A PRELIMINARY STUDY OF OIL SANDS CORES FROM THE DUPO AND COLMAR FIELD

By R. J. Piersol

Memorandum

To: Dr. M. M. Leighton

From: G. H. Bell

Re: Preisol's manuscript "Preliminary study of oil sand cores from the Dyso and Colmar fields"

Date: Jan. 28, 1937

I have read the attached memos from Drs. Reed and Rees and the reply by Dr. Preisol. I have gone over the manuscript again and have suggested some changes and corrections, all of which have been adopted by Dr. Preisol.

I recommend that the manuscript be edited for publication in an early number of Illinois Petroleum

Suggested revisions to Dr. Prevots' manuscript

A H Bell Jan 20, 1937

Change title to read

"A preliminary study of oil sand cores from the Dupo and Colmar-~~Plymouth~~ fields."

page 1 l. 3. for "artificial" read "improved."

page 1 lines 4 - ~~8~~ "Since .... flooding"

substitute

"Studies by the United States Bureau of Mines" seem to indicate that at present it is not economically feasible to mine oil in Illinois, and therefore the methods that remain to be considered are air repressuring and water-flooding.

line 7. for "either of these methods" substitute "any method"

page 6: lines 5 & 6. ~~The~~ "by the use of a sub," A "sub" may or may not be necessary. So far as I know no "subs" have been used in operations with our Core Barrel.

p. —.

I suggest
"and is substituted for the ordinary drilling bit."

Memorandum

To: Dr. Leighton

From: R. J. Piersol

Date: September 25, 1936

Re: Comments of Drs. Reed and Rees on manuscript, "A Preliminary Study of One Core from the Plymouth-Colmar Pool and Four Cores from the Dupo Pool."

1 - In paragraph 2, Dr. Reed points out the desirability of drawing conclusions from the results reported. In revising, this has been done.

2 - Contrary to Dr. Reed's statement in the last sentence of this same paragraph, I do not state that the methods used and the results obtained are open to doubt. As a matter of fact I do not believe this to be true. What I have pointed out is that the oil saturation of a sample at the time of testing probably differs somewhat from that of the sand in its original position. And this is altogether unrelated to the method or accuracy of experimental tests.

3 - Dr. Rees in his paragraph 1, suggests that proof should be given that at present it is not feasible to mine oil in Illinois. This has been done by giving reference to the U. S. Bureau of Mines Bulletin on this subject.

4 - In paragraph 2, Dr. Rees notes a correction in the method of testing as previously described by him. The suggested change has been made in the manuscript.

5 - Referring to Dr. Rees' comment in paragraph 3, the reasons for omitting the saturation values for the Plymouth-Colmar core have been included in the manuscript.

6 - Likewise the suggestions made by Dr. Rees in paragraph 4, have been included in the manuscript.

7 - I do not believe any response is necessary to paragraphs 5 and 6 in Dr. Rees' comments.

8 - All the changes have been gone over with Dr. Bell.

Robert J. Piersol

R J P
mmt

MEMORANDUM

TO: Dr. M. M. Leighton

FROM: F. H. Reed

RE: Comments on the paper entitled, "A Preliminary Study of One Core from the Plymouth-Colma Pool and from Cores from the Dupo Pool" by R. J. Piersol.

DATE: September 22, 1936

The following comments are made in response to your request of September 14, 1936.

1. Attached hereto are the comments of Dr. O. W. Rees on Dr. Piersol's manuscript. I believe Dr. Rees' comments worthy of careful consideration.

2. From Dr. Piersol's memorandum of August 4 to you, I understand that this manuscript is recommended for publication in "Illinois Petroleum," and that the Survey will be subject to criticism by the oil operators if publication is not made. This latter statement leads me to assume that Dr. Piersol believes certain conclusions can be drawn from these data by the operators. If such is the case, would it not be better for Dr. Piersol to draw the conclusions in the article? If no conclusions can be drawn from these data would it not be better to withhold publication until sufficient data are available to warrant certain deductions or hypotheses? There is, of course, the intermediate course in which the data are published merely as a record of findings. In this last case, however, I believe the methods used and the results obtained should not be as open to doubt as the author rightfully states these are.

F. H. Reed

MEMORANDUM

TO: F. H. Reed

FROM: O. W. Rees

RE: Comments on the paper entitled, "A Preliminary Study of One Core from the Plymouth-Colmar Pool and from Cores from the Dupo Pool" by R. J. Piersol.

DATE: September 15, 1936

In reading through this paper the following comments occurred to me:

(1) On page 1, lines 4-7, the statement is made as follows: "Since it is apparent that at present it is not economically feasible to mine oil in Illinois, etc." I was of the opinion that the mining of oil in Illinois had not been proven to be economically unfeasible. I believe there are not enough data available to prove it one way or the other.

(2) On page 8, under "Methods of Testing" the following comment should be made in regard to the description of the procedure for porosity determination. As stated by Dr. Piersol, "The sample of core to be tested was extracted by a Soxhlet extractor using carbon tetrachloride as a solvent." Instead of extracting the samples as so stated, the oil was burned out of them at 400° C. Such a change should be made in the description of the procedure.

(3) In Table I porosity data only are reported. No mention is made in the text as to why saturation data for this core are not reported. It seems to me that some such explanation should be made.

