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REPORT No. 1949/97
(Geol.Ser.65)

BAUXITE RESOURCES OF THE MOSS VALE DISTRICT, NEW SOUTH WALES.

by

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CANBERRA. 7th October, 1949.

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LIST OF PLATES.

I. SUMMARY.

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 N.S.W. from time to time.

The laterite has some application in commerce. Relatively 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 railed 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 Australian Aluminium Production Commission at Wingello during July and August 1948 and at Ellsmore in the early part of 1949.

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), and a limited amount of sampling at Deposits 3, 4 and 5 was done in addition. 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 Tables I, II, and III.

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

Table I.

Reserves held by Australian Aluminium Production Commission.

No.	Locality	Long Tons	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	Avail. Al_2O_3 %	Na_2O loss Cwt.
6	Wingello	60,000	7.5	36.4	31.2	4.4	31.6	0.86

Table II.

Reserves tested by Australian Aluminium Production Commission on alienated leases.

No.	Locality	Long tons	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	Avail. Al_2O_3 %	Na_2O loss Cwt.
2 (A)	Ellsmore	51,000	4.4	40.7	32.7	4.3	31.2	0.83
2 (B)	Ellsmore	132,000	2.9	37.7	33.0	5.5	33.1	0.73
2 (C)	Ellsmore	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	185,000	5.6	35.3	33.3	4.3	32.2	0.81

Table III.

Deposits not held by Australian Aluminium Commission and tested by other authorities.

No.	Locality	Long Tons	SiO_2 %	Al_2O_3 %	FeO %	Fe_2O_3 %	TiO_2 %
1.	Belanglo	3,500	Not sampled.				
2.	Ellsmore	1,625,000 (4)	5.37	39.38 (2)	0.97	31.12	5.17
3.	Murrimba	50,000	3.87	31.01 (2)	-	34.32	-
4.	Sutton Forest	170,000	4.17	36.84	1.74	35.88	4.16
		24,000 (1)	4.5	53.9	-	5.7	-
		73,000 (1)	6.5	43.2	-	12.6	-
		500,000 (1)	4.5	31.3	-	28.8	-
5.	Murrimba and Sutton Forest	270,000	4.03	36.72	1.60	37.39	4.98
6.	Wingello	1,200,000 (5)	-	27.2	-	-	-
7.	Wingello	Very small	-	- (2)	-	-	-
8.	Bumballa	175,000	7.52	35.18 (2)	-	30.21	-
9.	Bumballa	10,000	5.47	34.00 (2)	-	34.64	-
10.	Cawura	6,000	7.36	32.49 (2)	-	32.64	-

(1) Figures from Commonwealth Copper and Bauxite Committee, Eighth Report. Australian Bauxite Resources, Jan. 1942. All other figures except for No. 6 from report by Raggatt, H.G. Ferruginous Bauxite Deposits of the Moss Vale (Bundanoon-Wingello) District. Dept. of Mines, Sydney, 1939.

(2) Al_2O_3 soluble in 48% sulphuric acid. Analyses by B.H.P. Co. Ltd.

(4) Includes 273,000 tons shown in Table II.

(5) Tonnage estimate from resampling by A.A.P.C. The figure includes the 60,000 and 185,000 tons shown in Table I and II respectively. Al_2O_3 figures is Available Al_2O_3 extracted in alkaline solution under pressure.

II. INTRODUCTION.

A. Previous Work.

Bauxite from Wingello was identified by J.B. Jaquet (1898) who later described the deposits in this area (1901).

During 1920-1922 L.F. Harper (1921 and 1924) made a reconnaissance examination of the bauxite deposits of New South Wales.

At a later date sub-surface prospecting of the deposits was carried out by the Broken Hill Pty. Co. Ltd., and following this work a survey was made by H.G. Raggatt (1939) who incorporated the B.H.P. Co's results in his report.

After this survey some additional sampling was done by Sulphates Pty. Ltd. at Wingello (No. 6 deposit) and Sutton Forest (No. 5 deposit). Some of the results obtained by this company were incorporated in the eighth report of the Commonwealth Copper and Bauxite Committee (C.C.B.C. 1942).

B. Locality and Access.

All the deposits described herein lie in the County of Camden about 100 miles south-south-west from Sydney. They are easily accessible by road and all lie within 12 miles or less from stations on the Great Southern Railway. The nearest sea-port from which Moss Vale bauxite could be shipped is Port Kembla, 47 miles by rail from Moss Vale via Unanderra and Wollongong.

Road and rail distances between the more important of the deposits and Port Kembla are :-

Deposit	Road distance to railway at		Rail distance to Port Kembla
2. Ellsmore	Moss Vale	12 miles	47 miles
4. Sutton Forest and Murrimba	Exeter	6 miles	55 miles
5. Sutton Forest and Murrimba	Exeter	7 miles	55 miles
6. Wingello	Wingello	2 miles	66½ miles

(See Plate I, also Military Map, Moss Vale 1" = 1 mile).

