COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY.

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Plans Nos. 1163 and 1164.

REPORT ON

TESTING OF UPPER YARRAMAN BENTONITE.

- By -

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DEPARTMENT OF SUPPLY & SHIPPING.

MINERAL RESOURCES SURVEY BRANCH.

TESTING OF UPPER YARRAMAN BENTONITE.
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DEPARTMENT OF SUPPLY & SHIPPING.

Mineral Resources Survey Branch

TESTING OF UPPER YARRAMAN BENTONITE. Report No. 1944/49. Plans Nos. 1163 and 1164.

INTRODUCTION.

A description of the Yarraman bentonite deposit by Mr. H. G. S. Cribb of the Queensland Geological Survey was published in the Queensland Government Mining Journal, August, 1943, and information contained in that report will not be repeated here.

The testing programme described herein is the result of a recommendation made by the present author in a previous report (February 11th, 1944). Funds were provided by the Commonwealth Government, Department of Supply and Shipping, and twenty-four boreholes were put down during October, 1944, to determine the extent and quality of the bentonite and the associated clays. During the early part of this boring campaign the area was surveyed in detail by plane table with the assistance of Mr. T. Connah of the Queensland Geological Survey.

DETAILS OF BORING.

Eleven boreholes (Nos. 1, 3 and 4, 9, 10, 11, 13, 14, 15 and 16) were put down according to the 300-foot grid originally laid out, based on the main shaft and the northwesterly boundary of the lease. Nos. 5, 7, 8 and 12 were placed centrally in each of the four squares adjacent to the shaft, and the remaining holes were so located as to complete the testing of the main central portion of the deposit at approximately 150-foot intervals (Refer to Plate I). No. 2 hole was sunk from the bottom of the shaft to test the underlying formations and No. 22 was put down at the end of the South drive to improve the ventilation in the workings.

Boring was carried out with a 4½ inch posthole digger, fitted with removable extension rods. Overall length of digger and handle was 3 feet, and extension rods, of 3/4 inch galvanised piping, were 5 feet and 9 feet 6 inches long. The boring apparatus was provided by the Queensland Mines Department and the work was done by Messrs. S. R. & J. M. Elver and J. King under the general supervision of the author.

For holes deeper than about 15 feet, it was found desirable to erect a tripod, with a rope and pulley. This was made of thin bush saplings and stood 17-18 feet high. It was light enough to be easily dragged or carried from hole to hole. The hole could be taken down to 25 feet or so comfortably without uncoupling, but at greater depths the upper part of the rod when extracted from the hole, especially if the horizontal handle were left on, was liable to bend if caught by the wind or allowed to depart from the vertical position as the rods were being withdrawn. In the deeper holes an iron "strong arm" resting on the ground at the neck of the hole was used to prevent the rods slipping back into the hole while the position of the hauling rope was being changed. The cores were dumped on a bag and at each change of material were tipped into small heaps progressively farther from the shaft. Samples of the bentonite and bentonitic clays up to 10 lb. in weight were taken after thorough mixing on the bag.

Improvements that could be suggested to the boring apparatus are:-

(1) Rods of 4, 8 and 12 feet length so that the boring can be taken down in 4-foot stages which is about the ideal inter-

-val for easy hand operation.

(2) Provision of at least one coupling in which one pipe fits over the other and is fastened by a pin or bolt through a hole in both. This would be fitted at 27 feet depth (two 12-foot rods plus the 3-foot digger) and would obviate the comparatively slow unscrewing by means of Stilson wrenches every time the digger is drawn from the hole. Screw-on connections are more satisfactory for the remaining junctions as they are more rigid and have to be screwed and unscrewed once only each.

(3) A deeper cylinder above the bit so that a greater depth could be dug each time and the rods would require withdrawing less frequently.

Boring was found to be reasonably easy, especially in the bentonite and bentonitic clays. In very dry places, the cuttings sometimes failed to stick in the digger as it was being pulled up. This was remedied by pouring a little water down the hole. Occasional stones struck im the upper layers were dealt with by a jumper bit of chisel type which could be attached to the spare rods. No caving from the sides of the holes was experienced.

The three men completed the boring in three 44-hour weeks. Actual time spent on drilling was 15½ days. Twenty-four holes were put down, for a total footage of 618'3", or an average of 25'9" per hole. Deepest hole was 42'6". @ Average depth bored per day was 40 feet, average per hour 5 feet. Each posthole diggerfull represented an average gain in depth of 3 to 4 inches. The same auger was used for all the boring and was still in reasonably good condition at the completion of the campaign, except that it had been found necessary owing to a weakness in its construction to reinforce the side cutting bit by riveting on strips of steel at either side.

The actual cost of the boring was approximately £50, an average of just over £2 per hole or 1/8 per foot.

RESULTS OF BORING.

