per cent., analysis on dry basis.

Analysts: Avery and Anderson.

The presence in Pit No. 4 of completely bauxitized rock beneath a stratum of partly corroded dacite suggests that the former represents a bed of less resistant tuff or a more highly vesicular zone in the dacite.

Mode of Formation.

The attack on the dacite is extraordinarily rapid and complete. The bauxite crust in immediate contact with the tenuous grey film that coats the fresh rock consists almost wholly of gibbsite and goethite; clay minerals if present are in insignificant amount. From the foregoing analyses the following assumed mineralogical compositions of the parent and adhering bauxite have been computed:—

—	Dacite (Norm.).		Bauxite Crust.
	Per cent.		Per cent.
Quartz	25.1	Silica(1)	0.36
Orthoclase	16.7 }	{ Gibbsite	86.7
Andesine	41.0 }	{ Boehmite	Trace
Diopside	3.2 }	{ Goethite(2)	11.8
Hypersthene	12.0 }	{ Magnetite	0.2
Magnetite	1.4 }		
Ilmenite	0.9	Titania	1.1
	100.3		100.16

(1) Probably dispersed residuals of quartz. (2) Includes some adsorbed water.

The alteration is brought about in the oxidizing zone by acid ground water charged with organic matter. Drainage conditions are exceedingly good and it is apparent that all constituents of the parent rock with the possible exception of alumina are removed in part. At Nabobi the ground water evolved CO_2 freely, and presumably evolution of the gas also takes place at Lepatuan. The presence of free CO_2 would keep iron in solution as ferrous bicarbonate and precipitate alumina. There is no ground for assuming that alumina is added from some extraneous source and therefore the inescapable conclusion is that less alumina is lost than any other original constituent. On the assumption that the alumina remains fixed, or is wholly reprecipitated, the loss of the other constituents are:—

	Percentage eliminated.
SiO_2	99.9
Fe_2O_3	49.5
TiO_2	48.5
MnO	99.5
Na_2O, K_2O, MgO, CaO	100

Balanced against gains of water and oxygen the total nett loss of weight from the original rock is slightly more than 50 per cent. This figure accords reasonably well with the high porosity of the bauxite.

The favorable conditions that operate at Lepatuan and without which the bauxite could not form, or if formed could not survive, are—

(*a*) High mean temperature and rainfall, abundant vegetation.
(*b*) Relatively flat terrain with little erosion of the surface.
(*c*) Deep dissection of the surroundings by streams in narrow and consequently steep-walled valleys.

The last-mentioned feature ensures rapid lateral removal of ground water with its load of dissolved silica, &c.

The nodular bauxite is of two types, viz.:—

(*a*) Nodules *in situ* within bauxitized and partly kaolinized tuff, and
(*b*) Nodules in compacted clay-like bauxite overlying the granular dacitic bauxite.

The former has developed in three stages, passing through the normal kaolinic (halloysitic?) stage to earthy or textureless bauxite. This in turn has been subject to solution of part of the alumina which has been reprecipitated about favorable nuclei to form concretionary nodules, or along bedding planes to give thin tabular forms of highly aluminous bauxite. This process has operated at Nabobi and in the vicinity of Pits 2 and 2A, Lepatuan.

The second type may have originated in the same way from tuff overlying the dacite but the tabular forms of bauxite are absent and compaction and slumping have destroyed any relict texture that may have survived previously. It is unlikely that solution of alumina within the dacitic bauxite immediately beneath the shallow soil and may have been segregated in concretions, as the boundary between nodular and underlying dacitic types is sharp and shows no gradation.

Conclusion.

The significance of these discoveries is very great. It has been shown that, in the tropics, bauxite of high quality can develop on small elevated areas of low relief by lateritic weathering by remnants of a gently sloping or relatively flat land surface composed of amenable rocks, e.g., extrusives or pyroclastics containing alumina.

The deposits on Manus Island are too small or too difficult of access to be of much direct commercial interest, but when it is realized that an area of only one square mile could contain 10,000,000 tons of bauxite, the prospects of discovery of commercially valuable deposits within the volcanic arcs of the Bismarck Archipelago cannot be dismissed lightly. In this connexion it is worth mentioning that bauxitic clays containing 27 and 28 per cent. gibbsite have been reported from Santa Cruz and Vanikoro in the British Solomon Islands.[1] These are at least an indication that lateristic weathering is taking place in these localities.

Acknowledgments.

The writer is endebted to Mr. W. H. Williams, Director, and Mr. W. St. C. Manson, Chief Chemist and Metallurgist, Department of Mines, Tasmania, for analyses of samples 1 to 16 inclusive, and to Mr. R. A. Dunt, Chief Chemist, Australian Aluminium Production Commission for analyses of samples 8435 to 8442 inclusive. The analyses of dacite and adhering bauxite crust were made by Mr. V. G. Anderson of Messrs. Avery and Anderson, Melbourne.

Reference.

Thompson, J. E., 1952.—Report on the Geology of Manus Island, Territory of Papua and New Guinea, with reference to the occurrence of Bauxite. *Bur. Min. Resour, Aust. Rec.* 1952/82.

(1) Specimens collected by J. C. Grover, Senior Geologist, Honiara, B.S.I., 1951, and analysed at Tasmanian Mines Department Laboratory, Launceston.

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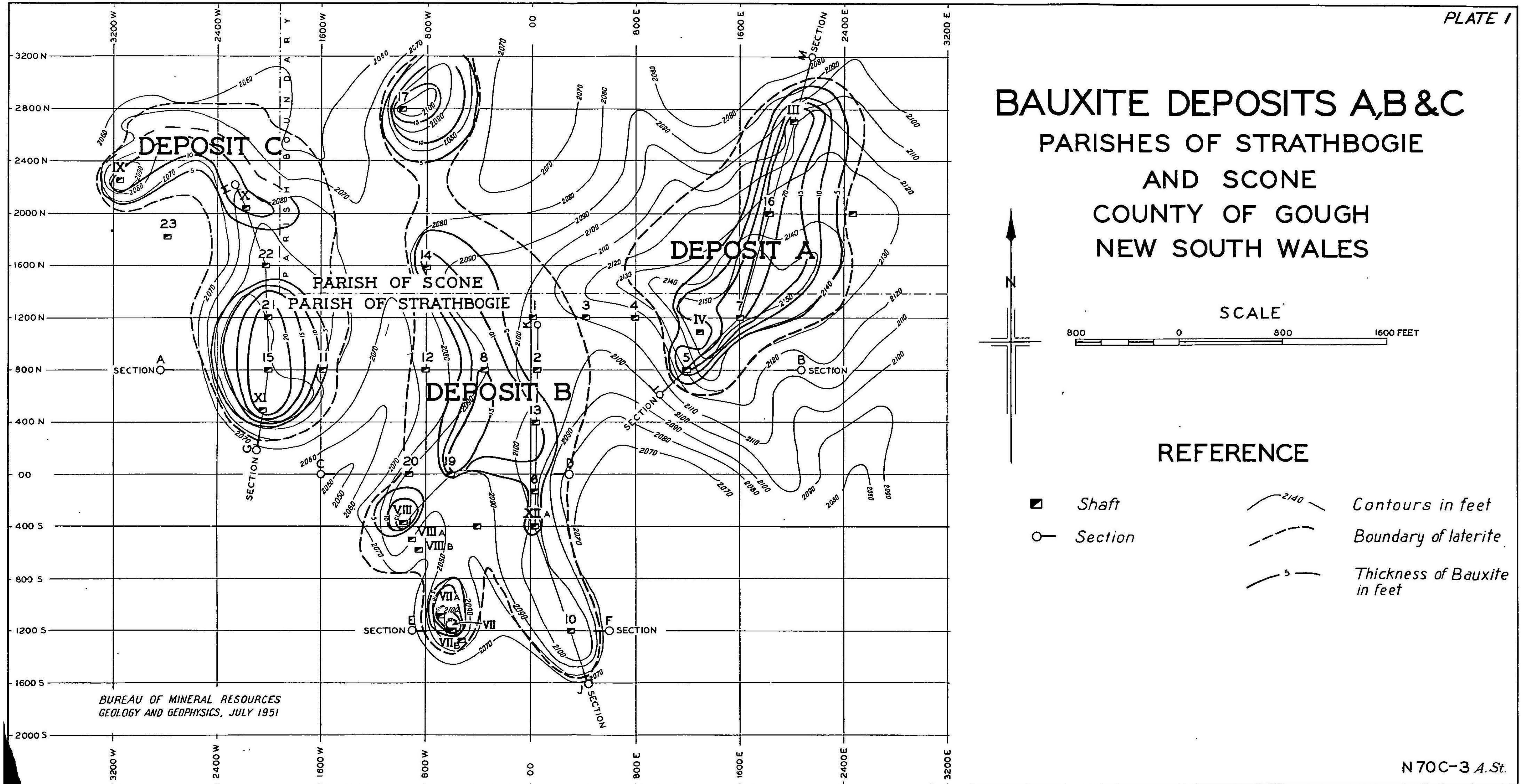
PLATE I
BAUXITE DEPOSITS A,B & C
PARISHES OF STRATHBOGIE
AND SCONE
COUNTY OF GOUGH
NEW SOUTH WALES
N
SCALE
800 0 800 1600 FEET
REFERENCE
Shaft
Section
Contours in feet
Boundary of laterite
Thickness of Bauxite in feet
DEPOSIT A
DEPOSIT B
DEPOSIT C
PARISH OF SCONE
PARISH OF STRATHBOGIE
PARISH BOUNDARY
SECTION A
SECTION B
SECTION E
SECTION F
SECTION G
SECTION J
SECTION L
SECTION M
3200 W
2400 W
1600 W
800 W
00
800 E
1600 E
2400 E
3200 E
3200 N
2800 N
2400 N
2000 N
1600 N
1200 N
800 N
400 N
00
400 S
800 S
1200 S
1600 S
2000 S
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N 70 C-3 A.St.

PLATE 2

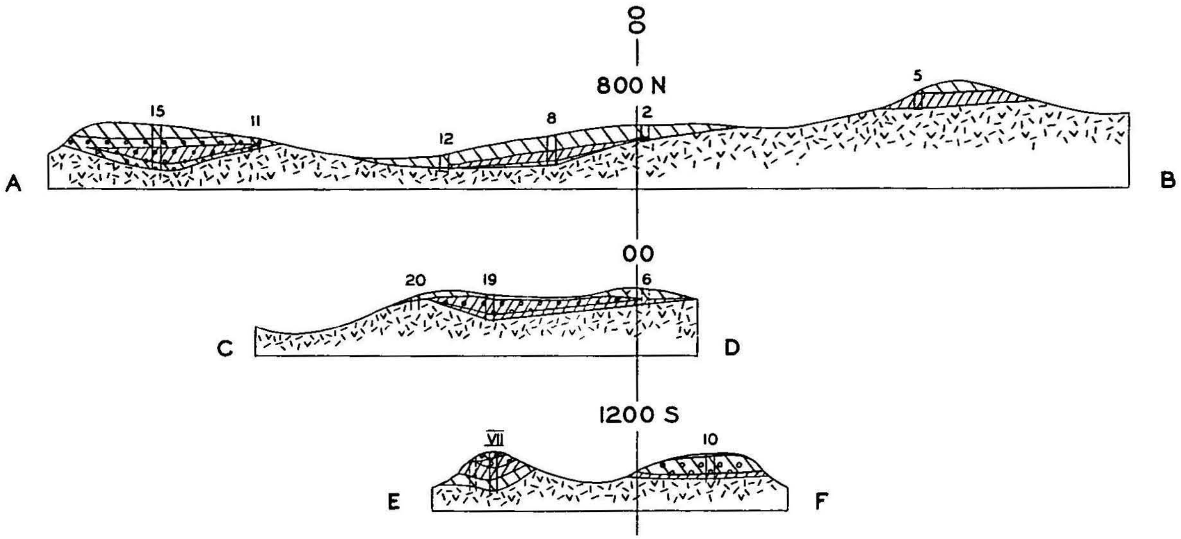
GEOLOGICAL SECTIONS

BAUXITE DEPOSITS A, B & C

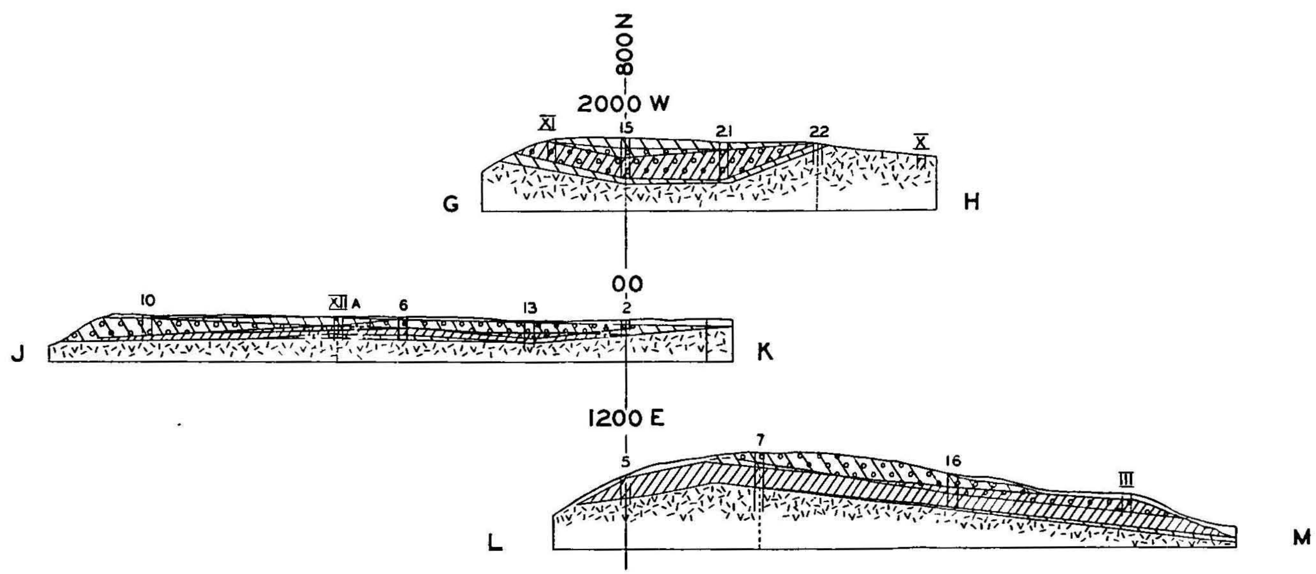
PARISHES OF STRATHBOGIE AND SCONE

COUNTY OF GOUGH

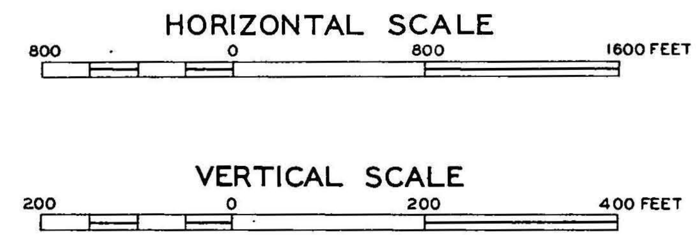
NEW SOUTH WALES



LONGITUDINAL SECTIONS AB, CD, EF.



CROSS SECTIONS GH, JK, LM.



