Director

RECORDS OF THE
GEOLOGICAL SURVEY
OF WESTERN AUSTRALIA

No. 1962/12.

TITLE: REPORT ON LAPORTE NOS.1,2,3 & 4 WATER BORES, AUSTRALIND, W.A.

AUTHOR: J. R. Passmore, B.Sc.

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REPORT ON LAPORTE NOS. 1, 2, 3 AND 4 WATER BORES, AUSTRALIND, W. A.

by

J. R. Passmore, B.Sc.

Record No. 1962/12

CONTENTS

ABSTRACT

Four bores drilled near Australind, Western Australia, to depths between 754 feet and 1104 feet were completed to yield a total of 2,600,000 gallons of water per day when tested separately but below maximum output. The water is of good quality, containing an average of 754 parts per million total dissolved solids and 406 parts per million sodium chloride.

The aquifers are relatively unconsolidated coarse grained sandstones occurring within the sandstones, mudstones and clays of the Capel River Group of Upper Jurassic to Lower Cretaceous age.

INTRODUCTION

Drilling for water at Australind, about 6 miles North-East of Bunbury, was undertaken by the Mines Department of Western Australia to provide 2 million gallons of water per day for Laporte Titanium Ltd. The supply of good quality water was required for an ilmenite-processing plant to be built at Australind. Drilling commenced on 5th March, 1961 and was completed on 2nd July, 1962.

No previous geological or hydrological information was available on the area except that at Bunbury artesian water is produced from bores of less than 200 feet depth, and that the 'Bunbury Basalt' was frequently encountered in these bores.

For the Laporte water supply only aquifers deeper than 200 feet below ground level were to be utilised, to eliminate interference with shallow bores on several farm properties nearby. Four sites were chosen by geologist J. Wyatt. These sites, each of which was drilled, are shown on the Locality Plan (Plate 1); the minimum distance between any two bores is 990 yards.

The bores were drilled under contract by J. Grill, using the Mines Department's Failing M.1 rotary rig. Collecti of samples, logging, and identification of aquifers, were carried out by the Geological Survey. Wellsite geologists

were K.H.Morgan (Bore No.1), L. Krlewaldt (Nos.2 and 3) and J.R.Passmore (No.4). The identification of aquifers was based on lithology determined from the cuttings. The quantity and quality of the water was determined after each bore was cased and completed. The Hydraulics Branch of the Public Works Department supervised the completion and testing of the bores.

Palynological examinations of selected samples were made by B.E. Balme of the University of Western Australia (Report No. 102) and H.S. Edgell of the Geological Survey of Western Australia (Appendix 1).

DRILLING RESULTS

Laporte No. 1 Water Bore

General Data

Location:	South-West Division. W.A. Lands Dept. Litho.411 A/40, Recreation Reserve 8025. Lat.33°16'30" S., Long.115°43'45"
Elevation:	Ground level 8.7' above M.S.L., Fremantle.
Total Depth Drilled:	754'.
Hole Size:	12"/0-40'; 9"/40'-344'; 6¾"/344'-754'.
Casing:	10" O.D./0-40'; 8" O.D./0-344'; 6" O.D./306'-754' 10" and 8" casing cemented.
Slots:	6" casing slotted from 425' to 655', slots 12" x
Commenced:	5th March, 1961.
Completed:	9th June, 1961.

Summary Log

From (feet)	To (feet)	Thick-ness (feet)	Water Potential	Lithology
0	120	120	partly aquifer	Sandstone siltstone and minor Mud stones interbedded.
120	340	220	aquifer	Sandstones: quartz, clean, fine-med coarse-pebble, and conglomerate san stones.
340	458	118	aqui-clude	Basalt (including weathering surfac of soft clay above and below most o the flows).
458	680	222	produc-ing aquifer	Sandstones: quartz, fine-medium-coa -pebble sandstones with an increasi amount of minor interbeds of silt-stones and mudstones from 600'-680'
680	754	74	aqui-clude	Mudstone-siltstone with interdigit-ates of quartz sandstone.

Hydrological Data

Date of Pump Test: 7th to 8th June 1961.

Static Water Level: 28' above ground level.

Yield: Pumped for 48 hours at 23,000 g.p.h.

Drawdown: 44'5".

Estimated Drawdown after 1 year's pump-ing at 23,000 g.p.h. 53'.

Quality of water: Total dissolved solids, 658 ppm.

Laporte No. 2 Water Bore

General Data

Location: South-West Division.

W.A.Lands Dept.Litho 411A/40,Wellington Location 31.

Lat.33°17'40" S., Long.115°42'55" E.

Elevation: Ground level 49.7' above M.S.L., Fremantle.

Total Depth Drilled: 900'.

Hole Size: 15"/0-40'; 13¼"/40'-461'; 9"/461'-900'.

Casing: 13¾" I.D./0-41'; 12" I.D./0-86'; 10" O.D./0-434'.
8" O.D./353'-857'. 15", 12", and 10" casing cemented.

Slots: 8" casing slotted 555'-805'; slots 12" x ⅛",
66 slots per 20'.

Commenced: 12th July 1961.

Completed: 18th December 1961.

Summary log

From (feet)	To (feet)	Thick-ness (feet)	Water Potential	Lithology
0	65	65	Aquifer	Sands: unconsolidated, quartz, coa grained, yellow from 0-48', white from 48'-65'.
65	485	420	Aquifer	Sandstone and minor Mudstone Sandstone: poorly consolidated, quartz, felspathic and micaceous, coarse grained. Mudstone: brown and black, with pyrite, minor lignite and coal. Beds up to 10' thick.
485	537	52	Aqui-clude	Mudstone: black and brown; minor be of white claystone, coars grained sandstone and coa
537	578	41	aqui-clude	Mudstone: red-brown, silty and sandy (fine); minor beds of whi claystone, black shale, an coarse grained quartz san stone.
578	625	47	aquifers with min-or aqui-cludes (partly produc-ing)	Sandstone, Conglomerate, minor Mud-stone, Claystone and Shale. Sandstone and conglomerate: Poor ly consolidated, quart coarse and very coars grained, with pebbles and boulders. Mudstone Claystone and Shale: Minor thin beds of brown mudstone, white claystone, and black shale.
625	900	275	produc-ing aquifer	Sandstone: poorly consolidated, quar coarse grained, mostly well sorted, with minor conglomerate.

Hydrological Data

Date of Pump Test:	3rd to 12th December 1961.
Static water level:	14' below ground level.
Yield:	Pumped for 200 hours at 24,000 g.p.h.
Drawdown:	44'.
Estimated Drawdown after 1 year's pumping at 24,000 g.p.h:	49'.
Quality of water:	Total dissolved solids, 400 p.p.m.