Bentonite of approximately similar quality to that mined and marketed by Elver Bros., as first-grade bentonite was found in boreholes Nos. 3, 11, 12, 17, 18 and 21. This is overlain by varying thicknesses of bentonitic clay corresponding to the material overlying the main bentonite seam in the underground workings, which is sold as second-grade bentonite. A lesser thickness, generally only 2 or 3 feet, of similar clay underlies the bentonite in these holes. In boreholes Nos. 4, 5, 6, 7, 8, 9, 19, 20 and 23, the bentonite was of inferior quality, similar, or in some cases, e.g. Nos. 19 and 20, slightly better than the second-grade material and in holes Nos. 1, 13 and 14, although white clay, in parts bentonitic, was passed through, the main bentonite horizon could not be identified with certainty. Holes Nos. 10, 15, 16, and 19A were apparently outside the limits of the bentonitic clay. Detailed logs of the boreholes are set out in Appendix I.

The general sequence of materials cut by the bores is similar to that of the main shaft. The surface soil is followed by up to 10 feet of reddish gravel apparently derived from the decomposition of pyroclastic rocks. This is underlain by 2 to 6 feet of greyish or bluish clay - which as a rule dries fairly white - and this in turn by varying thicknesses, up to 14 feet, of white clay which is usually somewhat bentonitic, especially towards the bottom.

@ It is interesting to compare these figures with those given by S. H. Lorain and M. Mihelich in Engineering and Mining Journal, September, 1944, pp.78-80.

In places a little ironstaining is present or a thin band of red or pink clay. The bentonite cut by the boreholes varies in thickness from 1'9" up to 7'3". (In the underground workings the bentonite exhibits a similar range in thickness, with numerous peaks and hollows, and in places cuts out altogether over a small area. It is probable that Borehole No. 8 passed through one such area, where the main bentonite seam was either very narrow or locally absent). Underneath the bentonite is 2 to 4 feet of white clay, usually bentonitic, in places powdery, and this is underlain by various shades of pink, white and red clays, many of which retain the texture of a volcanic tuff or fine agglomerate. Several holes passed through these clays either into a bluish weathered volcanic rock (Nos. 6 and 7) or into brown friable clay (Nos. 1, 2, 11, 13, 14, 19) the appearance of which suggests that it is a buried soil or weathered surface which had been developed before the volcanic ash and agglomerates which now comprise the bentonitic material had been laid down.

On the plan, Plate 1, the position of the boreholes is shown, together with the thickness of the bentonite, if present, and the total thickness of white clay, including the bentonite. Surface contours are the result of the plane-table survey and are drawn at 5 feet intervals. The approximate height above sea-level is obtained by aneroid reading, referred to Yarraman Railway Station. Contours are also drawn at the base of the bentonite. These are necessarily generalised as it is obviously impossible with bores 150 feet apart to indicate the minor variations such as occur every few feet in the underground workings. For the same reason, it is not possible to illustrate thickness contours for the deposit as local variations are of greater extent than areal variations. The average in the boreholes corresponds closely to the average thickness in the workings.

The bentonite bed rises gradually towards the southeast where it appears to pinch out against a rising bottom (Section B-B', Plate 2), which may be associated with the massive red agglomerate outcropping near the east corner of Portion 166V. On the western and eastern sides, the bentonite and bentonitic clays are cut off by the slope of the ground and to the north the bentonite seems to play out. Several prospecting holes are reported to have been put down in the adjacent Forest Reserve, but they struck only pink clays similar to those in Borehole No. 10.

ORIGIN OF THE BENTONITE.

From its texture and general appearance, the bentonite appears to have been derived from the alteration in situ of a bed of volcanic agglomerate of limited extent. The original rock fragments are sparsely distributed through the mass and are decomposed to a white clay, which is not noticeably bentonitic. These fragments are subangular and usually less than one inch in diameter, though they may in places be as much as 2 or 3 inches. The interstitial matter, originally fine volcanic ash, has been altered to bentonite, white, cream or pale green in colour, with characteristic waxy appearance. The powdered bentonite when immersed in clove oil and examined under the microscope appears to possess the optical properties of montmorillonite, but no detailed investigation has yet been made. The white clay which overlies and underlies the bentonite has apparently been derived from a fine-grained volcanic ash, and many of the lower clays cut in the deeper bores, mostly pink in colour, still retain definite tuffaceous texture.

During the examination of residues obtained after washing the bentonite through a 200 mesh sieve, Miss Crespin, Commonwealth Palaeontologist, found that several species of micro-fossils were present. Following is her report:-

MICRO-FOSSILS IN THE BENTONITE SAMPLES FROM YARRAMAN, QUEENSLAND.

When carrying out laboratory tests on bentonite from Yarraman, Dr. Fisher submitted the residue after washing for microscopic examination, with a view to finding micro-fossils. The result of this examination was the discovery of a small assemblage of marine, shallow water forms, consisting of foraminifera, sponge spicules, Mopsea joints, and bryozoa. Many of the tests of the foraminifera are broken, but the preservation is otherwise good. The diameter of the tests varies from 0.15 to 0.38 mm. The fragments of bryozoa are not well preserved, but are recognisable.

