Natural Resources and Environment

AGRICULTURE • RESOURCES • CONSERVATION • LAND MANAGEMENT

DEPT. NAT. RES & ENV
PE906250

WELL SUMMARY
PILOT BORE (W435)
(LAKES ENTRANCE OIL SHAFT)

	2 Referred to	3 Date	4 Clearing Officer's Initials	1 Folio No.	2 Referred to	3 Date	4 Clearing Officer's Initials

PILOT BORE-1 (W435)

Well Summary Report

Table of Contents

Enclosures

PE904189

This is an enclosure indicator page.
The enclosure PE904189 is enclosed within the container PE904188 at this location in this document.

The enclosure PE904189 has the following characteristics:

ITEM_BARCODE = PE904189
CONTAINER_BARCODE = PE906250
NAME = well card
BASIN = GIPPSLAND
PERMIT =
TYPE = WELL
SUBTYPE = WELL_CARD
DESCRIPTION = well card Pilot Bore 1
REMARKS = Lakes Entrance Oil Shaft-1
DATE_CREATED = 3/06/47
DATE_RECEIVED =
W_NO = W435
WELL_NAME = Pilot Bore-1
CONTRACTOR = Governments Lakes Oil Ltd
CLIENT_OP_CO = Governments Lakes Oil Ltd

(Inserted by DNRE - Vic Govt Mines Dept)

LITHOLOGY

PIOLET BORE.

(For Lakes Entrance Oil Shaft)

1st. hole abandoned at about 350'
2nd. hole located 16' back.
Spudded. 24th. March, 1943.
8" casing cemented at 319'
6" " " " 974'
5" " " " 1196'6"

Notes on Lithologeires taken from H. Cook's Report.

470'	- 480'	More polyzoal in the marl
480'	- 505'	Polyzoal limestone
505'	- 510'	Passed out of polyzoal limestone and into marl
	515'	Very sticky formation
591'	- 592'3"	Hard limey band
592'3"	- 595'	White marl (not polyzoal)
595'	- 598'6"	Green sticky marl
598'6"	- 605'	Whiter with much grit, probably polyzoal limestone
605'	- 635'	Bright green clay or very clayey marl
	690'	Compact sticky marl
	755'	Sticky marl
	778'	" "
	828'	Close grained marl
	880'	Dry marl
	954'	Brown micaceous clay - first appearance
	960'	" " " - quite definite
	1001'	Micaceous clay
	1138'	Micaceous series with plentiful iron pyrites in nodules ranging from minute particles to pieces as big as hen's egg.
1180'	- 1184'	Mud coming into hole.
	1186'	Miss I. Crespin found signs of glauconite sandstone
	1187'6"	Well marked signs of glauconitic sandstone
1192'	- 1193'3"	Micaceous mud
1193'3"	- 1194'3"	Consolidated mud and sand
1194'3"	- 1196'	Much glauconitic sand and some consolidated to definite glauconitic sandstone.
1204'5"	- 1206'5"	Core showed 2 sand layers between fragmented brittle glauconite.

W 435.

PILOT BORE.

Drilled to investigate formations aheadof the sinking of the Lakes Entrance Oil Shaft.

Spudded by Government	March, 1943.
Suspended by Government	January, 1945.
Re-spudded by Lakes Oil Ltd.	15th May, 1946. at 1233'6"
Abandoned " " " "	3rd June, 1947.

Lakes Oil Ltd. reported to Department of Mines:-

Cored Internal	Lithology
1223'6" - 1224'6"	
1224'6" - 1225'6"	- Glauconite
1225'6" - 1226'6"	
1226'6" - 1227'	
1227' - 1227'6"	
1227'6" - 1228'	- Sandy green glauconite
1228' - 1230'	
at 1230'	In green marl, just firm enoughto hold together, with fine sand.
at 1237'6"	Reasonably hard and dry marl
at 1240'6"	Last 4 feet in fine brown sandstone with mica, fairly soft and dry.
1240'6" - 1246'6"	As for 1240'6"
1246'6" - 1276'	Last 4'6" consisting of granitic material and fine sand
1276' - 1277'6"	Coarse granite wash, 2 pieces of granite recovered
1277'6" - 1293'6"	Green marl and granitic material
1322'6" (T.D.)	Granite below a hard band.

HYDROCARBON ANALYSIS

PILOT BORE

Oil and Gas shows recorded by H. Cook.

	560' - 590'	Small make of H_2S gas which all dissolves in water which makes from 550'-570'.
	682'	Signs of gas, very strong at 688' i.e. when the bailer is brought to the surface the gas bubbles out of the water very freely and burns with a non-luminous flame. (Gas mentioned sporadically in reports on to 909')
	909'	Gas is very plentiful and now bubbles up against the water. This gas sampled by Mr. Hadden during week ending 5th. November, 1943.
	974'	No gas after cementing casing.
	1043'	Definite though not heavy showing of gas
	1138'	Gas evident but not in very marked quantity
	1158' - 1166'	Gas more active
	1187'6"	Faint showings of oil
Core	1192' - 1196'6"	Definite signs of oil
	1196' - 1219'	Hole cored, bailed and rise tests conducted gave maximum of 49•6 pints per day of dry oil.

Oil as bailed was oil/water mixture
38•5% oil 61•5% water.

STATE LABORATORIES.
Gisborne Street,
Melbourne C.2.

24th November, 44.

REPORT ON SAMPLES Nos.M.703-708/1944.

Samples ... Emulsified Oils.
Locality ... Pilot Bore - Lakes Entrance.
Sender ... H.J.Cook,
Supervisor,
Lakes Entrance Oil Project.

DESCRIPTION.

No.703	Emulsified Oil	- taken	23/10/44
704	" "	- "	24/10/44
705	" "	- "	26/10/44
706	" "	- "	31/10/44
707	" "	- "	7/11/44
708	Separated Oil	-	-

RESULTS.

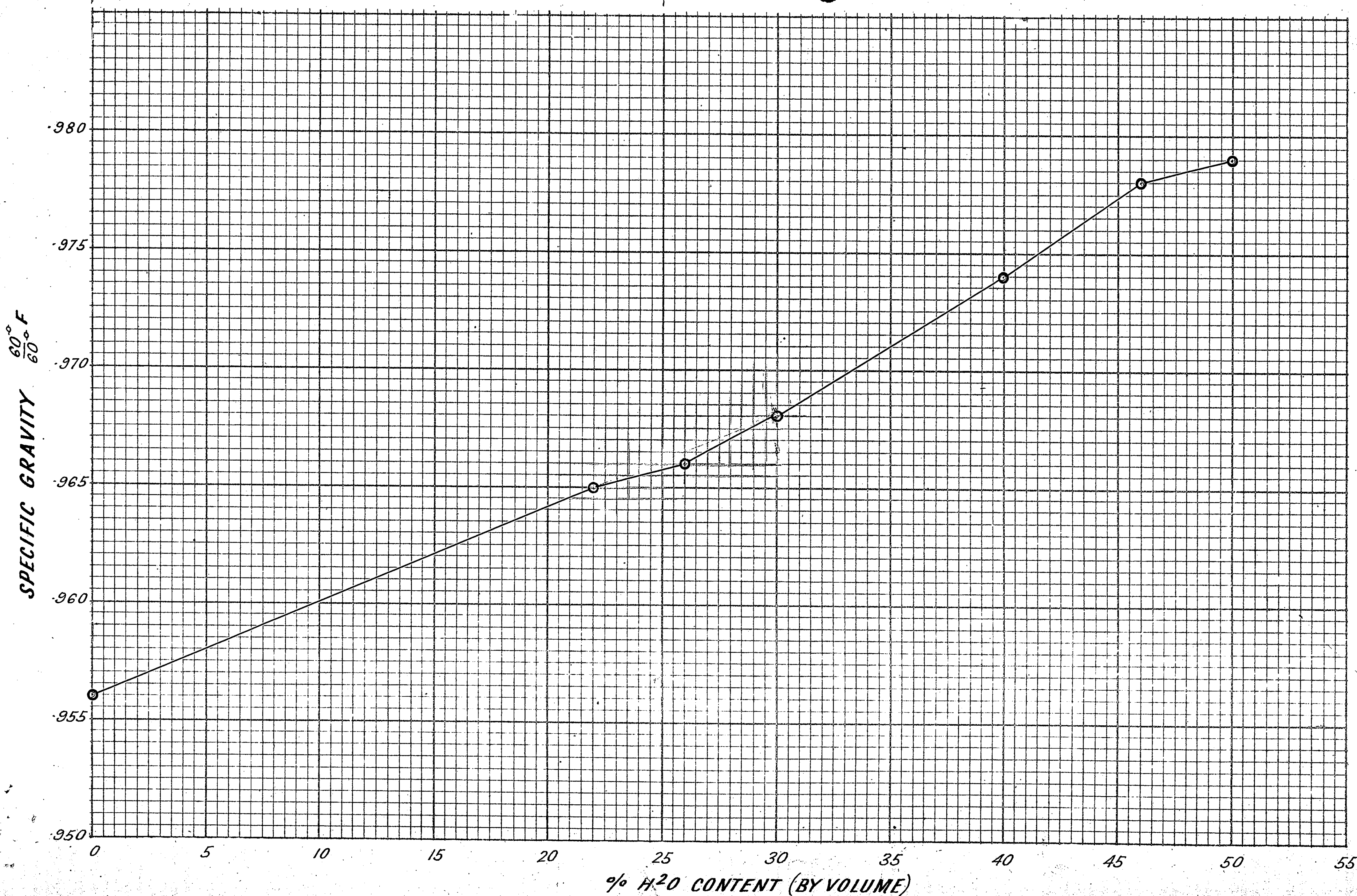
No.	H_2O content.	Specific Gravity $\frac{60^\circ}{60^\circ F.}$
703	50 %	.979
704	46 %	.978
705	26 %	.965
706	40 %	.974
707	30 %	.968
708	nil	.956

COMMENT.

The graph attached where the above figures are plotted shows that the specific gravity of the emulsion will give a good approximation of the H_2O content.

L. L. Field
CHEMIST & ASSAYER, MINES SECTION.

OIL EMULSIONS, LAKES ENTRANCE. PILOT BORE



CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

27th December, 19 44.

REPORT ON SAMPLE No.M.750/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance,
Sender	...	H.J.Cook, Lakes Entrance Oil Project.

Samples taken - 18/12/44.

RESULT.

Water content .... - 18.0 % (volume)

Specific Gravity 60°/60°F. = .963.

[signature]

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines,
Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

9th January, 1945.

REPORT ON SAMPLE No.M.1/1945.

Sample	..1	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Lakes Entrance Oil Project.

Sample taken - 21/12/44.

RESULT.

Water content	=	12.0 % (volume)
Specific Gravity 60°/60°F.	=	0.962

[signature]

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

20th December, 1944.

REPORT ON SAMPLE No.M.749/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Supervisor, Lakes Entrance Oil Project.

Sample taken - 13/12/1944.

RESULT.

Water Content = 10.0 % (volume)

Specific Gravity $60^{o}/60^{o}$F. = .960

[signature]
CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone : F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

11th December, 1944.

REPORT ON SAMPLE No.M.726/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance,
Sender	...	H.J.Cook, Supervisor, Lakes Entrance Oil Project.

Sample taken		...	5/12/44.
Depth	...	...	1219' 9".

RESULT.

Water content	=	32.0 % (volume)
Specific Gravity $\frac{60^\circ}{60^\circ F.}$	=	.968

[signature]

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

6th December, 1944.

REPORT ON SAMPLE No.M.720/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Supervisor, Lakes Entrance Oil Project.

RESULT.

Sample taken - 28/11/44.

Water content (by volume)	=	17.0 %
Specific Gravity $\frac{60^{\circ}}{60^{\circ}F.}$	=	.961

[signature]

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines,
Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

30th November, 1944.

REPORT ON SAMPLE No. M.716/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J. Cook, Supervisor, Lakes Entrance Oil Project.

RESULT.

Sample taken 23/11/44.

Water content (volume) = 18.0 %

Specific Gravity $\frac{60^{\circ}}{60^{\circ}F.}$ = 0.963.

[signature]

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

6th November, 1944.

REPORT ON SAMPLES Nos.M.682-684/1944.

Sample ... Emulsified Oil.

Locality ... Pilot Bore - Lakes Entrance.

Sender ... H.J.Cook,
Supervisor Oil Project,
Lakes Entrance.

