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 URBANA

## "TRENTON" PRODUCTION IN ILLINOIS

BY

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### "TRENTON" PRODUCING AREAS

Soon after the discovery of oil in the Devonian limestone in some of the new pools in Illinois during 1940, interest was centered on the possibilities of the "Trenton" limestone. This formation has produced oil for a number of years in the Westfield pool, Clark County, in southeastern Illinois, and in the Dupo and Waterloo pools, St. Clair and Monroe counties, in southwestern Illinois. The "Trenton" was successfully tested in the Centralia pool in two wells during 1940. Early in 1941 development of this formation in the Salem pool was started. As of April 22, twenty-one "Trenton" wells have been completed in this pool. These wells were deepened from the Devonian limestone. The "Trenton" limestone has been tested in a number of small pools in the State and found to be unproductive (fig. 1). Production from this formation in Illinois so far has been limited to structures that have considerable closure.

The principle "Trenton" producing area east of Mississippi River is the Lima-Indiana field which has produced oil and gas in considerable quantities from rocks of Ordovician age. Other than in Illinois small amounts of gas have been produced from the "Trenton" in the Cumberland saddle, southern Kentucky, and in Oswego and Oneida counties, New York.<sup>1</sup>

The Lima-Indiana district extends through an area of about 12,000 square miles, only a small part of which produced oil and gas.<sup>2</sup> In Indiana the "Trenton"

has produced both oil and gas since 1886. The total area of crude oil production is 127,000 acres and that of natural gas 650,000 acres. Crude oil production in this area from the "Trenton" to the end of 1939 was 107,000,000 barrels, a recovery of 840 barrels per acre. Natural gas production to the end of 1939 was 800 billion cubic feet.<sup>3</sup> The producing zone was largely restricted to the upper 50 feet of the "Trenton" limestone. A. F. Melcher held that the "Trenton" in this area had sufficient primary porosity to permit movement of fluids. He did not believe that the cavities were sufficiently interconnected to permit the movement of fluids for any great distances.<sup>4</sup>

### STRATIGRAPHIC POSITION

Trenton limestone was first defined by L. Vanuxem in 1838 as the light gray or sparry limestone which forms the upper mass of Trenton Falls, Oneida County, New York. It is underlain by dark or black, almost compact limestone and overlain by the black Utica shale. The thickness of Trenton as first described was from 10 to 125 feet. In 1842 Vanuxem defined Trenton limestone as 0 to 300 feet thick, practically repeated his 1838 description of its lithology, and called the

<sup>1</sup> Ley, Henry A., Lima-Indiana District, Indiana and Ohio, in *The Geology of Natural Gas*: Am. Assoc. Petroleum Geologists, p. 852, 1935.

<sup>2</sup> *Idem.*

<sup>3</sup> Esarey, R. E. and Fix, G. F., Oil and gas developments in Indiana during 1939: *Trans. A.I.M.E.* vol. 136, p. 282, 1940.

<sup>4</sup> Ley, Henry A., *op. cit.*

"TRENTON" PRODUCTION IN ILLINOIS

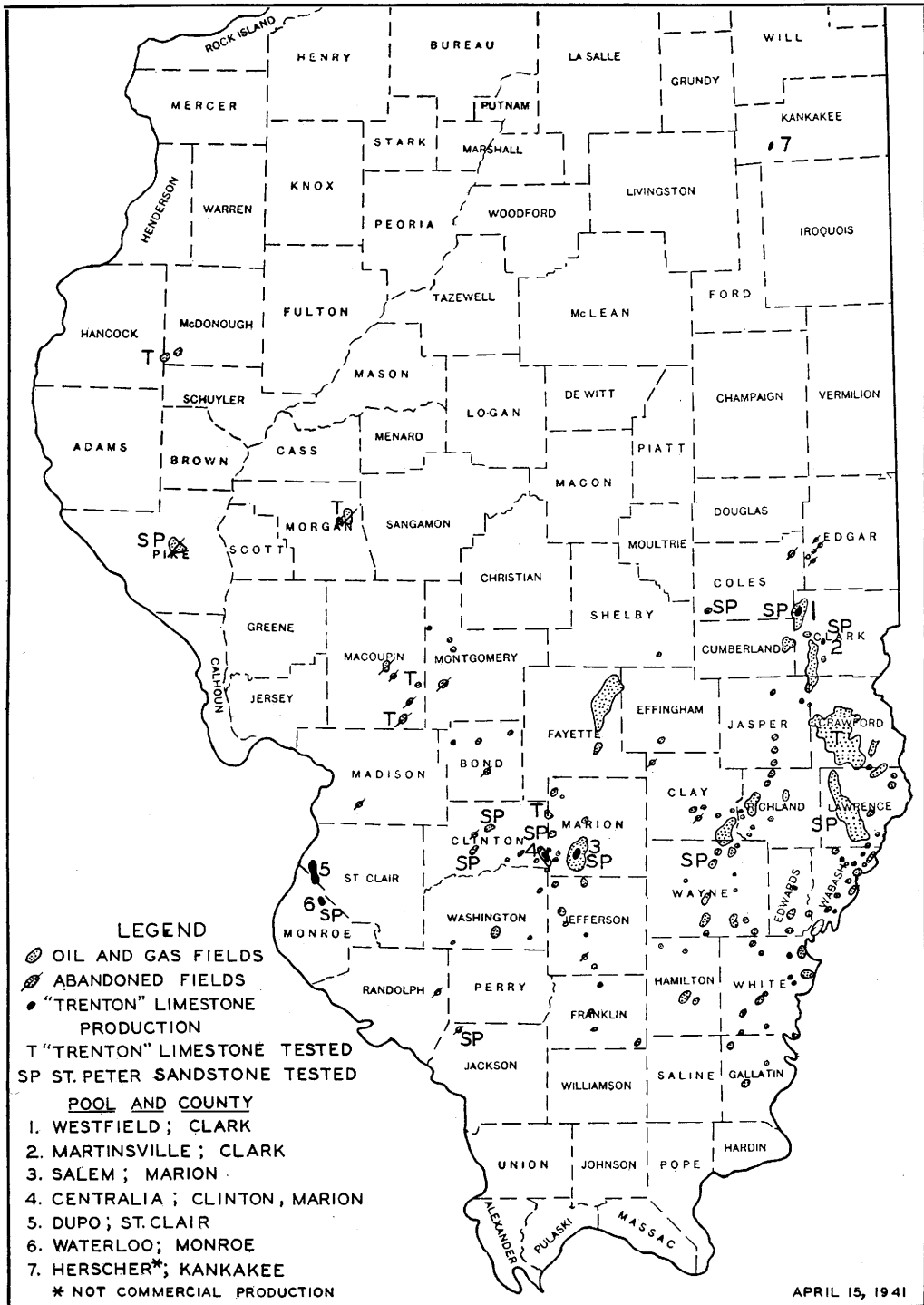


FIG. 1.—Oil and gas fields in Illinois. Areas of "Trenton" production are shown in black, and fields in which "Trenton" or St. Peter strata were tested are indicated. Wildcat tests to "Trenton" or St. Peter are not shown.