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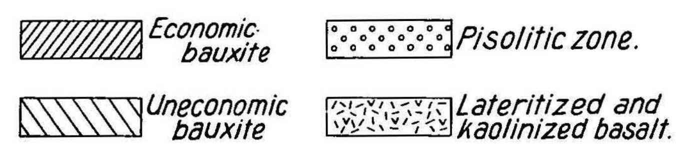

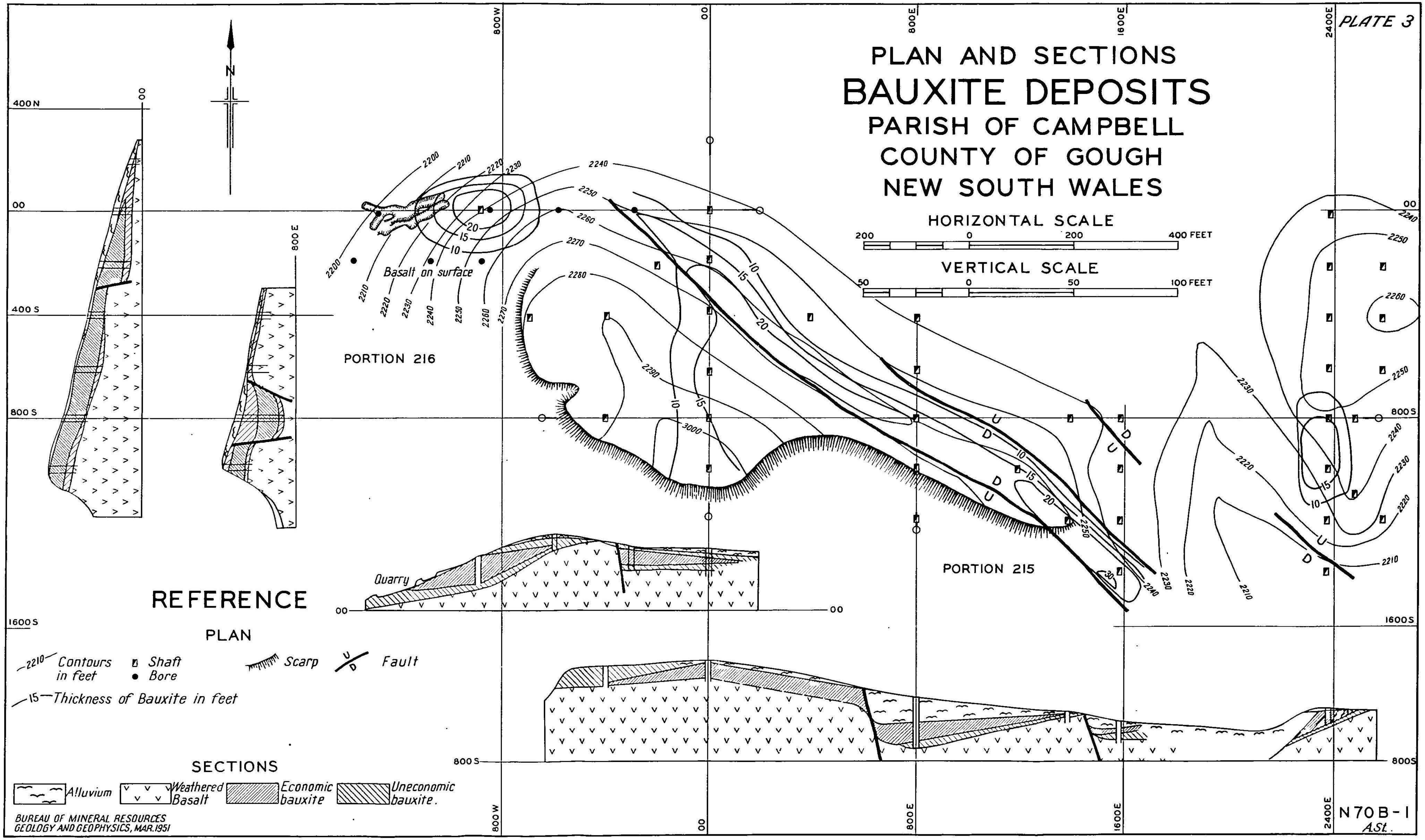
PLATE 3
PLAN AND SECTIONS
BAUXITE DEPOSITS
PARISH OF CAMPBELL
COUNTY OF GOUGH
NEW SOUTH WALES
HORIZONTAL SCALE
200 0 200 400 FEET
VERTICAL SCALE
50 0 50 100 FEET
PORTION 216
PORTION 215
Basalt on surface
Quarry
REFERENCE
PLAN
Contours in feet
Shaft
Bore
Scarp
Fault
Thickness of Bauxite in feet
SECTIONS
Alluvium
Weathered Basalt
Economic bauxite
Uneconomic bauxite.
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N70B-1
Ast.

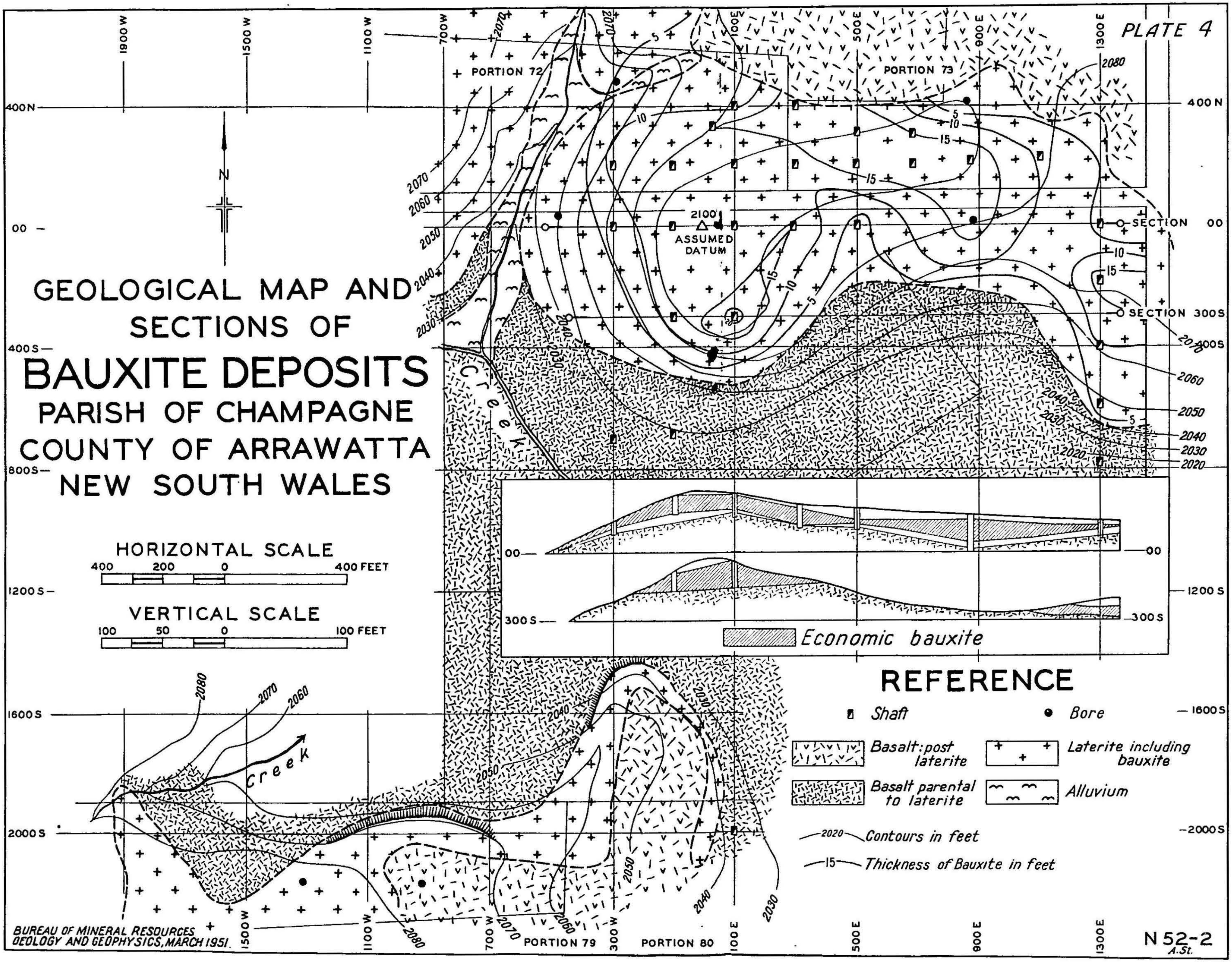
PLATE 4
GEOLOGICAL MAP AND
SECTIONS OF
BAUXITE DEPOSITS
PARISH OF CHAMPAGNE
COUNTY OF ARRAWATTA
NEW SOUTH WALES
HORIZONTAL SCALE
400 200 0 400 FEET
VERTICAL SCALE
100 50 0 100 FEET
PORTION 72
PORTION 73
PORTION 79
PORTION 80
2100'
ASSUMED DATUM
SECTION 00
SECTION 300S
Creek
Economic bauxite
REFERENCE
Shaft
Bore
Basalt: post laterite
Laterite including bauxite
Basalt parental to laterite
Alluvium
2020 Contours in feet
15 Thickness of Bauxite in feet
1900 W
1500 W
1100 W
700 W
300 W
100 E
500 E
900 E
1300 E
400 N
00
400 S
800 S
1200 S
1600 S
2000 S
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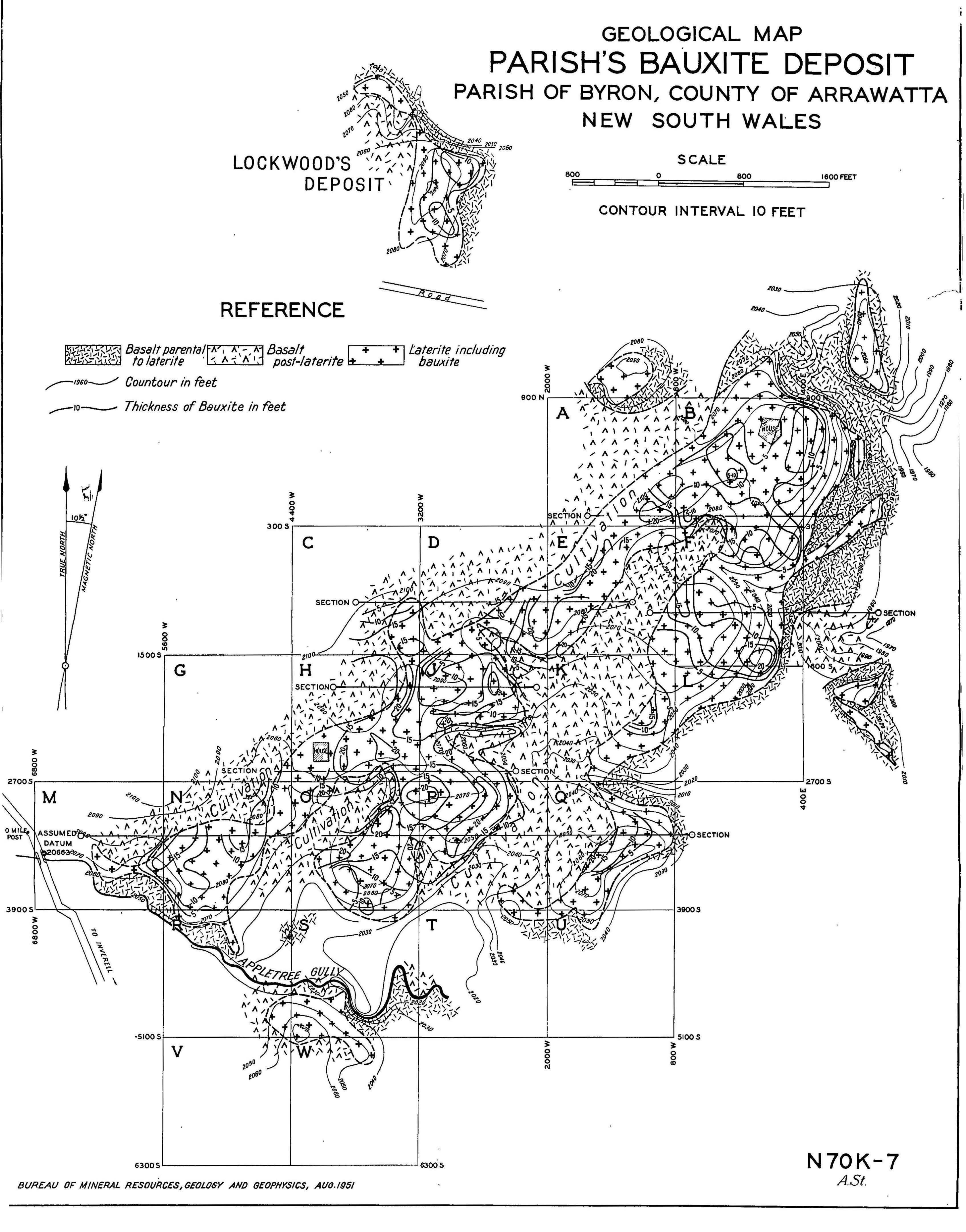
GEOLOGICAL MAP
PARISH'S BAUXITE DEPOSIT
PARISH OF BYRON, COUNTY OF ARRAWATTA
NEW SOUTH WALES
SCALE
800 0 800 1600 FEET
CONTOUR INTERVAL 10 FEET
LOCKWOOD'S DEPOSIT
Road
REFERENCE
Basalt parental to laterite
Basalt post-laterite
Laterite including bauxite
Countour in feet
Thickness of Bauxite in feet
TRUE NORTH
MAGNETIC NORTH
10½°
SECTION
Cultivation
HOUSE
APPLETREE GULLY
TO INVERELL
0 MILE POST
ASSUMED DATUM 2066.3
A
B
C
D
E
F
G
H
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
900 N
300 S
1500 S
2700 S
3900 S
5100 S
6300 S
6800 W
5600 W
4400 W
3200 W
2000 W
800 W
400 E
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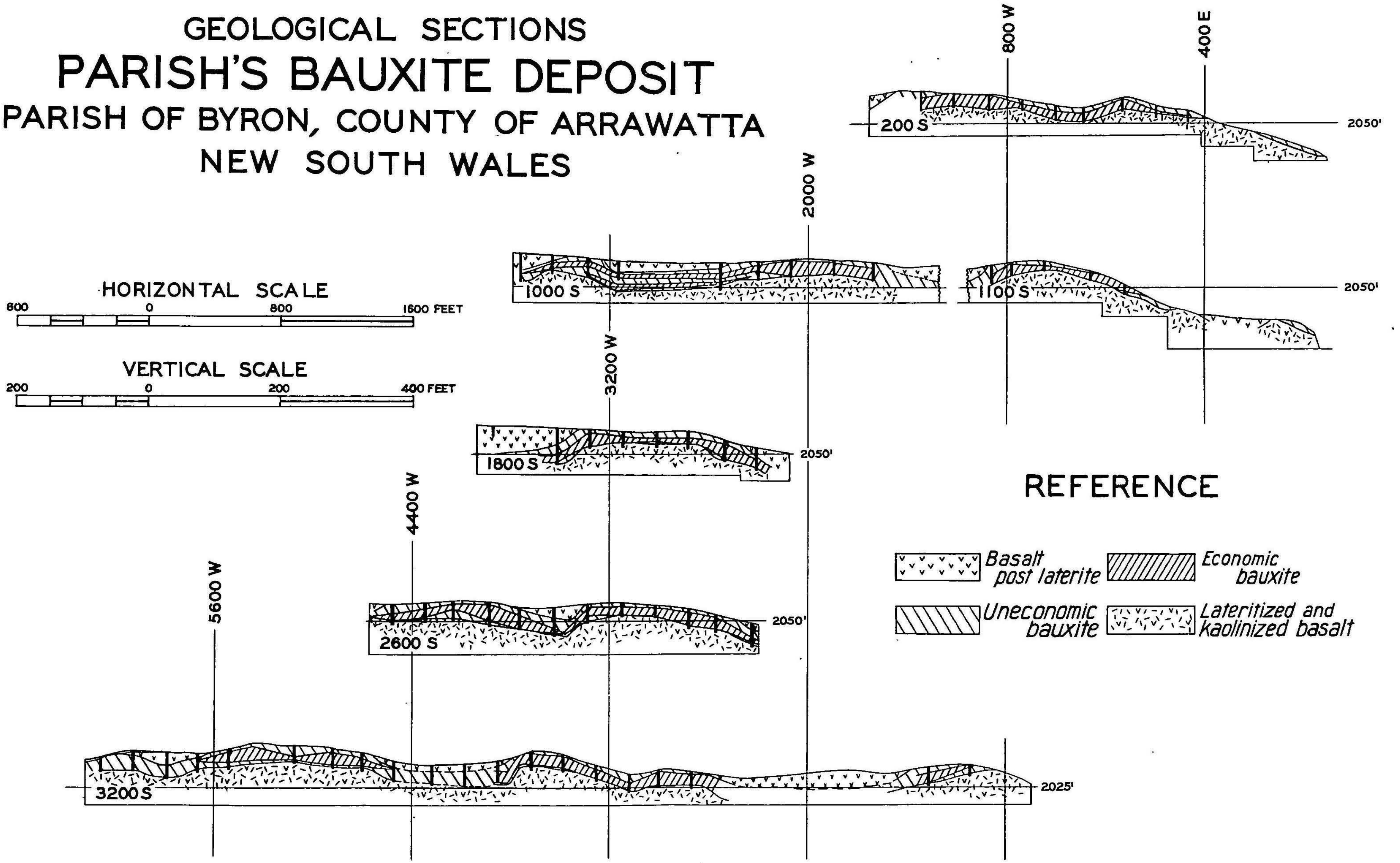
PLATE 6