Yarraman, Queensland.

The residue consists chiefly of fine, angular quartz grains, with a little mica, etc. The following fossils were recognised:-

Foraminifera.

Quinqueloculina lamarckiana (d'Orb.)
Bolivina robusta Brady
Lagena marginata (W. & B.)
cf. Globigerina
Cibicides ungerianus (d'Orb.)
Siphonina australis Cush.
Eponides haidingeri (d'Orb.)
Eponides spp.
Discorbis australis Parr
Nonion umbilicatula (Montagu)
Astrononion cf. fijiense Cushman

Spongida

Sponge spicules, cf. Ecionema

Bryozoa

Cellaria rigida var. perampla McG.
Retepora rimata McG.
Retepora sp.
Crisia cf. macrostoma McG.
Hornera tuberculata McG.

All recorded species of foraminifera are found living in seas at the present time, while the majority of them range upwards from Middle Miocene to Recent. The bryozoal assemblage, together with the Mopsea joints are typical of deposits of Middle Miocene to Lower Pliocene age in Australia, but as with the foraminifera they are found in recent shore sands.

It is suggested that the age of the deposits in which these micro-fossils have been found, is Pliocene. "

From the above, it appears that the original agglomerate and ash were laid down under marine, or at least saline conditions in shallow water. If it was deposited during a temporary transgression of the sea, it means that the area has been subject to uplift of at least 2,000 feet since possibly some time in the Pliocene. If on the other hand, the area was a lake at some elevation above sea-level containing water sufficiently saline for marine micro-fossils to exist, it is exceedingly difficult to explain how these forms came to be introduced into the lake.

TESTING OF THE BENTONITE.

SADLER'S TESTS.

Forty-two samples were taken from the borings and four for comparison from the underground workings. These samples were all subjected to the standard Sadler's test which is as follows:-

> The material to be tested is roughly powdered and dried over a waterbath for two hours. It is then powdered and passed through a 200 mesh (British Standard) sieve. 4 gms. of the material is taken and mixed with 0.2 gm. magnesium carbonate, then being placed in a 100 cc. stoppered graduated cylinder. The cylinder is half filled with water and thoroughly shaken, then filled up to the 100 cc. mark with water. The mixture is agitated mechanically for an hour and then let stand for 24 hours.
>
> If the substance is a pure bentonite at the end of that time there will be no clear supernatant liquid and the jar will be filled with a gel which will, if the bentonite is exceptionally pure, allow the jar to be inverted without losing its form.
>
> If there is 10 cc. of supernatant liquid, the substance is called a 90% bentonite and so on in that manner. Anything giving more than 50% is called a bentonite, while anything between 20 and 50% is called bentonitic. Most clays formed by weathering give a value less than 10%.

The percentage thus obtained is referred to in this report as the bentonitic index. In the samples tested, this figure ranged from 16 to 62% and the results are summarized in the following table:-

TABLE I.

SADLER'S TESTS YARRAMAN BENTONITE & BENTONITIC CLAYS.

Classification	No. of Samples	Hole Nos.	Range in Bentonitic Index	Average
First-grade bentonites.	7	3, 11, 12, 17, 18, 21, Mine.	24.5 - 62.0%	35.5%
Poorer bentonites.	5	5, 7, 9, 19, 20.	20-36%	29.3%
Overlying bentonitic clays.	22	1, 3, 4, 6, 7, 8, 11, 12, 17, 18, 19, 20, 21, 22, 23, Mine	17 - 41.5%	27.5%
Underlying bentonitic clays.	5	1, 2, 3, 11, Mine.	20 - 40.5%	27.0%
Powdery clays.	6	2, 8, 9, 12, 13, 17.	16.0 - 25.5%	20.0%

The classification in the first column is based on visual examination and comparison with the first-grade bentonite and the accompanying bentonitic clays which are exposed in the mine workings. The third category - overlying bentonitic clays - includes the bentonitic clays overlying the bentonite, and in holes where the bentonite is absent, such as Nos. 1, 4, 6, 8, 23, all the bentonitic clays down to the probable horizon of the base of the bentonite (see Sections, Plate 2). The fifth category comprises those clays

which are noticeably powdery in appearance. All of these underlie the bentonite (except in No. 13 hole where no bentonite is present) and most of them are below the underlying bentonitic clay, usually separated from it by several feet of pink clay.

It was found that the first-grade bentonite gave a higher bentonitic index after wetting and drying, and, with the best material from the workings, this figure could be increased by repeated wetting and drying to a maximum of 96%. On the other hand, the bentonitic index of the poorer bentonites and of the bentonitic clays either was not affected by this process or else was lowered several points.

MOISTURE CONTENT.

Bentonite from the mine workings was found on sun-drying to lose 25 to 30% of its weight. This figure was obtained after dry conditions had prevailed for some time, and might be higher after a wet season. The overlying clay contained slightly less moisture than the bentonite.