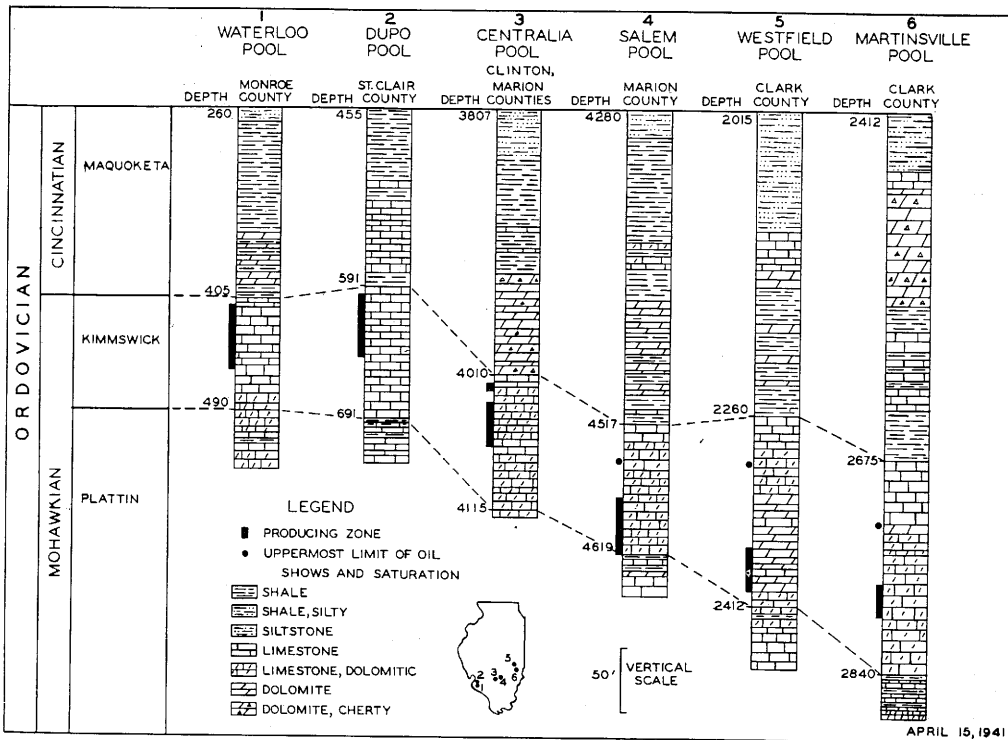


FIG. 2.—Columnar sections of upper Ordovician strata in pools producing from the “Trenton” limestone in Illinois.

underlying formation Black River limestone in which he included the Lowville of present nomenclature. This is the present commonly accepted definition, although for many years most writers used Trenton limestone to include not only the Trenton proper but also all of the underlying Black River group, whereas some writers used Trenton group, also Trenton formation and Trenton limestone, to include the Trenton proper, all of the Black River group, and in some cases Chazy limestone also.<sup>5</sup>

The name “Trenton” as used in Illinois includes all of the strata below the Maquoketa shale to the top of the Glenwood-St. Peter sandstone. Production to date has been found only in the Kimmswick limestone, the upper member of the Mohawkian series that also includes the Plattin formation. The Mohawkian series is correlated with Trenton and Black River strata of the New York section.<sup>6</sup>

EARLY PRODUCTION

The first “Trenton” production in Illinois, although non-commercial, was in sec. 32, T. 30 N., R. 10 E., Kankakee County, at the south edge of Herscher, Illinois (fig. 1, no. 7). A number of wells were drilled to the “Trenton” in this area in 1900. Of these, nine were pumped for eight months and then abandoned. The largest well produced less than one barrel daily, some gas was produced with the oil.<sup>7</sup> The “Trenton” was reached at a depth of 140 feet. Available subsurface data are not enough to determine the detailed structural conditions in this area, although contours based on elevations of the top of bedrock suggest an anticlinal nose extending in a southwesterly direction from the Kankakee arch. Several areas in northwestern Indiana along the Kankakee arch produced small amounts of oil from the “Trenton.”<sup>8</sup>

<sup>7</sup> Athey, L. P., Geology and mineral resources of the Herscher quadrangle: Illinois Geol. Survey Bull. 55, pp. 109-110, 1928.

<sup>8</sup> Logan, W. N., Handbook of Indiana Geology, pt. 5, chap. 10, 1922.

<sup>5</sup> Lexicon of Geologic Names of the United States: U. S. Geol. Survey Bull. 896, pt. 2, p. 2179, 1938.

<sup>6</sup> Ekblaw, G. E., Personal communication.

## "TRENTON" PRODUCTION IN ILLINOIS

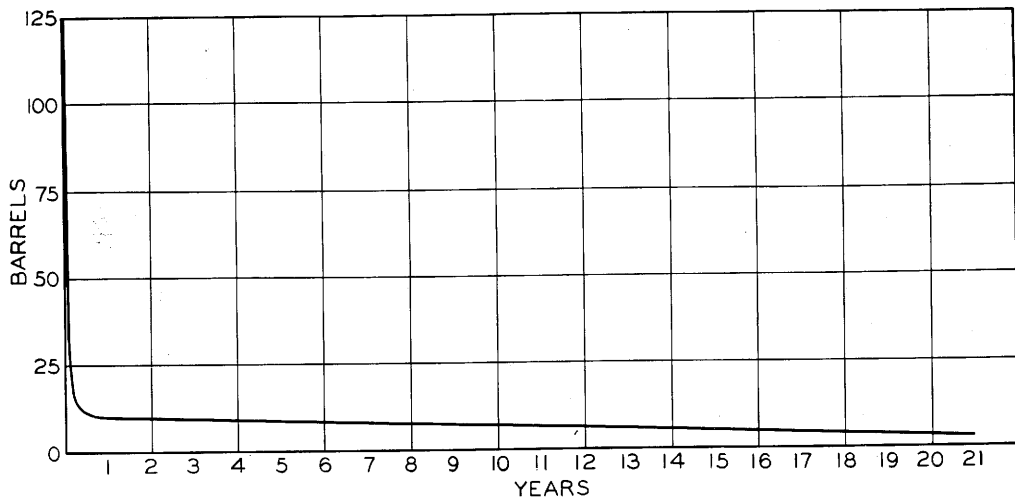


FIG. 3.—Daily production at end of yearly intervals for a "Trenton" well in the Westfield pool, Clark County.

## WESTFIELD POOL

The first commercial production from the "Trenton" limestone in Illinois was in the Westfield pool, Clark County, near the north end of the southeastern Illinois fields (fig. 1, no. 1). The first well, drilled in 1910, was a small producer. The initial production of the well was 65 barrels and the production for the second 24 hours was 20 barrels. The depth of the producing zone was from 2,395 to 2,445 feet. The well, which was abandoned ten years later, produced an estimated total of 10,000 barrels during that time.