C. Topography.

The deposits lie on the Southern Tableland at altitudes ranging from 2,556 feet above level at Ellsmore Trig. Station to 2,230 feet at Deposit No. 9 south of Wingello.

The laterite bodies, which are remnants of a former land surface of low relief, form the caps of low hills rising about 50 feet above the general level of the Tableland. Many remnants of the basalt from which the laterite has been derived, also form low residual hills of about similar height but more rounded profile. Consequently the surface of the tableland is one of moderate relief.

D. Definitions.

(1) Available Alumina.

The total alumina content of bauxite is not necessarily a safe indication of the amount of alumina which can be extracted by the Bayer process, as some alumina may be present as a hydrous silicate, some as monohydrate and the remainder as trihydrate.

A laboratory method which simulates Bayer plant conditions is used to determine the alumina available to extraction on a commercial scale. This alumina, which is extracted by hot alkali solution under pressure, is reported as Available Alumina. It is very probable that the available alumina figure is a close measure of the alumina present in the ore as trihydrate.

(2) Soda loss.

The alkali used in the Bayer extraction is recoverable after the precipitation of alumina from the sodium aluminate solutions, but there are inevitable loses due to the formation of an insoluble sodium aluminium silicate by reaction with the silica of kaolin, or opaline silica in the ore, (the so-called "reactive" or "free" silica of bauxite), and a small proportion of the soluble soda is also retained in the insoluble "red mud" which is discarded.

The laboratory method of determining available alumina permits an estimation of the alkali loss involved, and this is expressed in hundredweights (112 lb.) per long ton of alumina extracted.

(3) Bauxite.

The term bauxite was originally applied to the naturally occurring aluminium monohydrate at Les Beaux in southern France. With the great development of the aluminium industry the name has been applied to all aluminium ores which are essentially hydrates, irrespective of their mode of occurrence or origin.

In this report the word "bauxite" is used to denote laterite of any type which contains not less than 30 per cent of available alumina that can be extracted with a loss of alkali not exceeding certain permissible limits according to the following scale.

Available Alumina per cent.	Maximum Permissible loss of alkali in hundredweights of Na_2O per ton of Available alumina
30	1.20
31	1.31
32	1.41
34	1.56
36	1.70
38	1.83
40	1.95
42	2.05
44	2.15
46	2.24
48	2.32

III. GENERAL GEOLOGY.

The laterite is derived from Tertiary basalt which in places overlies lower Tertiary freshwater sediments and is probably of Oligocene age. It is considered that the laterite was formed during Miocene time (Raggatt, 1939, Woolnough, 1927).

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

At Ellsmore and at No. 3 Deposit Tertiary sediments underlie the basalt at shallow depth, and at Wingello the laterite lies on sandstone (presumably Tertiary) which has itself been lateritized.

Indistinct plant fragments were noticed in the sub-laterite sediments at Ellsmore and Cinnamomum has been identified in argillaceous sediments beneath the laterite of No. 3 Deposit (Jaquet 1901).

These observations indicate that the basalt, where lateritized was thin, ranging from a few feet at Wingello to about 50 feet thick at No. 3 Deposit. Elsewhere the thickness of the basalt may greatly exceed the latter figure, for example at Gingenbullen, between Sutton Forest and Berrima, the basalt is about 300 feet thick or more.

The basalt is not underlain by Tertiary beds at all points within the region being discussed. At the Cross Roads basalt rests on Upper Permian shales with thin coal seams, and at Freestone Trig. Station a small remnant of basalt, with a few residual boulders of ferruginous laterite, was found lying on Triassic (Hawkesbury) sandstone.

None of the laterites bear any cover of younger formations as in Tasmania, Victoria and northern New South Wales.

VI. DESCRIPTION OF LATERITE.

A general description of the laterite is given here to avoid unnecessary repetition in the discussion of individual deposits.

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 being between 5 and 10 m.m. 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; extreme cases require 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 Ellamore "B" Deposit shows the matrix to consist of closely packed oolites, of an average diameter of about 0.25 m.m., surrounded by a narrow rim (0.01 to 0.02 m.m. wide) of prismatic gibbsite crystals. These crystals radiate from the surfaces 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 (Rogers and Kerr, 1942 p. 204) with an outer 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.

Table IV.

	1.	2.	3.	4.
	%	%	%	%
SiO_2	3.6	8.1	4.1	3.5
Al_2O_3	38.2	39.9	42.1	38.0
Fe_2O_3	36.4	29.6	28.4	34.0
TiO_2	5.0	4.3	4.7	5.3
P_2O_5	0.09	0.24	0.28	-
V_2O_5	trace	0.07	0.05	-
Cr_2O_3	trace	-	-	2.0 FeO
Ign.loss	15.7	17.5	19.5	15.7
Avail.Al_2O_3	27.9	31.1	34.7	29.5
Na_2O loss	1.30 cwt	0.39 cwt	0.99 cwt	0.37 cwt.