GEOLOGICAL SECTIONS
PARISH'S BAUXITE DEPOSIT
PARISH OF BYRON, COUNTY OF ARRAWATTA
NEW SOUTH WALES



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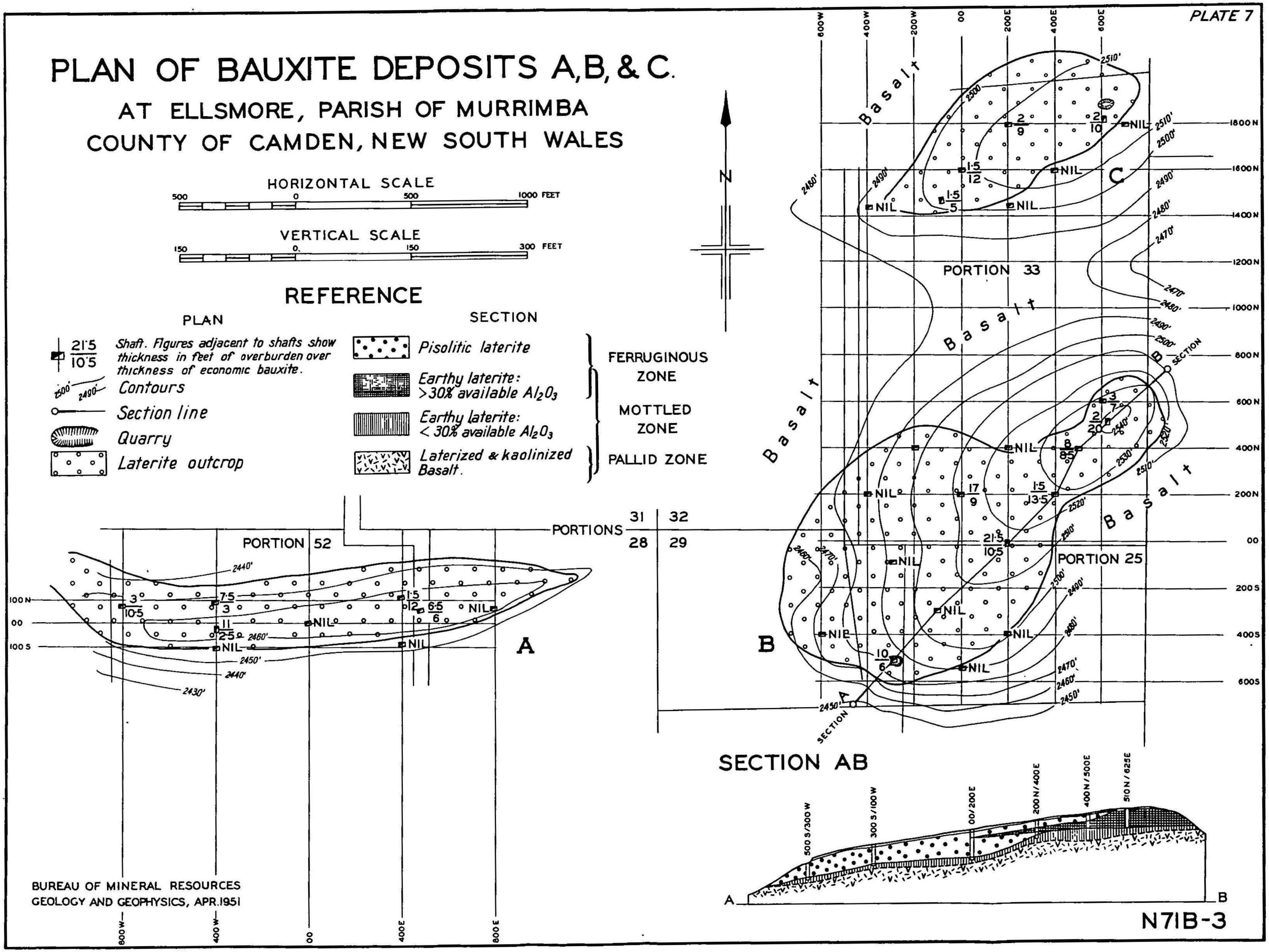
PLATE 7
PLAN OF BAUXITE DEPOSITS A, B, & C.
AT ELLSMORE, PARISH OF MURRIMBA
COUNTY OF CAMDEN, NEW SOUTH WALES
HORIZONTAL SCALE
500 0 500 1000 FEET
VERTICAL SCALE
150 0 150 300 FEET
N
REFERENCE
PLAN
Shaft. Figures adjacent to shafts show thickness in feet of overburden over thickness of economic bauxite.
Contours
Section line
Quarry
Laterite outcrop
SECTION
Pisolitic laterite
Earthy laterite: >30% available Al_2O_3
Earthy laterite: < 30% available Al_2O_3
Laterized & kaolinized Basalt.
FERRUGINOUS ZONE
MOTTLED ZONE
PALLID ZONE
PORTION 52
PORTIONS
31 32
28 29
PORTION 33
PORTION 25
Basalt
A
B
C
SECTION
SECTION AB
500 S/300 W
300 S/100 W
00/200 E
200 N/400 E
400 N/500 E
510 N/625 E
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N71B-3

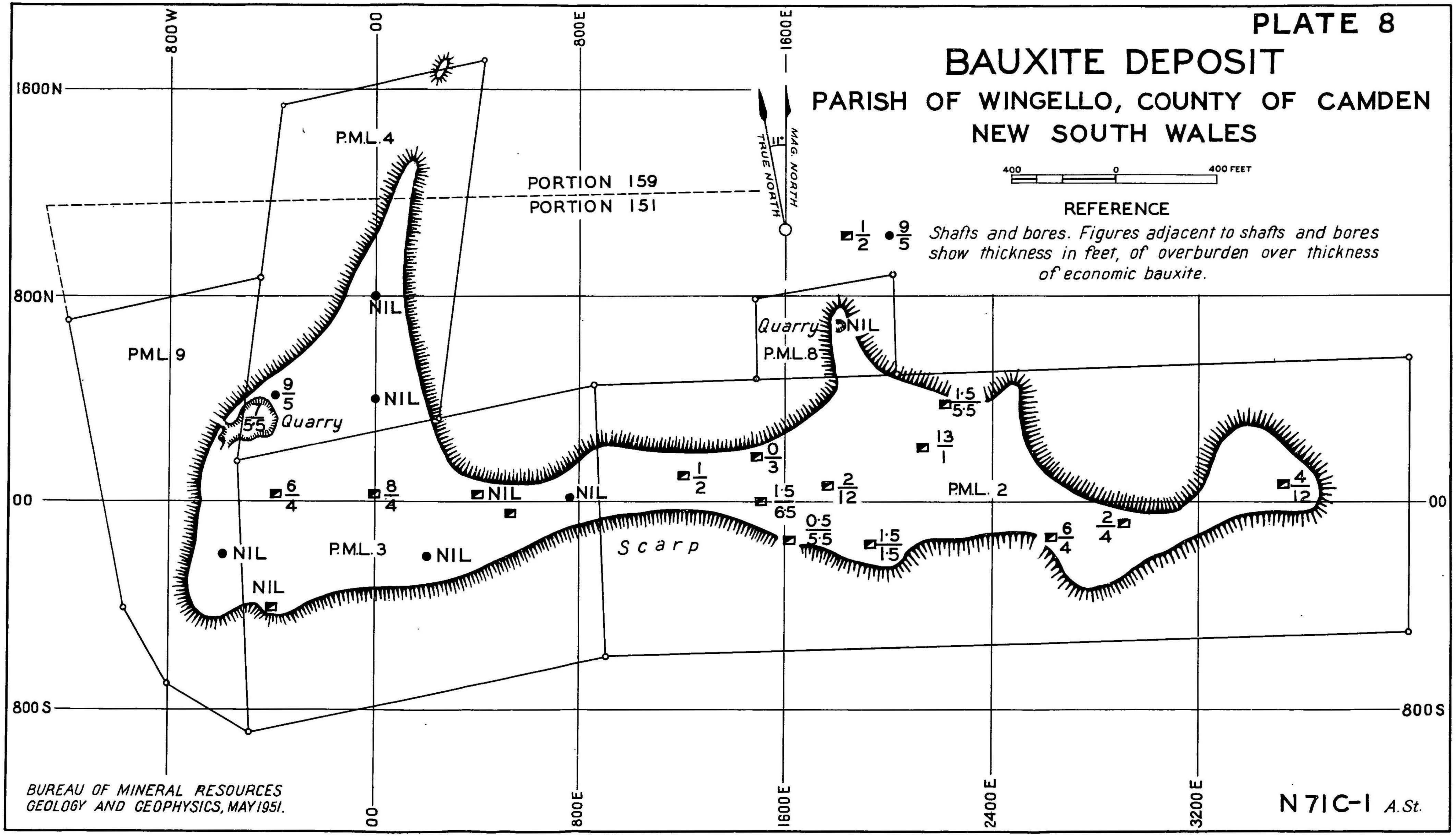
PLATE 8
BAUXITE DEPOSIT
PARISH OF WINGELLO, COUNTY OF CAMDEN
NEW SOUTH WALES
400
0
400 FEET
REFERENCE
Shafts and bores. Figures adjacent to shafts and bores show thickness in feet, of overburden over thickness of economic bauxite.
1/2
9/5
TRUE NORTH
MAG. NORTH
11°
800 W
00
800 E
1600 E
2400 E
3200 E
1600 N
800 N
00
800 S
P.M.L. 4
PORTION 159
PORTION 151
PML. 9
P.M.L. 3
P.M.L. 8
P.M.L. 2
Quarry
Quarry
Scarp
NIL
9/5
7/5·5
6/4
8/4
1/2
0/3
1·5/6·5
2/12
0·5/5·5
1·5/1·5
1·5/5·5
13/1
6/4
2/4
4/12
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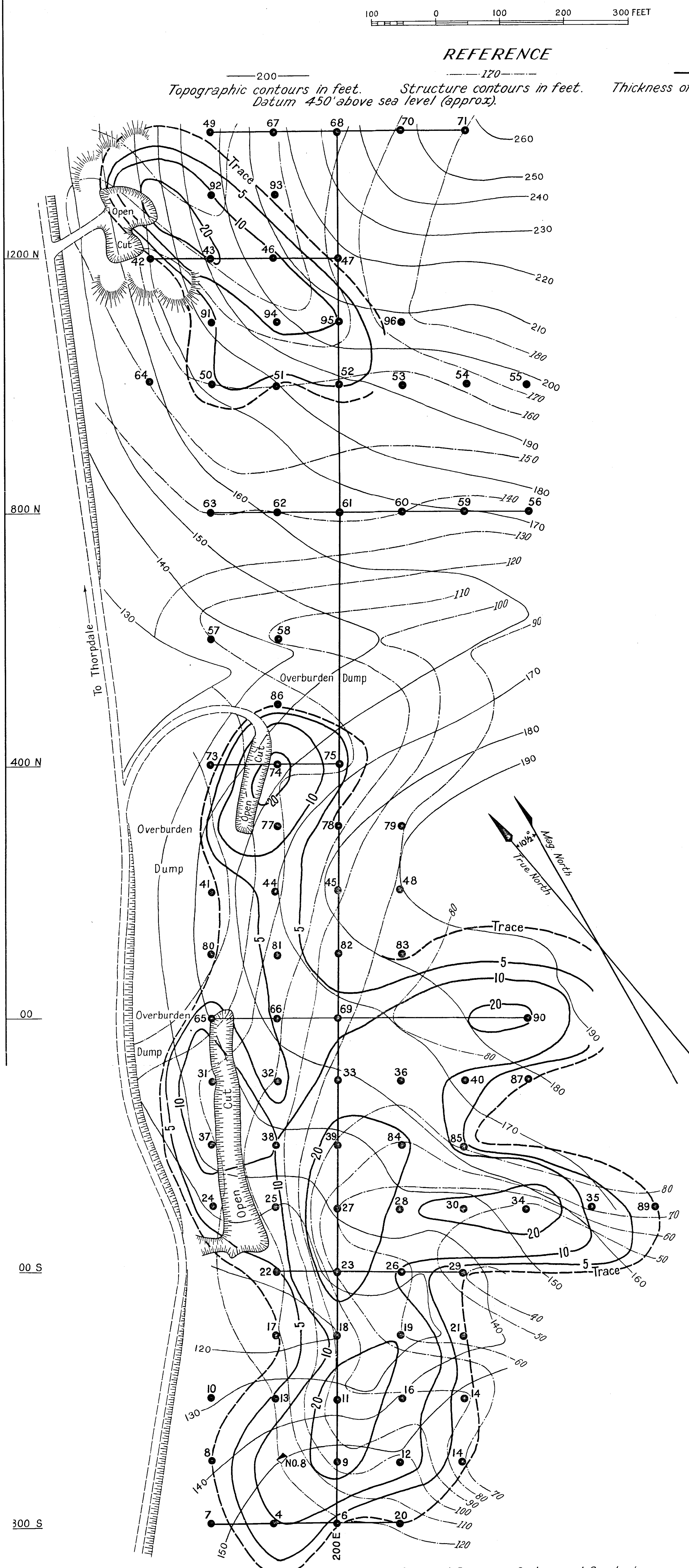
N 71C-1 A.St.