The Westfield pool is located on a dome on the axis of the LaSalle anticline. The principal producing formation is the Westfield limestone, correlated as the St. Louis-Salem limestones. The St. Louis limestone, which thins over the top of the dome, averages 60 feet in thickness on top.

The "Trenton" closure, which amounts to at least 160 feet, conforms closely to that of the overlying Mississippian strata.<sup>9</sup> Production is limited structurally to the upper 50 feet at the top of the structure.

Thirteen wells in the pool have produced an estimated total of 171,000 barrels of oil from the "Trenton." Two wells are still producing with an average daily production of approximately 3 barrels.

The wells are usually pumped only once a week. One well has produced for 20 years, the other for 22 years. The average life of the "Trenton" wells at Westfield has been 11 years. The average production per well per day throughout the life of each well was approximately 4 barrels. The recovery of crude oil from the "Trenton" limestone at Westfield is approximately 800 barrels per acre.

Production is obtained from the Kimmiswick formation in the Westfield pool at various depths throughout a zone averaging 90 feet in thickness (fig. 2). The zone consists of coarse dolomitic limestone, fossiliferous, with clear calcite crystals. The average depth to the top of the "Trenton" is 2250 feet and to the top of the "pay" 2340 feet. The "pay" is usually encountered from 90 to 100 feet below the top of the limestone. Where the formation contained oil in commercial quantity the wells had little or no water. The rate of the production suggests low porosity and permeability of the producing zone. The initial production averaged about 100 barrels per well and declined an average of 72 per cent the second 24 hours. Within 2 or 3 months the daily average production per well was 10 or 12 barrels. One well completed in the field with an initial production of 125 barrels was producing 6 barrels daily 14 years later and after 21 years was producing 3 barrels daily (fig. 3).

<sup>9</sup> Mylius, L. A., Oil and gas in east-central Illinois: Illinois Geol. Survey Bull. 54, pl. 26, 1927.

## MARTINSVILLE POOL

Four wells have tested the "Trenton" in the Martinsville pool, Clark County (No. 2, fig. 1), and two of the wells obtained production. The first well, Trenton Rock Oil Co.—McFarland No. 1 in the SE.  $\frac{1}{4}$  SE.  $\frac{1}{4}$  NW.  $\frac{1}{4}$  sec. 19, T. 10 N., R. 13 W., was drilled in 1921 on the side of the Martinsville dome, according to contours on top of the Devonian limestone,<sup>10</sup> and had an initial production of 125 barrels which declined to 10 barrels within a short time. The well was pumped for a number of months and then stood idle approximately three years before being abandoned; during this time it flowed at intervals. The total production of the well was approximately 6,000 barrels.<sup>11</sup>

During 1940 the Strickler-Jackson No. 1, NW.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  SW.  $\frac{1}{4}$  sec. 19, T. 10 N., R. 13 W., was drilled a short distance from the McFarland well and tested the "Trenton." The initial production was 4 barrels of oil and 15 barrels of water. The well was later plugged back to produce from the Carper sand encountered at a depth of from 1,302 to 1,364 feet. A study of the drill-cuttings from the well showed the Kimmswick to be at a depth of 2675 feet, and the top of the saturated zone was at 2729 feet (fig. 2). The well was drilled 104 feet below the top of the "pay" to a total depth of 2833 feet and was shot with nitroglycerine from 2772 to 2794 feet.

The St. Peter sandstone was tested on top of the Martinsville dome in the Trenton Rock Oil and Gas Co.—Carper No. 13, NW.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  sec. 30, T. 10 N., R. 13 W. This well had a show of gas in the "Trenton" at a depth of from 2732 to 2742 feet, and a show of oil from 2800 to 2868 feet. The well was shot with 200 quarts of nitroglycerine, and it then pumped 29 barrels of oil and 10 barrels of water. It was later deepened to the St. Peter sandstone, and several shows of oil were reported in the strata penetrated above the sandstone. As this well was favorably located on structure, and in view of the results of the other tests, the

<sup>10</sup> Moulton, G. F., Prospecting near the Martinsville pool: Illinois Geol. Survey Illinois Petroleum No. 4, fig. 1, page 3, 1926.

<sup>11</sup> Personal communication from Mr. Harry Werts, President, Trenton Rock Oil and Gas Company, Casey, Illinois.

"Trenton" does not appear very promising for further testing in this area.

## WATERLOO ANTICLINE

The Waterloo anticline is a long narrow structure extending north of west from Waterloo, through Dupo, Illinois, to St. Louis, Missouri. Lower Mississippian strata are at the surface along the structure. On this structure crude oil has been produced only from the "Trenton" in the Waterloo pool (fig. 1, No. 6) and the Dupo pool (fig. 1, No. 5).

## WATERLOO POOL

In the fall of 1920 oil was encountered in the Kimmswick limestone in a well drilled for water by the Waterloo Condensed Milk Company. Exploration and development along the anticline in the vicinity of Waterloo, as recommended by the State Geological Survey in two press bulletins,<sup>12</sup> resulted in the discovery of the Waterloo pool. The principal area of production is a long narrow strip extending through sec. 2, T. 2 S., R. 10 W., and south into the NW.  $\frac{1}{4}$  sec. 11. Early in 1922, some 33 producing wells had been drilled in the pool. Wells located high on structure had initial productions from 75 to 125 barrels but soon declined to 25 or 50 barrels a day.<sup>13</sup> The last producing well in the field was abandoned in 1930. The new development in oil and gas in Illinois revived the interest in obtaining further shallow production in this area. In 1939 and 1940 new wells extended the productive area along the crest of the anticline and west of the old producing area. Initial production of the new wells ranged from 15 to 60 barrels of oil and from 1 to 500 barrels of salt water. The total productive area of the pool is 230 acres, and the total crude-oil production to the end of 1940 was 197,000 barrels. The recovery to the end of 1940 has been 857 barrels per acre.

Contours representing the top of the Kimmswick limestone<sup>14</sup> in the Waterloo pool show more than 100 feet of closure

<sup>12</sup> Culyer, H. E., Geology and oil and gas possibilities in the vicinity of Waterloo, Monroe County, Illinois: Illinois Geol. Survey Press Bulletin, 1920.

Mylius, L. A., Oil and gas in Monroe County, Illinois: Illinois Geol. Survey Press Bulletin, 1921.

<sup>13</sup> Lamar, J. E., Notes on the Waterloo Anticline: Illinois Acad. Sci. Trans., vol. 15, p. 398-404, 1922.

<sup>14</sup> Bell, Alfred H., The Dupo oil field: Illinois Geol. Survey Illinois Petroleum No. 17, fig. 2, pp. 10-11, 1929.

on the anticline. Production is limited to the uppermost part of the structure.