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

B. The Massive and tubular types.

These types of ore occur below the pisolitic zone at No. 6 Area, Wingello and at No. 4 Area, 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 m.m. 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, apparently, were 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:-

Table V.

	1. %	2. %
SiO_2	4.6	5.3
Al_2O_3	34.2	32.6
Fe_2O_3	36.9	37.9
TiO_2	3.8	4.7
P_2O_5	0.24	0.23
V_2O_5	0.09	0.06
Ign. loss	19.9	18.4
Avail. Al_2O_3	32.4	31.1
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. 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 exceedingly numerous and probably account for the greater part of the silica figure given in the 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:-

Table IV.

	1.	2.	3.	4.	5.
	%	%	%	%	%
SiO_2	5.0	3.9	2.1	3.8	4.6
Al_2O_3	35.0	37.2	37.8	55.3	55.3
Fe_2O_3	32.2	32.1	32.3	4.2	3.3
TiO_2	6.3	5.2	5.7	6.7	5.8
P_2O_5	0.25	0.25	0.24	0.06	0.06
V_2O_5	0.05	0.05	0.04	trace	trace
Cr_2O_3	-	-	-	trace	trace
Ign. loss	20.7	21.2	21.6	30.1	30.5
Avail. Al_2O_3	31.2	32.2	36.1	50.3	50.8
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
Na_2O loss	0.87	1.37	0.52	0.80	0.69

1. Shaft No.9, No.2 Area, Ellsmore "B". Depth 3 to 4.5 feet
2. - do. - " 4.5 to 12 feet
3. - do. - " 12 to 18 feet
4. Quarry No.4 area. Sutton Forest " 5 to 9 feet
5. - do. - " 9 to 13 feet

D. The clayey type.

This 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.

Table VII.

	1.	2.	3.	4.
	%	%	%	%
SiO_2	18.3	29.5	32.3	32.[illegible]
Al_2O_3	25.5	28.6	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
Ign. loss	13.4	13.8	14.0	14.6
Avail. Al_2O_3	7.2	2.8	2.6	2.9

1. No.2 Area Ellsmore "A": Variegated lateritized basalt immediately underlying pisolitic zone.
2. - do. - 5' - 9', immediately below pisolitic laterite containing 6.4% SiO_2
3. - do. - 9' - 12', same shaft as 2.
4. - do. - 12' - 18.5' same shaft.

IV. DESCRIPTIONS OF INDIVIDUAL 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 Ellsmore 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 in the cases of Nos.2 and 6 areas, all tonnage estimates given are also quoted from the same sources.

A. Areas tested by the Australian Aluminium Production Commission.

1. No.2 Area, Ellsmore. See Plates 2 and 3.

Four deposits, remnants of a once continuous sheet, occur in the No.2 Area 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. On Deposits 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 nil underlies the pisolitic type on Deposit 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 sections shown on Plate 3.

DEPOSIT A. Shaft Co-ordinates 100N/410W

Depth - feet from	to	Field Description	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	Avail. Al_2O_3 %
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	Ditto 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

DEPOSIT B. Shaft Co-ordinates 500S/400W

Depth - feet from	to	Field Description	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	Avail. Al_2O_3 %
0	1.5	Soil (Quarry face)	-	-	-	-
1.5	5.5	Cemented pisolites (Quarry face)	4.9	37.8	36.4	25.3
5.5	8	Loose pisolites (Quarry face)				
8	10	Pisolites - not sampled				
10	11	Loose pisolites				
11	12.5	Cemented pisolites, passing to	7.0	41.1	25.3	34.8
12.5	16	pisolites in soft earthy Matrix				
16	19.5	Pisolites in light brown clay	-	-	-	27.0

DEPOSIT B. Shaft Co-ordinates 200N/400E

Depth - feet from	to	Field Description.	Ign. loss %	Avail Al_2O_3 %	Soda loss cwt.
0	1.5	Soil	-	-	-
1.5	6.5	Fine loose pisolites passing to	17.0	30.5	0.32
6.5	8	Coarse ferruginous nodules passing to	20.6	35.0	0.30
8	13	Light brown earthy bauxite with sparse nodules			
13	15.5	Cemented pisolites	19.6	30.8	1.45
15.5	18	Sub-pisolitic and earthy laterite with hard red clay			
18	22.5	Ditto	17.9	24.4	4.20

Composite sample.

1.5	13	SiO_2	1.8	per cent
		Al_2O_3	37.6	"
		Fe_2O_3	34.4	"
		TiO_2	5.6	"
		P_2O_5	0.09	"
		V_2O_5	0.10	"
		Cr_2O_3	0.07	"
		Ign. loss	19.4	"
		Avail. Al_2O_3	33.3	per cent
		Na_2O loss	0.31	cwt.