Sun-dried bentonite after 3 hours in a drying-oven at 100°C. lost 3.5% additional moisture. Composite samples of overlying and underlying clays lost, respectively, 2.0% and 2.5%.

RESIDUE.

Both the bentonite and the bentonitic clays leave, on washing, a small residue which consists almost entirely of angular quartz grains. Samples in which iron-staining is present also usually contain hard grains of limonitic material. A representative sample from the mine workings of 100 grams was washed through a 200 mesh sieve, without grinding, and gave a residue of 0.25%. Other samples of bentonite gave residues of up to 0.5%. Samples of the upper and lower bentonitic clays from the mine workings left residues of 3.2% and 3.5% respectively, which in both cases consisted almost entirely of fine-grained quartz.

GREEN AND DRY COMPRESSIVE STRENGTHS.

A sample of the Yarraman bentonite was previously tested by the Standard Chemical Company of Melbourne and gave the following results:-

Green Bond strength of synthetic sand, containing 4% Yarraman bentonite, 7.3 lbs. per square inch.

Dry compressive strength, after drying at 150°C. for 3 hours, 60 lbs. per square inch.

Following is a comparison of the properties of the Yarraman bentonite, imported bentonite (Volclay) from Wyoming, bentonite from Marchagee, Western Australia and bentonitic clay from Trida, western New South Wales.

TABLE II.
COMPARISON OF PROPERTIES OF BENTONITES.

Locality	Green Compressive Strength	Dry Compressive Strength	Permeability
Yarraman	7.3	60	210
Wyoming	4.8	79	240
Marchagee	5.0	38	210
Trida	2.4	9	-

Further samples have been submitted to the Foundry Sands Investigation Officer, Council for Scientific and Industrial Research, Melbourne, for determinations of green and dry compressive strength and permeability and for practical foundry tests.

RESERVES.

The area of the first-grade bentonite according to the interpretation of the drilling results shown on Plate 1 is 256,000 square feet (nearly six acres), and the average thickness from the boreholes over this area is 3 feet 6 inches, which corresponds closely with the average in the underground workings. All tonnage figures are given as sun-dried bentonite, for which a factor of 32 cubic feet per ton has been adopted. This was obtained by sun-drying and weighing the cuttings from a 3 foot horizontal borehole of exactly 5 inches diameter which was driven in the bentonite in the underground workings. Using this factor, the quantity of bentonite which may be considered proved is 28,000 tons. Not all of this can be extracted by the present method of mining. If the poorer quality marginal bentonite is included, this figure is increased by 9,000 tons. The total average thickness (from the boreholes) of the white, or nearly white, clays which accompany the bentonite is 8 feet over the whole area, representing a tonnage of 230,000 of which at least 180,000 tons is bentonitic.

The clays are thickest im the central area which contains the bentonite, and the tonnage of clay associated with the high-grade bentonite is approximately 108,000 tons, this being increased to 122,000 tons if the area of poorer quality bentonite is included.

The same factor, 32 cubic feet to the ton, has been used in all these calculations. No separate determination was made for the bentonitic clays.

CONCLUSIONS.

The boring campaign has shown that, although the high-grade bentonite at Upper Yarraman is not quite as extensive as might have been expected from the topography, this deposit alone contains sufficient tonnage to satisfy Australian requirements for bentonite for foundry sands at least for many years.

Production in 1943 was 134 tons of first-grade and 53 tons of second-grade. The present rate of approximately 10 tons of first-grade bentonite per month is not sufficient to fulfil orders. The adoption of a more efficient and more economical mining method would partly overcome this deficiency. Laboratory and practical tests now being made will help to determine the total quantity of bentonite that will be required from Yarraman for use in foundry sands and may indicate other uses for both the bentonite and the bentonitic clays.

CANBERRA, A.C.T.
28th December, 1944.

N. H. FISHER,
Chief Geologist.

APPENDIX I.

LOGS OF BORE HOLES - YARRAMAN BENTONITE.

(For position of holes see Plate 1).