The depth to the top of the Kimmswick limestone averages 410 feet, and the best saturated zone averages about 30 feet in thickness with shows of saturation throughout a thickness of 50 feet or more. Saturation is encountered near the top of the Kimmswick limestone which is overlain by a white dense crystalline limestone averaging 12 feet in thickness in the pool. This limestone has been correlated with Fernvale limestone which crops out in southwestern Illinois.<sup>15</sup> A study of the samples of a recent well drilled in the pool showed 7 feet of a light gray to buff fine- to medium-grained fossiliferous limestone immediately underlying the Maquoketa formation. Because this limestone is lithologically similar to the upper part of the Kimmswick as correlated in nearby wells recently drilled, it is included in the Kimmswick for the purpose of this report. Early in the life of the pool, water was encountered in the lower part of the "pay" high on structure but at shallower depths lower on structure. The producing zone consists of buff to brown crystalline limestone, fine- to coarse-grained (fig. 2).

The St. Peter sandstone was tested in the pool by the Remington-Kolmer No. 2, NW.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  NW.  $\frac{1}{4}$  sec. 2, T. 2 S., R. 10 W., which was drilled to a depth of 1802 feet. The well was plugged back to the "Trenton" from which production was obtained.

#### DUPO POOL

The Dupo pool, located on the northern extension of the Waterloo anticline, was discovered in 1928. During 1929, a total of 224 oil wells was completed in the field which was extended into the village of Dupo. Production from the town-lot wells declined rapidly because of their close spacing and many of the wells were soon abandoned. By the end of 1933 only 57 producing wells remained in the pool. Initial productions of the wells ranged from 50 to 350 barrels and the decline in production the second 24 hours ranged from 14 to 75 per cent, averaging 46 per cent for those wells for which production figures are available. One well which had an initial production of 200 barrels was

producing 50 barrels daily one week later.

Contours representing the top of the Kimmswick limestone<sup>16</sup> show at least 100 feet of closure in the pool, and production was limited almost entirely to the area of closure. Water encroached rapidly in the pay, and by 1934 it was found throughout the field. The amount of water produced with the oil increased so much that many wells were abandoned for this reason.

The top of the producing zone is usually about 5 feet below the top of the Kimmswick limestone (fig. 2) and extends throughout a zone averaging 50 feet in thickness. It is light brown to buff limestone, coarsely granular, compact, fossiliferous, and the drill cuttings show much clear calcite. Solution cavities and crevices have been encountered in the upper part of the producing zone in a few wells near the top of the structure. The initial production of these wells was larger than that of nearby wells.

The total oil production for the pool to the end of 1940 was 1,275,000 barrels and the productive area was 670 acres. The recovery to the end of 1940 was 1900 barrels per acre. At the end of 1940 there were 64 producing wells in the pool.

During the recent oil development in Illinois additional wells have been drilled in the pool. Initial production of these later wells ranged from 5 to 200 barrels of oil and from 0 to 6,000 barrels of water.

Centrifugal pumps were installed in some of the wells to handle large volumes of fluid which could not be produced with the customary pump-jack as lifting power. Such a pump was installed in one well drilled in a part of the pool where water had encroached in the pay causing nearby old wells to be abandoned. During 8 months operation of the centrifugal pump, the well produced approximately 47,000 barrels of oil and 903,000 barrels of water. The cost of the pumping equipment and power for operation of the pump during that period was approximately \$11,000.

The first day the well produced 6,000 barrels of water and no oil, the second day it produced 25 barrels of oil and 6,000 barrels of water, and with further operation of the well there was an increase in oil and a decrease in water production.

<sup>15</sup> Lamar, J. E., *op. cit.*

<sup>16</sup> Bell, A. H., *op. cit.*

The peak oil production of 400 barrels was obtained one month after the well was put in operation, at which time it still produced 5400 barrels of water with the oil. At the end of 8 months the well was producing 40 barrels of oil and 1800 barrels of water a day.

It is believed that this method of handling large fluid volumes may make it possible to recover a considerable amount of oil in certain old pools in the State where water-encroachment has greatly reduced oil production. By removing large amounts of fluid from the reservoir, oil which has been trapped with the channeling and by-passing of water would be drawn to the well and recovered.

The producing zone was cored by the Survey in four wells in the Dupo pool. The study of the cores showed the porosity to vary from 2.6 to 19.0 per cent with an average of 14 per cent; permeability ranged from 0 to 61 millidarcys with an average of 7.7 millidarcys; the average total fluid saturation of the pore space was 54.3 per cent. It is believed that where the "Trenton" is productive in Illinois the physical character of the producing zone is comparable to that in the Dupo pool. A study of one of the cores is as follows:<sup>17</sup>

Ohio Oil Co.—M. Dyroff well No. 27, SW. ¼ NW. ¼ SE. ¼ sec. 28, T. 1 N., R. 10 W., St. Clair County.

Surface elevation 405.5 feet.

Formation	Thickness Ft. In.	Depth Ft. In.
Beginning of core		401 0
Kimmswick limestone		
Limestone, light brownish-gray, very fine, some coarse areas, containing oil along stylolites and in more coarse-grained areas; sample 1	0 9	401 9
Limestone, light brownish-gray to gray, very fine to very coarse, crinoidal, oil in tubular areas in lowest 9 inches; samples 2-4	2 3	404 0
Limestone, brownish-gray, coarsely crystalline, porous with fossil impressions, containing oil	0 9	404 9
Limestone, grayish-brown, very fine to coarse, crystalline, compact; samples 5 and 6	2 0	406 9

	Thickness Ft. In.	Depth Ft. In.
Limestone, grayish-brown, coarse, crystalline, somewhat porous; samples 7 and 8	1 9	408 6
Limestone, brown, very coarse, crystalline, porous; samples 9 and 10	1 6	410 0
Limestone, grayish-brown, coarse, crystalline, compact; samples 11-13	3 6	413 6
Limestone, brown to grayish-brown, very coarse, more or less porous; samples 14-18	4 6	418 0
Limestone, brown with dark brown bituminous specks, coarse, crystalline, compact	0 2	418 2
Limestone, speckled brownish-gray and gray, medium to coarse, crystalline, thin layer of phosphatic nodules at base; sample 19	0 10	419 0
Limestone, speckled light brownish-gray and gray, very fine to coarse, crystalline	0 4	419 4
Limestone, brown, coarse, crystalline, somewhat porous, containing oil; samples 20-22	2 8	422 0
Limestone, light gray and brown speckled, coarse, crystalline, compact except near base; samples 23-25	3 0	425 0
Limestone, light gray and brown speckled, very coarse, porous; samples 26-28	3 9	428 9
Limestone, brown, coarse, crystalline, more or less porous, containing oil; samples 29-40	12 3	441 0
Limestone, brownish-gray, coarse, crystalline, somewhat porous; samples 41-42	2 0	443 0
Limestone, grayish-brown, medium to coarse, fairly compact; sample 43	1 1	444 1
Limestone, buff with brown specks, very fine, conodonts	0 1	444 2
Limestone, speckled light brownish-gray and brown, coarse, porous	0 5	444 7
Limestone, light brownish-gray, brown specks, very fine, compact, conodonts	0 1	444 8
Limestone, light to medium brown, coarse, crystalline, porous; sample 44	0 8	445 4
Limestone, brown, fine to coarse, crystalline, compact, areas of clear crystalline calcite filling former cavities, show of oil	0 8	446 0

<sup>17</sup> Piersol, R. J., Workman, L. E., Watson, M. C. Porosity, total liquid saturation, and permeability of Illinois oil sands; Illinois Geol. Survey Rept. Inv. No. 67, pp. 48, 49, 51, 1940.