(4) The data for the four Dupo pools as presented in Tables II, III, IV and V are shown graphically in Figure 4. Apparently both porosity and saturation data are shown for the four wells in this figure, although no title is provided in Figure 4 explaining this fact. It may therefore be confusing as to which curve is for porosity and which is for saturation. These should be clearly differentiated and explanation made on the figure as well as in the text. Furthermore, saturation data are presented in one form in the Tables and in another form graphically. I see no reason why they should not be presented in the same form in both Tables and graphs, unless there is some particular point to be gained by presenting them in the different form graphically. If this is the case adequate explanation as to why they are so presented differently should be given in the text of the paper.

(5) I have felt throughout the work done by the Analytical Division on this project that the methods used did not produce results of sufficient accuracy to justify publication. On several occasions I have so expressed myself during the work both verbally and in writing. I am still of this opinion and would therefore prefer that acknowledgement to me and to the Analytical Division be omitted in the paper.

(6) I have not pointed out editorial errors which I have found in the body of the text. I presume that these will be taken care of in the due process of editing.

Memorandum

To: Dr. F. H. Reed
From: Dr. M. M. Leighton
Re: Your opinion regarding the question of publishing attached manuscript, "A Preliminary Study of one Core from the Plymouth-Colmar Pool and from Cores from the Dupo Pool."
Date: September 14, 1936

I should appreciate having your comments regarding the proposal to publish the attached manuscript.

Memorandum

To: Dr. Leighton

From: R. J. Piersol

Date: August 4, 1936

Re: Manuscript, "A preliminary study of one core from the Plymouth-Colmar Pool and from cores from the Dupo Pool."

1 - Dr. Bell has reviewed this article and all suggestions made by him have been included in the present revision.

2 - I recommend this for your approval for immediate publication in the Illinois Petroleum.

3 - I am fully cognizant of the objections that have been raised to the publication of the results on saturation and porosity herein reported. Therefore, the sources of error beyond human control have been pointed out in the paper.

4 - If these results are not published the Survey will be subject to criticism due to our strong recommendations for coring. If they are to be eventually published, I suggest immediate publication.

Robert J. Piersol

Memorandum

To: Dr. Bell

From: R. J. Piersol

Date: June 30, 1936

Re: Preliminary report for suggested publication in Illinois Petroleum

Attached is preliminary draft of report, including tables, figures and appendix of sub-surface study.

Kindly go over the report carefully and make any suggested changes in pencil on the report itself. After you return it to me, we will submit it to the Chief for his approval for publication.

Robert J. Piersol

Introduction

Many of the oil pools in Illinois are passing through the stage of their natural decline in production when it becomes necessary either to disband operation or to introduce improved methods of recovery. Studies by the United States Bureau of Mines[1/] seem to indicate that at present it is not economically feasible to mine oil in Illinois, and therefore the methods that remain are air repressuring and water flooding. In order that any method be profitable, it is essential that the oil sand still retain a sufficiently large quantity of oil per acre that is removable with reasonable ease. The oil reserve per acre depends upon the thickness of the oil sand, its porosity and the oil saturation of the pore space. The proportion of the remaining oil which is subject to recovery by repressuring or water flooding depends to a large degree upon two factors, viz., the permeability of the oil sand as a whole and the differences in permeability of horizontal layers of the oil sand.

1/ Rice, G. S., Mining petroleum by underground methods; a study of some methods used in France and Germany and possible application to depleted oil fields under American conditions: U. S. Bur. Mines, Bull. 351, 1932.

The laboratories of the Illinois State Geological Survey are now equipped for accurate determination of per cent porosity and degree of permeability of oil sands, using the same methods and having checked the results with cores previously calibrated by the U. S. Bureau of Mines. Although the Survey laboratories are also equipped for determination of per cent saturation, as yet no standard method has been developed. Any method of extraction, whether by solvent or distillation, may show variation in per cent saturation. Because of the method by which cores are obtained, the oil saturation of the core does not necessarily represent the true oil saturation of the original sand. The drilling water may reduce the oil saturation by washing out part of the oil. The release of rock pressure may liberate from solution dissolved gases, thereby driving out some of the oil. If the saturation is determined in the usual method of total fluid saturation, which includes water as well as oil, then the entrance of the drilling water into the core may increase the determined saturation value. Therefore, when

experimental values of per cent saturation form the basis of calculation of barrels of oil reserve per acre, the estimated amount of oil is subject to the same percentage of error as that introduced by the variation between actual and determinable per cent saturation.

The purpose of this preliminary publication is to present information obtained by porosity and saturation analyses from the five oil well cores on the available pore space and the potential oil reserve.

This article will be followed by a Report of Investigations describing the relationship of improved methods of recovery to the flow of fluid through oil sands as determined by the permeability, porosity and saturation of these cores. Results will also be included for additional cores which are being obtained.

Previous coring in Illinois

In 1926, Moulton[1a] described the coring of a well at Allendale, Wabash County, recommending coring of oil sands as a means of choosing the preferable method of improved oil recovery.

In 1928, Lamar[2] reported results on the texture, the porosity and the saturation of a core taken in the Siggins pool, Cumberland County.

Also, a few wells were cored in the southeastern Illinois oil field, the most of which were on the repressured properties of Tide Water Oil Company north of Robinson.

[1a] Moulton, Gail F., Notes on a core bit for cable tools: Illinois State Geological Survey, Illinois Petroleum No. 2, May 29, 1926.

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[2] Lamar, J. E., A study of the core of the Yanaway Well No. 33 in the Siggins pool: Illinois State Geological Survey, Illinois Petroleum No. 15, May 12, 1928.

In 1931, the State Geological Survey obtained a cable tool core barrel for cooperative use with Illinois oil operators. The advantages of information thus obtained were described by Bell and Piersol.[3/]

3/ Bell, A. H., and Piersol, R. J., The need for sand coring in the southeastern Illinois oil field: Illinois State Geological Survey, Illinois Petroleum No. 21, December 19, 1921.