DEPTH From	DEPTH To	TYPE OF MATERIAL	SAMPLE NO.	SADLER'S TEST
Bore Hole No.1. R.L.Collar 1904'6", Depth 40'9".				
0	2'	Surface soil.	-	-
2'	11'6"	Decomposed volcanic rock, light brown to mauve in colour, gravelly texture.	-	-
11'6"	14'6"	Greyish iron-stained clay with slightly bentonitic appearance.	1	36.5
14'6"	20'	Greyish-white, slightly bentonitic clay. Larger pieces have white specks and look like a decomposed tuff.	2	29.0
20'	21'	Similar to above.	3	34.0
21'	22'3"	Brownish clay with small harder fragments; still tuffaceous in appearance.	-	-
22'3"	22'10"	Powdery white clay with nodules of decomposed tuff.	-	-
22'10"	24'	Pinkish powdery clay.	-	-
24'	24'8"	Powdery clay with nodules of decomposed tuff, slightly bentonitic in appearance.	-	-
24'8"	26'6"	Pinkish clay.	-	-
26'6"	30'	White clay, almost certainly weathered tuff.	-	-
30'	33'	Pink massive clay with white spots.	-	-
33'	35'6"	White massive clay with some pink bands, below 34' it becomes more bentonitic with semi-stratified appearance.	4	31.5
35'6"	38'3"	Banded red and grey clay.	-	-
38'3"	39'3"	White, slightly bentonitic clay.	-	-
39'3"	40'9"	Bands of grey or pink clay and brown friable clay.	-	-
Bore Hole No.2, R.L.Collar 1874' at Bottom of Shaft, Depth 17'3" (42'3" from Surface).				
0	3'	White bentonitic clay.	5	20.0
3'	4'6"	As above, more waxy appearance	6	22.0
4'6"	5'6"	Reddish clay.	-	-
5'6"	8'6"	White bentonitic clay, more powdery below 7'.	7	23.5
8'6"	9'6"	Pink and red clay.	-	-
9'6"	17'3"	Brown friable material which looks like a buried soil or very weathered volcanic rock.	-	-
Bore Hole No.3, R.L. Collar 1888', Depth 22'6".				
0	2'	Surface soil.	-	-
2'	4'6"	Red gravel.	-	-
4'6"	8'	Bluish-brown clay.	-	-
8'	11'6"	Iron-stained grey bentonitic clay.	8	38.0
11'6"	13'	White bentonitic clay, slightly ironstained.	9	41.5

DEPTH From	DEPTH To	TYPE OF MATERIAL	SAMPLE NO.	SADLER'S TEST
Bore Hole No.3, R.L.Collar 1888', Depth 22'6". (Cont'd.)				
13'	16'	White bentonitic clay.	10	26.0
16'	16'9"	Bentonite.	11	27.5
16'9"	18'	Red slightly bentonitic clay.	-	-
18'	20'	Main bentonite seam.	12	24.5
20'	22'6"	Slightly bentonitic clay with some iron-staining.	-	-
Bore Hole No.4, R.L.Collar 1893', Depth 25'6".				
0	5'	Red soil and gravel.	-	-
5'	9'	Bluish-brown clay.	-	-
9'	16'	Iron-stained greyish bentonitic clay.	-	-
16'	20'	Grey bentonitic clay.	-	-
20'	22'6"	White and pink clay.	-	-
22'6"	24'6"	Pinkish bentonitic clay. Main Bentonite Horizon.	13	27.0
24'6"	25'6"	Pink and red clay.	-	-
Bore Hole No.5, R.L.Collar 1897', Depth 22'6".				
0	9'	Soil, gravel and bluish-brown clay.	-	-
9'	13'6"	Iron-stained grey bentonitic clay.	-	-
13'6"	17'3"	Bentonitic clay. Main Bentonite Horizon.	14	20.0
17'3"	22'3"	White to greyish powdery clay.	-	-
22'3"	22'6"	Brown friable clay.	-	-
Bore Hole No.6, R.L.Collar 1886'6", Depth 16'2".				
0	1'	Surface soil.	-	-
1'	7'6"	Red gravel.	-	-
7'6"	10'	Bluish clay.	-	-
10'	12'	White bentonitic clay.	-	-
12'	14'3"	Brown clay with bentonite.	15	22.5
14'3"	15'6"	Powdery cream-coloured clay.	-	-
15'6"	16'2"	Blue weathered volcanic rock.	-	-
Bore Hole No.7, R.L.Collar, 1886'6", Depth 22'6".				
0	4'6"	Red soil.	-	-
4'6"	11'	Brown gravel.	-	-
11'	14'6"	Blue clay.	-	-
14'6"	17'6"	Slightly bentonitic clay.	16	17.0
17'6"	19'9"	White bentonitic clay with red stains. Main Bentonite Horizon.	17	27.0
19'9"	22'	White powdery clay.	-	-
22'	22'6"	Blue weathered volcanic rock.	-	-
Bore Hole No.8, R.L.Collar 1897'10", Depth 36'6".				
0	3'6"	Red soil.	-	-
3'6"	11'3"	Brown gravel.	-	-
11'3"	15'6"	Blue clay with iron-staining.	-	-
15'6"	20'6"	White bentonitic clay, in places powdery and iron-stained.	-	-
20'6"	22'6"	Iron-stained white bentonitic clay.	-	-
22'6"	27'	White bentonitic clay.	18	22.5
27'	29'3"	White bentonitic clay. Main Bentonite Horizon.	19	22.5
29'3"	30'6"	Bentonitic clay with red stains.	-	-
30'6"	32'6"	Pink clay.	-	-