The samples represent bailings from the pilot bore.

RESULTS.

	No.682	No.683	No.684
Date taken	23/10/44.	24/10/44.	26/10/44.
Water content (by volume)	50%	46%	26%

[signature]
CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines,
Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

4th November, 1944.

REPORT ON SAMPLE No.M.686/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Supervisor Oil Project, LAKES ENTRANCE.

RESULT.

Date taken	...	31/10/44.
Water content (by volume)	...	40 %.

[signature]
CHEMIST & ASSAYER, MINES SECTION.

Lakes

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

20th October, 1944.

REPORT ON SAMPLE No.M.637/1944.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Lakes Entrance.

The sample consisted of 3 ozs. of emulsified oil from Pilot Bore.

RESULTS.

Total water content = 61.5 % (by volume).

The separated water contained 70 grains solids per gallon.

61.5%

F. F. Field

CHEMIST & ASSAYER, MINES SECTION.

LAKES OIL ANALYSIS

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines,
Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

3rd June, 1944

Memorandum for :-

The Secretary for Mines.

re Lakes Entrance Oil Bore.

I have had a further talk with Mr. Cook on this matter, and I am of the opinion that the testing of the bore core for oil saturation at the bore hole would be impracticable. We have made a suggestion that I supervise the sampling and sealing of the core at the site and the necessary chemical tests be made at this laboratory - the core would then be forwarded to Canberra for further testing.

The suggestions are being sent by Mr. Cook for the approval of Dr. Raggett.

J. L. Field.

Chemist & Assayer, Mines Section.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,
GISBORNE STREET,
MELBOURNE, C.2.

6th February, 1945.

REPORT ON SAMPLE No.M.43/1945.

Sample	...	Emulsified Oil.
Locality	...	Pilot Bore, Lakes Entrance.
Sender	...	H.J.Cook, Supervisor, Lakes Entrance Oil Project.

Sample taken - 30/1/45.

Water content	=	8% (volume)
Specific Gravity $60^{o}/60^{o}$F.	=	.957

CHEMIST & ASSAYER, MINES SECTION.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

25th January, 1945

Report on Sample No. M. 39/ 1945.

Sample -- Emulsified Oil.

Locality -- Pilot Bore, Lakes Entrance.

Sender -- H.J. Cook, Supervisor,
Lakes Entrance Oil Project.

Sample collected 19/1/45.

Water content = 15% (by volume)

Specific Gravity $60^{\circ}/60^{\circ}$F. = .962

[signature]

Chemist & Assayer, Mines Section.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines, Victoria.

Phone: F 0234.

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2.

23rd January, 1945

Report on Sample No. M. 28/ 1945.

Sample - Emulsified Oil.

Locality - Pilot Bore, Lakes Entrance.

Sender - H.J. Cook,
Supervisor,
Lakes Entrance Oil Project.

Sample taken 12/1/45.

Water content = 18.0% (by volume)

Specific Gravity $\frac{60^\circ}{60^\circ}$F = .964

Chemist & Assayer, Mines Section.

CHEMICAL LABORATORIES—
Departments of Agriculture, Health, and Mines,
Victoria.

Phone: Cent. 6360.
F2131.

For Lakes Entrance
[handwritten initials]

State Laboratories,

GISBORNE STREET,
MELBOURNE, C.2,

21st September, 1944.

REPORT ON SAMPLES Nos.M.547-548/1944.

Samples ... No.547 - Crude Oil.
548 - Water.

Locality ... Lakes Entrance.

Sender ... Secretary for Mines,
Melbourne.

The samples were collected on 13/9/44 during an official visit to Lakes Entrance.

PARTICULARS.

near Shaft

No.547. Crude oil from Pilot Bore.

Obtained from bailings after separation from water by standing.

No.548. Water - Pilot Bore.

Settlings from crude oil after bailing.

RESULTS.

No.547 - Water content of crude oil = 30.0 %

No.548 - Oil in water settlings = 0.08 %

Emulsion
1/3 water

F. F. Field
CHEMIST & ASSAYER, MINES SECTION.

Copies sent to Mr A C Smith
Malcolm Newman
Mr Cook

STATE LABORATORIES,
Gisborne Street
Melbourne C.2

24th November, 44.

REPORT ON SAMPLE No.M.712/1944.

Sample ... Emulsified Oil.

Locality ... Pilot Bore, Lakes Entrance.

Sender ... H.J.Cook,
Supervisor,
Lakes Entrance Oil Project.

RESULT.

Date taken - 18/11/44.

Water content (by volume) = 22.0 %

Specific Gravity $\frac{60^\circ}{60^\circ F.}$ = .965

[signature]

CHEMIST & ASSAYER, MINES SECTION.

Lakes

COPY

Lakes Entrance Oil Project,
P.O. Box 38,
Lakes Entrance,
17th October, 1944.

F. F. Field, Esq.,
Mines Laboratories,
MELBOURNE, C.2.

Dear Sir,

This is to confirm yesterday's telephonic conversation with yourself. By post yesterday we sent you a sample of Oil as produced from our Pilot Bore hole, and will be pleased to have a determination of its water content.

I understand that a centrifuge method is being used for this estimation. In order that there may be no possible misunderstandings, I think it would be wise to make an estimate by some other method of the water in the centrifuged oil sample. If this should have to be appreciable, we can in future use the figure obtained as a correction.

By Goods train this week I am sending you two samples of water; one of these samples is of water produced with the oil from the bore hole, and the other is water from the shaft. This water is collected leakage water from various horizons, and is used as boiler water, for bath-houses, and general purposes.

Any comments you may care to make about these samples will be appreciated.

Yours faithfully,
(Signed) H. J. COOK,
Supervisor.

State Laboratory,
Melbourne, C.2.,
19th October, 1944.

H. J. Cook, Esq.,
Box 38,
LAKES ENTRANCE.

Dear Mr. Cook,

Your note to hand to-day. Confirming the telegram, the results are as follows:-

Total water content = 61.5% (by volume)
The separated water contained 70 grains solids per gallon.

As regards the emulsified oil, the method we adopt is as follows:-

To a measured quantity of sample a light spirit such as petrol is added in proportions of 1-1. The mixture is then centrifuged for a period of ½ hr. when the water separates out clearly and can be measured accurately. No water was found in the separated oil layer.

I would recommend that when submitting samples, a larger amount of emulsion be forwarded, as I regard the taking of a representative sample as one of your difficulties. If you wished, I could give you a simple method which could be performed on the spot and would give you an indication of the water content. These figures could be checked up periodically by samples sent here.

Kind regards,

Yours faithfully,

(Signed) F. F. FIELD,

CHEMIST & ASSAYER, MINES SECTION.

OIL PRODUCTION TESTS

AND RESERVOIR CHARACTERISTICS

Box 38, P.O.,
Lakes Entrance.

17th November, 1944.

The Controller of Minerals Production,
Department of Supply and Shipping,
<u>MELBOURNE</u>.

Dear Sir,

I recently commented on a copy of a Washington letter W.A.M.21322 enclosing an article printed in the "Oil City Derrick" of 9th September, 1944.

The article in question had been made available to us by courtesy of Mr. Ranney as an answer to our request for information on the progress of the Venango Ranneywell installation. It was greatly appreciated as a general outline of progress but, as we know so little of the type of oil field on which Mr. Ranney is working at Venango, we are finding some difficulty in applying his results to our own project.

It might be possible for Mr. Ranney to answer some, at least, of the following questions. The answers would, of course, be treated as strictly confidential:-

(i) What was the average daily yield per vertical well under production on the field (Venango) at the time it was decided to install the Ranney system?

(ii) What production was obtained per foot of hole from Ranneywells before shooting. Is there a "decline of production" curve available for such wells?

(iii) What is the effect of shooting a well? Is there a decline curve available for a shot well?

(iv) What is the effect of applying vacuum?

(v) Other points of interest include a description of the oil sand, top and bottom water, a cross section of the oil sand showing the oil saturation foot by foot.

(vi) Information relative to the gravity and type of oil produced, the ratio between oil and water produced and emulsification troubles, if any.

A letter, dated 7th October, was recently addressed by Mr. Ranney to Mr. A. V. Smith, a copy of this was marked for me and what now follows is an answer to that portion which concerns the Lakes Entrance project. The various points are discussed in the order they appear in Mr. Ranney's letter.

<u>Pilot Bore Hole Coring & Production Tests</u>.

The latest information under this heading will already have reached Mr. Ranney in the weekly reports from Lakes Entrance. Mr. Taggett is supervising the coring and has taken steps to see that the cores yield the fullest possible information. We have no intention of drilling the Pilot Bore Hole clear through to the artesian water. Coring will stop at 22' to 24'.

I can answer some of Mr. Ranney's queries as regards the <u>mud seams</u>. Mr. Taggett will doubtless cover this point fully in his report. Firstly, the mud seams are not greatly in evidence. There is absolutely no difficulty in cleaning the hole after taking a core. It is safe to say that mud does not run into the hole and consequently squeezing of the mud lenses is most improbable. I think that Mr. Ranney's surmise that the mud is really a shale is probably correct.

To date the Pilot Hole has not been allowed to stand more than 48 hours. The actual hole in the oil sand is about 4½" in diameter so that from the bailing figures Mr. Kenney can calculate the daily rise and pressure. Gas is practically absent. There is no flow of gas out of the hole and the oil itself when bailed makes a close film of bubbles which disappear after a few hours.

As regards the oil water ratio the later weekly letters will make it clear that the water produced is not increasing, in fact, it is tending to decrease. As suggested, it may be passing round the seal, or it may be coming from the top of the glauconite. As the quantity of water is nearly constant and the oil is increasing with further coring, the oil-water ratio is improving. Emulsification varies from day to day and varies between the limits of oil carrying 61.5% water to oil carrying 29%. On occasions all the water has been emulsified with the oil, but in most cases the daily yield consists of emulsified oil and free water.

Log of Pilot Hole above 1122'. The micaceous series, 230 ft. thick, lie above the glauconite. This material is variously described as a "clay" or a "mudstone". Occasionally it carries extremely fine sand in which case it is unstable and caves badly. We know of no water in this section of the bore hole. Proper water tests could not be made as removal of all water from the hole caused the casing to distort and the bailer would not pass. Refilling the hole with water straightened the casing again. I think it may be stated confidently that the micaceous is dry. The last two feet above the glauconite is a plastic mud of the same consistency as glaziers' putty. We expect much of the 230 ft. of micaceous to be similar.

As regards hard bands above the glauconite, these were absent in our pilot hole though they were present in all other holes on the field. The number of hard bands intersected varied from 6 to 11 in the various bores. As a consequence of our finding no hard bands there is a growing inclination to believe that the hard bands are in fact flat floaters in the micaceous series. As the shaft penetrates below 960 ft., where the micaceous begins, direct evidence on this point will be obtained. As Mr. Kenney observes it would be most comforting to have a thick hard band between us and the artesian water.

Blue Prints of Shaft, should have reached Mr. Kenney by this time. In any case it is sufficient to say that the shaft is of concrete 10' diameter in the clear. It is reinforced vertically and horizontally and at the bottom will have 24" walls. Pipes are not now embedded in the shaft walls, but are hung on the steel work. In addition there is a 27" diameter steel exhaust duct for ventilation.

The heaving ground encountered has been overcome so far without great trouble. It is fortunate that side pressure has not been very troublesome. It is probable that, unlike the bottom and top pressure which develops quickly, side pressure takes a much longer time to develop. That it does develop is a practical certainty.

Pre-grouting in soft ground: We attempted this in the polyzoal limestone in the heavy water zone about 300 ft. but were not successful. There were two difficulties. The first trouble was to set pipes in the soft rock in which the injection holes were drilled. The whole rock was porous and forced the cement away from the piped collars of the holes. This difficulty was eventually overcome, but the cement would not penetrate any distance into the soft country which acted as a filter and pressures soon rose to prohibitive figures.

Grouting with chemical solution was no more successful as the whole bottom of the shaft was lifted out when pressures reached about 300 lbs. per square inch.

This water was eventually sealed off very satisfactorily by back grouting through the shaft walls. With the water met at 600 ft. the method was not so successful and, as pressures built up, there was, and still is, leakage through the walls. This water has been picked up with garlands and there is no pump in the bottom. Our major problem at Lakes Entrance is the pressure of the artesian water below the glauconite. From what we know of this material, i.e. the 30 ft. glauconite oil sand, we cannot trust it alone to withstand this pressure. As a consequence we have suggested that it might be necessary to stop 100 ft. above it. If the artesian water should break through we fear the project might have to be abandoned because the shaft would fill not only with water in unlimited quantities, but also with fine sand.