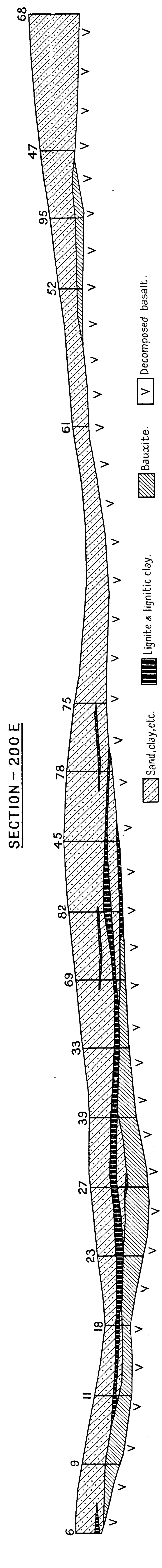
NAPIER'S NO. 1 BAUXITE DEPOSIT

PH. MIRBOO, CO. BULN BULN, VIC.



Bore No	R.L	Thickness of overburden in feet	Thickness of bauxite in feet
1*	162	–	–
2*	158	–	–
3*	154·5	–	–
4	156·5	10	9
5*	160	24	Nil
6	166·5	38	Nil
7	144·5	3	Nil
8	138	2	Nil
SHAFT 8	150	14	16
9.	156	35	24
10	128·5	Nil	Nil
11	137·5	36	20
12	161·5	47	13
13	136·5	20	Tr.
14	155	72	Tr.
15	171	72	Tr.
16	140	47	15
17	116	6	Nil
18	118	22	12
19	129	49	19
20	176	57	Nil
21	134·5	71	Tr.
22	123	9	2
23	134·5	39	29
24	131·5	4	7
25	129·5	18	8
26	132	70	9
27	142·5	50	33
28	147	72	17·5
29	138·5	82	Nil
30	144·5	63	27
31	147	9	20
32	156	44	Tr.
33	157·5	56	17
34	155	72	34
35	167·5	89	7
36	163	63	12
37	141·5	7	12
38	146·5	34	10
39	145·5	43	24
40	173	76	9
41	153	5	Nil
42	172	11	Nil
43	191·5	27	21
44	169·5	41	6
45	182	76	3
46	207·5	53	11
47	219	52	Nil
48	189·5	101	Nil
49	200	65	Nil
50	170	5	9·5
51	180	16	Nil
52	188·5	26	6
53	193	38	Nil
54	194·5	31	Nil
55	199	23	Nil
56	173	35	Nil
57	136·5	17	Nil
58	141·5	34	Nil
59	170	36	Nil
60	168·5	29	Nil
61	169	25	Nil
62	162	23	Nil
63	155	10	Nil
64	158	6	Nil
65	150	9	7
66	162	45	6
67	218	68	Nil
68	235·5	76	Nil
69	167	67	8
70	247·5	76	Nil
71	258	79	Nil
72	171	76	16
73	143·5	6	Nil
74	156	11	24
75	167	48	Tr.
76	179	85	23
77	165	31	12
78	178	67	Tr.
79	187	96	Nil
80	153	10	Tr.
81	166	45	7
82	176	73	Tr
83	181	94	Nil
84	156	66	23
85	161	77	2
86	145	21	Nil
87	177·5	88	Tr.
88	182·5	98	2
89	176	100	3
90	184	96	12
91	183	19	Tr.
92	196	47	7
93	215	65	Tr.
94	196	32	11
95	206	40	10
96	207	25	Nil

* Denotes Bore south of area shown on plan.



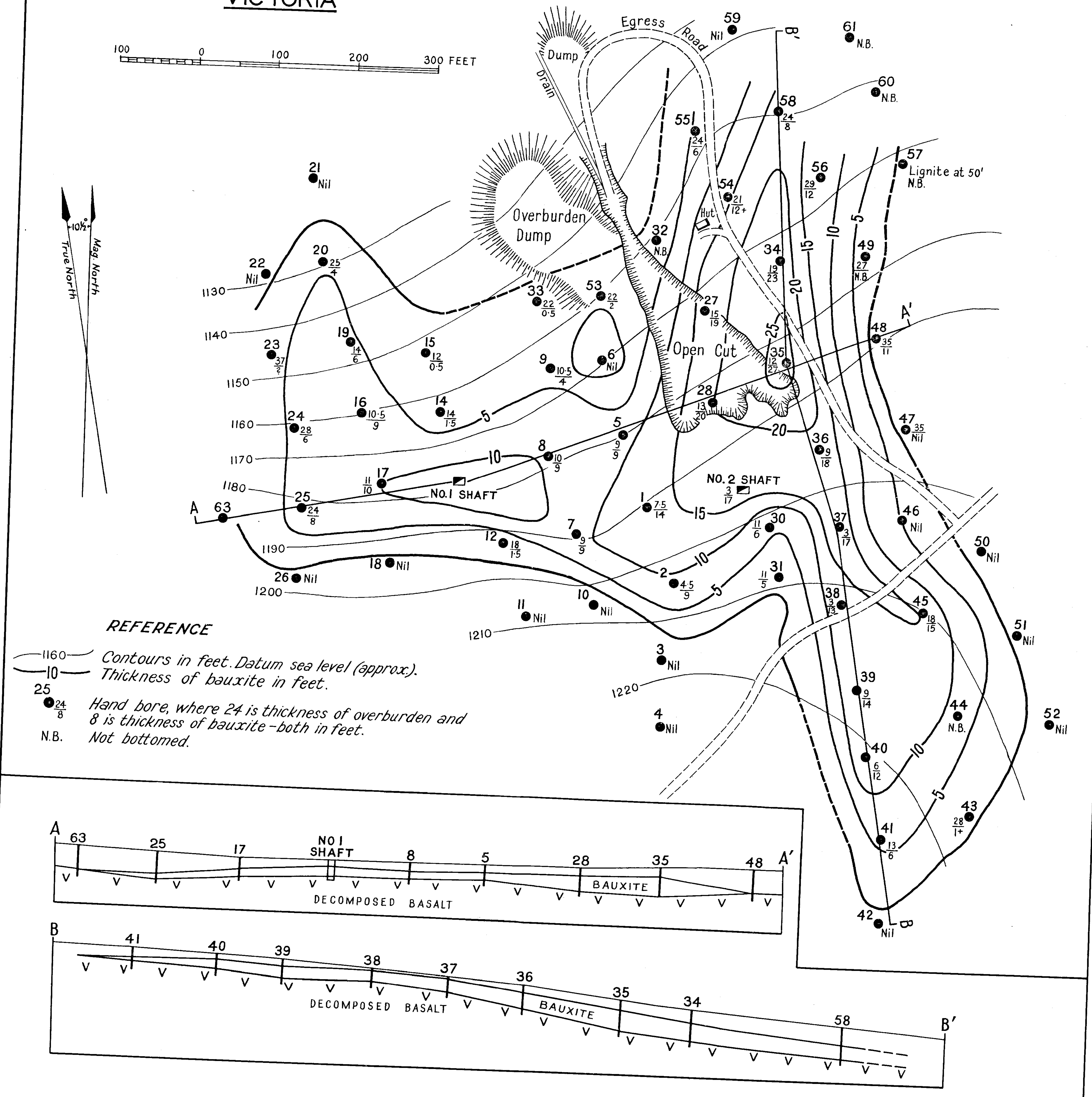
Bureau of Mineral Resources, Geology and Geophysics.

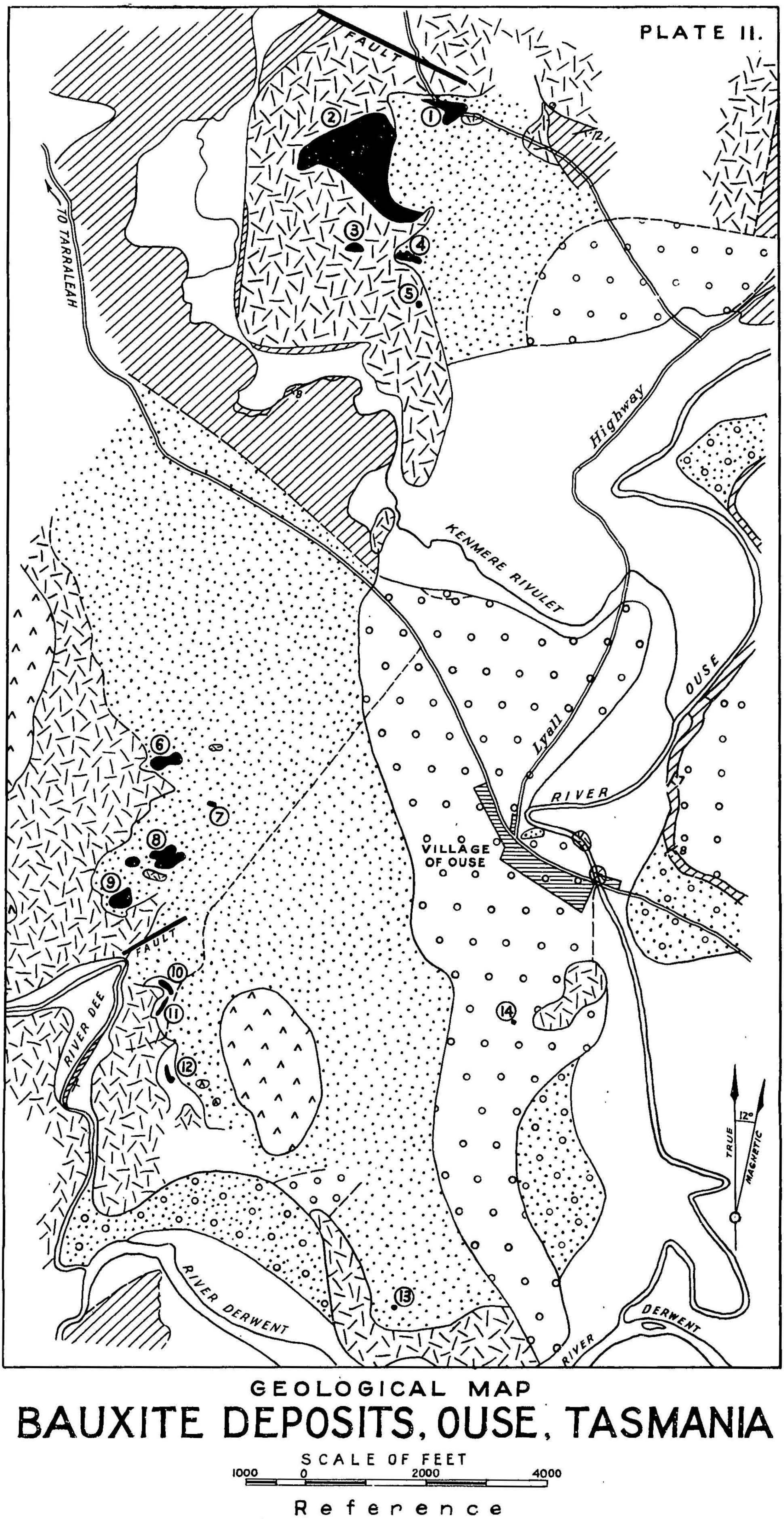
V5-65

"WATKINS" BAUXITE DEPOSIT

PH. ALLAMBEE EAST CO. BULN BULN

VICTORIA





GEOLOGICAL MAP

BAUXITE DEPOSITS, OUSE, TASMANIA

SCALE OF FEET

1000 0 2000 4000

Reference

RECENT	*Alluvium*	OLIGOCENE TO EOCENE (?)	*Lacustrine sands & clays with lignite.*
PLEISTOCENE	*River terraces, sands*	EOCENE	*Bauxite*
	Grits, boulder beds	JURASSIC	*Dolerite*
PLIOCENE	*Basic and coarse agglomerate*	TRIASSIC	*Sandstones, shales*

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T15-1 E.S.