Laporte No. 3 Water Bore.

General Data

Location:	South-West Division. W.A.Lands Dept. Plan No. 4/114/40, Wellington Location. Lat. 33°16'10" S., Long. 115°44'25" E.
Elevation:	Ground level 45' above M.S.L., Fremantle.
Total Depth Drilled:	1055'.
Hole Size:	18"/0-65'; 15"/65'-325'; 9⅝"/325'-1055'.
Casing:	15⅝" I.D./0-60'; 10" I.D./0-325'; 8" O.D./240'-1030'. 15⅝" and 10" casing cemented. Cement plug set at 1024'-1030'.
Slots:	8" casing slotted 740'-820' and 880'-1020'. Slots 12" x ⅛", 60 slots per 20'.
Commenced:	8th January 1962.
Completed:	13th March 1962.

Summary Log

From (feet)	To (feet)	Thickness (feet)	Water Potential	Lithology
0	23	23	Aquifer	Sand: unconsolidated, white, quartz coarse grained, with heavy minerals in fine fraction.
23	125	102	Minor aquifers	Sandstone and Mudstone interbedded Sandstone: poorly consolidated, quartz, felspathic, coarse grained. Mudstone: black and yellow.

Summary Log (Continued)

From (feet)	To (feet)	Thick-ness (feet)	Water Potential	Lithology
125	529	404	aquifer	Sandstone: poorly consolidated, quartz, felspathic, coarse grained. Some beds of conglomerate and mudstone.
529	571	42	aquiclude	Mudstone: black.
571	739	168	aquiclude	Sandstone: clayey, fairly well consolidated, coarse grained, with white clay matrix.
739	893	154	minor aquifers (partly producing)	Sandstone and mudstone interbedded. Sandstone: well consolidated, quartz, coarse [illegible]. Mudstone: grey, brown and [illegible].
893	1042	149	producing aquifer	Sandstone: poorly consolidated, quartz, coarse grained with very coarse gravel sections.
1042	1055	13	aquiclude	Mudstone: black.

Hydrological Data

Date of Pump Test:	4th to 13th March, 1962.
Static water level:	17' below ground level.
Yield:	Pumped for 200 hours at 28,000 g.p.h.
Drawdown:	35'.
Estimated Drawdown after 1 year's pumping at 28,000 g.p.h.:	38'.
Quality of water:	Total dissolved solids, 826 p.p.m.

Laporte No. 4 Water Bore.

General Data

Location:	South-West Division. W.A. Lands Dept. Litho. 4114/40. Wellington Location. Lat. 33°16'50" S., Long. 115°43'20" E.
Elevation:	Ground level 30.3' above M.S.L., Fremantle.
Total Depth Drilled:	1104'6".
Hole Size:	15"/0-40'; 12¼"/40'-543'; 9"/543'-1104'6".
Casing:	14" O.D./0-40'; 10" O.D./0-540'; 8" O.D./437'10" [illegible] 6" O.D./497'8"-1074'. 14" and 10" casing cemented. Cement plug set at 1062'-1068'.

Slots: 6" casing slotted 668'-791' and 865'-1062'.
Slots $\frac{1}{8}$" width, 4 slots 1' in length every 1'6".

Commenced: 29th March 1962.

Completed: 2nd July 1962.

Summary Log

From (feet)	To (feet)	Thick-ness (feet)	Water Potential	Lithology
0	25	25	aquifer	Sand: unconsolidated, yellow, medium to coarse grained.
25	45	20	aquifer	Sandstone: calcareous, consolidated white, medium to coarse grained.
45	113	68	aqui-clude	Mudstone, Clay and Sandstone Mudstone: silty, light brown and grey. Clay: light brown, black carbonaceous. Sandstone: clayey and silty, coarse grained.
113	447	334	aquifer	Sandstone, minor clay and Boulders Sandstone: mostly clayey, poorly consolidated, coarse grained. Clay: sandy, grey. Boulders: quartzite, pink, grey and white.
447	724	277	minor aquifers	Clay and Sandstone Clay: sandy, black, grey, brown and blue. Sandstone: clayey, medium to coarse grained.
724	803	79	produc-ing aquifer	Sandstone: slightly clayey, lightly consolidated, medium to coarse grained.
803	896	93	minor aquifers	Mudstone, Clay and Sandstone Mudstone: grey and brown. Clay: sandy, grey, brown and blue. Sandstone: clayey, consolidated, medium to coarse grained.
896	1104½	208½	produc-ing aquifer	Sandstone: slightly clayey, lightly consolidated, coarse grained, with minor thin beds of mudstone and cl...

Hydrological Data

Date of Pump Test:	24th June to 2nd July, 1962.
Static Water Level:	2' below ground level.
Yield:	Pumped for 200 hours at 33,000 g.p.h.
Drawdown:	58'
Estimated Drawdown after 1 year's pumping at 33,000 g.p.h.:	75'
Quality of Water:	Total dissolved solids, 1133 p.p.m.

GEOLOGY

General

The Australind area is in the southern part of the Perth Basin. The area is underlain by Mesozoic sediments of the Capel River Group (Fairbridge, 1953) which range in age from Upper Jurassic to Lower Cretaceous. Associated with these sediments are basalt flows correlated with the Bunbury Basalt (McWhae et al, 1956). Overlying them are Quaternary sands and clays.

The Quaternary geology of the area has been described by McArthur and Bettenay (1960). Sands of fossil dune systems were encountered to depths of 65 feet, 23 feet and 45 feet, in bores nos. 2, 3 and 4 respectively. The sands are white and yellow, in part calcareous, and contain minor amounts of heavy minerals. In its upper part bore no. 1 penetrated some dark clays and sands, which are alluvial deposits of the Brunswick River.

Upper Jurassic to Lower Cretaceous sediments were penetrated to depths of 1,100 feet by the drilling at Australind. They are predominantly non-marine poorly consolidated sandstones clays, and mudstones. The sandstones are mostly coarse grained, felspathic, poorly to moderately sorted, and with grains subangular to rounded. Felspars are mostly fresh but some are partly or wholly decomposed to kaolin. Clay, silt, fine sand, and pebbles occur within the sandstones and as minor interbeds. Pyrite occurs

as the cementing material of nodules of hard sandstone and associated with thin beds of coal and lignite. Beds of unconsolidated conglomerate consist of rounded pebbles and boulders of pink quartzite, grey quartzite, quartz, and chert.