Mr. Ranney now suggests that there is a well tried method of grouting cement into soft muddy material and thereby transforming it into a material of some real mechanical strength.

This method is new to us and further than that I have been unable to get particulars regarding it.

On 15th instant a cable was sent through the Washington Legation to Mr. Ranney reading as follows:-

"Your 1064 2nd November, Lakes Entrance. Please inform Ranney weekly reports have been forwarded and are being despatched at weekly intervals. Pilot Bore will not be drilled through glauconite. Shaft grouting is not at present necessary. Would appreciate particulars and literature showing method and apparatus required to carry out soft ground pre-grouting operation outlined Ranney's letter 7th October. No decision re ultimate depth of shaft is yet possible. Shall keep you advised."

Whilst on this subject of the artesian water pressure there is an aspect of it which I feel has not been fully appreciated. In the past it has been customary to visualise the layer of glauconitic sandstone lying as an impermeable barrier between the artesian water and the country above. Conditions in the Imray borehole throw some light on the subject. This borehole was not drilled completely through the glauconite but only about 2/3rds. of the way through yet at the present time the hole has a column of liquid in it approximately 1300' high. The casing of the bore hole is definitely sealed into the glauconite so that it is quite clear that the pressure equivalent to a head of 1300' does exist in the glauconite itself. This statement is definitely true under static conditions so that all that porous portion of this layer which is filled with gas oil or water is subject to a pressure acting in all directions and equal to a pressure head of 1300'.

If our shaft opening were carried down to approach the glauconite surface it appears that the glauconite itself would rupture one layer after another commencing at the surface.

If we can apply Mr. Ranney's pre-grouting method it would be possible to make a solid block of country say 30' to 40' thick above the glauconite and proceed with the work in safety.

As regards <u>tunnels and drill stations</u>, these do not present so serious a problem as the shaft because the openings required will be less vulnerable to pressure than the wide shaft excavation. The behavior of the plat at 900' will give some pointers on this problem. This plat is supported by heavy timbering but is not close-logged the idea being to allow the ground pressure to relieve itself by escape through the timber. This would mean frequent cleaning up of extruded material but might be preferable to other ills.

Now that Mr. Romney has had further weekly reports he will not be so disturbed about the oil water ratio. Samples of oil will be drawn from the surface of Imray well and also from greater depths to test the degree of emulsification and oil water ratio. We have no proposals at present for using the old vertical wells.

In conclusion, I would emphasize that information relative to soft ground pre-grouting is urgently required to enable the shaft to be satisfactorily bottomed.

Yours faithfully,

(H. J. Cook)

COMMONWEALTH OF AUSTRALIA.

Department of Supply and Shipping
Mineral Resources Survey,
Census Building,
City, Canberra.

104.5236

19th January, 1945.

Mr. A. C. Smith,
Executive Officer, Minerals,
Department of Supply & Shipping,
409 Collins Street,
MELBOURNE. C.1. VICTORIA.

I refer to your memorandum M6/3 of 17th January.

I think it is a bit premature to discuss the evidence available from the pilot bore at Lakes Entrance and am only offering this comment because you have requested me to do so. I would much prefer to talk than to write about these things as verbal discussion brings out points which may be missed in writing, and the written word can be misunderstood.

Mr. Cook's conclusion that the evidence of the pilot bore indicates that the amount of oil present in the glauconitic sandstone is 1/10th of that estimated by Ranney is not soundly based. There are four factors which have to be multiplied together to make an estimate of the probable oil recovery., These are thickness, porosity, saturation and recovery. Mr. Cook deals with only one of these factors 'thickness' and takes no cognisance of the other three. It will be clear that if one or more of the other three factors is higher than Ranney assumed, this will tend to offset any error in the figure taken for thickness. For instance if the saturation and recovery factors only were each three times that assumed by Ranney -- and this is not impossible -- the error due to a wrong assumption as to thickness of oil sand would be nearly offset. (3 x 3 = 9).

In this connection it should be remembered that these factors are not yet known for the actual oil zones as Thyer did not find any oil in the cores he examined.

(Incidentally it is considered that the total thickness of the oil mud veins is considerably more than 6". In saying this we do not confine the term 'oil mud vein' rigidly but interpret it to mean oil saturated layers.)

Personally I have never set much store on a calculation of the oil content of the reservoir based on assumptions similar to those made by Ranney. As Mr. Cook points out it is very doubtful whether Mr. Ranney himself placed much reliance on an estimate of this kind.

The statement by Ranney and Fairbank which is quoted hereunder is the one I think of which most notice should be taken.

> " It has been our experience that where vertical wells are capable of producing in excess of five gallons of oil a day from a sand of this thickness (30 feet), the field is susceptible to development by secondary methods. It has also been our experience that when a column of oil will rise more than 500 feet in a standing well in a sand of this thickness the field may be profitably developed by secondary methods of recovery."

The pilot bore has demonstrated that a yield of oil approaching five gallons is being obtained from a thickness of strata of somewhere about 3 feet. It would seem fair to assume that if Ranney and Fairbank had found that a field which produced upwards of five gallons

Mr. A. C. Smith. 19th January, 1945.

of oil from a thickness of 30 feet was susceptible to development by secondary methods, that it would be profitable to develop a sand with about the same yield from a considerably reduced thickness.

A great deal of thought is being given in this Branch to interpretation of the evidence available from Lakes Entrance. A start has been made with our analysis of the cores from the pilot bore and this work will be kept going without interruption. When these results are available we will present a report which it is suggested will provide a good basis for discussion.

(SGD.) H. G. RAGGATT

Director.

W 435 ?

DEPARTMENT OF SUPPLY AND SHIPPING.

BUREAU OF MINERAL RESOURCES.

Report No. 1945/34- Plans Nos. 1234 to 1236 inclusive.

THE DETERMINATION OF RESERVOIR PRESSURE FROM LIQUID LEVEL DATA, IMRAY AND PILOT BORES - LAKES ENTRANCE.

The pressure of the liquid, or reservoir pressure, within the glauconitic sandstone at Lakes Entrance has been the subject of conjecture in recent years and the low yields of oil which typify the field have been attributed by some observers to low reservoir pressure. Reservoir pressure, however, is only one of a number of factors upon which the rate of yield depends. Other factors of equal importance are the permeability of the producing formations and viscosity of the fluids produced.

However, it was not until the Imray bore had been drilled by Austral Oil Ltd. that any satisfactory evidence was obtained which permitted a true estimate of reservoir pressure being made. In this bore, glauconitic sandstone was entered at 1253 feet from the surface and drilling was stopped after 21 feet of glauconitic sandstone had been penetrated. It is probable that 10 to 20 feet of sandstone separates the bottom of the bore from the artesian water horizon. The sandstone provides an effective barrier to the ingress of water from the latter horizon. The bore is cased from the surface to the top of the glauconitic sandstone where it is seated in cement, and all aquifers above the sandstone are sealed off.

Bailing tests showed that the 23 feet of glauconitic sandstone exposed yielded a daily average of approximately 31 pints of oil and 9 pints of water. Later, the liquid yielded was allowed to accumulate in the bore casing and at intervals over a period of some 24 months, the liquid level was recorded. The curve in Fig. 1 shows the liquid level (H) plotted against time in months. The values used have been taken from a similar curve published in The Petroleum Times (1).

It will be observed that the rate of rise, for instance the rise per month, decreased as time went by - this decrease becoming more apparent towards the end of the test period. It is evident that the curve is tending asymptotically towards a value of H of the order 1200 to 1400 feet, at which value the back pressure provided by the liquid column would be sufficient to prevent the flow of liquid from the reservoir. In other words, the back pressure would be equal to the reservoir pressure.

A particular method of plotting enables a reasonably accurate estimation of reservoir pressure to be made from such a curve as Fig. 1 without the necessity of waiting until the liquid level reaches its final value. As this method will be applied to data from the Pilot bore as well as Imray, its description will be delayed until the Pilot bore and the data obtained in tests conducted on it are described.

The Pilot bore is the most recent in the Lakes Entrance district and was under close observation from its inception. It was drilled primarily to obtain information of the yield from water-bearing formations which the nearby shaft would penetrate, but, as has been described elsewhere (2), it provided valuable information about the oil and water yields from the glauconitic sandstone.

The bore is cased with five inch casing from the surface to the top of the glauconitic sandstone at 1196 feet, into which it is firmly cemented. Before proceeding with the drilling of the glauconitic sandstone, bailing tests proved that the cement provided a tight seal and no water entered the casing from formations above the glauconitic sandstone. This was of utmost importance to the subsequent bailing tests as it could be assumed that any fluid entering the bore after sections of the glauconitic sandstone had been drilled came from the glauconitic sandstone exposed.

The glauconitic sandstone was drilled in steps of approximately two feet and bailing tests were made after each successive two foot section was drilled. Drilling was suspended when 22 feet 10 inches of glauconitic sandstone had been penetrated. After the necessary bailing tests had been completed, the liquid yielded by the section of glauconitic sandstone was allowed to accumulate in the bore and daily records were kept of the height of the liquid column as it rose in the casing.

The height was found by lowering the bailer into the bore to a predetermined depth - withdrawing it and noting the position of the liquid coating on the bailer. With experience it was possible to determine in advance the depth to which the bailer should be lowered so that it penetrated this liquid by a matter of only two or three inches. A correction was applied to the liquid height to allow for the liquid displaced by the bailer. The test was conducted over a period of 65 days the final height of the liquid column being 513 feet 10 inches.

The liquid heights are shown in Fig. 2 plotted against the time in days. Because of the shorter time used in this test, the falling off in the rate of rise with time is not so marked in this curve as it is in the corresponding curve (Fig. 1) for the Imray test, but a comparison with the straight line drawn through the origin and tangential to the curve at the origin demonstrates the decline in the rate of rise with time.

<u>Determination of Reservoir Pressure from Liquid Level Data.</u>

Time and the liquid level are related to one another by the following relationship:- (3)

$$\frac{ygct}{a} = - \log_e \frac{He - H}{He - Hi} \qquad ---- \quad (1)$$

where y = density of liquid column.
g = gravitational constant.
c = productivity index which is a constant for the bore.
t = time
a = area of cross section of bore casing.
He = liquid height corresponding to reservoir pressure.
H = liquid height at time t.
Hi = liquid height at time zero.

Equation (1) may be expressed as:-

$$t = K \log_{10} (He - H) \qquad ---- \quad (2)$$

i.e. if values of t are plotted against corresponding values of $\log_{10}$ (He-H), the curve will be a straight line with a slope θ where $\tan \theta = K$.

In the examples under consideration, the value of He is unknown, but equation (2) provides a means of determining it. This can be done by a method of trial and error. Various values of He are assumed and curves derived from equation (2) are plotted. The correct value of He will give a straight line, whereas the curves for other values of He will depart from the straight line. In the case of the Imray bore, a set of such curves is shown in Fig. 3. Values of He range from 1200 feet to 1400 feet. It will be observed that the curve for He = 1250 feet is the closest to a straight line of those shown. A closer approximation could be found by choosing intermediate values of He, but as will be shown presently in connection with the results from the Pilot bore, the value of He which gives the closest approximation to a straight line can be found by another method.

The set of curves for the Pilot bore, corresponding to those in Fig. 3 for Imray, are shown in Fig. 5. Selected values of He range from 800 feet to 2000 feet.

A departure from a straight line is clearly evident in the curves for He = 800 and 1000 feet and is present, but not very obvious in some of the other curves.

The choice of the most probable value of He, i.e. the value that gives the closest approximation to a straight line, is not at all evident from these curves, but a value has been arrived at in another way, which has also been applied to the Imray results.

A set of values typical of those used in plotting the curves in Fig. 3 and 5 are tabulated below:-

Imray Bore.

Time (months)	H feet	He = 1200 feet. He - H	He = 1200 feet. $\log_{10}$(He - H)	d. log (He - H)	Departure from mean
0	240	960	2.9823		
				.2713	.0961
5	686	514	2.7110		
				.3045	.0629
10	945	255	2.4065		
				.3273	.0401
15	1080	120	2.0792		
				.4994	.1320
20	1162	38	1.5798		
				.3674 (Mean value)	.3311 (Total)

The ratio of total departure to mean d.log (He-H) = $\frac{.3311}{.3674}$ = .90 and will be called the departure function.