DEPTH From	DEPTH To	TYPE OF MATERIAL	SAMPLE NO.	SADLER'S TEST
Bore Hole No.8, R.L.Collar 1897'10", Depth 36'6". (Cont'd.)				
32'6"	33'6"	Pink and white granular clay.	20	18.0
33'6"	35'	Red bentonitic clay.	-	-
35'	36'6"	Grey clay.	-	-
Bore Hole No.9, R.L.Collar 1902', Depth 31'2".				
0	4'	Red soil and gravel.	-	-
4'	11'6"	Brown gravel.	-	-
11'6"	12'	Red gravel.	-	-
12'	14'9"	Grey clay.	-	-
14'9"	22'	White bentonitic clay. Main Bentonite Horizon.	21	33.5
22'	23'	White powdery clay.	-	-
23'	26'	Red clay.	-	-
26'	28'	Pink clay.	-	-
28'	31'	White powdery clay.	22	25.5
31'	31'2"	Pink clay.	-	-
Bore Hole No.10, R.L.Collar 1906', Depth 39'.				
0	11'	Red soil.	-	-
11	17'6"	Brown gravel.	-	-
17'6"	19'	Red weathered volcanic rock.	-	-
19'	27'	Red clay and white powdery clay.	-	-
27'	31'6"	Hard pink clay, spotted white.	-	-
31'6"	32'6"	Grey and pink spotted clay. Very slightly bentonitic.	-	-
32'6"	39'	White powdery material. Probably decomposed volcanic agglomerate.	-	-
Bore Hole No.11, R.L.Collar 1900', Depth 30'.				
0	11'	Red soil and brown gravel.	-	-
11'	12'6"	Iron-stained white clay.	-	-
12'6"	15'	White clay, powdery when dry.	23	27.5
15'	22'3"	White bentonite, slightly iron-stained in places.	24	62.0
22'3"	24'6"	White bentonitic clay.	25	40.5
24'6"	27'	Brown and pink clay.	-	-
27'	28'6"	Powdery white clay.	-	-
28'6"	30'	Brown friable clay.	-	-
Bore Hole No.12, R.L.Collar 1906', Depth 42'6".				
0	6'6"	Red soil and gravel.	-	-
6'6"	12'6"	Gravel and blue clay.	-	-
12'6"	18'2"	Brown and white clay.	-	-
18'2"	20'3"	White clay with red stains.	-	-
20'3"	22'6"	White clay.	-	-
22'6"	24'	White clay with red stains.	-	-
24'	29'8"	Red and white bentonitic clay.	26	33.5
29'8"	32'6"	White clay with texture of weathered volcanic agglomerate.	-	-
32'6"	37'	Bentonite.	27	26.0
37'	40'6"	Powdery white clay.	28	16.0
40'6"	42'6"	Grey clay.	-	-
Bore Hole No.13, R.L.Collar, 1908'6", Depth 31'6".				
0	4'	Soil and red gravel.	-	-
4'	7'	Blue clay.	-	-
7'	10'	White clay.	-	-
10'	13'3"	White, slightly bentonitic powdery clay.	29	16.5

DEPTH From	DEPTH To	TYPE OF MATERIAL	SAMPLE NO.	SADLER'S TEST.
Bore Hole No.13, R.L.Collar, 1908'6", Depth 31'6". (Cont'd.)				
13'3"	17'6"	Red weathered volcanic rock and brown and white clay.	-	-
17'6"	20'9"	Red and white powdery clay.	-	-
20'9"	22'	Red clay.	-	-
22'	31'6"	Brown clay.	-	-
Bore Hole No.14, R.L.Collar, 1891'6", Depth 11'.				
0	7'6"	Red soil and gravel.	-	-
7'6"	10'	White powdery clay.	-	-
10'	11'	Brown clay.	-	-
Bore Hole No.15, R.L.Collar, 1891'6", Depth 26'4".				
0	5'	Red soil.	-	-
5'	26'4"	Blue and yellow clay; bottom pink and grey volcanic tuff.	-	-
Bore Hole No.16, R.L.Collar, 1881'6", Depth 12'6".				
0	3'	Red soil.	-	-
3'	12'6"	Yellow clay; brown clay at bottom.	-	-
Bore Hole 17, R.L.Collar, 1901'10", Depth 28'11".				
0	13'6"	Red soil and gravel.	-	-
13'6"	16'	Blue clay.	-	-
16'	20'6"	White clay with iron-staining.	-	-
20'6"	25'	White clay.	30	23.5
25'	28'8"	Main bentonite seam.	31	38.5
28'8"	28'11"	White powdery clay.	32	19.0
Bore Hole No.18, R.L.Collar, 1904', Depth 33'.				
0	13'	Red soil and gravel.	-	-
13'	15'10"	Blue clay.	-	-
15'10"	30'6"	White bentonitic clay.	33	18.5
30'6"	33'	Main bentonite seam.	34	32.0
Bore Hole No.19, R.L.Collar, 1890', Depth 28'.				
0	4'	Red soil and gravel.	-	-
4'	5'6"	Bluish bentonitic clay, white when dry.	-	-
5'6"	10'	White bentonitic clay with iron-stains.	35	27.5
10'	11'9"	Main bentonite seam.	36	30.0
11'9"	13'4"	Red and yellow clay.	-	-
13'4"	14'6"	White powdery clay.	-	-
14'6"	17'	Pink powdery clay.	-	-
17'	20'3"	Red and cream bentonitic clay.	-	-
20'3"	27'	Red, white and brown clay.	-	-
27'	28'	Brownish-yellow clay.	-	-
Bore Hole No.19A, R.L.Collar, 1867'6", Depth 17'6".				
0	17'6"	Red soil and bluish-grey sub-soil probably weathered volcanic agglomerate.	-	-