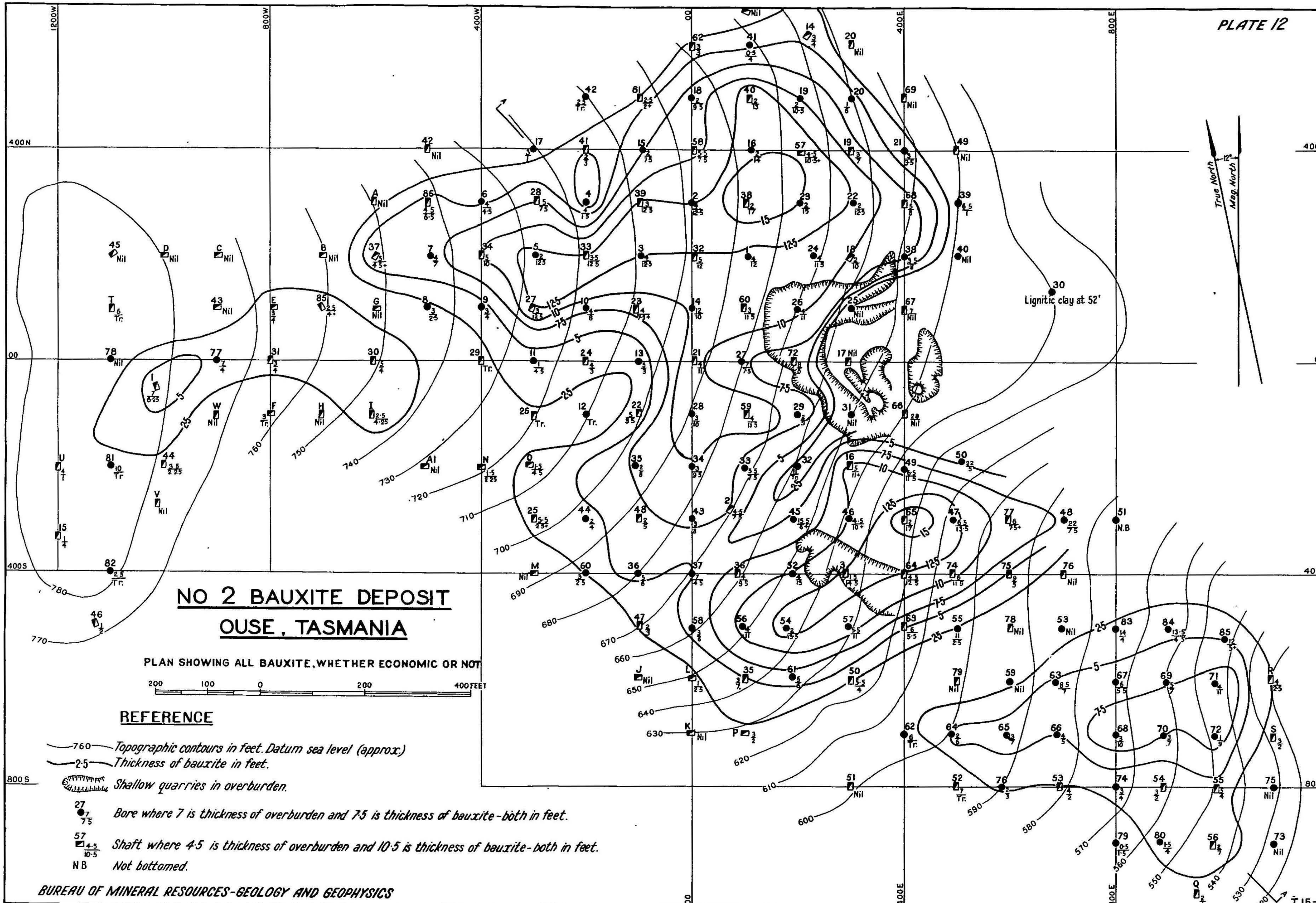
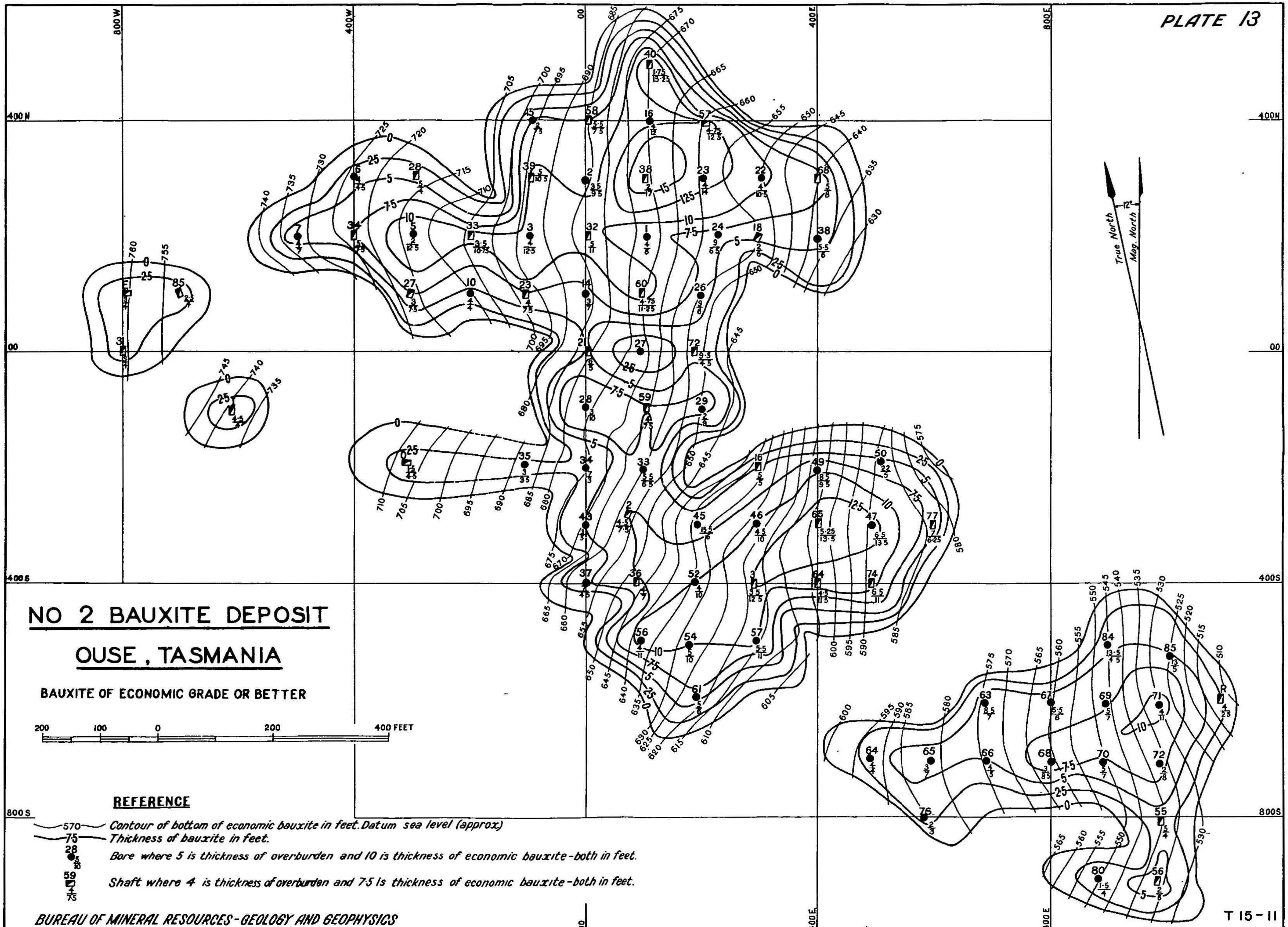


PLATE 12
NO 2 BAUXITE DEPOSIT
OUSE, TASMANIA
PLAN SHOWING ALL BAUXITE, WHETHER ECONOMIC OR NOT
200 100 0 200 400 FEET
REFERENCE
760 Topographic contours in feet. Datum sea level (approx.)
2·5 Thickness of bauxite in feet.
Shallow quarries in overburden.
27 Bore where 7 is thickness of overburden and 7·5 is thickness of bauxite-both in feet.
57 Shaft where 4·5 is thickness of overburden and 10·5 is thickness of bauxite-both in feet.
NB Not bottomed.
BUREAU OF MINERAL RESOURCES-GEOLOGY AND GEOPHYSICS
True North
Mag. North
12°
Lignitic clay at 52'
1200W
800W
400W
00
400E
800E
400N
400S
800S
T15-2



NO 2 BAUXITE DEPOSIT
OUSE, TASMANIA
BAUXITE OF ECONOMIC GRADE OR BETTER
200 100 0 200 400 FEET
True North
Mag. North
12°
400 N
00
400 S
800 S
800 W
400 W
400 E
800 E
REFERENCE
570 Contour of bottom of economic bauxite in feet. Datum sea level (approx)
7·5 Thickness of bauxite in feet.
Bore where 5 is thickness of overburden and 10 is thickness of economic bauxite - both in feet.
Shaft where 4 is thickness of overburden and 7·5 is thickness of economic bauxite - both in feet.
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T 15-11

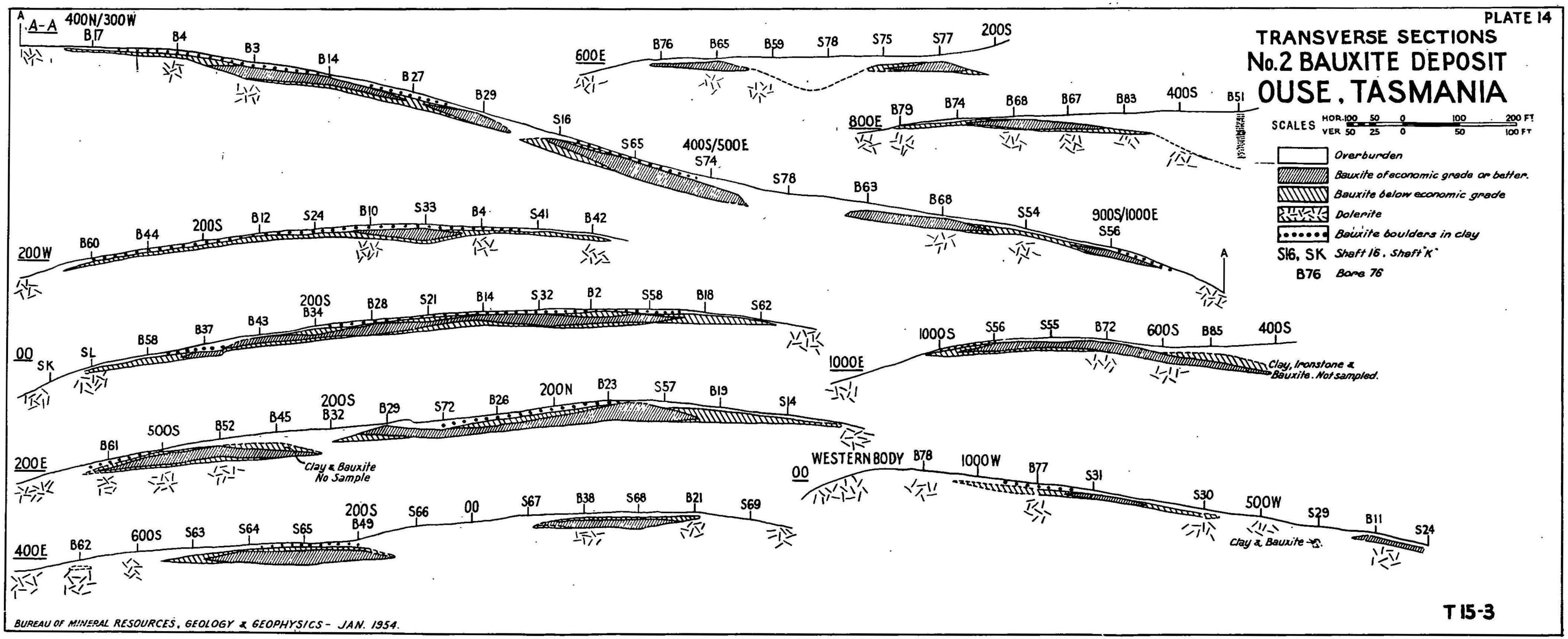
PLATE 14
TRANSVERSE SECTIONS
No.2 BAUXITE DEPOSIT
OUSE, TASMANIA
SCALES HOR. 100 50 0 100 200 FT
VER. 50 25 0 50 100 FT
Overburden
Bauxite of economic grade or better.
Bauxite below economic grade
Dolerite
Bauxite boulders in clay
S16, SK Shaft 16. Shaft 'K'
B76 Bore 76
A-A 400N/300W
600E
800E
200W
00
1000E
200E
400E
WESTERN BODY
400S/500E
900S/1000E
Clay, Ironstone & Bauxite. Not sampled.
Clay & Bauxite No Sample
Clay & Bauxite
T 15-3
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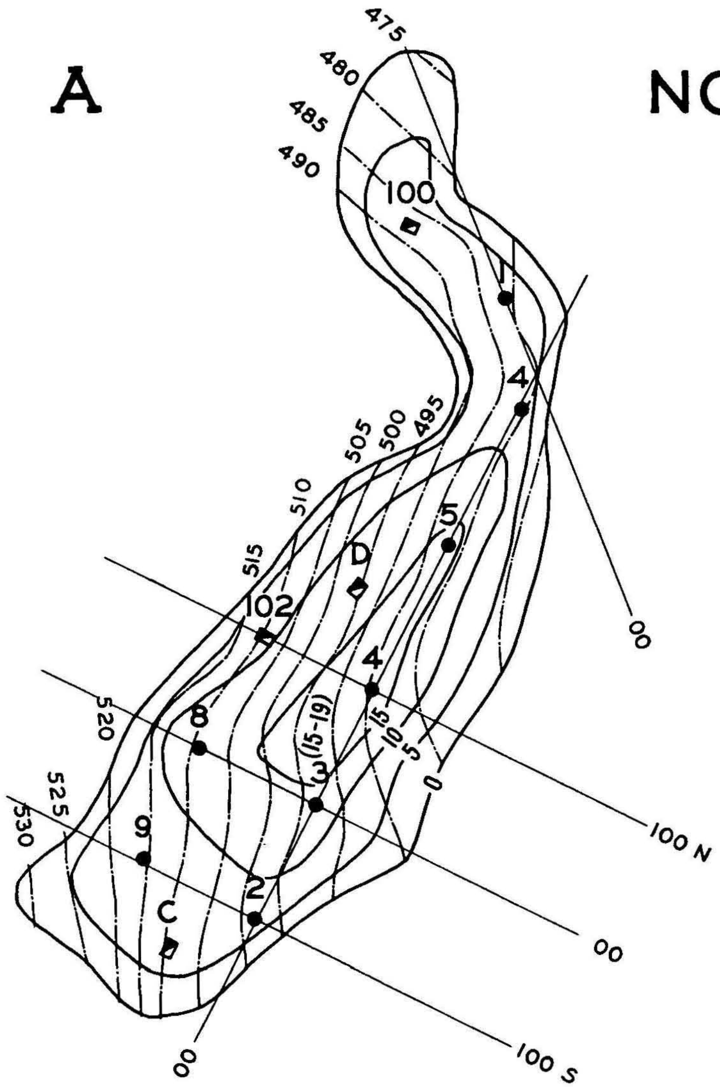
PLATE 15

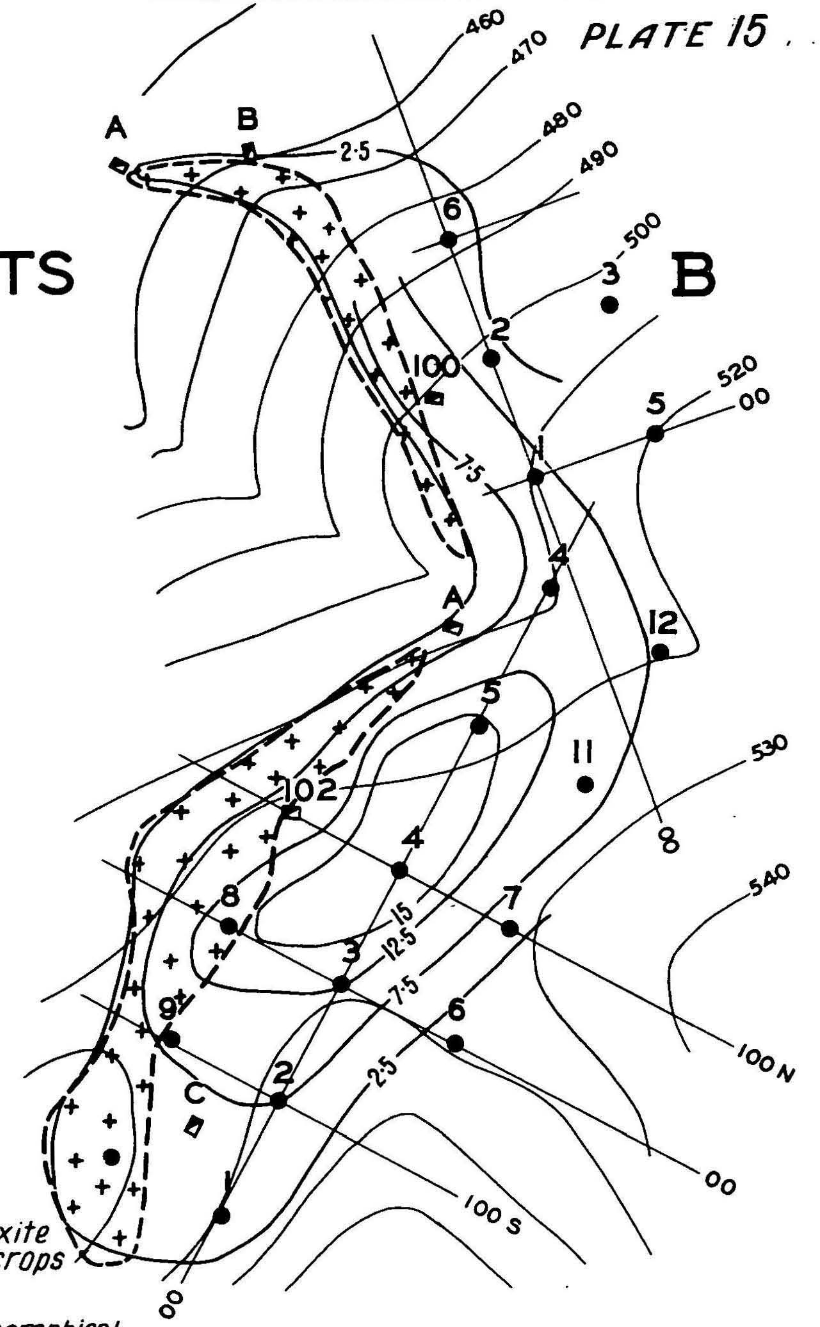
PLANS OF
NOS. 10 & 11 BAUXITE DEPOSITS
OUSE, TASMANIA.