In spite of curtailment of oil production, with resultant slump in oil drilling, five wells have been cored cooperatively up to May 1, 1936 by the Illinois producers and the State Geological Survey,/the preliminary results on porosity and saturation being herein reported.

Acknowledgments

The wells were cored through the cooperation with the Ohio Oil Company, their Engineer, Mr. M. H. Flood, assisting in the coring. Mr. M. J. Kenefake of the Tide Water Oil Company assisted in the coring of one of the wells. Further assistance in the selection and preparation of core samples was furnished by Dr. A. H. Bell, Geologist and Head, Oil and Gas Division, State

Geological Survey, and Mr. Perry McClure, Assistant Geologist, Oil and Gas Division, State Geological Survey. The porosity and saturation tests were made under the supervision of Dr. O. W. Rees, Associate Chemist, Analytical Division of the Geochemical Section, State Geological Survey. Mr. L. E. Workman, Associate Geologist, Subsurface Division, State Geological Survey, studied the drill cuttings from the wells from which the cores were taken, the detailed records being shown in the appendix.

Location

The Plymouth-Colmar core was obtained from the Ohio Oil Company's T. F. McFadden Well No. 31, C-NW-NE, sec. 15, T. 4 N., R. 4 W., LaMoine Township, McDonough County.

The four Dupo cores were obtained from the Ohio Oil Company's Dyroff Well No. 27, Tarlton Well No. 6, Dyroff Well No. 28, and Dyroff Well No. 29, respectively, all located in sec. 28, T. 1 N., R. 10 W., St. Clair County.

The location of the Plymouth-Colmar and the Dupo fields is shown in Fig. 1. Also the location of the individual wells from which the Dupo cores were obtained is shown in Fig. 2.

Method of coring and sampling

In the coring of an oil sand the core barrel is attached to the drill stem and is substituted for the ordinary drilling bit. A cross-section of a modern type cable tool core barrel is shown in Fig. 3. The bit is attached to the outer core barrel, being raised and lowered like an ordinary bit. The inner core tube remains stationary except that it is driven downward as drilling progresses. The average length of the coring run in the five wells was about three feet, the core drilling rate being from one to two feet per hour. At the end of each run the core barrel is pulled from the well, the core removed by means of a hydraulic pump, the drillings removed from the well by a pump, about 30 gallons of water poured into the well and the coring resumed.

The core as it is removed from the barrel is fed along a trough. Usually about two-thirds of the "sand" is recovered in the form of biscuits, from a fraction of an inch to about three inches in thickness. The fine material is discarded, and the biscuits are wrapped with wax paper in cylindrical packages about seven inches long. The package is tied with cord and dipped into melted paraffin, being removed and cooled until the paraffin has solidified. To insure against loss of fluid the package is re-wrapped and re-paraffined. It is then placed in a core box. Each run (screw) of the core is given a consecutive letter, a card inscribed with respective number and letter being placed in each package before it is sealed. In addition the depth of the well at the beginning of each run is marked on the core box at its proper position as the samples composing each run are inserted.

As soon as possible after each well was cored, tests were made. At this time the cores were unwrapped and inspected by Mr. Workman. Either Dr. Bell or Mr. McClure selected the biscuits

for porosity and saturation tests, the latter being made immediately by the Analytical Division in order to avoid evaporation.

Methods of testing

Porosity tests

The Russell method [4] for determination of total porosity

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[4] Russell, W. L., Bull. Am. Assoc. Petroleum Geol., 10, 93, 939, (1926).

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was used in these tests. The fluid was removed from the sample of core to be tested by burning out the oil at a temperature of 400°C. until smoking had ceased for a short time, this period usually being about one hour. The sample was then dried and all loose grain removed.

The bulk volume was determined first by a Russell volumeter. The apparatus was filled with tetrachlorethane to the reference mark. The sample was saturated with the same liquid in a beaker from which it was taken with tweezers and after the surplus liquid adhering to its surface was removed by a blotter, it was inserted into the apparatus. The new liquid level was read and the bulk volume of the sample calculated from the difference between the new liquid level and the reference level.

The grain volume was determined likewise by the Russell volumeter. The sample was dried and crushed to grain size in a mortar. A new reference level was determined for the apparatus, the sand inserted, the resultant level measured and the grain volume calculated from the difference in levels.

The final calculation is as follows:

$$P = \frac{V_B - V_G}{V_B} \times 100$$

where the total porosity P is expressed in per cent and the bulk volume V_B and grain volume V_G are expressed in cc.

Saturation tests

The Soxhlet extraction method was used to determine the total liquid (both oil and water) content of the sample. Carbon tetrachloride was used as a solvent.

The sample was weighed immediately after the paraffined wrapping was removed in order to avoid evaporation losses. Then the sample was extracted in the Soxhlet extractor, the sample dried and reweighed.

The saturation may be calculated as follows:

$$S = \frac{D_S}{D_L \times P} \left(\frac{W_L - W_E}{W_E}\right) \times 100$$

where the total liquid saturation S is expressed in per cent of available pore space; the density of the fluid D_L and the density of the extracted sample D_S, in terms of specific gravity; and the porosity P in per cent; and the weight of the unextracted sample W_L and the extracted sample W_E, in grams.

The density of the extracted sample D_S may be determined directly by the Westphal balance method or it may be calculated from the density of the sand grains D_G and per cent porosity P as follows:

$$D_S = \frac{D_G\ (100 - P)}{100}$$

Experimental results

Since the Plymouth-Colmar core is from a different geologic horizon than the Dupo cores, the results are considered separately.