## "TRENTON" PRODUCTION IN ILLINOIS

Porosity and Permeability of Kimmswick Lime  
Dyroff well No. 27

Sample No.	Depth (ft.-in.)	Porosity (per cent)	Permeability (millidarcys)
1	401-0	5.0	0.30
2	402-0	1.9	0.00
3	403-0	10.0	0.00
4	404-0	13.0	60.9
5	405-0	6.7	4.4
6	406-0	2.6	0.00
7	407-0	13.0	12.9
8	408-0	14.6	16.8
9	409-0	13.5	9.5
10	410-0	10.4	3.4
11	411-0	7.8	0.80
12	412-0	9.6	1.8
13	413-0	9.8	7.7
14	414-0	14.2	12.3
15	415-0	14.7	11.1
16	416-0	11.9	6.2
17	417-0	17.0	11.5
18	418-0	7.6	0.90
19	419-0	4.3	0.00
20	420-0	8.3	0.40
21	421-0	10.1	3.3
22	422-0	6.1	0.00
23	423-0	9.5	4.9
24	424-0	4.4	0.00
25	425-0	9.8	4.9
26	426-0	7.3	1.0
27	427-0	6.3	0.0
28	428-0	14.0	1.8
29	430-0	15.3	10.9
30	431-0	16.6	9.0
31	432-0	15.9	12.1
32	433-0	16.0	17.9
33	434-0	16.3	19.4
34	435-0	10.5	1.4
35	436-0	16.5	13.9
36	437-0	15.0	13.9
37	348-0	15.9	21.5
38	439-0	16.6	24.5
39	440-0	11.1	3.3
40	441-0	11.4	1.1
41	442-0	5.8	0.40
42	443-0	12.5	9.9
43	444-0	8.5	1.6
44	445-0	8.1	1.7

## CENTRALIA POOL

In the Centralia pool, Clinton and Marion counties (fig. 1, No. 4), two wells are producing from the "Trenton" limestone. Both wells were drilled in 1940 near the center of the structure. The top of the Trenton was reached at a depth of 4018 feet in the Ames—Hicks No. 2 well located in the SW.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  SE.  $\frac{1}{4}$  sec. 12, T. 1 N., R. 1 W., Clinton County. The well was first drilled to a depth of 4068 feet, and the producing zone was acidized. The initial production was 120 barrels. Later the well was deepened to 4123 feet

Vertical and Horizontal Permeability of  
Kimmswick Lime,  
Dyroff Well No. 27

Depth (ft.-in.)	Permeability (millidarcys)		
	Vertical 1×1×1 cm.	Horizontal 1×1×1 cm. 1×1×2 cm.	
401-0		0.0	0.30
403-0	0.0	0.161	0.00
405-0	0.464	0.220	4.4
407-0	18.1	16.8	12.9
409-0	11.4	11.92	9.5
411-0	0.678	1.083	0.80
413-0			7.7
415-0	12.93	17.2	11.1
416-0	2.88	3.675	6.2
418-0	0.720	0.833	0.90
420-0	0.648	1.648	0.40
422-0	0.354	0.456	0.00
424-0	0.136	0.289	0.00
426-0	0.258	0.568	1.0
428-0	0.887	1.003	1.8
431-0	2.02	5.20	9.0
433-0	8.17	9.43	17.9
435-0	1.315	1.013	1.4
437-0	12.43	13.45	13.9
438-0	9.07	8.42	21.5
440-0	0.770	1.004	3.3
442-0	0.503	11.0	0.40
444-0	1.198	0.829	1.6
445-0	2.89	4.27	1.7

and plugged back to 4121 feet. Water was encountered near the base of the producing zone. The well was shot from 4066 to 4121 feet, and the initial production was 74 barrels of oil and 16 barrels of water.

The second well drilled to the "Trenton" was the Borton-Storer No. 1, NW.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  NE.  $\frac{1}{4}$  sec. 13, T. 1 N., R. 1 W., Clinton County. The well was completed December 3 with an initial production of 100 barrels. The top of the "Trenton" was at a depth of 4010 feet, and saturation was reported at depths 4016 to 4024 feet and at 4032 to 4056 feet. The well was drilled to a depth of 4120 and was plugged back to 4070 feet. Water was encountered from 4115 to 4120 feet.

Production from both wells has been small. The total production from one of the wells, which flows and pumps by "heads", for a three-months period was estimated to be slightly more than 3000 barrels. Production declined to 30 barrels daily within 13 days after being completed, but further decline in daily production almost three months later was only 5 barrels.

The producing zone consists of light gray to buff crystalline limestone, slightly



dolomitic and cherty, and stylolitic in the lower part (fig. 2). Drill-cuttings from the producing zone showed only slight porosity.

#### SALEM POOL

The first well to be drilled to the "Trenton" limestone in the Salem pool, Marion County, (fig. 1, No. 3), was completed early in 1941. Up to April 22, some 20 additional wells had been completed and 13 others were nearing completion. These wells formerly produced from the Devonian limestone but were deepened to the "Trenton." The average depth to the top of the Kimmswick limestone is 4500 feet, and the total depth of the wells averaged 4625 feet.

The largest reported initial production of any well to the above date was 343 barrels, and the average for all wells was 155 barrels. The physical character of the reservoir is such that most of the wells flow by heads, and the amount of oil produced daily is no greater when the wells are pumped. One of the early wells produced approximately 10,000 barrels of oil during 50 days of operation, a more recent well, which was drilled as an offset to other producing wells, produced a total of 4300 barrels in 36 days of operation.

Although the initial productions are small as compared to wells completed in more porous and permeable formations, production from these wells has been fairly stable. From the available data the decline in daily production for the first month's operation has been in the order of 40 per cent. It appears that the rate of decline of "Trenton" production in the Salem pool will be less than in any other area of "Trenton" production in Illinois. No water has been reported in the wells drilled within the 50 feet of structure between the structurally highest and lowest wells completed to date. It is expected that the area of "Trenton" production will be somewhat smaller than the overlying Devonian limestone which has a productive area of 5000 acres.

Saturation is usually encountered about 25 feet below the top of the Kimmswick limestone and is reported at various intervals to an average depth of 105 feet below the top of the limestone. The average thickness of the "pay" is 50 feet. It has been reported that the best saturation

is near the base of the Kimmswick which is slightly more than 100 feet thick in the Salem pool.

The producing zone consists of buff slightly dolomitic limestone which is fine-to coarse-grained and partly crystalline and is stylolitic in the lower part (fig. 2). A study by a commercial laboratory of a core taken near the base of the producing zone, which is also near the base of the Kimmswick, showed a variation in permeability of from 0 to 195 millidarcys and an average porosity of 7 per cent. The total water content varied from 8.8 to 34.5 per cent of the pore space, and residual oil averaged 7 per cent of the pore space. Although the amount of core recovered was small, it appears to be fairly representative of the remainder of the pay when compared with the results of the studies of cores from the Dupo pool.