Mudstones and clays of black, brown, grey, yellow, and blue colours are interbedded with the sandstones. They are often silty, sandy, or micaceous. Black mudstones and clays contain carbonaceous material either in a finely divided state or as thin beds of shaly coal or lumps of black coal. In these mudstones pyrite is found as nodules or partly replacing pieces of coal.

Basalt similar to that which crops out at Bunbury was intersected in bore no. 1 from 340 feet to 458 feet between Lower Cretaceous sediments. Two sections, 31 feet and 82 feet thick, are separated by five feet of brown mudstone. The upper and lower surfaces of the basalt are decomposed; seven feet and five feet of green clay with decomposed basalt were encountered at the top and bottom respectively of the basalt section. The stratigraphic sections intersected in the four bores are shown in the Correlation Chart (Plate 2) and in the Composite Logs (Plates 3 to 6). Detailed sample logs of the bores are not included in this report but are available at the Geological Survey.

Stratigraphy and Correlation

Definite lithological correlation between the bores is not possible, due to the lensing nature of the beds and the lack of distinctive horizons within the interbedded mudstones and sandstones. The sequences in bores nos. 2 and 4 are somewhat similar, consisting of upper and lower sections of predominantly sandstones, and middle sections of black and brown mudstones with minor sandstones (see Correlation Chart, Plate 2). These sections are not distinctive in the other two bores.

The sediments are correlated with the Capel River Group (Fairbridge, 1953), a sequence of continental siltstones and shales which is poorly exposed in several areas in the southern part of the Perth Basin. The group is known from bores in this area, the thickest section being 1700 feet in the Abba River Bore no. 1. Although the group has been divided by Fairbridge into four formations, based largely on the known outcrops, no correlations

with them are made here as the stratigraphic relationships between the formations are uncertain, and lithologies are not distinctive.

The age of the pre-Quaternary sediments is Upper Jurassic to Lower Cretaceous. The results of palynological age determinations by Balme and Edgell are included in Appendix 1. Microfloras are similar to those of the South Perth Formation and the Claremont Sandstone of the Perth area, and the Yarragadee Formation of the Northern part of the Perth Basin (McWhae et al. 1958).

Four assemblages of spore, pollen and microplankton forms have been recognised (Balme, Report No.102; Edgell, Appendix 1). Assemblage A is of Upper Jurassic age, assemblage B of Upper Jurassic to Lower Cretaceous age, and assemblages C and D of Lower Cretaceous age. Balme notes that assemblage B is poorly defined, depending on the absence of typical Cretaceous forms, and that "it could not be distinguished from an impoverished assemblage C". The distinction between assemblages C and D is that assemblage D contains hystrichosphaerids, which are microplankton indicating marine or estuarine conditions of deposition.

Appendix 1 and the Correlation Chart (Plate 2) show correlations based on the age determinations; the exactness of the boundaries is limited by the small number of determinations made. Jurassic sediments occur in the lower parts of bores nos. 1,3 and 4. The depths at which they were encountered indicate either a dip of 10-15° to the south, or a fault between bores nos. 1 and 4 with downthrow to the south, or a late Jurassic-early Cretaceous unconformity. The absence, in bores nos. 2 and 4, of sediments containing assemblage B could be due to such an unconformity or to a difference in facies. At present there are not enough data to allow interpretation of the Jurassic-Cretaceous boundary.

The age determinations show that the basalt occurs within Lower Cretaceous sediments and is therefore of similar age to the basalt penetrated in Abba River Bore no. 3.

Lower Cretaceous sediments containing hystrichosphaerids occur at the top of the Mesozoic sections in bores nos.1,2 and 4.

Their absence from sediments in bore no. 3 is probably due to facies difference - the lack of marine influence - rather than difference in age.

HYDROLOGY

General

Good supplies of water were obtained from each of the four bores. The water is produced in each case from sandstones which are coarse grained, fairly well sorted and porous, and which contain minor conglomerate beds. The aquifers are heterogeneous in that production intervals contain sandstones of varying grain size sorting and porosity, and interbeds of clays and mudstones. Although there is hydrological connection between bores the aquifers are discontinuous and lense with non-porous clays and mudstones. There is no definite correlation of aquifers between bores.

Only bore no. 1 produced flowing water. It is situated in a topographically low area so that the static water level of the confined water is about 28 feet above ground level. In the other bores the static water levels are as much as 18 feet below ground level. These levels, reduced to height above Mean Sea Level, Fremantle, in Table 1, are controlled by the piezometric surface of the confined aquifer system.

Table 1.

Static Water Levels

Bore No.	Height above M.S.L. (feet)	Date
1	36.5	30/5/62
2	35.0	20/6/62
3	30.7	30/5/62
4	29.8	3/7/62

When compared with the bore locations (Plate 1) these figures do not indicate a definite gradient for the piezometric surface. The small differences in levels may be due to different amounts of aquifer development.

Yield

The pump tests showed that the bores can be pumped at rates of 23,000 gallons per hour to 33,000 gallons per hour with drawdowns of 35 feet to 58 feet below static water levels. D. Collett of the Hydraulics Branch, Public Works Department, has analysed the results of the pump tests and estimated the increased drawdowns resulting from pumping each bore for a period of about one year. The figures are given with the hydrological data. When all bores are pumped simultaneously drawdowns will be greater than those calculated for each bore separately because they are known to interfere. When bore no. 3 was pump tested, no. 1 drew down 2 feet; when bore no. 1 was allowed to flow for 14 days, no. 3 drew down 3 feet; when bore no. 4 was pump tested, no. 1 drew down 4.4 feet, no.2 drew down 0.8 feet, and no. 3 drew down 4.3 feet.

If it can be assumed that the aquifers will be replenished sufficiently through intake beds by winter rains, the drawdowns should not increase greatly over a number of years. This assumptio can be tested by observations of static water levels in the bores over one or two years. It is noted that at Bunbury, the decrease in static water levels in the town supply bores over the summer period is restored during winter.

Quality

The quality of water obtained from the Laporte bores is good, with low chloride and iron contents.

Analyses were carried out by the Government Chemical Laboratories, Perth, on one gallon samples taken from each bore near the completion of pump tests. The results of the complete analyses are given in Appendix 2; the concentrations of significant mineral ions in solution are given in the following table:

Table 2.

Concentrations of Significant Minerals Ions

Ion	Laporte No.1 P.P.M.	Laporte No.2 P.P.M.	Laporte No.3 P.P.M.	Laporte No. P.P.M.
Sodium, Na	153	77	222	301
Potassium, K	19	18	24	27
Calcium, Ca	17	20	11	34
Magnesium, Mg	16	13	17	25
Iron, Fe	0.2	9	5.9	0.1
Chloride, Cl	175	134	306	452
Sulphate, SO_4	25	14	36	51
Bicarbonate, HCO_3	235	110	174	228
Silica, SiO_2	15	-	30	14
Total Dissolved Solids (from Appendix 2)	658	400	826	1133
Assumed Sodium Chloride	260	194	468	704

These figures show that water from bore no. 2 has the lowest concentrations of total dissolved solids and sodium chloride. Although the iron content of this water is relatively high, it is not as significant as chloride content because it may be reduced by filtration.