DEPOSIT B. Shaft Co-ordinates 510N/625E

Depth - feet From	to	Field Description	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	Avail Al_2O_3 %
0	2	Soil	-	-	-	-
2	4.5	Sparse nodules in red earthy bauxite	5.0	35.0	32.2	31.2
4.5	12	Red earthy bauxite	3.9	37/2	32.1	32.2
12	12.5	Hard red earthy bauxite	2.1	37.8	32.3	36.1
12.5	13	Horizontal band of cemented pisolites				
13	17	Hard red earthy bauxite				
17	20.5	- do. -	-	-	-	33.1
20.5	21.5	- do. -	-	-	-	35.3
20	22.5 (1)		-	-	-	32.5
22.5	24 (1)	- do. - with clay	-	-	-	32.3

(1) Later sampling which overlapped previous sample channels.

Composite sample

2	20 feet	SiO_2	3.75	per cent
		Al_2O_3	37.1	"
		Fe_2O_3	32.0	"
		TiO_2	5.4	"
		P_2O_5	0.10	"
		V_2O_5	0.08	"
		Cr_2O_3	0.07	"
		Ign. loss	20.8	"
		Avail. Al_2O_3	32.9	per cent
		Na_2O loss	1.20	cwt.

DEPOSIT B. Shaft Co-ordinates 1470N/90W

Depth - feet From	to	Field Description	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	Avail. Al_2O_3 %
0	1.5	Soil	-	-	-	-
1.5	6.5	Cemented pisolites	7.1	39.3	27.8	33.1
6.5	11	Ditto, with little clay from 10' - 11'	12.8	37.4	25.8	26.3
11	15.5	Lateritized basalt	21.6	31.6	27.5	11.2

DEPOSIT D. Old Shaft No.1[a]

			SiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %
0	1	Hard capping)				
1	5	Pisolitic bauxite)	4.40	41.71	28.14	2.70
5	10	Loosely pisolitic	4.20	41.82	27.71	1.93
10	15	Loosely pisolitic	6.60	39.71	28.43	0.64
15	20	Laterite, some lateritized basalt	23.92	27.61	29.29	0.26

(a) Descriptions and analyses by B.H.P.Co.Ltd. Quoted from Raggatt (1939 p.8)

Reference to Plate 2 will show that Deposit 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 50 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 t accompanying plan revealed small volumes of economic bauxite, i.e., containing more than 30% Available Al_2O_3 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 Deposit A are estimated to be :

TABLE VIII.

	Long Tons	SiO_2 %	Al_2O_3 %	Avail Al_2O_3 %	Na_2O loss cwt.	Overburden Cu.yds
(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	30.5	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 30% available Al_2O_3
(c) total of (b). Contains 32.7% Fe_2O_3 and 4.3% TiO_2

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

Deposit 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 pisolitie zone has been removed by erosion and the earthy materia outcrops as a superficially hardened massive laterite.

The results of sampling fourteen shafts are set out in the following table -

TABLE IX.

Long tons	SiO_2 %	Al_2O_3 %	Avail. Al_2O_3 %	Na_2O loss cwt.	Overburden cu.yds.
(a) 470,000	-	-	30.1	1.04	30,000
(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, exeluding samples containing less than 25% Available Al_2O_3. The total includes tonnages (b) and (c)
(b) Pisolitic bauxite (i.e. excluding any below 30% Avail.Al_2O_3)
(c) Earthy bauxite at north-eastern end of deposit
(d) Total of (b) and (c). Contains 33.0% Fe_2O_3 and 5.5% TiO_2.

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

TABLE X.

Long tons	SiO_2 %	Al_2O_3 %	Avail. Al_2O_3 %	Na_2O loss cwt.	Overburden cu.yds.
(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% Avail. Al_2O_3. Contains 29.6% Fe_2O_3 and 5.0% TiO_2.

Deposit D, which lies 1500 feet east from Deposit C, was not tested by the Aluminium Commission. It has been estimated by Raggatt (1939 p.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% SiO_2 41.1% Al_2O_3 1.76% FeO 28.1% Fe_2O_3 17.8% Ign.loss

The ignition loss figure suggests that the available Al_2O_3 content is about 31%.

2. <u>No.6 Area, Wingello</u>. (See Plate 4)

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 wouth-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 4 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. One shaft revealed quartz sand underlying the laterite.