As the available data regarding the character of the producing zones on the Kimmswick limestone are not abundant it is difficult to estimate the ultimate recovery from that formation in the Salem pool. It is certainly one of the most promising structures for "Trenton" production yet discovered in Illinois. However, the increased costs of drilling, equipment, and operation as a result of the greater depth may cause the abandonment of "Trenton" wells in the Salem pool earlier than in pools where the Trenton is shallower, thus resulting in lower ultimate recovery. The other areas of "Trenton" production in Illinois, with the exception of the Centralia pool, are at much shallower depths. In two of these areas the recovery has been to date approximately 800 barrels per acre, and this amount compares with the "Trenton" in Indiana. The Dupo field, however, which offers the best record for "Trenton" production in Illinois, has produced 1900 barrels per acre. In consideration of the size of the Salem structure, the nature of the "pay," and the character of the wells completed, it seems within reason to expect an ultimate recovery at least comparable to that in the Dupo pool.

Since development of the "Trenton" in the Salem pool began, a well was drilled on structure to a depth 400 feet below the top of the St. Peter sandstone which was encountered at a depth of 5250 feet. No shows were reported below the Kimmswick limestone.

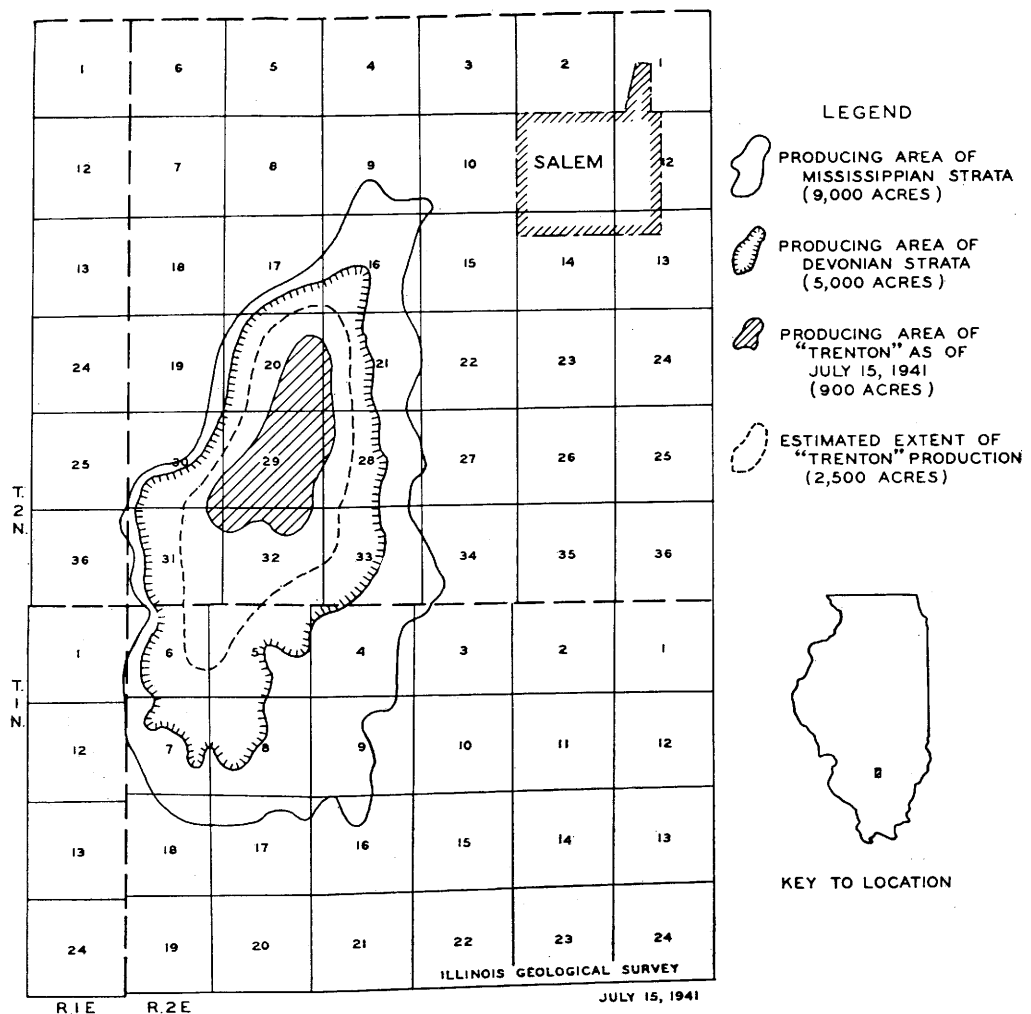


Fig. 4.—Area of "Trenton" production in the Salem pool, Marion County, Illinois.

The available subsurface data to date in the Salem pool indicate that on top of the anticline and on the uppermost part of the east flank the structure conforms fairly well with that of the overlying Devonian limestone. Subsurface data are insufficient to determine the structural relationship on the west flank.

#### ADDENDA

Additional data regarding "Trenton" development in the Salem pool have been obtained since the manuscript was prepared. As of July 15, 1941, 74 wells were producing from the "Trenton" in the Salem pool, and the productive area

proved by drilling was 900 acres. The total productive area of the "Trenton" in the pool is estimated to be 2500 acres (fig. 4).

The average initial production of the first 13 wells completed in the pool was 175 barrels and of the wells drilled during June and July 72 barrels. One of the early wells produced approximately 22,000 barrels of oil during six months operation. A decline curve of this well is shown in figure 5.

The available subsurface data in the Salem pool indicate that on top of the anticline and on the uppermost part of the east and west flanks the structure con-

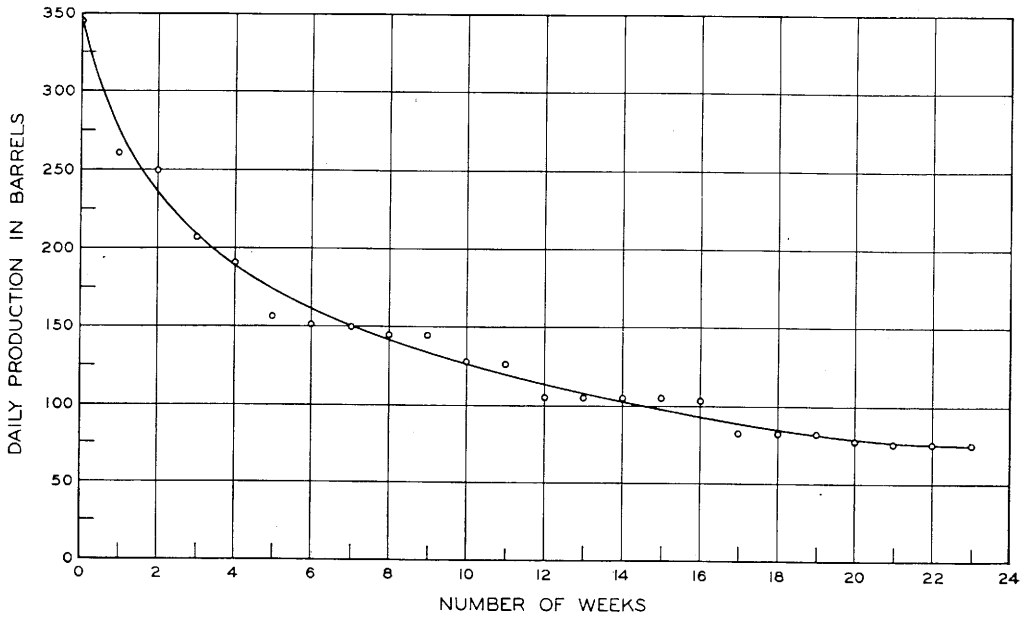


FIG. 5.—Decline curve of a "Trenton" well in the Salem pool, Marion County, Illinois.