The water from bore no. 4 has the highest salinity. While the concentration of 704 p.p.m. sodium chloride is not too high for most purposes, it is considered by Laporte Titanium Ltd. to be too high for the chemical processes for which the water will be used. Also, the salinity can be expected to rise with continued pumping.

The ratios of bicarbonate to chloride ions are relatively low, which is typical of waters that have moved long distances from intake areas (Chebotarev, 1950). The decrease in the ratios from bore nos. 1 to 4 corresponds with depths of the aquifers (482'-582', 575'-900', 758'-1042', and 724'-1104'6" respectively) rather than geographic position. This also corresponds with increase in the

ratios of sodium ions to the sum of calcium, magnesium and sodium ions except that bore no. 2 has a smaller ratio than bore no. 1.

From the comparisons of these ratios it is expected (following Chebotarev,1950) that the salinities of the waters from the deeper aquifers of bores nos. 3 and 4 are likely to increase with pumping more than those of the waters from the shallower aquifers of bores nos. 1 and 2.

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Appendix 1.

Record of Palaeontological Examination No. 6/1962

by H. S. Edgell, Ph.D. Palaeontologist.

Material: Rotary ditch samples from four Laporte water bores, namely Laporte No. 1, 620 feet-630 feet, Laporte No.2, 600 feet, Leporte No.3, 710feet and 890 feet, and Laporte No.4, 620 feet and 930 feet.

Locality: Laporte Titanium Water Bores No.1,2,3 and 4 in the vicinity of Australind, Perth Basin.

Submitted by: Hydrology Division, J. E. Passmore.

Date submitted: 30th July 1962.

Information required: Microfloral assemblages and geological age of the samples for purposes of stratigraphic correlation.

Date information supplied: 3rd August, 1962.

Palaeontological identifications: The argillaceous fractions of these sandy samples were macerated and yielded the following spores and pollen grains:

Laporte No. 1

620 feet - 630 feet.

Spores:

cf. Acanthotriletes spinulosus (Cookson)(v r)
Cyathidites cressiangulatus Balme (v r)
Cyathidites cf. minor Couper (v r)

Pollen:

Araucariacites australis Cookson (v r)
Microcachryidites antarcticus Cookson (r)

Laporte No. 2

600 feet

Spores:

Acanthotriletes levidensis Balme (r)
Cicatricosisporites australiensis (Cookson)(r to f)
Concavisporites infirmus Balme (v r)
Cyathidites australis minalis Balme (r)
Ischyosporites crateris Balme (r to f)
Ischyosporites cf. scaberis Cookson & Dettmann (v r)

Pollen:

Classopollis cf. torosus (Reissinger) (v r)
Entylissa nitidus Balme (r)
Pityosporites simplis Balme (v r)

Laporte No. 3

710 feet

Spores:

Cyathidites australis minalis Balme

Pollen:

Zonalapollenites dampieri Balme (f)
Inaperturopollenites turbatus Balme (r)
Classopollis sp. (tetrad) (v r)
? Microcachrydites antarcticus Cookson (v r)

890 feet

Spores:

Acanthotriletes lovidensis Balme (r to f)
Cyathidites crassiangulatus Balme (f)
Ischyosporites crateris Balme (r)

Pollen:

Zonalapollenites dampieri Balme (f)
Zonalenollenites cf. trilobatus Balme (v r)
Araucariacites australis Cookson (r to f)
Pityosporites grandis Balme (v r)
Cavtriclletes pallidus (Reissinger)(v r)
Pityosporites simplis Balme (r)
Microcachrydites antarcticus Cookson (r)
Entylissa nitidus Balme (v r)

Laporte No. 4

620 feet

Spores:

Cyathidites crassiangulatus Balme (f to c)
Lycopodiumsporites austroclavatidites Cookson (v r)
Osmundacidites comaumensis (Cookson) (r)
Zonalasporites acusus Balme (v r)

Pollen:

Araucariacites australis Cookson (f to c)
Classopollis cf. torosus (Reissinger) (v r)
Microachrydites antarcticus Cookson (f)
Pityosporites cf. elligticus (Cookson) (r)

930 feet

Spores:

Cicatricosisporites australiensis Cookson (v r)
Cirratriradites verrucosus Cookson & Dettmann (v r)
Cyathidites australis rimalis Balme (f)
Cyathidites cf. minor Couper (v r)
Divisisporites cuakirchenoides Thompson (v r)
Lycopodiumsporites austroclavatidites Cookson (v r)
Microreticulatisporites parvireticus Balme (v r)
Osmundacidites comanensis (Cookson) (f)

Pollen:

Araucariacites australis Cookson (c)
Classopolis cf. torosus (Reissinger) (r)
Entylissa nitidus Balme (r)
Microachrydites antarcticus Cookson (f)
Pityosporites grandis (Cookson) (f)

Remarks: The samples examined came from depths intermediate to, and lower than those determined by B.E.Balme (Palynological Report No.102 "Laporte Mitanium Bores in the Australind District"),July 1962

Additional age determinations were required to permit more accurate correlation between bores. Although predominantly arenaceous each of the samples submitted yielded a significant microflora, which enabled the geological age and assemblage zone to be determined. They are samples of non-marine sediments and no microplankton was observed. Results of this study can be amalgamated with those of Mr. Balme as shown in the accompanying diagram.