Four typical shaft logs are given -

Depth	Field Description	Ignition loss %	Avail Al_2O_3 %	Na_2O loss 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	- ditto -	21.0	33.9	0.94 x
10 - 14	Soft brown laterite	18.0	25.7	-
14 - 18.5	- ditto -	15.0	12.6	-
18.5-20.5	Brown sand	-	-	-

x 4.2% SiO_2, 37.7% Al_2O_3, 31.5% Fe_2O_3, 4.9% TiO_2

	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	-	-	-

Depth	Field Description	Ignition loss %	Avail Al_2O_3 %	Na_2O loss cwt.
	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	- ditto -	19.3	26.6	2.44
14 - 16	Ditto becoming softer at 15' and 16'	23.1	35.6	0.78
16 - 20	Soft red earthy laterite	18.8	24.8	-
20 - 26	Basaltic clay	-	-	-

4 - 16feet Composite sample

SiO_2	8.9%
Al_2O_3	34.8%
Fe_2O_3	30.8%
TiO_2	4.8%
P_2O_5	0.40%
V_2O_5	0.06%
Cr_2O_3	trace
Ign. loss	20.2%
Avail.Al_2O_3	31.6%
Na_2O loss	1.23 cwt.

P.M.L. 2. Shaft No.8

Depth	Field Description	Ignition loss %	Avail. Al_2O_3 %	Na_2O loss cwt
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	- ditto -	20.3	32.5	0.43
Below 14	Inaccessible			

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

TABLE XI

Tonnage : No.6 Deposit, Wingello.

Long Tons	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	Avail. Al_2O_3 %	Na_2O loss 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 faces in P.M.L's 3 and 4. Held by A.A.P.C.

(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, respectively.

(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 at 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 increased the measurable volume of economic ore to any appreciable extent. Some advantage might have been gained by testing at 00/2000E and 00/2400E in P.M.L.2 but this course was not feasible at the time.

B. Descriptions of Areas not tested by Australian Aluminium Production Commission.

No.1 Area: (Raggatt 1939, p.6)

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.3 Area:

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, p.7) gives the following log of a shaft sunk and sampled by the B.H.P.Co.Ltd.

Depth - feet	Description(1)	SiO_2 %	Al_2O_3(2) %	Fe_2O_3 %
0 - 5	Pisolitic bauxite, some loosely cemented	2.96	31.85	38.90
5 - 10	Pisolitic bauxite	2.70	32.12	30.36
10 - 15	- ditto -	3.42	27.56	43.27
15 - 20	- ditto -	3.64	28.10	43.27
20 - 25	- ditto -	4.96	34.91	30.01
25 - 28	- ditto -	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 -

SiO_2	3.8 per cent
Al_2O_3	28.5 "
Fe_2O_3	41.3 "
TiO_2	7.2 "
P_2O_5	0.25 "
V_2O_5	0.08 "
Avail.Al_2O_3	27.8 "

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

No.4 Area.

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, p.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.	ins.	Description
103	1	9	Red soil with loose pisolites
104	5	0	Pisolitic 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 %	Ign. loss %
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 writer with the following result:

Sample No.	1	2
Depth from surface, feet	5 to 9	9 to 13
SiO_2	3.8%	4.6%
Al_2O_3	55.3	55.3
Fe_2O_3	4.2	3.3
TiO_2	6.7	5.8
P_2O_5	0.06	0.06
V_2O_5	trace	trace
Cr_2O_3	"	"
Ignition loss	30.1%	30.5%
Avail. Al_2O_3	50.3	50.8
Na_2O loss	0.80 cwt.	0.69 cwt.

It is estimated in a report of the Commonwealth Copper and Bauxite Committee (1942, p.7), that reserves of aluminous laterite and bauxite contained in No.4 Deposit amount to -

Tons	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %	TiO_2 %
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 Area:

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, p.15)

Sample No.	Depth feet	Description.	
24	0 - 5	Loose pisolitic bauxite.	Red.
27	5 - 10	Pisolitic bauxite.	Brown.
38	10 - 15	- ditto -	Dark red
39	15 - 20	- ditto -	Dark red
40	20 - 25	- ditto -	Chocolate
44	25 - 29	- ditto -	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 %	Ign.loss %
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 -

SiO_2	3.6 per cent
Al_2O_3	38.2 "
Fe_2O_3	36.4 "
TiO_2	5.0 "
P_2O_5	0.09 "
V_2O_5	trace
Cr_2O_3	trace
Ign.loss	15.7 per cent
Avail.Al_2O_3	27.9 per cent
Na_2O loss	1.30 cwt.

Reserves probably amount to 270,000 tons containing 4% SiO_2, 31.5% Al_2O_3 soluble in 48% H_2SO_4, and 37.5% Fe_2O_3

No.7 Area.

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

No.8 Area.

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 B.H.P.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 by solid ore.

One shaft penetrated 15 feet of pisolitic ore containing 5.3% SiO , 35.9% Al_2O_3 soluble in H_2SO_4 and 30.9% Fe_2O_3

Reserves have been estimated at 175,000 tons.

No.9 Area.

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 B.H.P.Co.Ltd.

The deposit is unusual in that the siliceous zone at the base is pisolitic in habit though containing more than 20% SiO_2.

No.10 Area.

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.

V. NOTES ON THE ORIGIN OF THE LATERITE.

As a detailed discussion bearing on the origin of laterite generally is in course of preparation it is not proposed to enter deeply into the subject here, but rather to stress some features of the laterite in the Moss Vale district.