Departure functions have been determined for each value of He for both the Imray and Pilot bores, and they are tabulated below.

Imray Bore.

He (ft.)	Dept.function
1200	.90
1250	.175
1300	.20
1400	.70

Pilot Bore.

He (ft.)	Dept.function
800	.81
1000	.35
1200	.136
1400	.106
1600	.138
1800	.175
2000	.244

When the departure function is a minimum the curve of equation (2) will more nearly approximate a straight line than for any other value of He.

The departure functions are plotted against the appropriate values of He. In the case of the Imray bore, this curve is shown in Fig. 4. It has a minimum value at approximately He = 1270 feet.

The corresponding curve for the Pilot bore is shown in Fig. 6. It has a very broad minimum as one would expect from the nature of the curves in Fig. 5. It extends from approximately 1280 feet to 1380 feet with a mean of 1330 feet.

The values of He obtained for the Imray and Pilot bores are 1270 feet and 1330 feet respectively. The average density of the fluid in the Imray bore was 0.99 and in the Pilot bore 0.97. The pressures corresponding to these values of He are respectively 550 lb/sq. inch and 560 lb/sq. inch. These pressures are very close to the estimated artesian water pressure of 600 lb/sq. inch and it is reasonable to assume that reservoir pressure is identical with artesian water pressure.

This seems a rational result in view of the fact that none of the bore logs examined or bore cores tested for permeability suggests the presence of an impermeable layer between the artesian water horizon and the glauconitic sandstone such as would of necessity be present if reservoir and artesian waters pressure were substantially different.

In many of the bore logs the cores when brought to the surface have been described as being "dry". There is an inference in such a description that the pore spaces in the cores are incompletely saturated with liquid. If this is so, then the pores must contain gas at a pressure equal to reservoir pressure and one would expect, as a consequence of its very low viscosity relative to water and oil, a gas yield of a magnitude which would be immediately apparent. The amount of gas escaping from Imray and the Pilot bore is, however, of a negligible quantity.

It is the writer's belief that the pore spaces in the glauconitic sandstone are completely filled with liquid, this liquid being in contact through the pores of the rock with the water in the artesian horizon and in consequence, the liquid in the glauconitic sandstone (the reservoir) has a pressure comparable with that of the artesian water.

If, as is implied above, the glauconitic sandstone is completely saturated with liquid and the reservoir pressure is of the order of 600 lb. per sq. inch, it may seem surprising that so little liquid is yielded by the glauconitic sandstone. The writer believes, however, that the known physical properties of the glauconitic sandstone provide an explanation.

The rate at which a bore hole will produce liquid depends upon the reservoir pressure and the permeability of the producing formation, other factors being constant for any given bore hole. If a reservoir pressure of approximately 600 lb. per sq. inch exists, then the low yield rate is apparently due to extremely low permeability.

Tests of permeability on samples of glauconitic sandstone from 1255 feet to 1291 feet in the No. 10 bore (4) gave an average value of approximately 2.2 millidarcies for dry samples. This section of No. 10 bore corresponds to the glauconitic sandstone exposed in the Imray and Pilot bores. This figure, however, of 2.2 millidarcies would be considerably decreased by the presence of water as was shown in a number of tests conducted for the purpose of ascertaining the magnitude of this effect. It was shown (5) that in certain types of glauconitic sandstone, the effect was more marked than in others. For instance, samples from 1277 - 1278 feet showed an average decrease of 2.4 per cent. in permeability for 1 per cent. water saturation, while samples from 1291 - 1300 feet showed an average of only 0.73 per cent. decrease per 1 per cent. water saturation.

It is believed that in the latter case the decrease may be due entirely to the reduction in the cross-section of the interstices between the grains due to water adhering to the grains. In the former case, however, the effect appears to be too great to be explained in this fashion and an alternative explanation is offered, namely, that some of the material comprising the sandstone takes up water and swells, and that this swelling is partly responsible for the decrease in permeability.

Garrison (1939) in an article on the surface chemistry of clays and shales describes the swelling which can occur when certain minerals take up 'planar water' by the agency of weak electrostatic forces on the tops and bottoms of flat plates of micaceous minerals. Bentonite exhibits an extreme case of this swelling. The swelling of deep shales from which the planar water has been pressed out by the pressure of overburden is attributed to the re-entry of planar water. If favourable minerals are present in the glauconitic sandstone the abnormal reduction in permeability may be due to such minerals taking up 'planer water' and swelling.

Sandstone of the kind represented by the samples from 1277' - 1278' would tend to have very low permeability at moderately high water saturations. It is believed that the sandstone exposed in Imray and the Pilot bores is of this kind. The latter kind are typical of the section 1294 - 1300 feet in No. 10 bore. Sandstone of this latter kind could be expected to have appreciable permeability at high water saturations and thus yield appreciable quantities of water as was found to be the case when they were penetrated in the No. 10 bore.

ACKNOWLEDGMENTS.

The writer wishes to acknowledge the work of Mr. L.C. Noakes in co-ordinating and plotting the data from the Pilot bore. It is desired also to acknowledge the interest and co-operation of Mr.H.J. Cook, Supervisor of the Lakes Entrance project, and particularly to commend the care with which the liquid level measurements were carried out by the driller Mr. Ted Smith.

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(1) The Petroleum Times, Page 502. Sept., 18th, 1943.

(2) L.C. Noakes, Preliminary Report on the Examination of Cores from the Pilot Bore - Lakes Entrance, Vic., Comm. Min. Res. Surv. Report No. 1945/24.

(3) Morris Muckat - Use of Data on the Build-up of Bottom-hole Pressure. A.I.M.M.E. Trans. Vol. 123, 1937, p.45.

(4) R.F. Thyer. Permeability, Porosity and Other Physical Properties of a Number of Rocks and Minerals - Comm. Min. Res. Surv. Report No. 1944/1.

(5) R.F. Thyer. op cit, page 11.

(6) Allan D. Garrison - 1939, Surface Chemistry of Clays and Shales. Trans. A.I.M.M.E. Vol. 132.

June, 1945.
CANBERRA, A.C.T.

R.F. Thyer,
Geophysicist.

ex Cook's Report of Superior Lakes Entrance Oil Shaft Project.

PILOT BORE.

3-10-42	water 60′
	l.s 240′
21-1-43	325′
1-3-43	8″ casing lost 50.
	pull out.
29-3-43	85′ in new bore
5-4-43	200′
≈15-4-43	315′ – casing lowered.

	Depth.	Total water in gas/hr.	Increase in last sec.
29-3-43	319′	2.6 pints/hr.	cemented off.
	324′	4 gals/hr.	4 gals/hr.
	329′	6 2/3	2 2/3
	335′	10	3 1/3
	340′	10	Nil.
	345′	12.5	2 1/2
	350′	14	1 1/2
	356′	12.5	-1 1/2
	361′	15	2 1/2
	365′	14	-1
	370′	16	2
	375′	16	Nil
	380′	16	Nil
	385′	16 2/3	2/3
	390′	17.5	5/6
	395′	17.5	Nil
	400′	18	1/2
	405′	18	1
	410′	19	Nil
	415′	18 3/4	-1/4
	420′	20	1 1/4
	425′	20.5	1/2
	430′	20	-1/2
	435′	21 2/3	1 2/3
	440′	21 2/3	Nil

	Depth	Total water in gals/hr.	Inc. in last section.
5 - 6 - 43	440	21 2/3	—
"	445	22 1/2	5/6 gal ~~1 1/3 gal~~
	450	24 1/6	1 2/3 gal
	455	24 1/6	—
	460	24 1/6	4
	465	24 1/2	1/3 "
	470	33	8 1/2 "
	475	35	2 "
	480	31 2/3	-3 1/3 "
11 - 6 - 43	485	45	13 1/3 "
	490	50	5 "
	495	74	24 "
	500	87	13 "
	505	90	3 "
18 - 6 - 43	510	80	-10 "
	515	102	22 "
2 - 7 - 43	520	121	19 "
	525	110	-11 "
	530	118	8 "
	535	120	2 "
	540	117	-3 "
	550	122	5 "
10 - 7 - 43	560	148	+26 ← sulphuretted H_2 gas.
	570	170	22
	580	171	1
1[illegible] 7 - 43	590	200	29
	600	600	400 } a lot of quick changes in formation.

Run in 6" casing – to prevent entrance of H_2O.

1 - 8 - 43	625' 9"	no water	
13 - 8 - 43	635'	" "	
3 - 9 - 43	690'	" "	
17 - 9 - 43	755'	" "	
25 - 9 - 43	778'	casing to 772'	
8 - 10 - 43			
25 - 10 - 43	853'	" "	834'
29 - 10 - 43	880'	" "	854'
5 - 11 - 43	909'	" "	895'
23 - 11 - 43	970'	" "	953'
	974'	– 6" casing put in – awaiting 5" casing.	

3-4-44	1001'	casing to	
	1012'		1003'
	1020'		1015'
	1043'		1030'
15-5-44	1057'		1049
		casing requires straightening.	
3-6-44	1075'		
10-6-44	1104'		1098'
19-6-44	1139'		1118'
27-6-44	1155		1142 Rept. 88 Pge 3.
			Pilot log bore : Ref. to caving gnd.
3-7-44	1159		1153
10-7-44	1166		1158
17-7-44	1180		1176
31-7-44	1186	→ showing of glauconitic S.S.	
●			
13-8-44	1192'		
21-8-44	1196' 6"		
24-8-44	1198		1196' 6"
			Casing cemented at this level.

OIL PRODUCTION TESTS ASSOCIATED WITH CORING IN THE OIL SAND ARE PROCEEDING. (29/9/44)

Date 2-9-44

date Sept	Depth	No of hr standing.	Total Fluid bailed Pints	Water Pints	Oil Pints.	% oil	Total yield oil 24 h. pints.	yield oil in Last section.	Av yield.
●	1195	21	71	67	4	5.64	4.57	4.57	
4	..	45	164	154	10	6.1	5.34	5.34	5.68
5	1196' 3"	19½	88	83	5	5.7	6.15	1.07	
6	..	23	86	80	5.95	6.86	6.15	1.07	1.07
7	1198' 3"	18½	72	64	8	11.1	10.4	4.25	
8	..	23¼	84	76	8	9.54	8.25	2.1	
9	..	23½	75	62	13	17.3	13.2	7.15	
11	..	46½	124	106	18	14.5	9.3	3.15	3.96
12	1200' 2"	19	57	50	7	12.25	8.85	1.26	
13	..	24	59	48	11	18.7	11	.89	
14	..	24	59	48	11	18.7	11	.89	.17
15	"	..	55	44	11	20.0			
16	1201' 9"	19	71	64	7	9.9			
18	"	18	119½	102	17½	11.64			

Date	Depth	No of hrs. standing	Total Fluid Pints	Water Pints	Oil Pints	% of oil in Fluid	Total yield	
19	1201'9"	24	58	48	10	17.24	10.0	
20	..	..	62	49	13	20.97	13.0	
21	..	..	55	47	8	14.55	8.0	
22	..	..	52	43	9	17.31	9	
23	..	..	53	45	8	15.09	8	
25	..	49	95	77	18	18.95	8.8	
26	..	23	54	44	10	18.52	10.45	
27	..	24	44	36	8	18.18	8	
28	..	..	52½	44½	8	15.24	8	
29	..	..	45½	35½	10	21.98	10	
October								
2	..	72½	135	110	25	18.52	8.3	
3	..	23½	56	47	9	17.86	9.2	
4	..	24	46	36	10	21.94	10.	
5	..	24	44	37	7	15.91	7.	
6	1204'5"	17½	48½	41	7½	15.4	10.3	
7	..	24	45	36	9	20.0	9.0	my oil
9	..	48	95	75	20	21.05	10.0	7 pints
10	..	24	44½	36	8½	19.10	8.5	5.9
11	..	24	42½	33½	9	21.18	9	6.3
12	..	24	44½	33	11½	25.84	11.5	8.0
13	1206'5"	18	72½	25	47½	65.7	63.3	24.7
14	..	24	82	1	81	98.78	81.0	* 31.6
16	..	48	160		160	100	80.0	31.2
17	..	24	90		90	100	90.0	35.1
18	..	..	76		76	100	76	29.6
19	..	..	81½		81½	100	81.5	31.8
20	..	..	78½	1	77½	98.73	77.5	30.2
21	..	..	76	1	75	98.7	73	29.2
23	..	48	143½	½	143	99.7	71.5	27.9
24	..	24	72½	¼	72	99.7	72.0	
25	..	24	75½	1	74½	98.7	74.5	
26	1208'2"	17	72½	29½	43	59.3	60.7	
27	"	24	86½	13½	73	84.4	73	49.6
28	"	24	74½	10	64½	86.6	64.5	~~64~~ 40
30	1 ~~48~~	48	140½	Nil	140½	% of water in oil. 46		37.9
31	" ~~24~~	24	78¾	8¾	70	44		39.2