DEPTH From	DEPTH To	TYPE OF MATERIAL	SAMPLE NO.	SADLER'S TEST
Bore Hole No.20, R.L.Collar, 1886'6", Depth 22'10".				
0	6'6"	Red soil and bluish clay.	-	-
6'6"	18'4"	White clay partly bentonitic.	37	28.0
18'4"	21'	Main bentonite seam.	38	36.0
21'	21'6"	Pink powdery clay.	-	-
21'6"	22'10"	Red powdery clay.	-	-
Bore Hole No.21, R.L.Collar 1894'6", Depth 25'4".				
0	3'	Red soil and gravel.	-	-
3'	9'6"	Blue clay.	-	-
9'6"	15'	White clay with iron-stains.	-	-
15'	19'8"	White bentonitic clay.	39	25.0
19'8"	25'4"	Main bentonite seam; bottom powdery white clay.	40	33.0
Bore Hole No.22, R.L.Collar 1896'6", Depth 27'6".				
0	3'	Red soil.	-	-
3'	12'6"	Brown gravel with some small stains.	-	-
12'6"	17'6"	Bentonitic clay.	41	30.5
17'6"	20'6"	White bentonitic clay.	42	32.0
20'6"	25'6"	Main bentonite seam.	43	34.0
25'6"	27'6"	White bentonitic clay. (This hole was put down to the top of the drive, depth 17'6", for ventilation. Samples 42, 43, 44 were taken in the drive adjacent to the hole and in a shallow bore hole put down from the floor of the drive).	44	20.5
Bore Hole No.23, R.L.Collar, 1877'6", Depth 17'6".				
0	1'3"	Black soil.	-	-
1'3"	3'	Brown sub-soil.	-	-
3'	6'	Bluish-brown clay.	-	-
6'	8'6"	Bentonitic clay, lighter in colour.	45	24.0
8'6"	12'3"	Brownish clay, friable in texture in part.	-	-
12'3"	14'	White clay.	-	-
14'	15'6"	Brownish-red friable clay.	-	-
15'6"	17'6"	Very red clay.	-	-

PLATE I.

PLAN OF BENTONITE DEPOSIT UPPER YARRAMAN

PORTION 116V, PH. OF COOYAR.
CO. CAVENDISH, QUEENSLAND.

0 100 200 300 FT.

REFERENCE

- APPROXIMATE EXTENT OF BENTONITE
- APPROXIMATE LIMITS OF 2ND. GRADE BENTONITE
- " " " WHITE CLAYS.
- NO. 7 NUMBER OF BOREHOLE.
- 2'3" * THICKNESS OF BENTONITE * SIGNIFIES 2 ND. GRADE ONLY
- 7'6" TOTAL " " " AND WHITE CLAYS.
- 1900' SURFACE CONTOURS, 5' INTERVALS
- 1870' CONTOURS AT BASE OF BENTONITE, 5' INTERVALS
- ELEVATION ABOVE SEA LEVEL APPROXIMATE ONLY

M.N

← To Maidenwell — To Yarraman →

FOREST RESERVE

PORTION 116V.

M.L. 64

NO. 10 NIL NIL
NO. 19A NIL NIL
NO. 9 3' * 8'3"
NO. 20 2'8" 14'6"
NO. 3 2'0" 14'0"
NO. 8 NIL 15'0"
NO. 21 5'8" 16'+
NO. 19 1'9" 7'9"
NO. 11 7'3" 13'6"
NO. 23 NIL 5'6"
NO. 18 2'6" 17'+
NO. 14 NIL 2'6"
NO. 7 2'3" * 7'6"
NO. 22 5'0" 13'+
NO. 17 3'9" 13'+
NO. 12 4'6" 27'6"
NO. 13 NIL 6'3"
NO. 6 NIL 5'6"
NO. 5 3'9" * 8'9"
NO. 1 NIL 9'6"
NO. 4 NIL 4'0"
NO. 15 NIL NIL
NO. 16 NIL NIL

Gate
Datum peg
Lease peg
Bagging Shed
Collapsed Shaft
Collapsed Shaft
Old workings
Drying Shed
Shaft 4' & No 2 Hole 17'6"
Present workings (Not shown in detail)
Collapsed Shaft
ROAD
Outcrops of red volcanic agglomerate
Fence
To Upper Yarraman
Road

A — A'
B — B'
C

T.H. Fraser.
CHIEF GEOLOGIST
MINERAL RESOURCES SURVEY
7.12.44

1163

PLATE 2.