forms with that of the overlying Devonian limestone.

The "Trenton" limestone has slightly steeper dip than the Devonian, shown in the variation in interval between the tops of the two formations. The interval at the crest of the fold is 1180 feet. From this point there is an increase of 16 feet in  $\frac{3}{4}$  mile southeast, 18 feet in  $1\frac{1}{4}$  miles northeast, and 33 feet in  $1\frac{1}{2}$  miles south. No increase in interval was noted in the short distance west of the crest of the fold where the "Trenton" has been tested.

#### SUMMARY

Crude-oil production from the "Trenton" in Illinois to date represents less than one per cent of the State's total production. Production has been limited to the upper part of structures with considerable closure. Shows of oil have been reported in the "Trenton" on other structures where it has been tested but commercial production was not obtained. As the producing zone has had low porosity and permeability in the known productive areas, initial productions of wells have been small. In the absence of early water

encroachment the wells should be fairly long lived. The recovery per acre-foot has been much less than that for other producing formations. The increased depth of the "Trenton," which results in greater drilling and operation costs, makes the testing and development of this formation in the new pools less attractive. However, it is believed that in areas where the "Trenton" is sufficiently porous and permeable for commercial production and where the structure has sufficient closure, such testing and development is warranted although the financial return is slower and smaller than it has been with other formations.

#### ACKNOWLEDGMENTS

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The summary well logs have been prepared by L. E. Workman, Head of the Subsurface Division, from sample studies made by members of that Division.

## SUMMARY LOGS

Based on studies of the drill-cuttings from representative wells in areas of "Trenton" production.

## 1. Westfield pool, Clark County

*W. R. Miller—Booth No. 1, SE. ¼ NE. ¼ NW. ¼ sec. 17, T. 11 N., R. 14 W., Clark County.*

Surface elevation 665 feet. Drilled 1939.

Formation	Thick- ness Ft.	Depth Ft.
Pleistocene system	40	40
Pennsylvanian system		
Shale, sandstone, lime- stone and coal	270	310
Mississippian system		
Iowa series		
Meramec group		
St. Louis limestone	41	351
Salem limestone	171	522
Osage group		
Siltstone and sandstone	556	1078
Kinderhook group		
Rockford limestone	14	1092
Mississippian-Devonian systems		
Kinderhook—New Albany shale	106	1198
Devonian and Silurian systems		
Limestone and dolomite, sandy	77	1375
Limestone and dolomite	505	1880
Limestone and dolomite, pink and gray	170	2050
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, gray	60	2110
Limestone, some shale	74	2184
Shale, brownish	110	2294
Mohawkian series		
Kimmswick limestone	150	2444
Plattin limestone	18	2462 T.D.

*Associated Producers and Tidewater—Spellbring No. 34, 404 feet from N. line, 926 feet from E. line, NW. ¼ NW. ¼ sec. 8, T. 11 N., R. 14 W., Clark County.*

Surface elevation 659 feet. Drilled 1924 to 245 feet; deepened in 1936 to 3009 feet.

Pleistocene, Pennsylvanian, and Mississippian systems	1165	1165
Devonian and Silurian systems		
Limestone	825	1990
Ordovician system		
Cincinnatian series		
Maquoketa shale and limestone	255	2245

Formation	Thick- ness Ft.	Depth Ft.
Mohawkian series		
Kimmswick limestone, pet- roliferous	163	2408
Plattin limestone, partly pet- roliferous	337	2745
Chazyan series		
Joachim formation		
Dolomite, partly petrolif- erous	166	2911
Sandstone, shale and dolo- mite	73	2984
St. Peter sandstone	25	3009
2. Martinsville pool, Clark County		
<i>Trenton Rock Oil and Gas Co.—J. S. Carper No. 13, 330 feet N. of S. line, 330 feet E. of W. line of NE. ¼ sec. 30, T. 10 N., R. 13 W., Clark County.</i>		
Surface elevation 599 feet. Drilled 1928-29.		
Pleistocene and Pennsylvanian systems	477	477
Mississippian system		
Iowa series		
Meramec and Osage groups		
No record, except lime- stone at top	808	1285
Osage group		
First Carper sand	45	1330
Shale?	11	1341
Second Carper sand	55	1396
Kinderhook group		
Shale?	19	1415
Rockford limestone	11	1426
Mississippian-Devonian systems		
Kinderhook—New Albany shale	124	1550
Devonian and Silurian systems		
Limestone	131	1681
Limestone, sandy	59	1740
Limestone	511	2251
Limestone, pink to gray	184	2435
Ordovician system		
Cincinnatian system		
Maquoketa formation		
Shale and siltstone, gray	45	2480
Limestone, some shale	120	2600
Shale, brown	95	2695
Mohawkian series		
Kimmswick limestone	165	2860
Mohawkian—Chazyan series		
Plattin and Joachim for- mations	540	3400
Chazyan series		
St. Peter sandstone	11	3411

*F. D. Strickler—Minnie Jackson No. 1, 350 feet from N. line, 225 feet from W. line, NE. ¼ SW. ¼ sec. 19, T. 10 N., R. 13 W., Clark County.*

Surface elevation 555 feet. Drilled 1939.

Formation	Thick-ness Ft.	Depth Ft.
Pleistocene and Pennsylvanian systems.....	410	410
Mississippian system		
Chester series		
Limestone, sandstone, and shale.....	19	429
Iowa series		
Meramec group		
Ste. Genevieve limestone.....	66	496
St. Louis limestone.....	160	656
Salem limestone.....	122	778
Osage group		
Limestone.....	132	910
No record.....	200	1110
Shale, siltstone, and sandstone.....	291	1401
Kinderhook group		
Shale, green.....	9	1410
Rockford limestone.....	10	1420
Mississippian-Devonian systems		
Kinderhook—New Albany shale.....	120	1540
Devonian and Silurian systems		
Limestone.....	105	1645
Dolomite, oil shows.....	37	1682
Sandstone and dolomite, oil shows.....	23	1705
Dolomite, oil show at top.....	565	2270
Dolomite, pink to gray.....	144	2414
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, gray.....	23	2437
Limestone and shale.....	30	2467
Dolomite.....	97	2564
Shale, brownish; some limestone.....	111	2675
Mohawkian series		
Kimmswick limestone, oil show.....	158	2833

### 3. Salem pool, Marion County

*Kingwood Oil Co.—Shanafelt No. 18A, 614 feet from N. line, 1212 feet from W. line, NE. ¼ sec. 20, T. 2 N., R. 2 E., Marion County.*

Surface elevation 533 feet. Drilled 1939.