A - STRUCTURE CONTOURS AND THICKNESS OF BAUXITE OF ECONOMIC GRADE

B - OUTCROP AND THICKNESS OF ALL BAUXITE IRRESPECTIVE OF GRADE

150 100 50 0 150





REFERENCE

Shaft ● Bore

A

Structure Contours in feet. (520)

Thickness of Bauxite in feet (10, (15-19))

B

Bauxite Outcrops

Topographical Contours in feet (530)

Thickness of Bauxite in feet (7·5)

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T15-43 A.St.

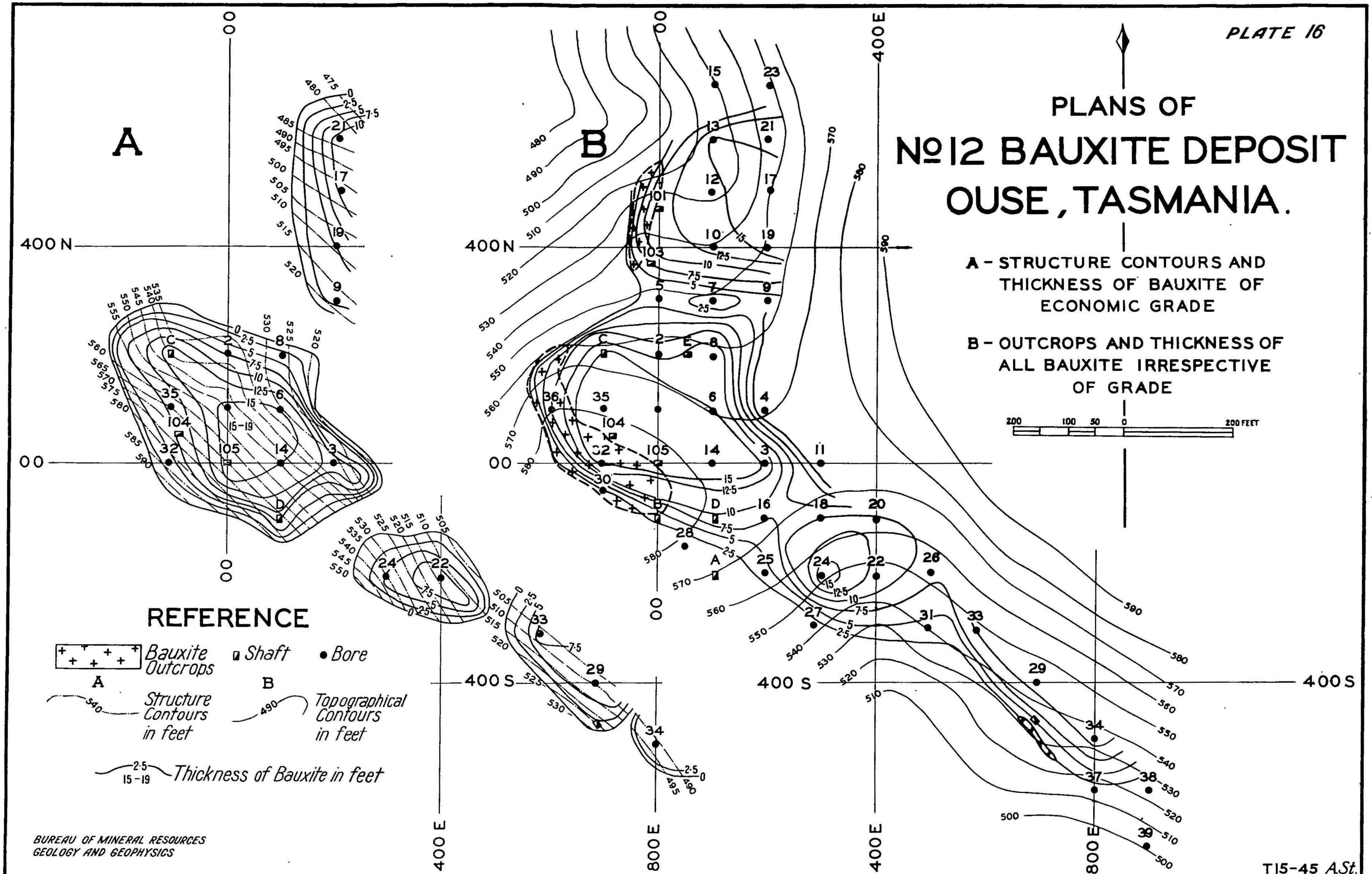
PLATE 16
PLANS OF
Nº 12 BAUXITE DEPOSIT
OUSE, TASMANIA.
A - STRUCTURE CONTOURS AND THICKNESS OF BAUXITE OF ECONOMIC GRADE
B - OUTCROPS AND THICKNESS OF ALL BAUXITE IRRESPECTIVE OF GRADE
200 100 50 0 200 FEET
A
B
400 N
00
400 S
400 E
800 E
REFERENCE
Bauxite Outcrops
Shaft
Bore
A
B
Structure Contours in feet
Topographical Contours in feet
Thickness of Bauxite in feet
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GEOLOGY AND GEOPHYSICS
T15-45 A.St.

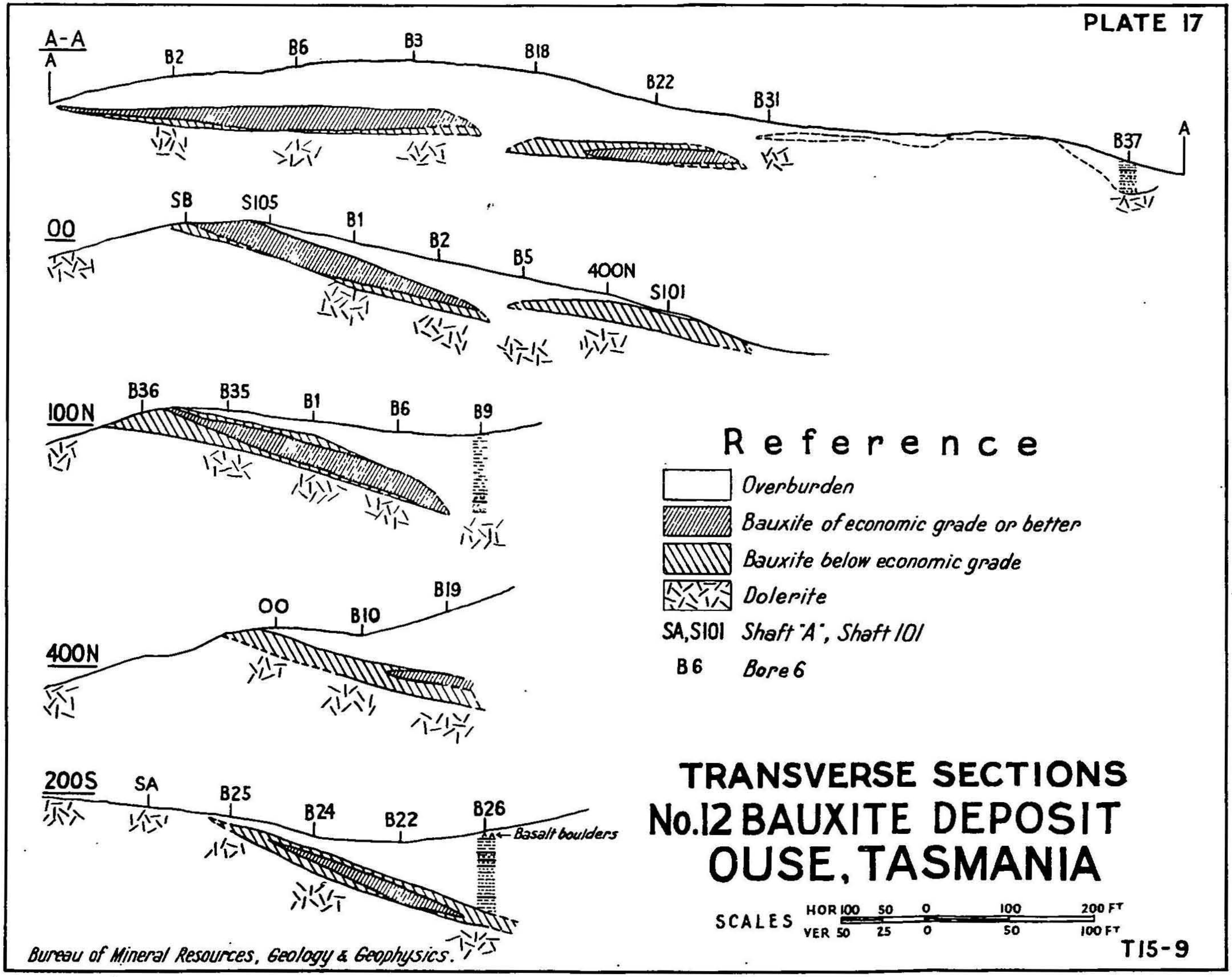


PLATE 17
A-A
A
B2
B6
B3
B18
B22
B31
B37
A
00
SB
S105
B1
B2
B5
400N
S101
100N
B36
B35
B1
B6
B9
400N
00
B10
B19
200S
SA
B25
B24
B22
B26
Basalt boulders
Reference
Overburden
Bauxite of economic grade or better
Bauxite below economic grade
Dolerite
SA, S101 Shaft "A", Shaft 101
B6 Bore 6
TRANSVERSE SECTIONS
No.12 BAUXITE DEPOSIT
OUSE, TASMANIA
SCALES HOR 100 50 0 100 200 FT
VER 50 25 0 50 100 FT
Bureau of Mineral Resources, Geology & Geophysics.
T15-9

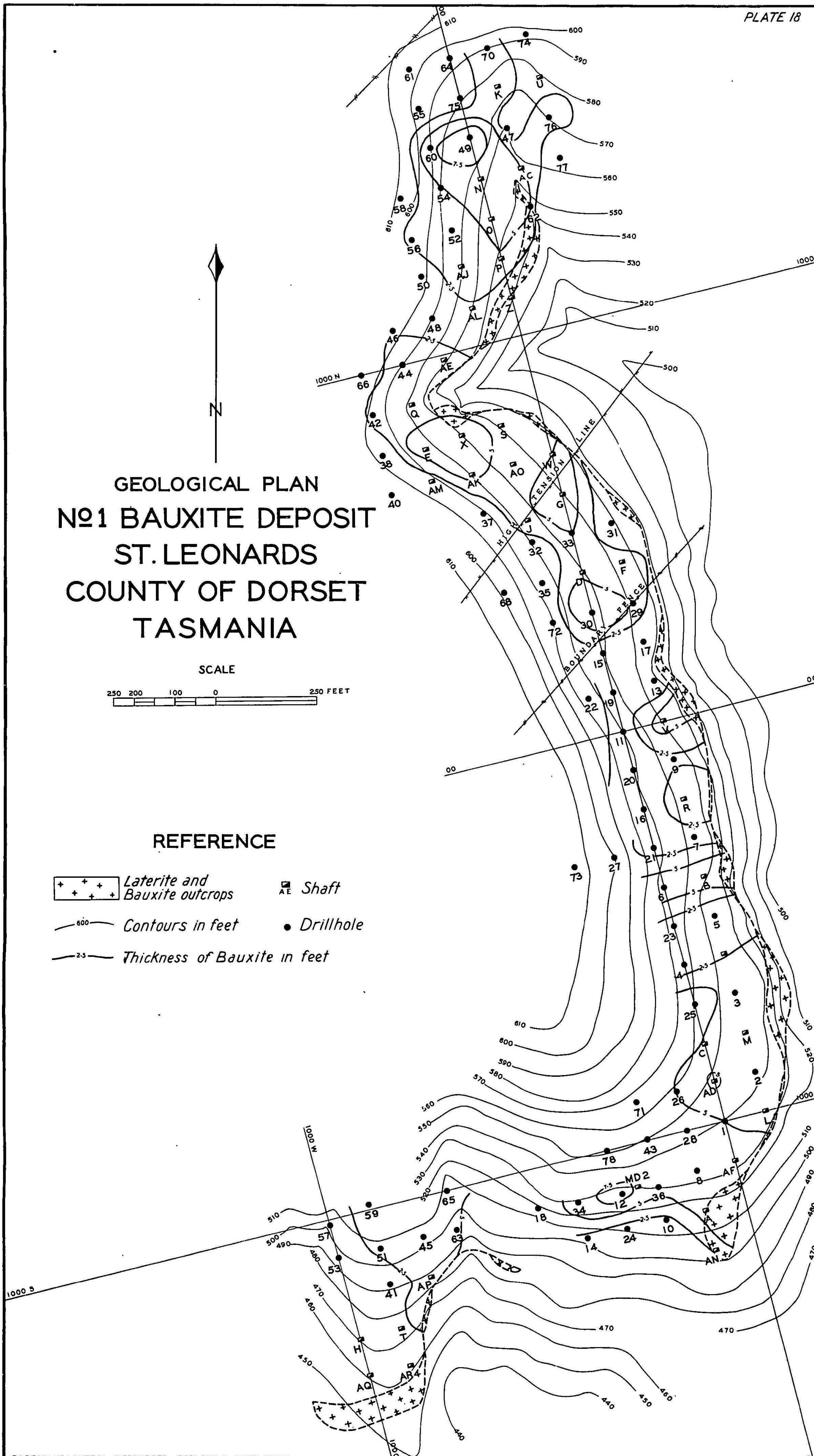
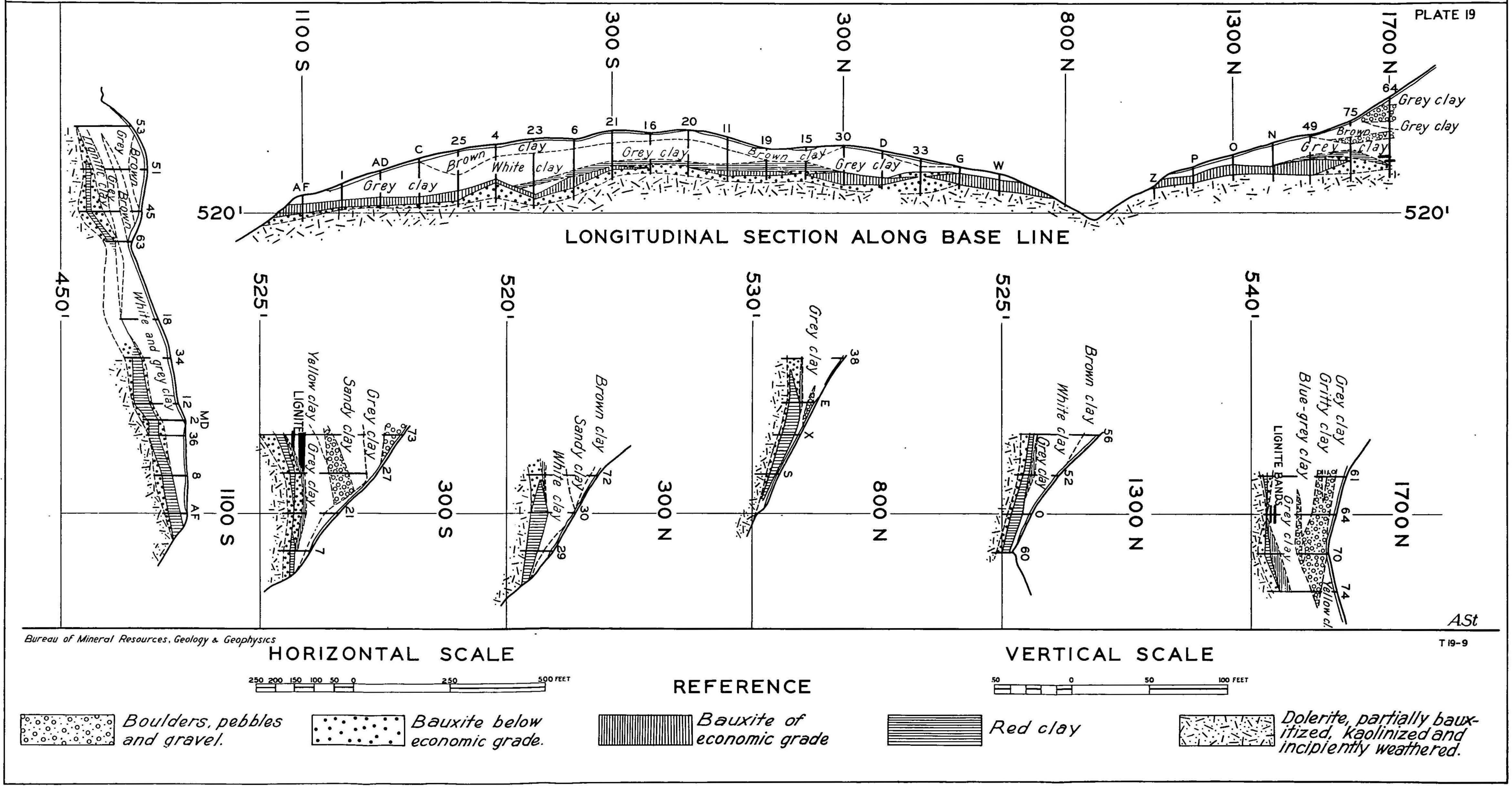