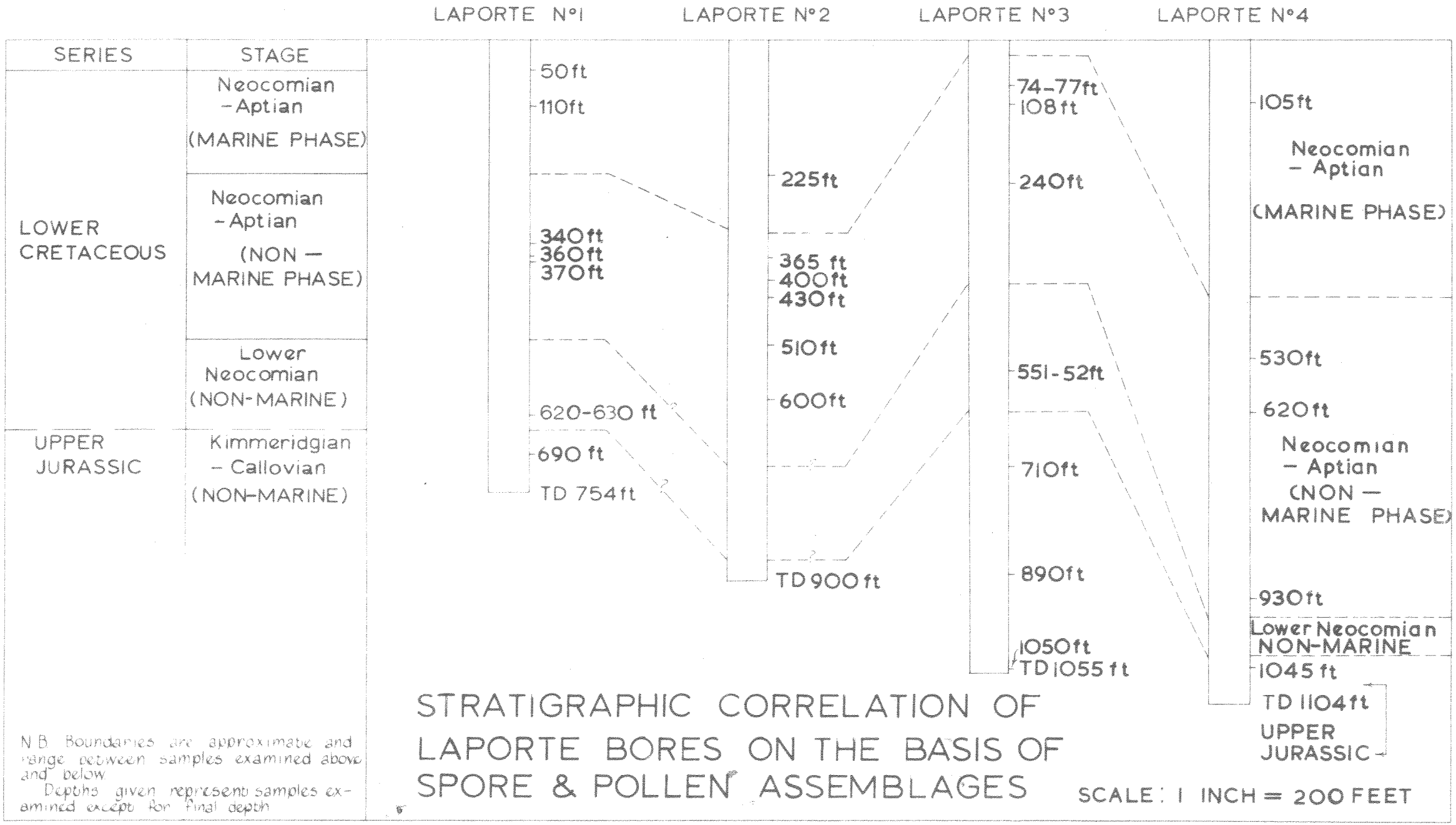
Conclusions

At a depth of 620 feet to 630 feet in Laporte No. 1 sediments encountered are non-marine of Early Cretaceous age assignable to microfloral assemblage B.

In Laporte No. 2 Neocomian-Aptian spores and pollen of assemblage C occur in a terrigenous sediment at a depth of 600 feet.

The two samples from Laporte No. 3 at depths of 710 feet and 890 feet are both of Late Jurassic age as indicated by frequent Zonalapollenites dampieri Balme. They contain microfloral assemblage A or IIa of Balme and are non-marine in origin.

Samples from Laporte No.4 at depths of 620 feet and 930 feet are from Lower Cretaceous non-marine strata and are both assignable to assemblage C. Palynological age determination of the above samples has provided a more exact correlation of the Laporte bores which should enable the aquifers to be traced laterally



STRATIGRAPHIC CORRELATION OF LAPORTE BORES ON THE BASIS OF SPORE & POLLEN ASSEMBLAGES

SCALE: 1 INCH = 200 FEET

N.B. Boundaries are approximate and range between samples examined above and below.
Depths given represent samples examined except for final depth

H.S. Edgell. 3/8/62.

APPENDIX 2.

Water Analyses

by Government Chemical Laboratories.