Date NOV	Depth	Hours standing	Total Fluid	Free Water	oil	% of Water in oil	Total yield	Dry oil
1		24	71	8½	62½	42	~~36.25~~	36.25
2		24	75¾	8	67¾	42	~~37~~	39.3
3		24	76	12	64	34		42.2
4	1208' 2"	24	76½	12½	64	36		41.0
6	-	24	145	4.5	140.5	46		38
7	..	16	71	13	58	31		40
8	1210' 6"	24	90	40	50	.		.
9	..	24	72	22	50	32		34
10	..	24	69	16	53	34		35
11	..	24	66	17½	48.5	24		36.9

	Hours Standing	Depth.						
16	24	1210' 6"	63.5	17½	46	22		35.9
17	24	..	67	18	49	24		37.2
18	24	..	62	18¼	43¾	20		35
20	46½	1211' 8"	142½	46½	96	38		30.7
21	24	--	71¾	20¼	51½	24		39.1
22	24	..	70	21	49	22		38.2
23	24	..	61½	20½	41	20		32.8
24	24	..	69½	21	48½	24		36.9
25	24	..	65½	20¼	45¼	20		36.2
27	48	—	137	30	107	30		37.4
28	24	..	66¼	20¼	46	18		37.7
29	24	..	66	21	45	18		36.9
30	24	..	69	24	45	16		37.8
Dec 1.	17	1212' 9"	77½	38	39½	32 [illegible]		37.8
5	98	..	261½	60	201½	35		32.0
6	12	..	63	20½	42¾	21		36.8
7	24	..	67¾	22¼	45	16		37.8
8	24	..	66½	22½	44	16		37.0
9	24	..	65	22	43	17		35.7
11	48	~~128~~	128	30	98	34		32.5
12	24	~~63~~	63	26	43	18		35.3
13	24	~~64~~	64	21½	42½	17		35.3
14	24	~~64~~	64	22	42	13		36.5
15	18	1214' 9"	56¾	26	30¾	.		.
16	24	"	66	24	42	11		37.4

Date	Depth	Hours standing	Total fluid pints	Free water pints	oil pints	% of H2O in oil	Total yield	Dry oil
18	12'14'9"	48	~~66~~	~~24~~				–
19	..	24	120 3/4	32 1/4	88	19		35.6
20	..	26	61 1/4	20 1/2	40 3/4	8		37.5
21	..	22	66 1/2	24 1/2	42	8		35.7
22	..	24	60 1/4	18 3/4	41 1/2	15		38.5
27	..	120	62	22	40	12		35.2
30	..	72	305	72	233	32		31.7
			180	40	140	32		31.7
Jan								
2	..	~~72~~	189	45	144	28		34.6
3	..	24	62	19	43	15		36.5
4	..	24	60	21	39	11		34.7
5	12'16'9"	18 1/2	65	28	37	28		34.54
6	24	24	56 1/4	20 1/2	35 3/4	13		31.1
8	~~48~~ ..	48	127	45	82	10		36.9
9	..	24	56	20	36	12		31.7
10	..	24	62 3/4	23 1/4	39 1/2	14		34.0
12	..	48	120 3/4	43 3/4	77	14		33.1
13	..	24	60 1/4	21	39 1/4	14		33.8
	daily average prodn = 4 + gallons.							
15	..	48	124 1/2	42 1/2	82	15		34.9
16	..	24	55	16 1/4	38 3/4	16		32.6
17	~	..	54	8 1/4	45 3/4	24		34.8
18	..	..	67 3/4	27	40 3/4	24		31.0
19	..	..	61 1/2	20	41 1/2	15		35.3
20	..	..	60 1/2	21	39 1/2	15		33.6
	av. prodn. 4 1/4 gallons.							
22	..	48	119 1/4	43 1/4	76	16		31.9
23	..	24	58	21	37	13		32.2
24	12'19'0"	18	77	38	39	–		–
25	..	24	61 1/2	24 1/2	37	–		–
26		24	58	22	36	12		31.7
27	–	24	60 3/4	22	38 3/4	17		32.2
29	..	48	123 1/2	45 1/2	78	17		32.4
30	..	24	59 1/2	21	38 1/2	12		33.9
31	..	..	61 1/4	23 1/2	37 3/4	12		33.2
Feb 1	–	..	60 3/4	25	35 3/4	11		31.8
2	–	..	59 3/4	23	36 3/4	12		32.3
5	–	72	181	64 1/2	116 3/4	20		31

Date	Depth	Hours Standing	Total fluid pmd	Free water	oil	% of H_2O in oil	Total yield	dry oil
6	..	24	58¾	22¼	36¼	12		32.1
7	..	24	59	22	37	10		31.5
8	..	24	60	25	35	12		30.8
9	..	24	60½	22	38½	12		33.9
10	..	24	60	23	37	12		32.6
12	..	48	118¼	45¾	73	15		31

Production tests on the bore have now ceased and rise tests are under way.

Date	Hours Standing	Todays Level	Rise in last period.	Rise in 24 hrs.
13	24	11'0"	11'0"	11'
14	--	23'5"	12'5"	12'5"
15	—	32'8"	9'3"	9'3"
16	—	42'5"	9'7"	9'7"
17	—	51'0"	8'9"	8'9"
19	48	66'10"	15'10"	8'7½"
20	"	76'4"	8'1"	8'1"
21	"	85'0"	8'8"	8'8"
22	..	94'6"	9'6"	9'6"
23	..	103'4"	8'10"	8'10"
24	-	112'5"	9'1"	9'1"
26	..	130'5"	18'0"	9'10"
27	24	139'2"	8'9"	8'9"
28	..	148'3"	9'1"	9'1"
Mar 1	..	156'6"	8'3"	8'3"
2	..	165'7"	9'1"	9'1"
3	..	173'9"	8'2"	8'2"
5	48	191'0"	17'3"	8'7½"
6	24	199'2"	8'2"	8'2"
7	..	207'2"	8'0"	8'0"
8	..	215'8"	8'6"	8'6"
9	..	224'0"	8'4"	8'4"
10	..	232'0"	8'0"	8'0"
12	48	248'9"	16'9"	8'4½"
13	24	256'3"	7'6"	7'6"
14	..	264'5"	8'2"	8'2"
15	-	272'4"	7'11"	7'11"
16	—	280'3"	7'11"	7'11"
17	—	288'0"	7'9"	7'9"

Date	~~Depth~~ Hours Standing.	~~Hours Standing~~ Todays Level	~~Total Fluid Fuils.~~ Rise in Last period	~~Free Water~~ Rise in 24 hrs
19	48	303'5"	15'5"	7'8½"
20	24	311'0"	7'7"	7'7"
21	..	318'9"	7'8"	7'8"
22	..	326'4"	7'8"	7'8"
23	..	333'11"	7'7"	7'7"
24	..	341'2"	7'3"	7'3"
26	48	356'7"	15'5"	7'8½"
27	24	363'11"	7'4"	7'4"
28	..	371'0"	7'1"	7'1"
29	..	378'3"	7'3"	7'3"
31	48	392'9"	14'6"	7'3"
Apr 3.	72	413'5"	20'8"	6'10⅔"
4	24	420'1"	6'8"	6'8"
5	24	427'0"	6'11"	6"11"
[illegible]	24	433'11"	6'11"	6'11"
9	72	453'3"	19'4"	6'4⅔"
10	~~120~~ 24	460'0"	6'9"	6'9"
11	24	465'11"	5'11"	5'11"
12	24	472'4"	6'5"	6'5"
13	24	478'4"	6'0"	6'0"
14	24	484'5"	6'1"	6'1"
	On 20th, Baling commenced.			
17	72	502'5"	18'0"	6'0"
18	24	507'10"	5'5"	5'5"
19	24	513'10"	6'0"	6'0"
2[illegible]				

Total column oil 283'5" = 220 gallons
water 230'5" = 178 "
513'10" 398 "

		Total Fluid	Water	Oil	% water in oil	Oil in 24 hrs.	Dry Oil in 24 hrs.
24	21½	53½	21½	32	–	35.7	–
26	48	109	35	73	14	36.5	31.4
27	24	52	17	35	12	35	30.8
28	24	51¾	18¾	33	12	33	29.0
30	48	106	35½	70½	10	35¾	31.7
May 1	24	50¼	17¼	33	..	33	29.7
2	24	50½	18	32½	..	32¾	29.2
3	24	50	17¾	32¼	..	32¼	29.0
4	24	50	18	32	..	32	28.8
5	24	49	16½	32½	..	32½	29.2

Date	Hours Standing	Total Fluid	Water	Oil	% water in Oil	Oil in 24 hrs.	Dry oil in 24 hrs.
7	48	98 1/2	33 1/2	65	8	~~32 1/4~~ 32 1/2	29.9
8	24	50 1/4	16 1/2	33 3/4	8	33 3/4	31.0
10	48	99 3/4	35	64 3/4	10	32.4	29.2
11	24	47	10	30	8	30	27.6
Sept							
7	19 1/2	53 1/2	19 1/2	34	21	41.85	33.1
8	24	52 3/4	16 1/4	36 1/2	9	36.5	33.2
10	48	97 1/2	25 1/2	72	14	36.0	31.0
11	24	52 1/2	18 1/2	34	9.5	34.0	30.8
12	24	51	18	33	7	33	30.7
13	24	48	15	33	7	33	30.7
14	24	48	16 1/2	31 1/2	6.5	31.5	29.5
15	24	47 3/4	16 1/4	31 1/2	9	31.5	28.7
1[illegible]	77	193 1/2	66 1/2	127	6	31.4	29.5
20	23	45	15	30	6	31.3	28.2
21	24	45 1/4	14 1/2	30 3/4	6 1/2	30.75	28.7
22	24	41 1/2	12	29 1/2	6 1/2	29.5	27.6
24	48	91 3/4	31	60 3/4	8.5	30.4	27.8
25	24	48	18	30	7.5	30	27.7
26	..	44 3/4	16	28 3/4	6.5	28.75	26.9
27	..	44 1/2	14 1/2	30	8.5	30	27.4
28	..	44 1/4	15 3/4	28 1/2	5	28.5	27.1
29	..	44 3/4	15 3/4	29	5.5	29	27.4
Oct	48	89	31	58	5.5	29	27.4
2	24	45 1/2	16	29 1/2	7.0	29.5	27.4
3	..	43 3/4	15 1/2	28 1/4	5.5	28.25	26.7
4	~	45	16	29	5.5	29.0	27.4
5	--	4 3/4	15 1/2	27 3/4	4.0	27.75	26.6
6	..	43 3/4	15 1/2	28 1/4	5.0	28.25	26.8
8	48	88 1/2	31 1/2	57	6.0	28.5	26.8
9	24	43 1/4	15 1/4	27 3/4	4.0	27.75	26.6
10	..	43	15 3/4	27 1/4	4.0	27.25	26.2
11	..	43 1/4	15 3/4	28	3.5	28.0	27
12	..	42 1/2	15 1/2	27	3.5	27.0	26
13	..	43	15 3/4	27 1/4	4.0	27.25	26.2
15	48						
16	24						
17	..						