These laterites conform generally to the normal profile developed on a basic rock, i.e., (1) ferruginous zone, (2) earthy or mottled zone and (3) kaolinized or pallid zone. (The word pallid is scarcely applicable to the kaolinic products of basic rocks which generally are highly coloured; yellow, red, purple and blue are colours commonly observed).

At Moss Vale (and elsewhere) the ferruginous zone requires further division into an upper pisolitic zone overlying hard massive laterite of very similar composition. Also it is not possible to draw a sharp line between ferruginous and earthy zones.

All zones may not be present in any particular deposit, or being present together over part of the body may not persist throughout. An extreme example is afforded by No.5 Deposit where 29 feet of pisolitic ore directly overlies the kaolinized zone (or what may be siliceous mottled zone) without the interposition of massive or earthy laterite.

At Ellsmore "B" deposit earthy ferruginous laterite exposed by the erosion of pisolitic ore passes beneath the pisolitic zone and dies out in a few hundred feet leaving pisolitic material lying directly on the siliceous mottled zone.

There is ample evidence that the laterite of the district is derived from basalt; at Deposits 2, 4 and 6 relict basaltic texture in the basal clays has been observed by the writer, and similar parent rock has been reported at the other deposits by Raggatt (1939).

So far as known, the eastern end of No.4 Deposit is the only place where leaching of the mottled zone proceeded to the advanced stage at which high-grade bauxite results.

Once it is conceded that the whole laterite profile throughout the district is derived from similar rock, the differences in character between various deposits can be explained only by a greater or lesser degree of leaching or varying efficiency of the removal of iron and silica in solution. The development of high-grade bauxite containing only 4 per cent Fe_2O_3 at No.4 Deposit was undoubtedly brought about by the lateral movement of iron westerly to form an unusually thick (26 feet) deposit of pisolitic laterite containing about 37 per cent Fe_2O_3.

It has been remarked in preceding sections of this report that the laterite contains grains of quartz. The presence of quartz grains is most marked at Wingello where strongly cemented pisolitic ore from the base of the pisolitic zone was observed to contain abundant quartz grains in the cores of the pisolites and not in the lithoidal cementing material. The pisolites or nodules consist of roughly spherical cores up to 1.5 cm. diameter surrounded by a thin rim of dense iron-aluminium hydrates. In extreme cases the core may contain about 25 per cent quartz in grains up to 1 m.m. diameter consisting of both white milky and clear glassy quartz. The massive and tubular laterite at Wingello contains quartz grains more or less evenly dispersed. H.F. Whitworth in an appendix to the report by Raggatt (1939) suggests that the quartz grains result from wind or water-borne sand gaining access to cracks in the laterite during its formation, the cracks later becoming sealed by iron and aluminium oxides or hydroxides.

This suggestion appears inadequate on the ground that even if sand had been able to enter cracks in the laterite the quartz grains would be present as vein-like concentrations and not widely disseminated.

If the iron solutions ascending from the mottled and pallid zones precipitated the burden of iron within a sandy sediment overlying the basalt or on the floor of a swamp in which a limited amount of detritus was being deposited simultaneously a dissemination of sand in the ferruginous zone could be expected. Argillaceous fractions of the sediments would be decomposed with downward removal of silica and addition of iron and alumina to that derived from the basalt.

This explanation may not be wholly satisfactory when applied to the quartz grains contained in the high-grade bauxite at No.4 Deposit, but it must be remembered that the bauxite here is unique in the district and probably has been formed by the removal of iron from a former ferruginous zone which had been contaminated with quartz in the manner suggested above.

VI. ACKNOWLEDGMENT.

Except where the contrary is evident from the text all chemical analyses herein are by R.A. Dunt, Chief Chemist, Australian Aluminium Production Commission.

H.B. Owen.

(H.B. Owen)
Senior Geologist.

CANBERRA.
7th October, 1949.