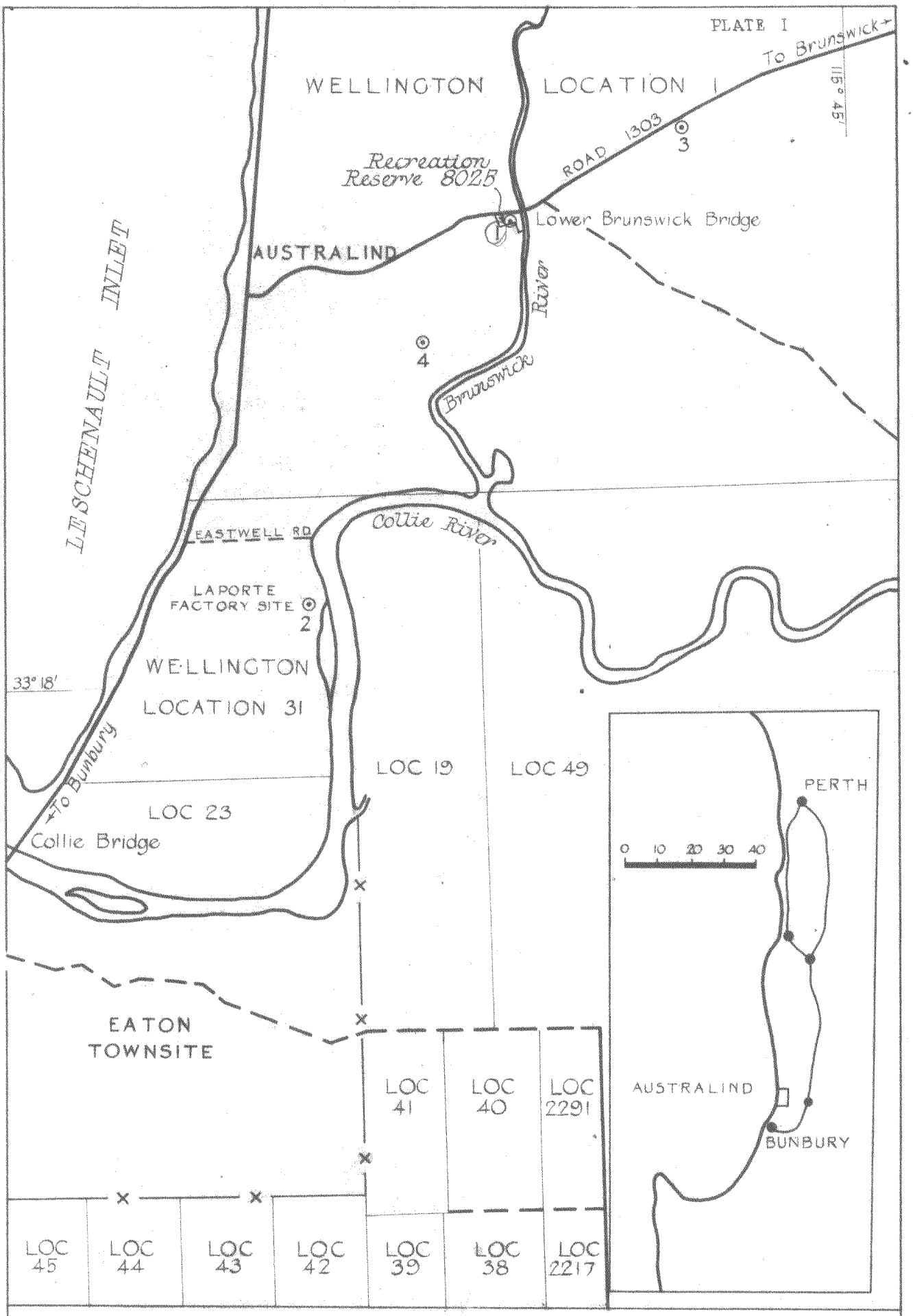
	Laporte No.1	Laporte No.2	Laporte No.3	Laporte No.4
Date collected	12/4/61	18/12/61	13/3/62	2/7/62
Conditions	After 48 hr. pump test.	After 200 hr. pump test.	After 200 hr. pump test.	After 200 hr. pump test.
Colour A.P.H.A.units	Colourless	n.d.	n.d.	Less than 5
Odour	Odourless	n.d.	n.d.	n.d.
Reaction	Faintly alkaline	neutral	Faintly alkaline	Faintly alkaline
pH	8.1	7.7	8.0	7.9
Specific Conductivity 20°C. Micromhos	n.d.	n.d.	n.d.	2220
Turbidity A.P.H.A.units	n.d.	n.d.	n.d.	Less than 5
Mineral Matter (P.P.M.)				
Calcium, Ca	17	20	11	34
Magnesium, Mg	16	13	17	25
Sodium, Na	153	77	222	301
Potassium, K	19	18	24	27
Bicarbonate, HCO_3	235	110	174	228
Carbonate, CO_3	nil	nil	nil	nil
Sulphate, SO_4	25	14	36	51
Chloride, Cl	175	134	306	452
Nitrate, NO_3	1	Less than 1	Less than 1	Less than 1
Silica, SiO_2	15	n.d.	30	14
Iron oxide, Fe_2O_3	0.3	13	n.d.	n.d.
Aluminium oxide, Al_2O_3	2	n.d.	n.d.	n.d.
Iron, Fe	n.d.	n.d.	5.9	0.1
Aluminium, Al	n.d.	n.d.	n.d.	1
Manganese, Mn	n.d.	n.d.	0.2	Less than 0.
Total (by summation)	658	400	826	1133
Total (by evaporation)	523	n.d.	n.d.	1010
Assumed Combination Evaporation at N.T.P.				
Calcium carbonate, $CaCO_3$	42	50	27	85

APPENDIX 2.

Water Analyses (cont.)

	Laporte No.1	Laporte No.2	Laporte No.3	Laporte No.4
Magnesium carbonate, $MgCO_3$	55	34	59	86
Sodium carbonate, Na_2CO_3	89	n.d.	48	n.d
Magnesium sulphate, $MgSO_4$	nil	16	n.d.	1
Sodium sulphate, Na_2SO_4	37	2	53	74
Potassium chloride, KCl	36	34	46	52
Sodium chloride, NaCl	260	194	468	704
Sodium nitrate, $NaNO_3$	1	Less than 1	n.d.	n.d.
Hardness calculated as Calcium Carbonate				
Total Hardness	108	105	98	188
Bicarbonate (temporary) hardness	108	90	98	187
Non-carbonate (permanent) hardness	nil	15	nil	1
Calcium hardness	42	50	28	85
Magnesium hardness	66	55	70	103

n.d. denotes not determined.



LEGEND

Roads (sealed) ———

Roads (unsealed) – – –

Laporte Water Bores 2 ⊙

GSWA

LOCALITY PLAN

LAPORTE WATER BORES

AUSTRALIND

Scale : 40 chs = 1 inch

Litho 411 A/40

CORRELATION CHART
LAPORTE WATER BORES

LAPORTE No. 2 WATER BORE.

Microfloral Assemblage | Depth in Feet | G.L. 49·7' above M.S.L.

0' Sands, yellow and white.
65
LOWER CRETACEOUS (MARINE)
D
Coarse sandstone and minor brown and black mudstone.
C
C
C
485
C Mudstone, black and brown.
537
Interbedded sandstone and red-brown mudstone.
578'
C Sandstone, conglomerate and minor mudstone.
625
Sandstone, coase, and conglomerate.
900'
LOWER CRETACEOUS (NON-MARINE)

1903 yds.

LAPORTE No. 4 WATER BORE.

Microfloral Assemblage | Depth | G.L. 30·3' above M.S.L.

0' Yellow sand.
25
Calcareous sandstone.
45
Mudstone and clay.
73
Clayey sandstone.
99
D Black clay.
113'
Sandstone, minor clays, and boulders.
447
Black clay with coal.
466
Sandstone, coarse.
519
C Black clay with coal
535
Sandstone.
549
Sandstone and red-brown clay.
588
Sandstone and blue, brown clay.
620'
Dark brown clay.
638
Sandy clays, blue and brown.
724'
Sandstone, medium to coarse.
803
Mudstones, clays, and sandstones.
896
Sandstone.
926'
C Black mudstone.
937
Sandstone, medium to coarse.
A
1104' 6"

992 yds.

LAPORTE No. 1 WATER BORE.

Microfloral Assemblage | Depth | G.L. 8·7' above M.S.L.

D
LOWER CRETACEOUS (MARINE)
D
0' Sandstone, siltstone and minor mudstone.
120'
Sandstone, fine to coarse, and conglomeratic.
C
C
C
340'
Basalt (including weathering surfaces above and below most of the flows.)
458
B
A
680'
Mudstone siltstone with minor sandstone.
754'
LOWER CRETACEOUS (NON-MARINE)
LATE MIDDLE JURASSIC TO UPPER JURASSIC

1207 yds.

LAPORTE No. 3 WATER BORE.