Date.	Hours Standing	Total fluid	water	oil	% water oil	Ad. 24 hr.	Dry oil in 24 hr.
18	48	42 1/4	15 3/4	27	4.0	27.0	25.9
19	–	42 1/2	15	27 1/2	4.5	27.5	25.9
20	–	42 3/4	15 1/2	27 1/4	3.5	27.25	26.3
22	–	85 3/4	31 1/4	54 1/2	3.5	27.25	26.3
24	–	86 1/2	30 1/2	56	4.0	28.0	26.9
25	24	42	15 1/2	26 1/2	4.0	26.5	25.8
26	..	42 1/2	15 1/2	27	3.5	27.0	26.1
27	..	42 1/2	15 1/2	27	3.0	27.0	26.2
28	–						
29	48	86 1/2	32 1/2	54	5.0	27.0	25.6
30	24	43	15 1/2	27 1/2	5.5	27.5	26
31	..	42 1/4	15 1/2	26 3/4	3.5	26.75	25.8
Nov 1	..	43	16 1/2	26 1/2	2.0	26.5	26
2	..	40 1/4	14	26 1/4	3.0	26.25	25.5
3	–	39 1/2	12 1/2	27	7.0	27.0	25.1
4							
5	48	~~4~~ 87 1/2	34	53 1/2	6.5	26.75	25.0
6	24	41 1/4	14 1/2	26 3/4	4.0	26.75	25.7
7	..	41 1/2	15	26 1/2	3.5	26.5	25.6
8	..	41	14 1/4	26 3/4	3.5	26.75	25.8
9	..	42 1/2	16	26 1/2	4.0	26.5	25.4
10	–	43 1/2	15 1/2	28	11.0	28.0	24.9
11							
12	48	85 1/4	31	54 1/4	7.5	27.125	25.1
13	..	42	15 1/2	26 1/2	5	26.5	25.2
14	..	42 1/2	16	26 1/4	4	26.25	25.2
15	..	41 3/4	15 3/4	26	2	26	25.2
16	..	41 3/4	15 3/4	26	3	26	25.2
17	..	41 3/4	15	26 1/4	4	26.25	25.2
18							
19	48	85 3/4	32	53 3/4	7	26.87	25
20	24	40	14	26	4	26	25.
21	..	41 1/4	15 1/2	..	5	26	24.7
22	24	40 1/4	14 3/4	..	6	26	24.4
23	–	–	–	–	–	–	
24	~~24~~ 48	82 3/4	30 1/2	52 1/4	6	26 1/8	24.6

Date	Hours Standing	Total fluid	Water	Oil	% water oil	Oil in 24 hrs.	Dry oil in 24 hr.
25							
26.	48	80	28	52	6	26	24.4
27	24	40.25	13.75	26.5	5	26.5	25.2
28	..	40.5	15.5	25	4	25	24.0
29	..	40.75	15	24	3	24	23.1
30	..	40	14.5	25.5	4	25.5	24.5
Dec 1	..	35.25	10	25.25	4	25.25	24.2

OIL & WATER SATURATION REPORT

W435.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY.

REPORT No. 1945/25.

- Preliminary Report -

RESULTS OF TESTS OF OIL AND WATER SATURATION, PILOT BORE, LAKES ENTRANCE, VICTORIA.

By

R. F. Thyer,
GEOPHYSICIST.

CANBERRA. 12th April, 1945.

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DEPARTMENT OF SUPPLY AND SHIPPING

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- Preliminary Report -

RESULTS OF TESTS OF OIL AND WATER SATURATION, PILOT BORE, LAKES ENTRANCE, VICTORIA.

(Report No.1945/25.)

This report deals with saturation and porosity tests carried out on 28 core samples from the pilot bore at Lakes Entrance.

The cores were obtained with a Baker core barrel operated by a percussion drilling rig. This type of coring tool is generally regarded as a satisfactory means, from a lithological point of view, of obtaining samples of the formations drilled, but as far as saturation tests are concerned, the core samples obtained are so broken and subject to contamination and flushing by the drilling water that saturation results obtained from them must be regarded with considerable suspicion. The position was aggravated in the tests under discussion by the fact that the more competent sandstones, which yielded the largest fragments (the so-called biscuits) and hence those least likely to be flushed or contaminated by drilling water, were found to be singularly free of oil. It seemed likely that the less competent layers of sandstone, which had been reduced by the action of drilling to either small sized pieces or sand, were the ones carrying oil and the material derived from such sandstones was most susceptible to flushing and contamination by drilling water.

The experimental work in connection with saturation determinations is necessarily slow as each sample is under test for a period of from 5 to 15 hours. In order to limit the time required for the presentation of results and because of the uncertainty in the interpretation of results it has been considered advisable to confine the tests to those core samples which correspond to oil horizons as indicated by an increase in oil yield when the particular section was drilled.

Sections which yielded oil are represented by cores 5, 6, 7, 11, 12, 13 and 14. They amount to 93 inches out of a total of 274 inches drilled and it is considered unlikely that any of the remaining 181 inches would be oil-bearing as bailing tests showed that it did not contribute any oil to total oil yield for the bore.

Tests were made of selected portions of the abovementioned cores and one test was made of sand from an unproductive section, namely Core 23. Of the 93 inches which corresponds to sections yielding oil, it was obvious from visual inspection of the cores that not all of it was oil-bearing. Saturation tests were made on samples representing 51 inches. Of the remaining 42 inches approximately 10 inches was lost in coring and 32 inches rejected when visual observation clearly indicated that it had no oil in it. Some tests were carried out on samples rejected in this manner as a check on the observation and no oil was detected by test.

A visual inspection of the cores indicated that oil was confined to the 'sand' and fine, angular fragments. The more solid portions, i.e. the so-called biscuits and larger angular fragments were oily in appearance when first seen but upon breaking them in halves it was obvious that the oil was purely superficial in occurrence - the oil appearing as a thin coating on the fragment. The thickness of this coating varied from a maximum of approximately 1/8 inch to a mere film.

In most cases where oil saturation was determined for the larger fragments, this oily film or coating was carefully removed with a wire brush before the test was commenced. In one case, however, namely Core 12 - (3.1" - 6.2"), a comparison was made between the apparent oil saturation of the oil-coated fragment and the saturation of adjacent fragments from which the oil coating had been scraped. It was found that the failure to remove the oil coating resulted in an apparent oil saturation (expressed as if the oil was evenly distributed throughout the sample) of approximately 8 per cent. whereas the removal of the coating reduced this figure to approximately 1 per cent.

As the oily coating was of the order of 1/16 inch thick and its volume small in comparison to the volume of the sample as a whole it is evident that its saturation must have been high.

The nature of the oily coating is not self-evident. It may be oil which has been yielded by adjacent formations, and which has adhered to the fragments, or it may have been derived from highly saturated beds of glauconitic sandstone of low competency which have been squeezed out of the formation during drilling and been distributed throughout the cored section.

A test is in hand at the present time to determine what apparent oil saturation can be attained by water saturated sandstone fragments which have been standing in oil, but whatever such a test might reveal, the initial uncertainty arises through the method employed for coring. It is understood that a second 'pilot bore' is contemplated from which it is hoped to obtain rotary or diamond drill core samples taken with due regard to precautionary measures which can be adopted to reduce contamination of the core to a minimum or at least permit of an estimation of the degree of contamination to be made.

In nearly every sample tested the liquid content was found to be sufficient to fill the pore space completely. However, it was found as a result of experiments carried out with typical samples of glauconitic sandstone that fragments of size similar to those in the cores, become completely saturated upon immersion in water for periods as short as 30 minutes. As the coring process was carried out under water it is not surprising that the cores were completely saturated, and further, the fact that they were completely saturated cannot be taken as evidence that the glauconitic sandstones are completed saturated in situ.

As mentioned above, some of the core samples had the consistency of sand which it is believed has been derived from the complete crushing of an incompetent sandstone. This belief is based partly on the fact that unconsolidated sand does not occur in the glauconitic sandstone section in any of the neighbouring bores which have been cored with a rotary drill and partly on evidence arrived at by Mr. Noakes[1] by grain size analysis and general considerations of the cementing material present.

As this material seems to be associated with the occurrence of oil, its true nature is of considerable importance in understanding reservoir conditions. The true nature, however, can best be determined from fresh evidence which it is hoped the second 'pilot bore' will give, and until such time as this fresh evidence is available, the true nature must remain in doubt.

<u>The Measurement of Oil and Water Saturation.</u>

The apparatus used in the tests is shown in Figure 1 and it is similar to that described by Yuster[2].

The sample to be tested was reduced to pieces about the size of a pea, weighed and placed in the extraction thimble. The thimbles

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(1) See accompanying report by L.C.Noakes.

(2) S.T.Yuster. Determination of Saturation by Extraction and Distillation. Oil Weekly, March 20th, 1944.

generally recommended for this work are 'Alundum' or 'Alfrax' of suitable permeability but, as thimbles of this type were unprocurable, a thimble was made from a piece of glass tubing which was drawn down to make a fine hole at one end. This hole was at the bottom of the thimble and it allowed the solvent to drain through the sample during the extraction process. A cotton wool plug in the bottom of the thimble prevented the escape of any of the sample or the blocking of the hole. The thimble holds approximately 15 cc. of sample.

The thimble was next placed in the apparatus and the solvent boiled. The solvent used was Shell cleaner X2 with a boiling point range from 90° - 110°C.

The flow of hot solvent vapour past the thimble vapourized the water which was carried over with the solvent vapour, condensed, and collected in the graduated water receiver. Condensed solvent overflowed from the water receiver and was returned to the extraction thimble - flowing down through the sample and returning by way of the hole in the bottom of the thimble to the boiling flask.

The heat was regulated to permit the thimble to remain full of solvent without overflowing.

After several hours all the water vapour had been driven off and collected in the graduated water receiver while the oil had been removed from the sample by the continuous flow of hot solvent through the sample in the thimble. The time required for a complete extraction depends on the fineness of the sample. Five hours was usually sufficient for the sand samples while angular fragments or biscuits reduced to pea size usually required from 10 to 15 hours.

When the extraction was complete, the thimble was removed, its contents dried and weighed to obtain the total loss of weight.

The weight of the water lost was determined from that collected in the graduated receiver, while the oil removed was taken as the difference between total loss of weight and weight of water collected.

The dried sample was next tested for porosity. In the case of sand samples, the dried sand was packed firmly into a measuring cylinder and tamped until its volume was a minimum. The volume so obtained was taken as the overall volume of the sample. The sand was next added to a measured quantity of petrol in a measuring cylinder, stirred until no air bubbles issued from it, and the volume of the grains found from the change in reading.

The volume of the voids was the difference in these two volumes and was expressed as a percentage of the overall volume.

In the case of fragments of sandstone the procedure differed in that the volume of the fragments was found by saturating them in petrol and adding them to a measured quantity of petrol in a graduated cylinder. They were then dried, powdered and the grain and void volumes determined as outlined above.

Saturations were expressed as percentages of the pore volume or voids filled with water and oil respectively.

Results of the Tests.

The results of the tests are shown in the accompanying table. It will be observed that the oil saturation was not determined for six samples. These were samples which visual inspection showed to be oil free and their water saturations were determined by loss of weight on drying.

It will be seen that the tabulation shows a number of samples for which the total saturation - water plus oil, exceeds 100 per cent. This is no doubt due to errors in the measurement of the pore volume. A slight adjustment to the porosity, which is proportional to the pore volume, is sufficient to reduce all the measured saturation to 100 per cent. total. This adjustment has been made in the tabulation, the figure in parenthesis being the adjusted values.

In the case of sand samples, or samples containing a significant proportion of sand, an oil saturation has been calculated on the assumption that the sand has been derived from an incompetent sandstone of porosity 35 per cent. and that the oil extracted from the sand was originally present in the pores of this sandstone. The porosities calculated in this manner are tabulated under the heading, "oil saturations calculated for 35 per cent. porosity".

Some of the saturation figures so calculated are of the order 12 - 14 per cent. but as these sand samples were those most susceptible to contamination or flushing by drilling fluid it is doubtful whether this figure has any real significance.

Some of the sand samples were either free of oil or had very low oil contents. For example, Cores 5 (6.3" - 11") and 7 (5" - 7") gave zero oil saturation in spite of the fact that they occur in cored sections which as a whole yielded oil although they do not necessarily represent those parts of the sections which yielded oil.

A third sample, namely Core 23 (1" - 3") had zero oil saturation but it comes from a section of glauconitic sandstone which yields no oil.

The fact that these sands have no oil in them suggests that any change in their original fluid content which may have been caused through flushing or contamination did not increase their oil content. However, there is no evidence to suggest that the reverse is true, namely that their oil contents have been reduced to zero by flushing or contamination.

In fact there is no real evidence from any of the tests carried out to suggest whether or not the original fluid content of the core samples has been changed during coring.

One test which was carried out might have some bearing on this question and it will be described in brief.