Plymouth-Colmar core

The results of porosity tests for the Plymouth-Colmar core are shown in Table 1. The depths reported are the approximate depths of series of two adjoining biscuits, each of which is tested. The average porosity is 21.2 per cent.

The porosity tests on the Plymouth-Colmar core were made under the supervision of Mr. T. W. Johnson, Natural Gas Engineer at the Bartlesville Station of the U. S. Bureau of Mines. "The porosity[5] of the sands was determined by the use of compressed air in arriving at the volume of the sand grains in the specimens. The volume of sand grains plus the volume of the pores (bulk volume) was determined with a Russell volumeter using acetylene tetrachloride as described in Bureau of Mines Reports of Investigations 2876 entitled 'Use of Acetylene Tetrachloride Method of Porosity Determinations in Petroleum Engineering Field Studies,' by

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5/ Personal communication from Dr. John W. Finch, Director, U. S. Bureau of Mines, May 23, 1935.

Chase E. Sutton, published in 1928. The difference between the bulk volume and the volume of the sand grains gives the volume of the voids in the sample, and this volume divided by the bulk volume multiplied by 100 gives the porosity in per cent."

Although saturation tests were made for this core, the results are not reported herein because their accuracy is questionable due to possible evaporation losses before testing. In the meanwhile another Plymouth-Colmar core has become available, the saturation results of which will be included in a later report.

Dupo cores

The results of porosity and saturation tests for the four Dupo cores are shown in Tables 2 to 5. As noted in the tables, the saturation values are expressed both in terms of percentage of total volume of the sample and of its pore volume. These same results are shown graphically in Fig. 4, where the ordinates represent the depths and the abscissae represent

the per cent saturation of total volume (shown in cross-hatch) and the per cent porosity.

The average porosities of these four Dupo cores are 12.8, 15.3, 13.7, and 14.0 per cent, respectively, which gives an over-all average of 13.95 per cent porosity. The average saturations of total volume are 7.74, 7.02, 7.49, and 7.48, respectively, with an over-all average of 7.43 per cent. The average saturations of pore space are 61.5, 45.4, 55.3, and 55.0 per cent, with an over-all average of 54.3 per cent.

The conversion factor between per cent saturation of total volume and barrels of oil per acre-foot thickness of sand may be obtained as follows:

The area of one acre is 43,560 square feet or one acre-foot is 43,560 cubic feet. One acre foot equals 325,829 gallons. Since a barrel of oil contains 42 gallons, an acre foot is equivalent to 7758 barrels. Multiplying this conversion factor by the per cent of oil by volume gives the number of barrels of

oil per acre-foot.

Assuming that the oil sand contains the amount of oil indicated by the saturation results, the area represented by these four Dupo wells contains 7758 barrels times 7.43 per cent or 576 barrels of oil per acre-foot. Referring again to Tables 2 to 5, the thicknesses of the producing sand are 45, 43, 26.5 and 33 feet, respectively, with an average thickness of 36.9. Therefore the total producing sand contains 576 barrels times 36.9 or 21,250 barrels of oil per acre.

Table 1

Porosity tests [1]

McFadden Well No. 31, Plymouth-Colmar Pool

Sample No.	Depth [2] Feet	Porosity Per cent
1	491.5	23.0
5		20.4
2	495	22.8
6		22.3
3	499.5	18.8
7		20.6
4	502	21.4
8		20.3

1/ These tests were made under the supervision of Mr. T. W. Johnson, Natural Gas Engineer at the Bartlesville Station of the U. S. Bureau of Mines.

2/ The depths reported are the approximate depths of series of two adjoining biscuits, each of which is tested.

Table No. 2

Porosity and saturation tests

Dyroff well No. 27, Dupo Pool

Lab No.	Depth Feet	Porosity (per cent)	Saturation of total volume (per cent)	Saturation of pore space (per cent)
0-84	401 - 404	9	4.95	55
0-85	404 - 406	11	4.29	39
0-86	406 - 410	13	11.70	90
0-87	410 - 413.5	11	9.46	86
0-88	413.5-418	15	9.90	66
0-89	418 - 422	9	5.85	65
0-90	422 - 425	11	4.29	39
0-91	425 - 430	12	8.28	69
0-92	430 - 433	18	11.52	64
0-93	433 - 437	17	7.99	47
0-94	437 - 441	16	7.36	46
0-95	441 - 444	15	8.25	55
0-96	444 - 446	9	7.02	78
Average		12.8	7.74	61.5

Table No. 3

Porosity and saturation tests

Tarlton Well No. 6, Dupo Pool

Lab No.	Depth Feet	Porosity (per cent)	Saturation of total volume (per cent)	Saturation of pore space (per cent)
0-99	629 - 632	11	2.86	26
0-100	632 - 635	15	4.65	31
0-101	635 - 639	18	9.00	50
0-102	639 - 643	18	9.00	50
0-103	643 - 647	9	4.05	45
0-104	647 - 651	14	4.90	35
0-105	651 - 655	16	6.72	42
0-106	655 - 659	15	6.90	46
0-107	659 - 661.5	19	8.74	46
0-108	661.5-665	17	6.12	36
0-109	665-668.7	14	11.20	80
0-110	668.7-670.5	18	9.36	52
0-111	670.5-672	15	7.65	51
Average		15.3	7.02	45.4

Table No. 4

Porosity and saturation tests

Dyroff Well No. 28, Dupo Pool

Lab. No.	Depth Feet	Porosity (per cent)	Saturation of total volume (per cent)	Saturation of pore space (per cent)
0-112	404 - 407	8 2/	1/	1/
0-113	407 - 410	7 2/	1/	1/
0-114	410 - 413	11	8.36	76
0-115	413 - 417	12	6.24	52
0-116	417 - 419.5	12	7.08	59
0-117	419.5-424.5	15	7.95	53
0-118	424.5-429.5	15	7.95	53
0-119	429.5-432.5	13	5.33	41
0-120	432.5-436.5	18	9.54	53
0-121	436.5-441.5	14 2/	1/	1/
0-122	441.5-445.7	14 2/	1/	1/
Average		13.7	7.49	55.3

1/ Samples not suitable for saturation tests.