Microfloral Assemblage | Depth | G.L. 46' above M.S.L.

0' Sand.
23'
C Sandstone and black mudstone.
C
125'
Sandstone, coarse.
205'
Conglomeratic sandstone.
229'
C Yellow mudstone.
237'
LOWER CRETACEOUS (NON-MARINE)
Sandstone, coarse.
339'
343' Yellow mudstone.
Sandstone, coarse.
455'
470' Conglomeratic sandstone.
Sandstone, coarse.
529'
B Black mudstone.
571'
Sandstone, fine to coarse grained and pebbly, with minor interbeds of siltstones and mudstones 600' – 680'.
UPPER JURASSIC TO LOWER CRETACEOUS
A
Interbedded sandstones and mudstones, grey, brown and black.
A-
893'
Sandstone, coarse.
920'
928' Mudstone.
Sandstone, coarse to very coarse; minor mudstones.
A
1042'
1055' Black mudstone.

PLATE III.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

COMPOSITE LOG

LAPORTE NO.1 WATER BORE

AUSTRALIND

Vertical Scale: 50 Feet to an Inch

Lat. 33° 16′ 30″ S.

Long. 115° 43′ 45″ E.

Lands Dept. Litho 411A/40

Wellington Crown Reserve 8025

R.L. surface 8·7 feet above M.S.L.

Logged by: K. H. Morgan

Rig: Failing 1500 Rotary

Drilled by: W.A. Mines Dept. for Laporte Titanium Ltd.

Driller: J. F. Grill

Commenced: 5th March 1961

Completed: 9th April 1961

LEGEND

- Clay, mudstone
- Siltstone
- Sand, sandstone
- Felspathic sandstone
- Boulders
- Carbonaceous material
- Basalt
- py Pyrite
- mi Mica

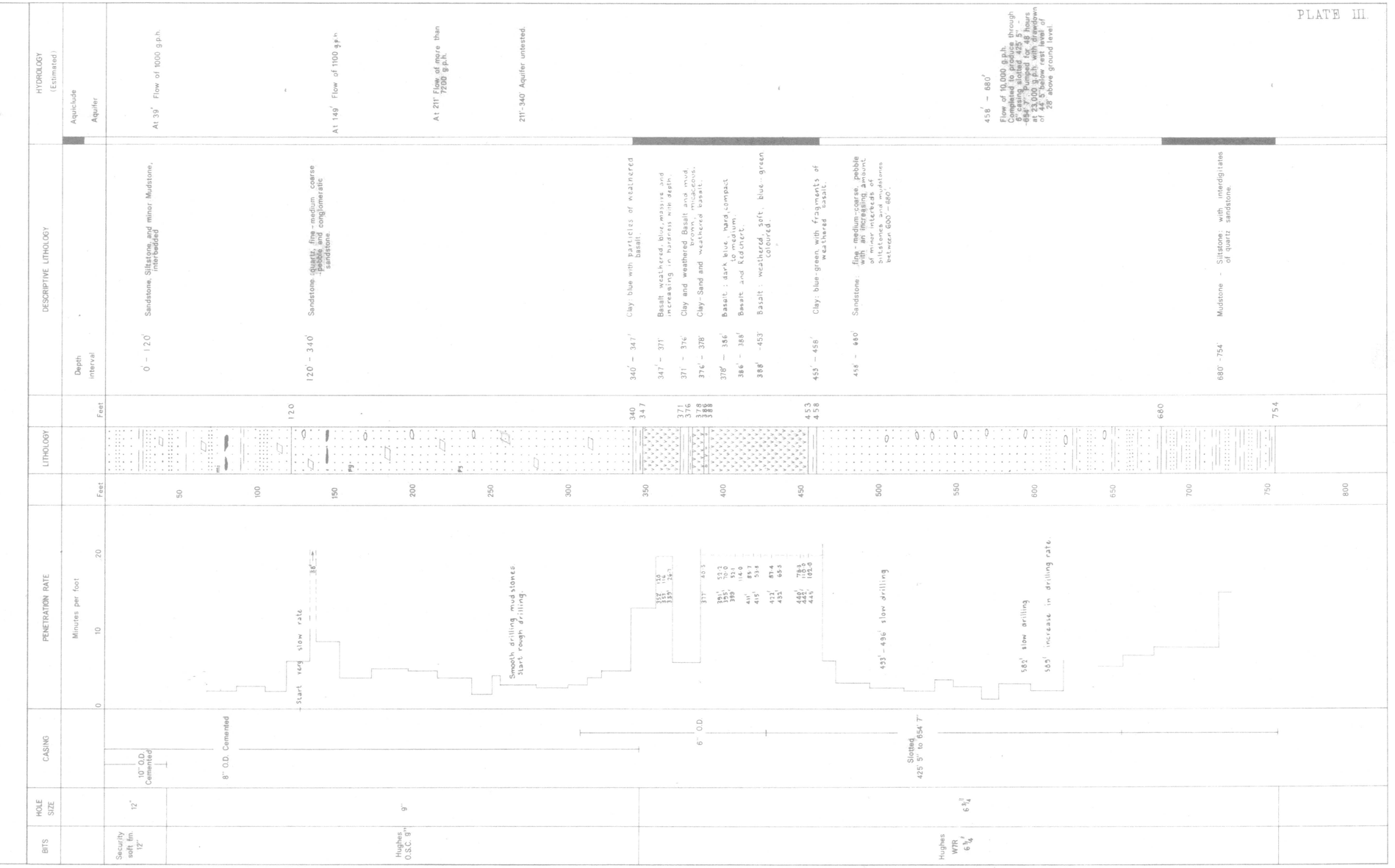


PLATE IV

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

COMPOSITE LOG

LAPORTE NO.2 WATER BORE

AUSTRALIND

Vertical Scale: 50 Feet to an Inch

Lat. 33° 17′ 40″ S.

Long. 115° 42′ 55″ E.

Lands Dept. Litho 411A/40

Wellington Loc. 31

R.L. surface 49·7 feet above M.S.L.

Logged by: M. Kriewaldt

Rig: Failing 1500 Rotary

Drilled by: W.A. Mines Dept. for Laporte Titanium Ltd.

Driller: J. F. Grill

Commenced: 12th July 1961

Completed: 18th December 1961

LEGEND

- Clay, claystone, mudstone, shale
- Sand, sandstone
- Felspathic sandstone
- Conglomerate
- Boulders
- Carbonaceous material
- py Pyrite
- mi Mica

HYDROLOGY (Estimated)

Aquiclude / Aquifer

108'-125' Probable small supply

214'-225' Probable good supply main section from 214'-216'

231'-245' Possible small supply

268'-320' Possible small supply

358'-382' Possible small supply

Water bailed from 434'-470' (bridge) after 10" casing set; static level 15' below ground; salinity less than 50 grs/gal.