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Plate I

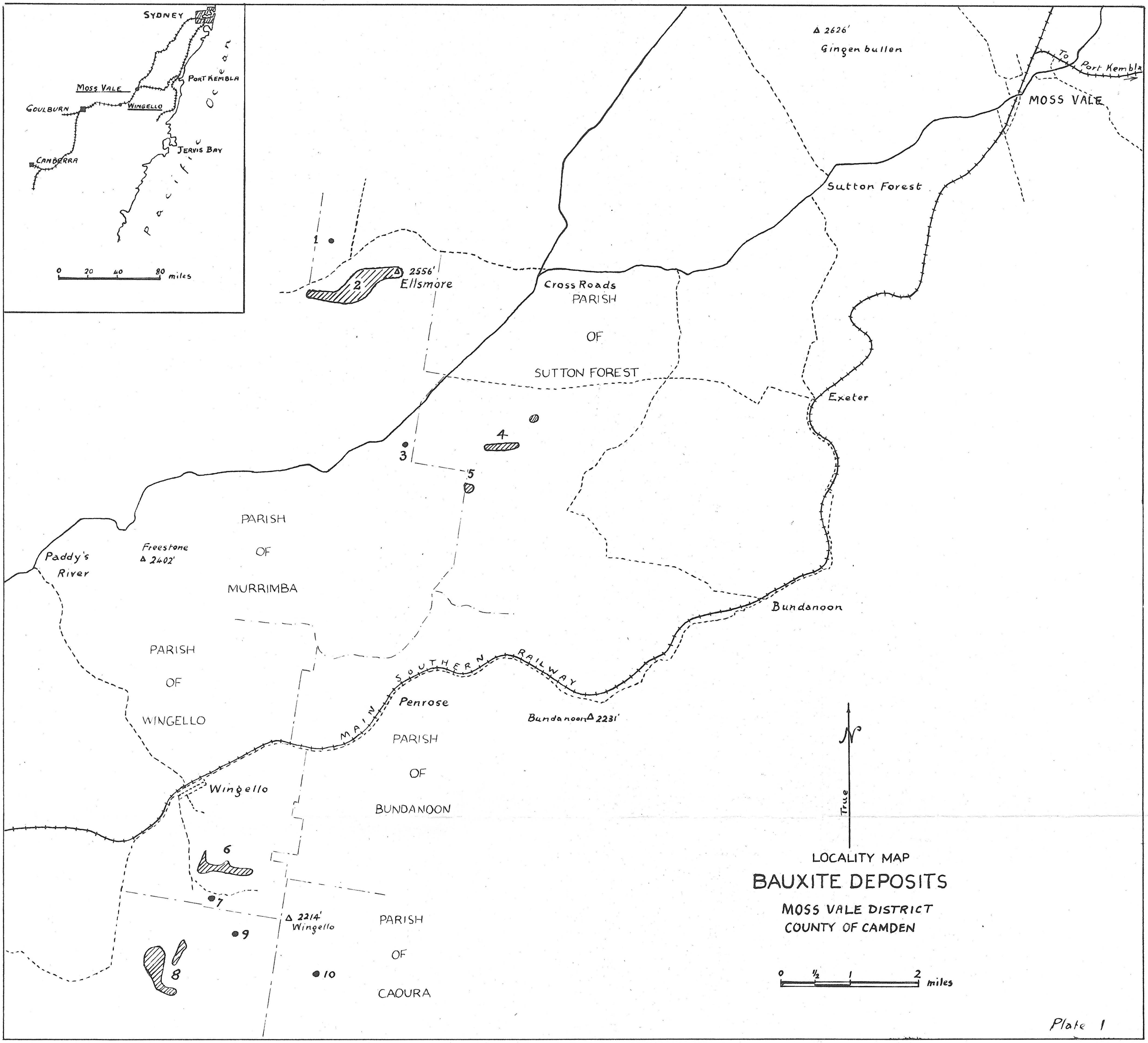
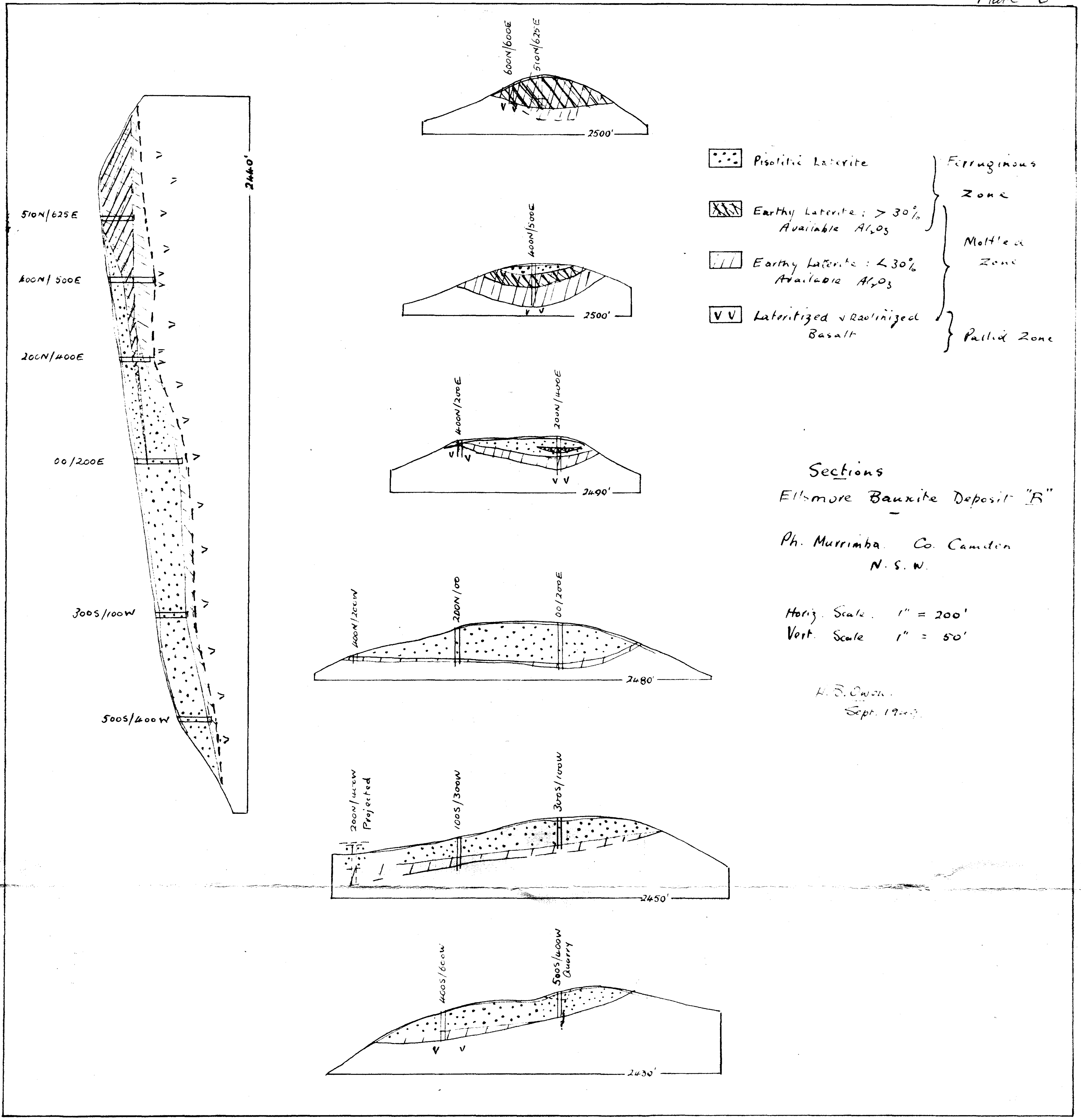