2/ Values omitted in calculation of average value.

Table No. 5

Porosity and saturation tests

Dyroff Well No. 29, Dupo Pool

Lab. No.	Depth Feet	Porosity (per cent)	Saturation of Total volume (per cent)	Saturation of pore space (per cent)
0-123	417-421.5	12.8	4.10	32
0-124	421.5-424.5	19.0	11.02	58
0-125	424.5-428	15.0	4.35	29
0-126	428-433	13.5	9.32	69
0-127	433-438.5	7.0	6.44	92
0-128	438.5-442.5	13.7	9.04	66
0-129	442.5-444.5	12.9	5.93	46
0-130	444.5-447	15.8	12.48	79
0-131	447-449	15.0	5.55	37
0-132	449-450	15.6	6.55	42
Average		14.0	7.48	55.0

Plymouth-Colmar

Dupo

Fig. 1

THE DUPO OIL FIELD

AS OF MARCH 1, 1936 —

— LEGEND —

● PRODUCING WELL

◉ PRODUCING WELL, CORE OF TRENTON TAKEN

SCALE

0 250 500 750 1000 FEET

W.C.I.M.B.T.

N

MOUSETTE

DITTENBACH

LA CROIX

DYROFF

HALL & WEIHL

BREUER

OTTEN

METTER

HOFFSTETTER

R.R. (ELECTRIC)

EAST ST. LOUIS COLUMBIA & WATERLOO

STATE HIGHWAY NO. 3

DYROFF

WM. ANDERLAN

O. ANDERLAN

FRYE

JUNG

TARLTON

TARLTON

REICHERT

GASKILL

SHANDY

FIG. 2

EQUIPMENT FOR CORING WITH STANDARD TOOLS

A cross-section of a modern type cable tool core barrel is shown in figure 2. By the use of "subs" it may be attached to drill stems of various sizes. It consists of (1) an outer core barrel to which the bit is attached and which is raised and lowered like an ordinary bit, and (2) an inner core tube which remains stationary except that it is driven downward as drilling progresses. A maximum of about 5 feet of core may be obtained in one run. The use of the core barrel is not very different from ordinary drilling and with experience the rate of drilling is not materially slackened.

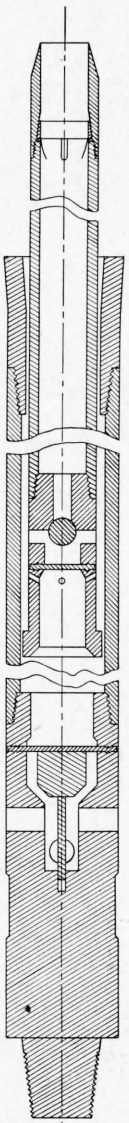

FIG. 2. Longitudinal section of a modern cable tool core barrel.

Figure Inverted

Fig. 3

LABORATORY TESTS

It is proposed to test cores for porosity, saturation with oil, and texture. Standard methods will be used for determining porosity and saturation. Texture will be determined by direct study with the binocular microscope and by microscopic study and photographs of sections similar to those shown in figure 3.

In addition to the above tests, a careful study will be made of the laws governing the flow of oil, water, air or gas through the sands. Cores of various types will be selected for this study.

The success of the program outlined above depends upon close coöperation between the individual operators and the Survey. This is particularly necessary at the outset in order that representative cores from various parts of the field may be obtained for testing. The cores will become the property of the Survey and will be placed on file at the Survey office in Urbana. Any core will be available for reference to the owner of the well from which it was obtained, and the Survey will gladly furnish full information to the well owner on tests of those cores which he has contributed. It is planned that, whenever sufficient data regarding cores have been accumulated, they will be published for the benefit of the industry.

CONCLUSION

The accumulation of knowledge of sand conditions resulting from core studies may be expected to be beneficial in the following ways:

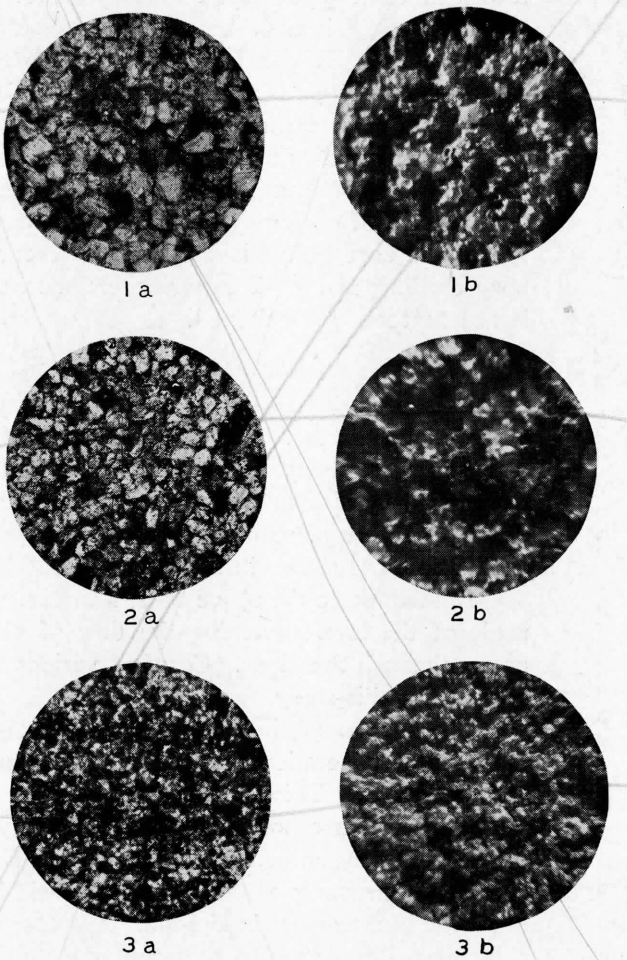

FIG. 3. Photomicrographs of oil sands of three grain sizes, rows 1, 2, and 3; column "a", thin sections, transmitted light; column "b", rough sections, incident light. Approximate magnification, × 20.

Rows 1 and 2.—Samples of Robinson (lower Pennsylvanian) sand obtained in cleaning out the One Sixth Oil Company's Jim Evans well No. 1, NE. ¼ NW. ¼ sec. 36, T. 8 N., R. 13 W., Crawford County, Illinois.

Row 3.—Sample of Carlyle (Chester) sand obtained in cleaning out the Ohio Oil Company's Peter Murphy well No. 8, NE. ¼ SW. ¼ SE. ¼ sec. 3, T. 2 N., R. 3 W., Carlyle field, Clinton County, Illinois.

Saturation and Porosity of Four Drepo Cores

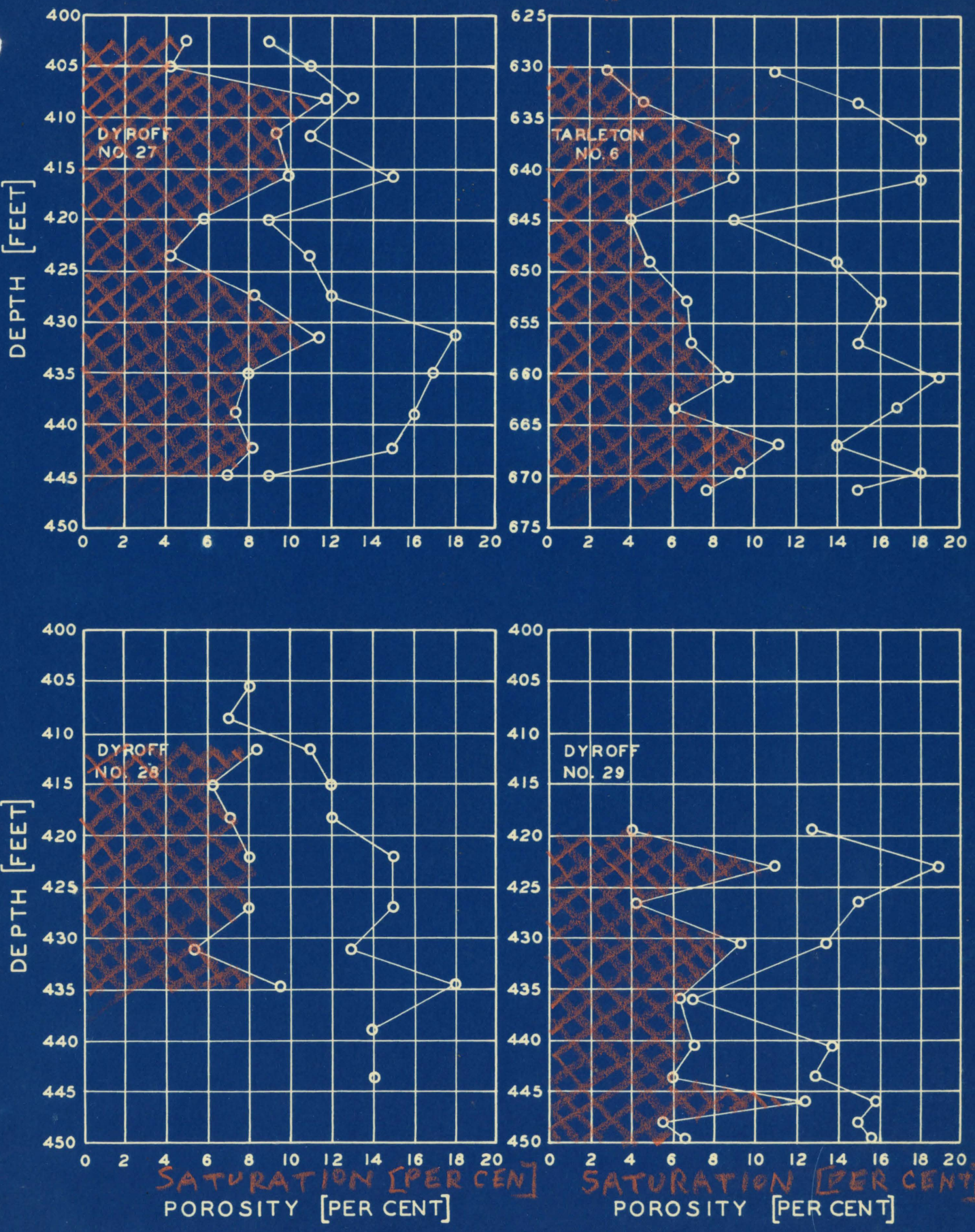

Fig 4

1. Ohio Oil Company, T. F. McFadden well No. 31, NW. 1/4 NE. 1/4 sec. 15, T. 4 S., R. 4 W., McDonough County (Drilled 1934) a/

Compiled from sample study by L. E. Workman and driller's log.