REFERENCE

- SOIL & GRAVEL
- GREY & BLUE - GREY CLAY
- WHITE OR NEARLY WHITE CLAY, BENTONITIC IN PART
- MAIN BENTONITE SEAM
- PINK, RED, OR BROWN CLAY

SECTIONS THROUGH BENTONITE DEPOSIT UPPER YARRAMAN

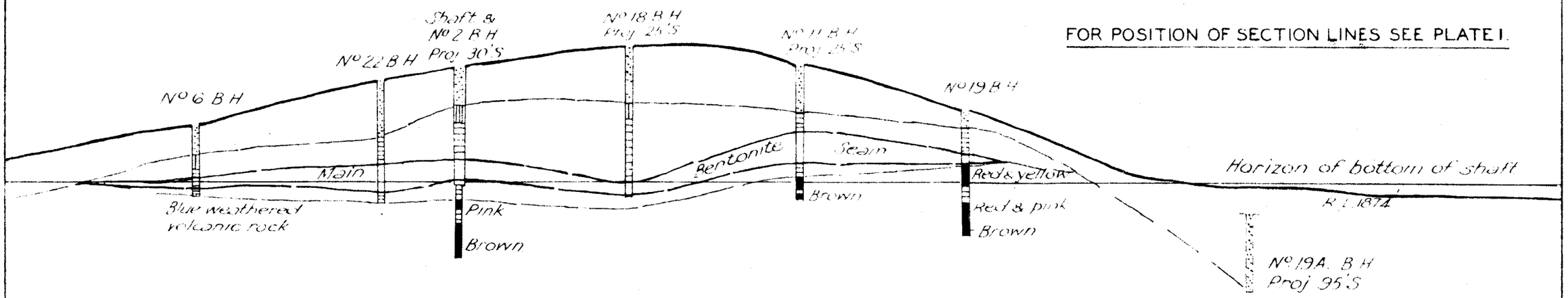
SHOWING BENTONITE SEAM AND UPPER & LOWER WHITE CLAYS

Hor Scale 0 50 100 200 300 Ft

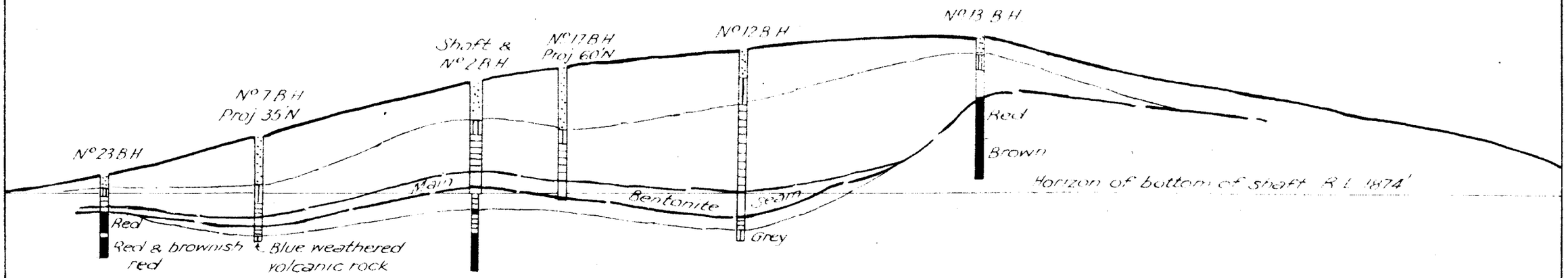
Vert Scale 0 25 50 75 Ft

FOR POSITION OF SECTION LINES SEE PLATE I.

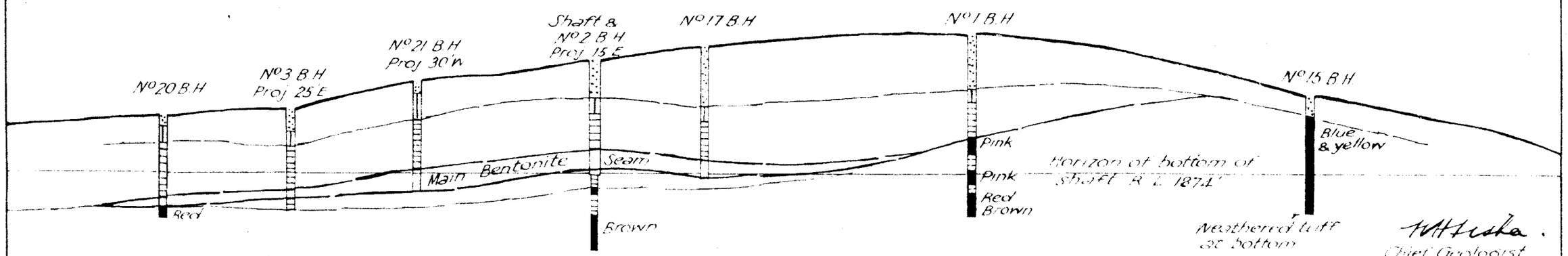
SECTION A-A'



SECTION B-B'



SECTION C-C'



W. Hitchcock.
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Mineral Resources Survey
1944