A sample of clean dry sand, obtained by grinding glauconitic sandstone, was saturated with oil. It was then agitated violently with water for 30 minutes, excess fluid squeezed from it and a saturation test made on it. It was found to have 83 per cent. oil and 17 per cent. water saturation.

Translating this result into terms of drilling and coring it might be claimed that if any portions of the glauconitic sandstone were 100 per cent. oil saturated, the material representing this in the cores would still have a very high oil saturation when removed from the core barrel even if it had been reduced to sand in the process of coring.

As mentioned earlier in this report, there is reason for believing that the oily material which coats some of the biscuits and larger core fragments has a high oil saturation. It is possible that this coating represents the remnants of glauconitic sandstone or similar rock which had a very high oil saturation initially. From the sparsity of such coating material in any of the core sections it could be inferred that if the above explanation is correct then this highly saturated material represents only a minor portion of the glauconitic sandstone section as a whole but not necessarily a minor part so far as oil yield is concerned.

In one important aspect, however, the test described above cannot represent reservoir conditions.

It is an observed fact that, almost without exception, reservoir rocks are partially saturated with water, and this water coats the mineral grains in the rock, the oil being nowhere in actual contact with the grains. In the test described above the sand grains were actually wet by the oil.

An entirely different result might have been obtained if the experiment had been performed with a sand in which the grains were water wet. In this case the water covering the grains would probably have been added to at the expense of oil, and water may even have entirely replaced the oil in the sand.

One may speculate almost indefinitely on the relationship which the observed oil content in the sands and smaller core fragments could bear to the original oil contents of the rocks from which they were derived but such speculation cannot lead to any satisfactory conclusions being drawn.

Conclusions.

Perhaps the most important conclusion that can be drawn from the results under discussion is that a very substantial proportion of the glauconitic sandstone is not oil-bearing. Bailing tests* showed that approximately 181 inches out of a total of 274 inches of the glauconitic sandstone drilled is either free of oil or has too low an oil content to contribute to the oil yield for the hole.

Of the remaining 93 inches, material representing approximately 51 inches was subject to saturation tests; the additional 42 inches being made up of core lost in drilling (approximately 10 inches) and cores not tested because they obviously had no oil in them.

Glauconitic sandstone obtained in the form of so-called biscuits proved to have zero oil saturation with the exception of a few samples for which the precaution of scraping the oily layer from the sample before testing, was not observed.

It is believed that all the glauconitic sandstone which cored in the form of biscuits can be eliminated from the 'possibly oil bearing' horizons because it is most unlikely that their oil content could have been entirely removed during coring by the flushing action of the drilling fluid.

The highest oil saturations were found in sand and finely fragmented samples although the relatively high oil saturations in many of the latter may have been due to oily films covering the fragments as was the case in some of the biscuits tested.

If we now consider all samples which gave 5 per cent. or more oil saturation irrespective of the treatment e.g. scraping of the sample, the total thickness of glauconitic sandstone represented by these samples is approximately 16 inches. If we add to this the 10 inches of glauconitic sandstone for which cores were not obtained (and hence no evidence to say that it wasn't oil-bearing) we arrive at a tentative figure of 26 inches for the maximum thickness of oil-bearing glauconitic sandstone.

In view of the uncertainties which arise in regard to such matters as change in original oil content, contamination of samples by oily layers etc. the figure arrived at above, namely 26 inches, is highly speculative and no good purpose can be served by carrying such speculations any further.

In summing up it might be said that the examination of core samples from the pilot bore has not provided any satisfactory evidence of the degree of oil saturation in the glauconitic sandstones at Lakes Entrance beyond eliminating a considerable portion of those sandstones as being non oil-bearing.

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* See accompanying report by L.C.Noakes.

It cannot be too strongly urged that in any subsequent coring operations undertaken with a view to obtaining representative reservoir samples every precaution should be observed which might reduce the chances of flushing or contamination of the cores by drilling fluid and where this cannot be avoided it is recommended that an indicator chemical be added to the drilling water to permit of an estimation being made of the degree of flushing or contamination that has occurred.

CANBERRA, A.C.T.
12th April, 1945.

(R. F. Thyer)
GEOPHYSICIST.

• PILOT BORE - LAKES ENTRANCE •

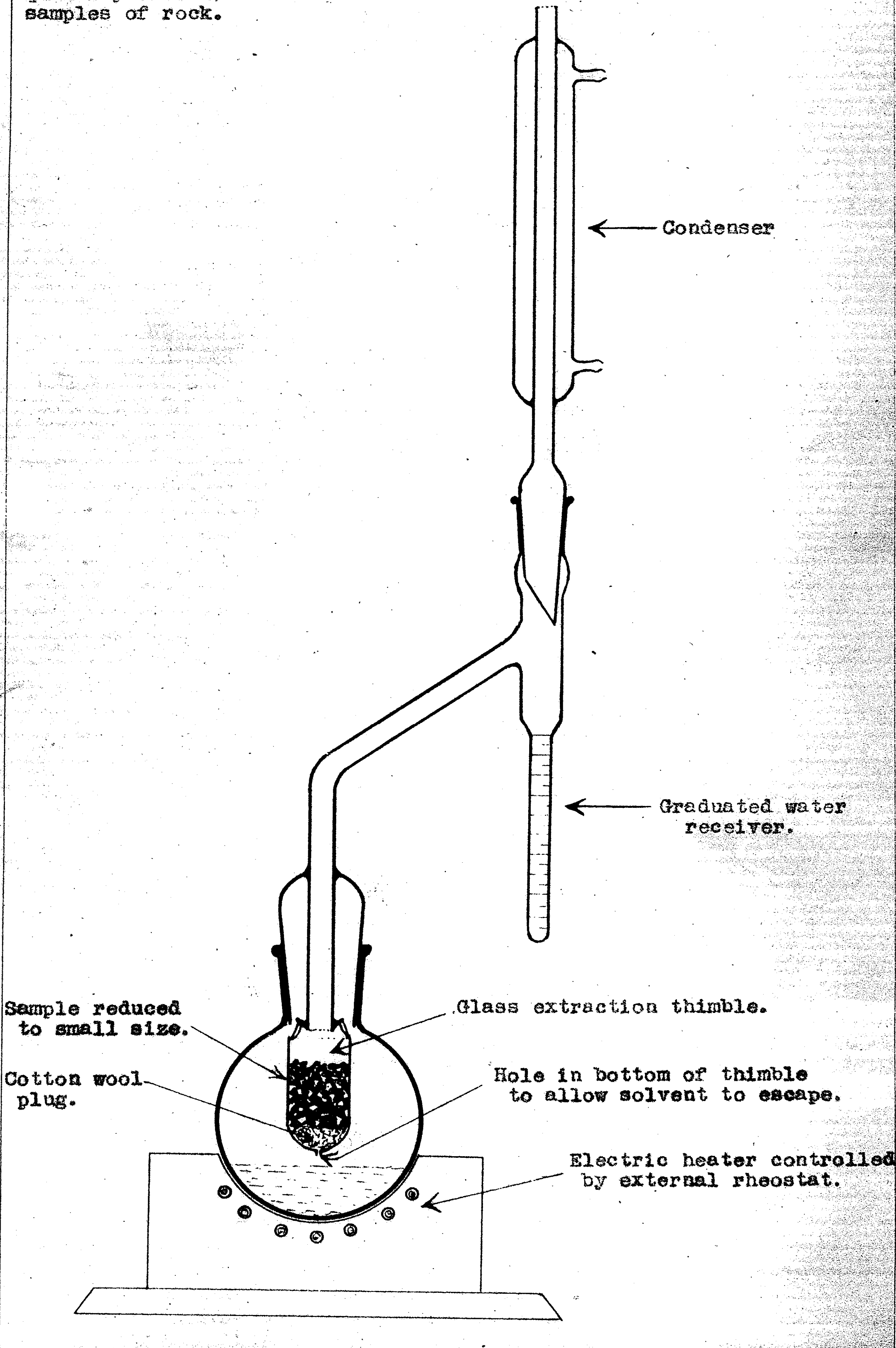
Saturation & Porosity Tests.

Core Number	Description of Sample	Oil Prod. per Day (Pints)	Porosity Per Cent.	Water Sat. Per Cent.	Oil Sat. Per Cent.	Oil Sat. Calc. for 35% Poro.
5(0 - 3")	Sand	4.3	51(53)	98(93)	7.3(7)	14
"	Biscuits(a)		40(44)	114(100)	-	-
5(3"-6.3")	Sand plus few fragments.		56(46)	80(98)	1.8(2)	4.6
"	Biscuits(a)		44(44)	101(100)	-	-
5(6.3"-11")	Fragments(a)		37(45)	122(100)	-	-
"	Sand and fragments.		41(37)	90(100)	0 (0)	0
5(11"-15")	Fragments(a)		35(36)	103(100)	-	-
6(9"-13")	Biscuits (b) (scraped)	2	35(x)	100	0	-
"	Sand		57(50)	83(94)	5(6)	11
6(13"-17")	Biscuits (b) (scraped)		40	100	0	-
7([illegible]")	Sand	1.4	54(53)	98(100)	0 (0)	0
11(2"-9")	Small fragments(c)	29	36(38)	105(98)	2 (2)	-
"	" " (c)		35(37)	105(98)	2 (2)	-
"	Fragments(b) (scraped)		33(32)	98(100)	0 (0)	-
12(0-3.1")	Biscuits (a)		19(23)	122(100)	-	-
"	" (a)		18(16)	93(100)	-	-
12(3.1-6.2")	" (a)		30(35)	110(93)	8.6(7)	-
"	" (b) (scraped)		32(32)	100(99)	1(1)	-
"	Sand		50(54)	100(92)	8.1(8)	14.5
12(6.2-8.5")	Fragments & little sand(c)		32 & 50(42)	91(93)	5.5(7)	-
12(8.5-10")	Biscuits (b) (scraped).		31(30)	98(100)	0 (0)	-
"	Small (c) fragments.		41(39)	87(92)	7.8(8)	-
"	Biscuits & fragments.		35(x)	93	7	
13(1"-3")	Fragments & sand (c).	3	38 & 55	98	2	-
14(1"-3")	Fragments (scraped) (b)		42(41)	98(100)	0	-
14(4"-6")	Fragments & sand (c).		51(48)	87(95)	6.7(7)	12.7
14(6"-8")	Sand		52(50)	94(98)	2(2)	4
23(1"-3")	Sand	0	54(47)	88(100)	0(0)	0

(a) No oil visible in freshly broken sample: Slight oily coating.
(b) Oily coating removed by scraping with wire brush before testing.
(c) Sample passed through 1/4" mesh sieve, oversize being rejected.
(x) Porosity estimated, not measured.

Figure 1.

Apparatus for determining the quantity of water and oil in samples of rock.



R.F.T.

CORE EXAMINATION REPORT

W 435.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY.

REPORT No. 1945/24.

Plan No. 1195.

PRELIMINARY REPORT ON

THE EXAMINATION OF CORES FROM THE PILOT BORE, LAKES ENTRANCE, VICTORIA.

- By -

L. C. NOAKES,
Geologist.

CANBERRA.

5th APRIL, 1945.

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DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY BRANCH.

PRELIMINARY REPORT ON THE EXAMINATION OF CORES FROM THE PILOT BORE, LAKES ENTRANCE, VICTORIA.

Report No. 1945/24. Plan No. 1195.

This report summarises the information so far obtained from the Pilot Bore, Lakes Entrance, and should be regarded as an interim statement pending the completion of work on the cores. The task of correlating this information with that obtained from other sources and the discussion of its bearing on regional problems are reserved for a more detailed report when the work has been concluded.

A. INTRODUCTION.

The Pilot Bore is situated 130 feet north of the Lakes Entrance Shaft and 80 feet above mean tide level. The principal purpose of the bore was to provide information on the position and flow of acquifers and on the nature of the rock ahead of shaft sinking operations. Percussion drilling was used to ensure that information on water horizons should be as accurate as possible.

Drilling on the present site commenced in March, 1943, and was completed at a depth of 1219 feet in January, 1945. The bore is cased with 5 inch casing for 1196 feet to the top of the glauconitic sandstone, where the casing was cemented and the top water shut off. Below this point an open hole was drilled with a Baker core barrel for 22'10" into the glauconitic sandstone. The coring of the sandstone was carried out in 13 separate sections, each approximately 21 inches in depth, with a period of about two weeks bailing between each coring operation. This enabled the distribution of oil and water within the sandstone to be determined and the production from each yielding zone to be measured with reasonable accuracy.