Elevation 576 feet

	Thickness Feet	Depth Feet
Pleistocene system		
"Soil"	25	25
"Sand, gravel, fine to medium, water at 75 feet"	106	131
Granule gravel, clean	4	135
Pennsylvanian system		
"White limestone, coal, and mud"	13	148
Coal	4	152
Mississippian system		
Osage series		
Burlington formation		
"Limestone"	12	164
Limestone, very cherty, white, medium grained	8	172
"Limestone"	12	184
Limestone, dolomitic, cherty, white, coarse; dolomite, white and greenish, fine	16	200
Limestone, dolomitic, cherty, white, coarse	16	216
Limestone, slightly sandy, cherty, gray, coarse	19	235
Kinderhook series		
Shale, silty, dolomitic, light bluish-green	9	244
"Blue shale"	212	456
Devonian system		
Cedar Valley formation		
Dolomite, sandy, greenish and brownish-gray, fine	4	460
Limestone, dolomitic, sandy, brownish-gray, fine to coarse, cherty near base	26	486
Sandstone, calcareous, dolomitic, light brown to white, more or less petroliferous	17	503
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, gray	5	508

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a/ Quotations are from driller's log.

2. Ohio Oil Company, Mathilda Dyroff well No. 26, NE. 1/4 SW. 1/4 SE. 1/4 sec. 28, T. 1 N., R. 10 W., St. Clair County
(Drilled 1934)

Compiled from sample study by L. E. Workman and driller's log. a/

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
"Drift"	62	62
Mississippian system		
Osage series		
Burlington and Fern Glen formations		
"Lime"	58	120
"Shale"	52	172
"Red rock"	26	198
Chouteau formation and Devonian system		
"Broken lime"	20	218
"Shale"	4	222
Silurian system		
Alexandrian series		
Edgewood formation		
"Lime"	23	245
Ordovician system		
Cincinnatian series		
Maquoketa formation		
"White shale"	5	250
"Hard shale"	16	266
"Soft blue mud"	50	316
"Brown shale"	86	402

2. Ohio Oil Company, Mathilda Dyroff well No. 26 - continued

	Thickness Feet	Depth Feet
Mohawkian series		
Kimmswick formation		
Limestone, light buff to brown, medium to coarse, petroliferous (sample cuttings)	41	443

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a/ Quotations are from driller's log.

3. Ohio Oil Company, Mathilda Dyroff well No. 27, SW. 1/4 NW. 1/4 SE. 1/4 sec. 28, T. 1 N., R. 10 W., St. Clair County
(Drilled 1935)

Compiled by L. E. Workman from sample study by H. X Bay.

Elevation 405.5 feet

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Clay, calcareous, gray	35	35
Sand, gray, medium	5	40
Mississippian system		
Osage series		
Burlington formation		
Limestone, cherty, gray, fine to coarse	10	50
Limestone, dolomitic, gray, fine	10	60
Dolomite, cherty, gray, fine to coarse; limestone, dolomitic, coarse	20	80
Fern Glen formation		
Limestone, argillaceous, cherty, dolomitic, green and pink, coarse; shale, calcareous, green	85	165
Limestone, as above; shale, calcareous, red	25	190
Kinderhookian series		
Chouteau formation		
Limestone, light gray, lithographic	10	200
Limestone, brownish to greenish-gray, lithographic to fine; little shale, green	10	210

3. Ohio Oil Company, Mathilda Dyroff well No. 27 - continued.

	Thickness Feet	Depth Feet
Devonian system		
Upper Devonian series		
Cedar Valley formation		
Limestone, cherty, white, very fine; little sandstone, probably at top	5	215
Limestone, cherty, white to light gray; very fine, slightly glauconitic	10	225
Silurian system		
Alexandrian series		
Edgewood formation		
Dolomite, cherty, brown, fine, oil show; shale, dolomitic, bluish-green at base	30	255
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, silty, dolomitic, greenish-gray, streaks of dolomite, argillaceous	60	315
Sandstone, dolomitic, brownish-gray, very fine; shale, dolomitic, silty, dark brown	5	320
Limestone, cherty, dolomitic, argillaceous, brownish-gray; shale, dolomitic, gray	79	399
Mohawkian series		
Kimmswick formation		
Limestone, buff, coarse, bituminous specks	2	401
Limestone, brown, fine to coarse, petroliferous	59	460

4. Ohio Oil Company, Mathilda Dyroff well No. 28, NW. 1/4 NW. 1/4 SE. 1/4 sec. 28, T. 1 N., R. 10 W., St. Clair County
(Drilled 1935)

Compiled by H. X Bay from sample study and driller's log[a/].