584'-620' Probable good supply

625'-630' Possible good supply

690'-857' Possible good supply

Completed to produce from 8" casing slotted in the interval 555'-805'. Pumped for 200 hours at 24,000 g.p.h. with drawdown of 44' below rest level which is 14' below ground level.

862'-900' Possible small supply

DESCRIPTIVE LITHOLOGY

Depth interval

0'-65' Sand: unconsolidated, quartz, coarse grained; 0-48' yellow; 48'-65' white.

65'-485' Sandstone and minor mudstone:
Sandstone – poorly consolidated, quartz, coarse grain, white; felspar and mica common; several water bearing beds.
Mudstone – brown and black; beds up to 10; minor occurrences of lignite and coal; pyrite common.

485'-537' Mudstone: black and brown; minor white claystone; coarse grain quartz sandstone and coal.

537'-578' Mudstone: red-brown; silty and sandy (fine); minor thin beds of white claystone, black shale and coarse grain quartz sandstone.

578'-690' Sandstone, conglomerate, minor mudstone, claystone and shale:
Sandstone, conglomerate – poorly consolidated, quartz coarse grain; quartz pebbles and boulders; water bearing beds.
Mudstone, claystone, shale – minor thin beds; brown mudstone, white claystone, black shale.

690'-900' Sandstone: coarse grain, quartz, very well sorted; minor conglomerate: water bearing beds.

Production interval 227'

LITHOLOGY

Feet: 65, 485, 537, 578, 680, 900

Feet: 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900

PENETRATION RATE

Minutes per foot: 0, 10, 20

64, 31, 38, 25

CASING

13 1/4" I.D. Cemented

12" I.D. Jammed to formation

10" O.D. Cemented

Collar

200' Blank (353'-555')

8" O.D.

Top of slots

Slotted 555'-805'

Bottom of slots

52' Blank

Bridged below 857'

HOLE SIZE

15"

13 1/4" tapering to 12 1/4"

9"

BITS

Hughes 15" O.S.C. 15"

Hughes 12 1/4" plus reamer 13 1/4"

Hughes W7R 9" hard formation

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

COMPOSITE LOG

LAPORTE NO. 3 WATER BORE

AUSTRALIND

Vertical Scale: 50 Feet to an Inch

Lat. 33° 16' 10" S.
Long. 115° 44' 25" E.
Lands Dept. Litho 411A/40
Wellington Loc. 1
R.L. surface 45 feet above M.S.L.
Logged by: M. Kriewaldt

Rig: Failing 1500 Rotary
Drilled by: W.A. Mines Dept. for Laporte Titanium Ltd.
Driller: J. F. Grill
Commenced: 8th January 1962
Completed: 13th March 1962

PLATE V

LEGEND

- Mudstone
- Clayey sandstone
- Sand, sandstone
- Felspathic sandstone
- Conglomeratic sandstone
- Boulders
- Carbonaceous material
- py Pyrite
- mi Mica

Depth interval	DESCRIPTIVE LITHOLOGY	HYDROLOGY (Estimated) Aquiclude / Aquifer
0–23'	Sand: unconsolidated, white, quartz, coarse grained, with heavy minerals.	
23–125'	Interbedded sandstone and mudstone Sandstone – poorly consolidated, white, quartz, coarse grained, felspathic Mudstone – black and yellow	
125–205'	Sandstone: poorly consolidated, white, quartz, coarse grained, felspathic.	
205–229'	Conglomeratic sandstone	
229–237'	Mudstone	
237–339'	Sandstone: poorly consolidated, white, quartz, coarse grained, felspathic	46–529' Probable good supply
339–343'	Mudstone	
343–455'	Sandstone: poorly consolidated, white, quartz, coarse grained, felspathic	
455–470'	Conglomeratic sandstone	
470–529'	Sandstone: poorly consolidated, white, quartz, coarse grained, felspathic	
529–571'	Mudstone: black	
571–637'	Sandstone: clayey, fairly well consolidated, white, coarse grained, white clay matrix.	
637–647' 647–652'	Interbedded sandstone and mudstone. Mudstone.	
652–676'	Sandstone: clayey	
676–715'	Interbedded sandstone and mudstone	
715–739'	Sandstone: clayey	
739–893'	Interbedded sandstone and mudstone Sandstone – well consolidated, white, coarse grained, felspathic. Mudstone – grey, brown, and black.	739–845' Good supply.
893–920'	Sandstone: poorly consolidated, white, quartz, coarse grained, with very coarse sections.	
920–928'	Mudstone: grey	
928–1042'	Sandstone: poorly consolidated, white, quartz, coarse grained, with very coarse grained sections.	893–1042' Good supply.
1042–1055'	Mudstone: black	Producing from 8" casing slotted in intervals 740'–820' and 880'–1020'. Pumped for 72 hours at 28,000 G.P.H. with drawdown of 35' below rest level of 17' below ground level.

LITHOLOGY: Feet 23, 105, 125, 205, 229, 237, 339, 343, 455, 470, 529, 571, 637, 647, 652, 676, 715, 739, 893, 920, 928, 1042, 1055

PENETRATION RATE: Minutes per foot (0, 10, 20)

CASING: 15 7/8" I.D. Cemented; 10" I.D. Cemented; Blank from 240'–740'; 8" O.D. Slotted from 740'–820'; Blank from 820'–880'; Slotted from 880'–1020'; Blank from 1020'–1050' Cement plug from 1024'–1050'

HOLE SIZE: 18"; 15"; 9 7/8"

BITS: Hughes O.S.C. 15" plus reamer 18"; Hughes O.S.C. 15"; Security H7 9 7/8"; Security H7 9 7/8"

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

COMPOSITE LOG

LAPORTE NO.4 WATER BORE

AUSTRALIND

Vertical Scale: 50 Feet to an Inch

Lat. 33° 16′ 50″ S.
Long. 115° 43′ 20″ E.
Lands Dept. Litho 411A/40
Wellington Loc. 1
R.L. surface 30·27 feet above M.S.L.
Logged by J. R. Passmore

Rig: Failing 1500 Rotary
Drilled by: W.A. Mines Dept. for Laporte Titanium Ltd.
Driller: J. F. Grill
Commenced: 29th March 1962
Completed: 2nd July 1962

LEGEND

- Clay, mudstone
- Sandy clay
- Clayey sandstone
- Sand, sandstone
- Calcareous sandstone
- Felspathic sandstone
- Boulders
- Carbonaceous material
- PY Pyrite
- mi Mica