PLATE 18
GEOLOGICAL PLAN
Nº1 BAUXITE DEPOSIT
ST. LEONARDS
COUNTY OF DORSET
TASMANIA
SCALE
250 200 100 0 250 FEET
N
REFERENCE
Laterite and Bauxite outcrops
Shaft
Contours in feet
Drillhole
Thickness of Bauxite in feet
HIGH TENSION LINE
BOUNDARY FENCE
1000 N
00
1000 S
1000 W
BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS.
T 19-10

SECTIONS OF Nº 1 BAUXITE DEPOSIT, ST. LEONARDS, TASMANIA



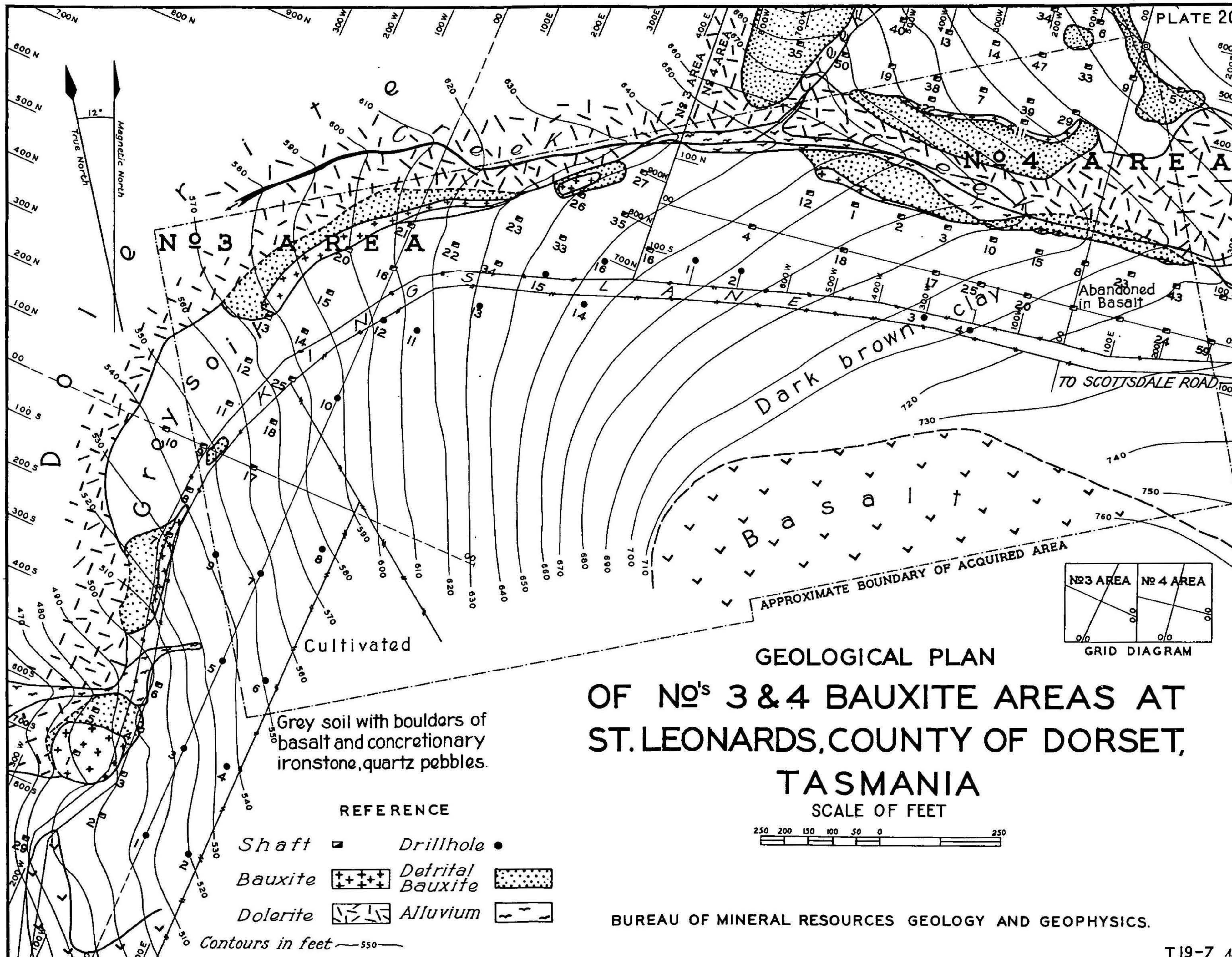


PLATE 20
GEOLOGICAL PLAN
OF No's 3 & 4 BAUXITE AREAS AT
ST. LEONARDS, COUNTY OF DORSET,
TASMANIA
SCALE OF FEET
250 200 150 100 50 0 250
No 3 AREA
No 4 AREA
GRID DIAGRAM
True North
Magnetic North
12°
Dolerite
Grey soil
Dark brown clay
Basalt
Cultivated
Abandoned in Basalt
TO SCOTTSDALE ROAD
APPROXIMATE BOUNDARY OF ACQUIRED AREA
Grey soil with boulders of basalt and concretionary ironstone, quartz pebbles.
REFERENCE
Shaft
Drillhole
Bauxite
Detrital Bauxite
Dolerite
Alluvium
Contours in feet 550
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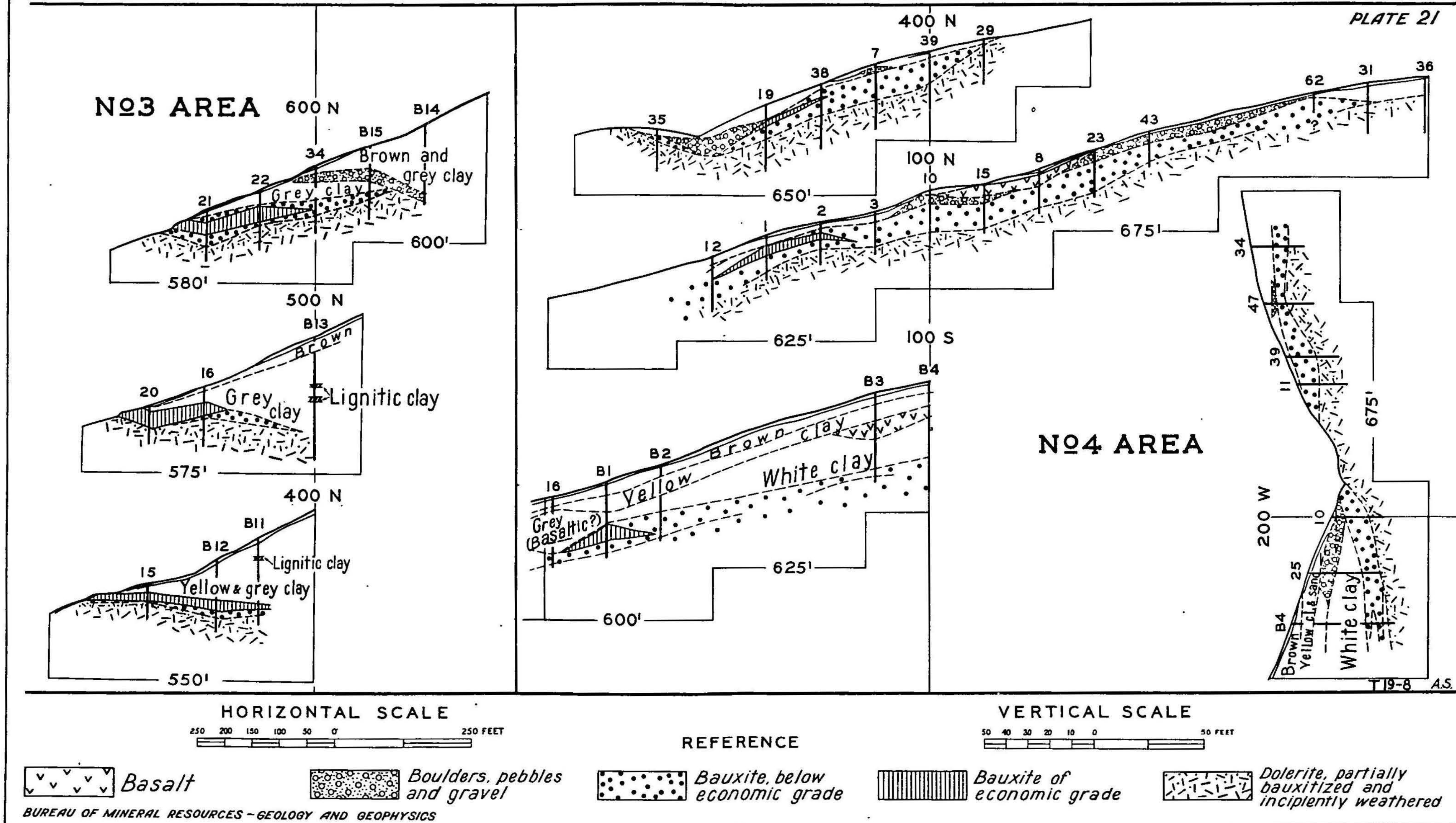
T 19-7

SECTIONS OF No's 3&4 BAUXITE AREAS, ST. LEONARDS, TASMANIA

PLATE 21



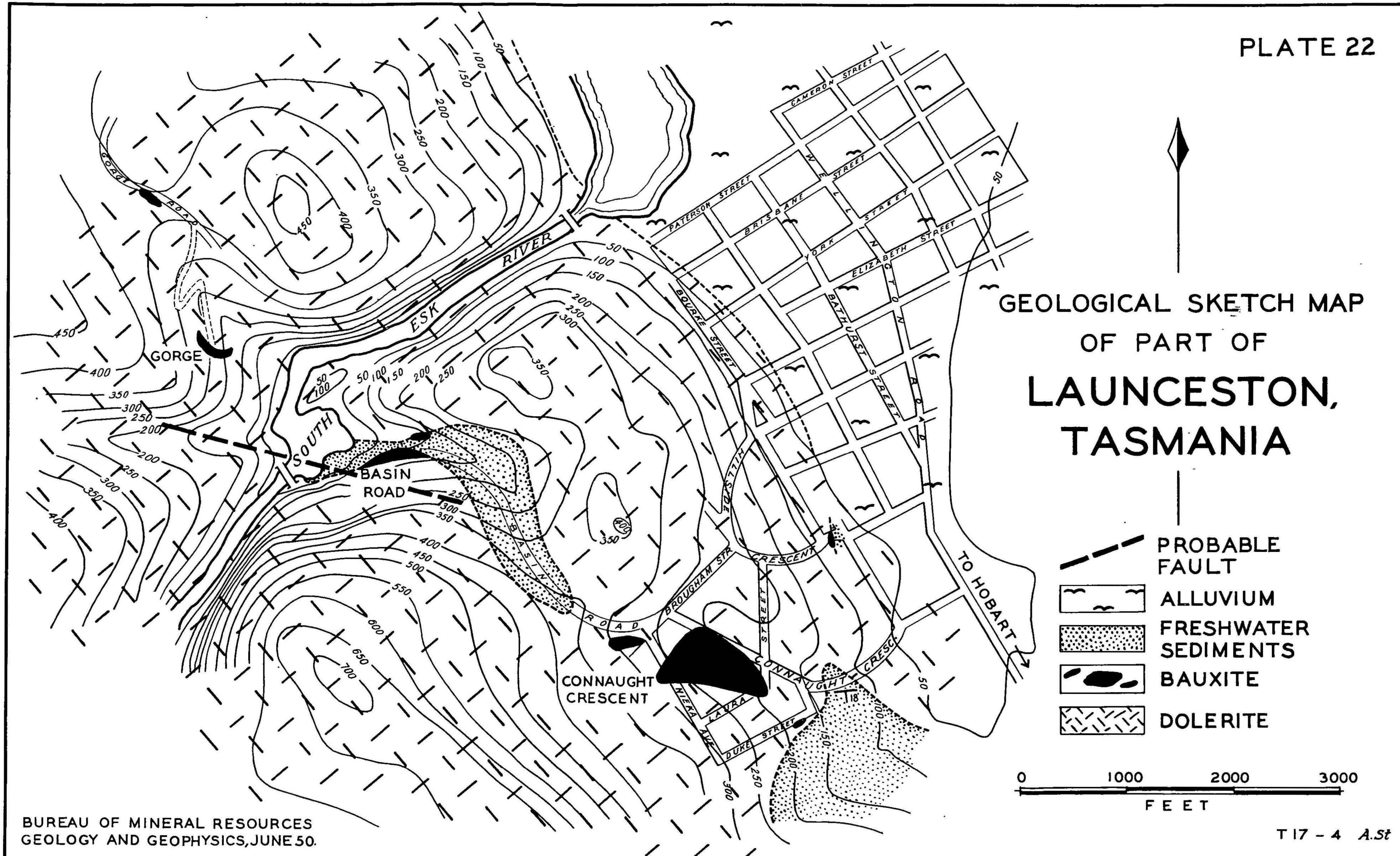


PLATE 22
GEOLOGICAL SKETCH MAP
OF PART OF
LAUNCESTON,
TASMANIA
PROBABLE FAULT
ALLUVIUM
FRESHWATER SEDIMENTS
BAUXITE
DOLERITE
0
1000
2000
3000
FEET
GORGE
BASIN ROAD
SOUTH ESK RIVER
CONNAUGHT CRESCENT
TO HOBART
CAMERON STREET
PATERSON STREET
BRISBANE STREET
YORK STREET
ELIZABETH STREET
WELLINGTON ROAD
BOURKE STREET
BATHURST STREET
BROUGHAM STR
LAURA
DUKE STREET
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GEOLOGY AND GEOPHYSICS, JUNE 50.
T 17 - 4 A.St