The fluid obtained by daily bailings consisted of free water and an oil-water emulsion in which the percentage of water varied considerably. Free water was drained off and measured, after the fluid had been allowed to stand for about half an hour. The oil-water emulsion was then measured and from samples taken the water content was determined by tests carried out at the bore. The amounts of water and dry oil in the emulsion were thus calculated and the day's production recorded as total water and dry oil. In each bailing period, a few duplicate samples of the emulsion were sent to Melbourne for determination by the Chief Chemist at the Victorian Mines Department to check the accuracy of the local determinations.

The cores obtained from the Baker core barrel were transferred to air tight cylindrical tins and remained sealed until required for examinations. It was not possible to determine the percentage of core recovered from the drilling operations, but recovery was certainly high, and with the possible exception of very thin layers, all changes in lithology should be recorded. The thickness of the various bands within the sandstone could not be measured accurately from the fragmented material in the core barrel, but a close approximation of the thickness was calculated by relating the total length of fragmented core recovered to the true depth cored and adjusting the measurement of each section of the core accordingly.

B. THE GLAUCONITIC SANDSTONE.

The cores provide an almost complete record of the 23 feet of glauconitic sandstone penetrated, but, owing to the limitations of the core barrel, the record consists of rock chips in varying degrees of fragmentation from which the nature of the original rock has to be deduced. This is comparatively simple where the core provides large fragments, but becomes difficult where fine grained sandy material is produced.

The cores show alternations of three types of material.[x]

(i) Disc-like fragments ("biscuits") of hard glauconitic sandstone about an inch in diameter, with flat upper surfaces and convex lower surfaces, varying from ¼ to 1 inch in maximum thickness. As many as a dozen of these may form one section of a core with no admixture of finer fragmentary material.

(ii) Small angular chips and fragments of glauconitic sandstone.

(iii) Fine sandy material usually withdrawn from the core barrel as a continuous soft core resembling an unconsolidated sand or sandy shale. It usually contains very small fragments of hard glauconitic sandstone and, in some cases, grades into coarser fragmentary material.

The three types of cuttings usually occur in distinct sections as if representative of alternating bands within the glauconitic sandstone although in actual fact they probably represent variations in texture which grade one into another with few clear lines of demarcation.

The sections of core composed of disc-like fragments are considered to represent bands of particularly tough, fine-grained sandstone which breaks in this manner under the successive blows of the Baker core barrel. Discs of this kind have been reported as a product of the Baker core barrel from areas other than Lakes Entrance, and the quality of "toughness" may be the dominant factor in their production. Most of the discs are clean and provide no evidence to suggest that partings of finer grained or less consolidated material exists between them. However, some of the discs carry a thin veneer of shaly material which may indicate that partings of some kind exist in these sections. In other parts of the section, a single disc is found in unconsolidated sandy material where it probably represents a band or lens of tough massive sandstone interbedded with a more friable rock.

The sections composed of small angular chips are also considered to represent massive glauconitic sandstone although the type of fracture indicates some essential difference from the type of sandstone which produces discs. At the present stage of the petrographic examinations, the sandstone in the angular chips appears to be slightly coarser than that of which the discs are composed.

The origin of the fine sandy material has not been definitely established. In some cores, the material resembles unconsolidated sands in appearance, but the presence of such beds in the section of sandstone exposed in the Pilot Bore is considered very unlikely. Another interpretation is that the fine sandy sections are drillings introduced into the core by the core barrel inadvertently lifting off the bottom of the hole during the upstroke of the drilling tool. This is a possible explanation, but is also considered to be unlikely. The results of petrographic examination suggest that the material represents glauconitic sandstone which is distinctly coarser and less competent than those represented by discs and by angular fragments. The sandstone has presumably been completely broken during coring and emerges from the barrel as a core of wet sand, containing small angular or sub-angular fragments of glauconitic sandstone.

If this interpretation is correct, these beds or lenses are the most important lithological units in the section. On the basis of grainsize and the percentage of very fine material present, they should have a higher permeability than the other types of glauconitic sandstone, and appear the most likely beds to act as reservoirs for oil. Furthermore, this sandy material constitutes the principal sections of the cores which have yielded oil in the laboratory extractions.

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x Columnar section not available until examination of cores complete.

The average thickness of these bands or lenses in situ is approximately 3 inches and the total aggregate thickness in the Pilot Bore approximately 4 feet. Cores from the productive oil zones record six lenses (?) with an aggregate thickness of 24 inches.

Although it appears, at this stage, that these sandy sections represent thin bands or lenses of less competent sandstone, it is as well to point out that cores such as these are inadequate for a lithological study of the glauconitic sandstone, and that the sequence of textural changes within the formation can only be established with certainty on a complete sequence of solid cores.

C. PRODUCTION OF WATER.

The production and distribution of oil and water are shown in Table 1, which summarises the results of all the bailing tests carried out between coring.

The only acquifer encountered in the 23 feet of sandstone lies near the top of the formation, and yields approximately 27 pints of water per 24 hours.

The initial yield was approximately 85 pints per day, but production declined throughout coring operations and over the last 40 days a degree of stability appeared to have been reached and the yield averaged 27 pints per day.

The exact position of the acquifer is not known, but the water may come from the same beds which yielded oil near the upper limit of the formation.

Production figures show conclusively that the formation below this ~~top~~ acquifer does not yield any measurable quantity of water. This is subject to two interpretations.

(i) The part of the formation exposed is dry.

(ii) The formation contains water, but the low permeability, in conjunction with other physical factors, prevents any measurable flow.

Tests which Mr. R. F. Thyer, Geophysicist of this Branch, intends to carry out in the near future may determine which of these interpretations is correct. It is considered on the evidence available at present that, with the exception of any truly impermeable bands which may exist, the formation does contain water at a pressure approximating that of the artesian water known to occur beneath it. If this is correct, the inference is that certain beds or lenses within the formation contain both water and oil, but yield oil only, due to the combination of various physical factors of which permeability and saturation are probably the most important.

D. PRODUCTION OF OIL.

The bailing results show that there are only two productive oil zones in the 23 feet cored. These consist of a minor productive zone (initial production approximately 8 pints per day) at the top of the formation, with a maximum thickness of 4 feet, and a major productive zone (initial production 32 pints per day) 8'3" to 12 feet below the upper limit of the sandstone. The production of oil is, therefore, limited to 7'9" of the total of 22'10" of formation exposed.

At the close of coring, the oil yield was 32 pints per day. This is a yield of 1.4 pints per day per vertical foot over the whole formation exposed, or 1.5 and 7 pints per day per vertical foot in the minor and major productive zones respectively.

There is no apparent difference in the lithology of the cores from productive and unproductive sections which suggests that suitable reservoirs are not confined to the productive zones, and may be distributed over the whole formation.

If the reservoir beds are represented in the unproductive sections, it is purely speculative whether they contain oil, but are inhibited from yielding, or whether they are barren, due to factors involving source and migration.

There appears to be three ways in which oil may be stored in the formation:-

(i) Sandy sections, presumed to represent bands or lenses of less competent sandstone, appear in each of the productive zones, with a total aggregate thickness of 24 inches and oil has been extracted from most of these. (See Preliminary Report by R. F. Thyer, 1945/25).

(ii) Discs of glauconitic sandstone, with shaly coatings, carry a film of oil, which may have been yielded by thin horizontal partings in the sandstone and oil extracted from some of the more finely fragmented material may be of similar origin. The total thickness of sandstone carrying such partings in the two productive zones, would not exceed 18 inches, of which a small fraction would be constituted by the partings themselves.

(iii) There is no evidence of regular jointing within the formation, but small cracks have been recorded in specimens of sandstone from Foster's Bore. Some oil may be yielded from oil-filled fractures in massive and otherwise barren glauconitic sandstone, but the consistency of the yield in the Pilot and in other bores can hardly be explained on the basis of cracks.

In brief, the maximum aggregate thickness of oil-bearing strata in the two productive zones appears to be little in excess of 24 inches and may be between 24 and 30 inches.

E. RESERVES OF OIL.

The factors involved in calculating the reserves of oil in a reservoir are the cubic capacity of the reservoir, the porosity of the reservoir rock, the degree of oil saturation and the anticipated recovery. It cannot be said that any of these factors has been definitely established by the Pilot bore and consequently any estimates made would be based largely on assumptions. For this reason, the discussion of oil reserves should be deferred until estimates can be placed on a factual basis.

F. SUMMARY.

1. The cores from the Pilot Bore show that the glauconitic sandstone is not a homogeneous formation, but contains variations probably due to changes in the grainsize and texture of the sandstone.

2. At least three variations occur, probably in bands or layers, many of which may grade one into another without sharp demarcation. In addition, thin partings may exist in some sections of the sandstone.

3. Except for a small acquifer near the top of the formation, the glauconitic sandstone does not yield water, although the beds are not considered to be dry.

4. Only 93 inches of the formation so far cored can be said to yield oil, and of this thickness the oil-bearing strata probably constitute little more than 24 inches.

5. Further data on reservoir beds and oil saturations should be obtained before estimates are made of the oil reserves available.

6. The bailing results have provided more precise information on the distribution of oil and water than was available before, and it is anticipated that a second pilot bore, with suitable drilling equipment, can provide more conclusive evidence on oil reserves and reservoir conditions.

CANBERRA, A.C.T.
5th April, 1945.

L. C. NOAKES,
Geologist

TABLE 1.

SUMMARY OF OIL AND WATER PRODUCTION, PILOT BORE, LAKES ENTRANCE.
(September, 1944 - February, 1945).

1 Depth of Bore.	2 Depth below Top of Glauconitic Sandstone	3 Core Section No.	4 Cores No.	5 Total Water per 24 hrs. Av. for Section. Pints ø	6 Dry oil per 24 hrs. Stab. prod. for Section. Pints	7 Initial increase in dry oil yield per Section. x Pints 24 hrs.	8 % of total dry oil prod.	9 Water content of emulsion. Average per Section. %	10 Dry oil as percentage of total fluid. Average per Section
1196'3"	Top	1	5	85.5	4.3	4.3	11.0	30 z	4
1198'2"	1" - 2'0"	2	6	66.0	6.3	2.0	5.0	30 z	9
1200'2"	2' - 4'	3	7	49.9	7.7	1.4	3.5	30 z	13
1201'9"	4' - 5'7"	4	8	44.8	6.3 @	-	-	30 z	12
1204'5"	5'7" - 8'3"	5	9 10	38.3	6.8 @	-	-	30 z	15
1206'5"	8'3" - 10'3"	6	11 12	40.75	36.8	30.0	73.0	51 z	46
1208'2"	10'3" - 12'0"	7	13 14	34.7	39.75	3.0	7.5	40	54
1210'6"	12'0" - 14'4"	8	15 16	31.8	36.3 @	-	-	32.5	53
1211'8"	14'4" - 15'6"	9	17	30.6	36.0 @	-	-	25	55
1212'9"	15'6" - 16'7"	10	18 19	30.5	35.7 @	-	-	25	53
1214'9"	16'7" - 18'7"	11	20 21	25.8	36.3 @	-	-	13.5	59
1216'9"	18'7" - 20'7"	12	22 23	26.5	33.7 @	-	-	15.0	56
1219'0"	20'7" - 22'10"	13	24 25	27.8	32.3 @	-	-	13.25	54

ø Includes free water (measured) and water contained in emulsion (calculated).
@ Average yield is given in unproductive sections.
x The initial yield from the bore totals 40.7 pints, but production had declined to 32.3 pints at the close of coring.
z Based on incomplete data, but error considered small.

PE906251

This is an enclosure indicator page.
The enclosure PE906251 is enclosed within the container PE906250 at this location in this document.

The enclosure PE906251 has the following characteristics:

ITEM_BARCODE = PE906251
CONTAINER_BARCODE = PE906250
NAME = Oil Production Graph
BASIN = GIPPSLAND
PERMIT =
TYPE = WELL
SUBTYPE = DIAGRAM
DESCRIPTION = Graph of Production of Dry Oil, Emulsion and Water by Core Sections from Pilot Bore-1
REMARKS =
DATE_CREATED = 29/03/45
DATE_RECEIVED =
W_NO = W435
WELL_NAME = PILOT BORE-1
CONTRACTOR =
CLIENT_OP_CO = LAKES OIL LIMITED