Elevation 406 feet

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
"Mud"	20	20
"Sand"	53	73
Mississippian system		
Osage series		
Fern Glen formation		
Limestone, argillaceous, cherty, green and gray, fine to coarse; shale, calcareous, green	97	170
Limestone, argillaceous, cherty, red, coarse; shale, calcareous, red	25	195
Kinderhook series		
Chouteau formation		
Limestone, gray, lithographic	10	205
Limestone, gray and greenish-gray, very fine to lithographic	15	220
Devonian system		
Upper Devonian series		
Cedar Valley formation		
Limestone, cherty, gray, fine; little sandstone, calcareous, white, at top	5	225
Silurian system		
Alexandrian series		
Edgewood formation		
Dolomite, cherty, brown, fine, oil show	35	260

4. Ohio Oil Company, Mathilda Dyroff well No. 29 - continued

	Thickness Feet	Depth Feet
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, dolomitic, greenish-gray	50	310
Same; shale, very silty, dolomitic, brown	5	315
Limestone, argillaceous, cherty, gray and brownish-gray	15	330
Limestone, argillaceous, gray; shale, dolomitic, gray, phosphate nodules at base	73	403
Mohawkian series		
Kimmswick formation		
Limestone, buff to pink, fine to medium bituminous specks	1	404
Limestone, slightly dolomitic, brown, bituminous specks, fine to coarse	6	410
Limestone, slightly dolomitic, brown, fine to coarse, petroliferous	35 9"	445 9"

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a/ Quotations are from driller's log.

5. Ohio Oil Company, Mathilda Dyroff well No. 29, NE. 1/4 NE. 1/4 SW. 1/4 sec. 28, T. 1 N., R. 10 W., St. Clair County
(Drilled 1935)

Compiled from sample study by L. E. Workman and driller's log by H. X Bay a/.

Elevation 405 feet

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
"Mud, gray, soft"	18	18
"Gravel"	71	89
Mississippian system		
Osage series		
Fern Glen formation		
"Shale, gray, soft"	5	94
Limestone, argillaceous, gray and green, coarse	29	123
Limestone, cherty, argillaceous, gray and green; shale, calcareous, green	47	170
Shale, calcareous, pink and green	6	176
Limestone, argillaceous, red and green, coarse	29	205
Limestone, argillaceous, light gray to light greenish-gray, lithographic to very fine	20	225
Devonian system		
Upper Devonian series		
Cedar Valley formation		
Limestone, cherty, partly argillaceous, light brown to green, very fine to medium; a little sandstone, at top	11	236
Silurian system		
Alexandrian series		
Edgewood formation		
Dolomite, cherty, brown, fine porous; oil show	36	272

5. Ohio Oil Company, Mathilda Dyroff well No. 29 - continued

	Thickness Feet	Depth Feet
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, dolomitic, greenish-gray	51	323
Siltstone, dolomitic, brown; trace of oil	5	328
Limestone, argillaceous, dolomitic, cherty, gray, fine, phosphate nodules at base	84	412
"Shale, gritty, hard"	1 6"	413 6"
Mohawkian series		
Kimmswick formation		
Limestone, more or less dolomitic, brown, coarse, petroliferous	36 6"	450

6. Ohio Oil Company, G. L. Tarlton well No. 6, NW. 1/4 SE. 1/4 SE. 1/4 sec. 28, T. 1 N., R. 10 W., St. Clair County (Drilled 1935)

Compiled by L. E. Workman from sample study by H. X Bay and from driller's log[a/]

Elevation 618 feet

	Thickness Feet	Depth Feet
Pleistocene system		
"Soil"	15	15
"Lime shale" (probably glacial till)	5	20
Mississippian system		
Meramec series		
Salem formation		
Limestone, partly sandy, slightly cherty, light buff, coarse	25	45
Limestone, light and dark gray, fine to coarse, Endothyra	25	70
Dolomite, gray, very fine	10	80
Limestone, dolomitic, slightly glauconitic, medium and dark gray speckled, fine to coarse	10	90
Dolomite, sandy, gray, very fine	10	100
Warsaw formation		
Limestone, dolomitic, argillaceous, mottled light and medium gray, coarse; shale, silty, gray	60	160
Dolomite, argillaceous, cherty, gray; shale, silty, gray	25	185
Osage series		
Keokuk formation		
Limestone, cherty, speckled gray, coarse	10	195
Dolomite, argillaceous, gray to brown; limestone, very cherty, light buff, coarse	15	210

6. Ohio Oil Company, G. L. Tarlton well No. 6 - continued

	Thickness Feet	Depth Feet
Burlington formation		
Limestone, cherty, light gray to white, coarse	65	275
Dolomite, cherty, gray, fine	15	290
Limestone, dolomitic, cherty, gray, very fine to coarse	25	315
Fern Glen formation		
Limestone, cherty, partly argillaceous, light gray, pink and green, coarse; little shale, pink and green	35	350
Shale, calcareous, green, interbedded with limestone, argillaceous, cherty, green and gray	55	405
Limestone, argillaceous, red and green, coarse; shale, calcareous, red and green	25	430
Kinderhook series		
Chouteau formation		
Limestone, light gray to greenish, lithographic to very fine	20	450
Devonian system		
Upper Devonian series		
Cedar Valley formation		
Limestone, very cherty, slightly dolomitic, light buff to white, very fine; little sandstone, calcareous, at top	10	460

6. Ohio Oil Company. G. L. Tarlton well No. 6 - continued

	Thickness Feet	Depth Feet
Silurian system		
Alexandrian series		
Edgewood formation		
Dolomite, cherty, brown, very fine	26	486
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, silty, dolomitic, greenish-gray	56	540
Siltstone, sandy, dolomitic, brown	15	555
Limestone, argillaceous, brownish-gray, very fine; shale, silty, gray	70	625
Mohawkian series		
Kimmswick formation		
Limestone, buff, fine to coarse, bituminous specks, compact	7	632
Limestone, dolomitic, brown, fine to coarse, petroliferous	40	672