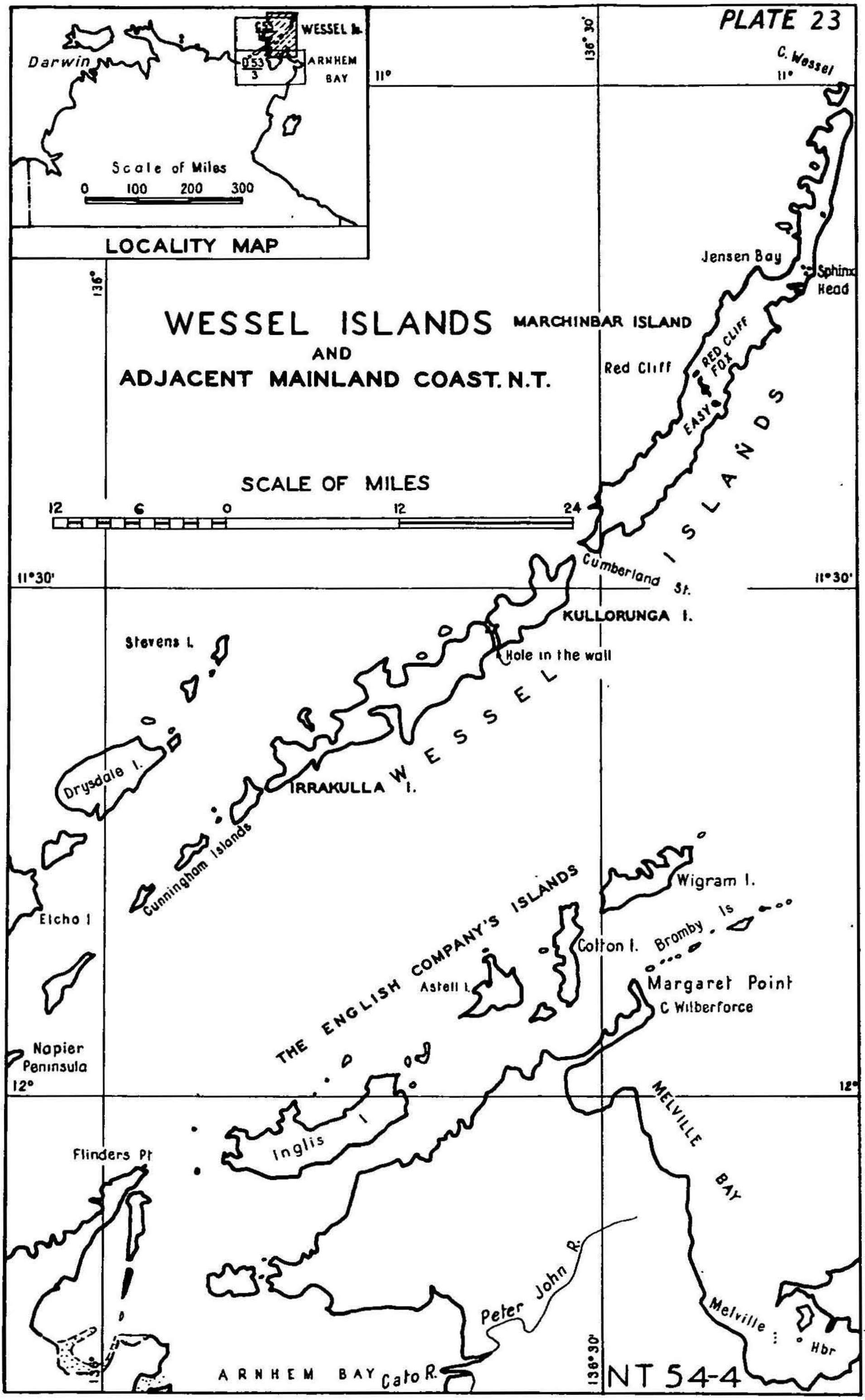
PLATE 23
WESSEL ISLANDS
AND
ADJACENT MAINLAND COAST. N.T.
LOCALITY MAP
Darwin
WESSEL Is.
ARNHEM BAY
Scale of Miles
0 100 200 300
SCALE OF MILES
12 6 0 12 24
MARCHINBAR ISLAND
C. Wessel
Jensen Bay
Sphinx Head
Red Cliff
RED CLIFF
FOX
EASY
Cumberland St.
KULLORUNGA I.
Hole in the wall
WESSEL ISLANDS
IRRAKULLA I.
Stevens I.
Drysdale I.
Cunningham Islands
Elcho I
Napier Peninsula
THE ENGLISH COMPANY'S ISLANDS
Wigram I.
Bromby Is
Cotton I.
Astell I.
Margaret Point
C Wilberforce
Inglis I
Flinders Pt
MELVILLE BAY
Peter John R.
Melville Hbr
ARNHEM BAY
Cato R.
136°
136° 30'
11°
11°30'
12°
NT 54-4

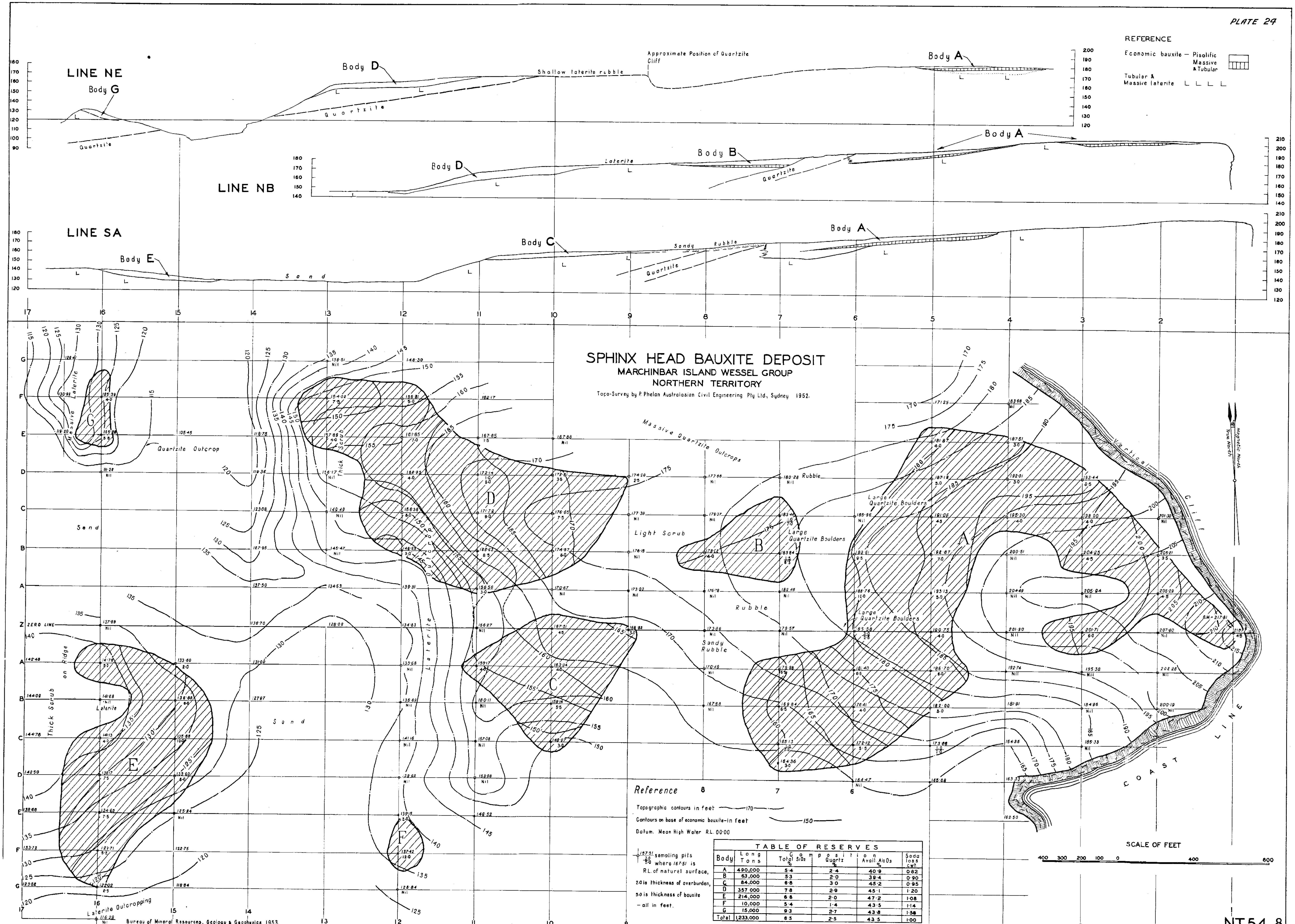

TABLE OF RESERVES					
Body	Long Tons	Composition: Total SiO_2 %	Quartz %	Avail. Al_2O_3 %	Soda loss cwt.
A	490,000	5·4	2·4	40·9	0·82
B	63,000	5·3	2·0	39·4	0·90
C	84,000	6·8	3·0	45·2	0·95
D	357 000	7·8	2·9	45·1	1·20
E	214,000	6·8	2·0	47·2	1·08
F	10,000	5·4	1·4	43·5	1·14
G	15,000	9·3	2·7	43·8	1·58
Total	1,233,000	6·5	2·5	43·5	1·00

PLATE 25

NT54-10

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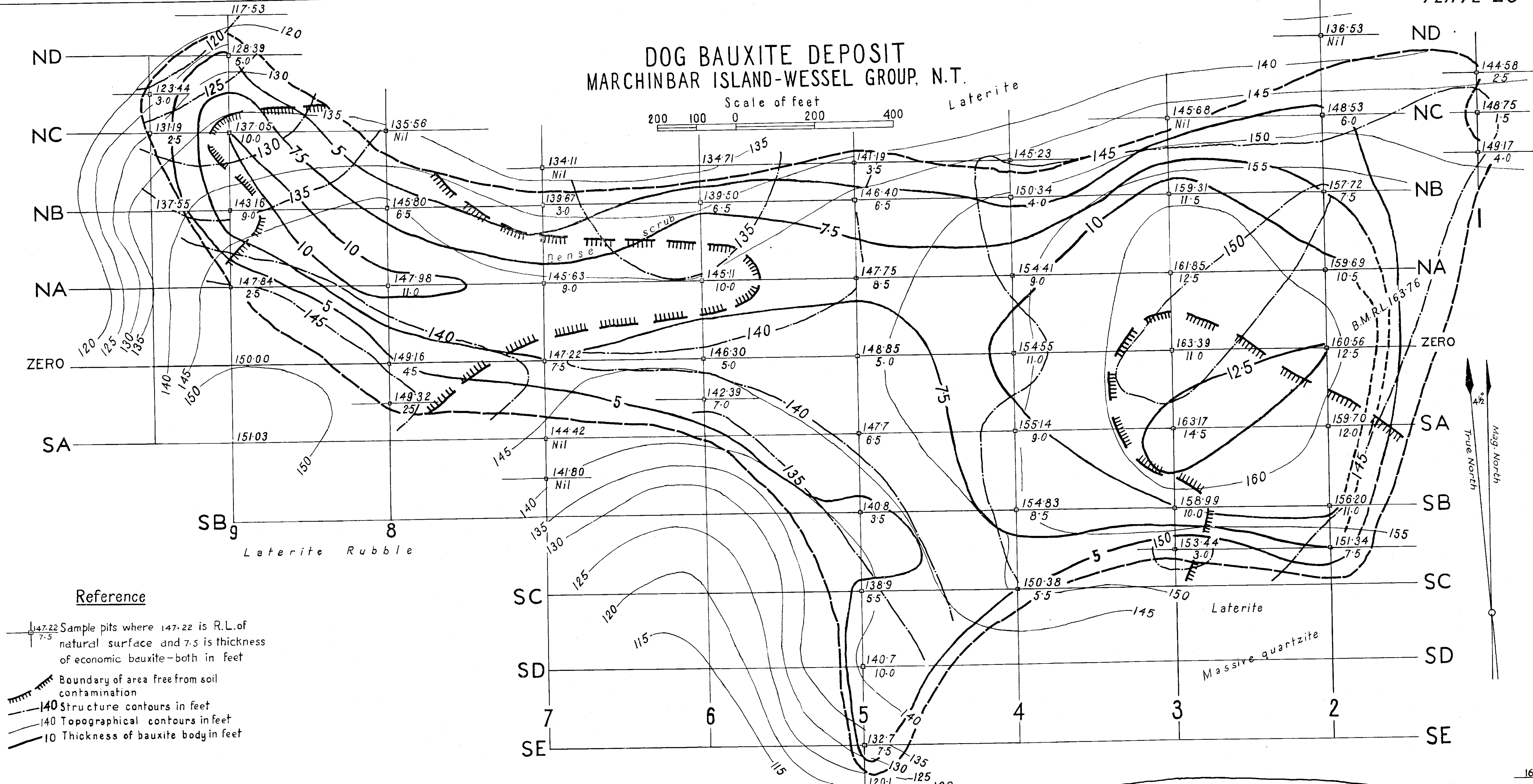
PLATE 26

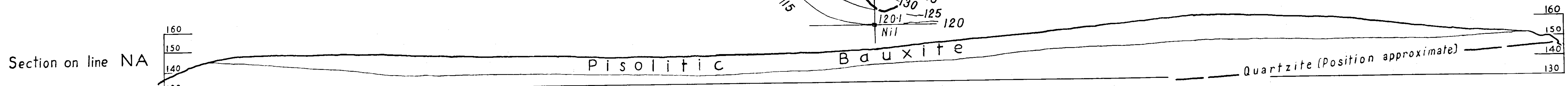
DOG BAUXITE DEPOSIT

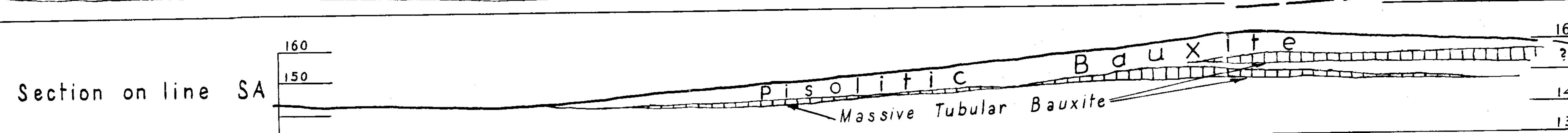
MARCHINBAR ISLAND-WESSEL GROUP, N.T.



Reference

- 147·22 / 7·5 Sample pits where 147·22 is R.L. of natural surface and 7·5 is thickness of economic bauxite – both in feet
- Boundary of area free from soil contamination
- 140 Structure contours in feet
- 140 Topographical contours in feet
- 10 Thickness of bauxite body in feet





Topo. Survey by P. Phelan
Australasian Civil Engineering Pty Ltd
Sydney 1952.

NT54-13

Bureau of Mineral Resources, Geology & Geophysics. September 1953.

LATERITE PROFILES

T 28-3