Plate I

Plate 2.

N
Plan of Bauxite Deposits A, B & C
at Ellsmore, Ph. of Murrimba
Co. Camden, N.S.W.
Scale of Feet
0 100 200 300 400
Figures adjacent to shafts show thickness of overburden over thickness of economic bauxite in feet.
"A"
"B"
"C"
Basalt
Tertiary Sediments
32
33
42
31
28
29
52
25
4
1800 N
1600 N
1400 N
600 N
400 N
200 N
00
200 S
400 S
600 S
100 N
100 S
600 W
400 W
200 W
200 E
400 E
600 E
800 W
800 E

Plate 3



600N/600E
510N/625E
2500'
400N/500E
2500'
400N/200E
200N/400E
2490'
400N/200W
200N/00
00/200E
2480'
200N/400W Projected
100S/300W
300S/100W
2450'
400S/600W
500S/400W Quarry
2430'
510N/625E
400N/500E
200N/400E
00/200E
300S/100W
500S/400W
2440'
Pisolitic Laterite
Earthy Laterite: > 30% Available Al_2O_3
Earthy Laterite: < 30% Available Al_2O_3
Lateritized & Kaolinized Basalt
Ferruginous Zone
Mottled Zone
Pallid Zone
Sections
Ellsmore Bauxite Deposit "B"
Ph. Murrimba Co. Camden
N.S.W.
Horiz. Scale 1" = 200'
Vert. Scale 1" = 50'
Sept. 19

Plate 4

BAUXITE DEPOSIT
PARISH of WINGELLO
COUNTY of CAMDEN
0 100 200 400 feet
Shafts shown thus .... 6 2/4 2290·4'
where 6 is number of shaft
" 2 - thickness of overburden in feet
" 4 - " " bauxite " "
and 2290·4' is R.L. of Shaft collar.
Bores shown ....
Areas underlain by economic bauxite shown ......
Magnetic
N
PORTION 159
PORTION 151
P. M. L. 4
P. M. L. 9
P. M. L. 3.
P. M. L. 8
P. M. L. 2.
Quarry
Quarry Nil
800N
00
800W
00
800E
1600E
2400E
3200E
2284'
2300'
2229'
2200'
2271·5'
2 Nil 2288·7'
3 Nil 2277·5'
1 9/5 2274·7'
7/5·5
6 Nil 2258·6'
6/4 2265·1'
8/4 2268·7'
5 Nil 2266·3'
Nil 2271·1
15 Nil 2271·9'
Nil 2273·9'
Nil 2253·9'
14 Nil 2280·1
13 1/2
2280'
11 0/3 2281'
12 1·5/6·5 2279'
16 0·5/5·5 2276'
10 2/12 2281·4'
9 1·5/7·5 2278·4'
2279·5
7 1·5/5·5 2289·7
2288'
8 13/1 2286·2'
2288'
5 6/4+ 2285'
6 2/4 2290·4'
2289·3
Shallow
2300·2'
4/12