Formation	Thick-ness Ft.	Depth Ft.
Pleistocene and Pennsylvanian systems.....	1200	1200
Mississippian system		
Chester series		
Menard limestone and shale	76	1276
Vjenna limestone and shale.....	56	1332
Tar Springs sandstone.....	103	1435
Glen Dean limestone and shale.....	42	1477
Hardinsburg sandstone.....	41	1518
Golconda limestone and shale.....	137	1655
Cypress sandstone.....	45	1700
Paint Creek limestone and shale.....	64	1764

Formation	Thick-ness Ft.	Depth Ft.
Bethel sandstone.....	40	1804
Renault formation.....	51	1855
Aux Vases sandstone.....	42	1897
Iowa series		
Meramec group		
Ste. Genevieve formation		
Levias limestone member.....	9	1906
Rosiclare sandstone and sandy limestone member.....	34	1940
Fredonia limestone member.....	130	2070
St. Louis limestone.....	180	2250
Salem limestone.....	276	2526
Osage group		
Limestone.....	104	2630
Shale and siltstone.....	525	3205
Kinderhook group		
Shale, green.....	30	3235
Rockford limestone.....	7	3242
Mississippian-Devonian systems		
Kinderhook—New Albany Shale.....	108	3350
Devonian system		
Limestone and dolomite, petroliferous zones....	152	3502
<i>Magnolia Petroleum Co.—Sam Shanafelt No. 32, 334 feet from N. line, 380 feet from W. line of SE. ¼ SW. ¼ sec. 29, T. 2 N., R. 2 E., Marion County.</i>		
Surface elevation 536 feet. Drilled 1940.		
Pleistocene, Pennsylvanian and Mississippian systems.....	3320	3320
Devonian and Silurian systems		
Limestone and dolomite	960	4280
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Siltstone.....	19	4299
Shale, gray; siltstone at top.....	46	4345
Shale, gray and brown....	35	4380
Shale and dolomite, gray and brown.....	125	4505
Mohawkian series		
Kimmswick limestone.....	104	4609

### 4. Centralia pool, Clinton County

*Algona Oil Co.—E. B. Marshall No. 1, 200 feet from S. line, 221 feet from E. line of SW. ¼ sec. 12, T. 1 N., R. 1 W., Clinton County.*

Surface elevation 493 feet. Drilled 1940.

Formation	Thick-ness Ft.	Depth Ft.
Pleistocene system.....	92	92
Pennsylvanian system.....	948	1040
Mississippian system		
Chester series		
Glen Dean—Golconda formations.....	160	1200
Cypress sandstone.....	95	1295
Paint Creek shale and limestone.....	63	1358
Bethel sandstone.....	52	1410
Renault—Aux Vases formations.....	100	1510

## "TRENTON" PRODUCTION IN ILLINOIS

Formation	Thick- ness Ft.	Depth Ft.	Formation	Thick- ness Ft.	Depth Ft.
Iowa series			Ordovician system		
Meramec group			Cincinnatian series		
Ste. Genevieve formation			Maquoketa formation		
Levias limestone mem- ber.....	25	1535	Shale, gray.....	55	510
Rosiclare sandstone member.....	25	1560	Shale, brown; limestone, sandy.....	5	515
Fredonia limestone member, and St. Louis and Salem limestones	780?	2340?	Limestone, gray; shale at top and bottom...	76	591
Osage and Kinderhook groups, Miss. —Dev. shale			Mohawkian series		
Shale, siltstone, and lime- stone.....	532?	2872	Kimmswick limestone, pet- roliferous.....	46	637
Devonian system			<i>S. G. Lockwood—Dyroff No. 1, N.W. cor. NE. ¼ s ec. 26, T. 1 N., R. 10 W., St. Clair County.</i>		
Limestone.....	65½	2937½	Surface elevation 590 feet. Drilled 1925.		
<i>Pray and Reynolds, and Borton—Storer No. 1, 196 feet from N. line, 126 feet from W. line, NE. ¼ NE. ¼ sec. 13, T. 1 N., R. 1 W., Clinton County.</i>			Pleistocene system.....	26	26
Surface elevation 493 feet. Drilled to 2915 by Pray and Reynolds, deepened to 4120 by Borton, 1940; samples below 2909 feet.			Mississippian system		
Pleistocene and Pennsylvanian systems.....	1085	1085	Iowa series		
Mississippian system.....	1782	2867	Meramec group		
Devonian system			St. Louis limestone.....	247	273
Dolomite and limestone..	593	3460	Salem limestone.....	152	425
Silurian system			Osage group		
Dolomite and limestone, pink and gray.....	347	3807	Warsaw shale and dolo- mite.....	75	500
Ordovician system			Keokuk and Burlington limestones.....	181	681
Cincinnatian series			Fern Glen shale and lime- stone.....	74	755
Maquoketa formation			Kinderhook group		
Siltstone.....	36	3843	Chouteau limestone.....	30	785
Shale, gray; some lime- stone.....	87	3930	Grassy Creek shale.....	13	798
Dolomite, brownish.....	80	4010	Silurian system		
Mohawkian series			Dolomite.....	70	868
Kimmswick limestone.....	105	4115	Ordovician system		
Plattin limestone.....	4	4119	Cincinnatian series		
5. Dupo pool, St. Clair County			Maquoketa formation		
<i>Ohio Oil Co.—Tarlton No. 7, SW. ¼ NE. ¼ NE. ¼ sec. 33, T. 1 N., R. 10 W., St. Clair County.</i>			Shale, gray.....	57	925
Surface elevation 580 feet. Drilled 1936.			Shale, brown.....	10	935
No record.....	10	10	Siltstone; and dolomite, silty.....	15	950
Mississippian system			Shale and limestone, brownish.....	65	1015
Iowa series			Mohawkian series		
Meramec group			Kimmswick limestone....	98	1113
Salem limestone.....	43	53	Plattin limestone and dolo- mite.....	212	1325
Osage group			Chazy series		
Warsaw shale and lime- stone.....	102	155	Joachim dolomite.....	148	1473
Keokuk and Burlington limestones.....	130	285	St. Peter (and Joachim?) sandstone.....	159	1632
Fern Glen limestone and shale.....	111	396	Prairie du Chien series		
Kinderhook group			Powell and Cotter dolo- mites.....	263	1895
Shale, green.....	2	398	Jefferson City dolomite...	260	2155
Chouteau limestone.....	12	410	Roubidoux formation		
Silurian system			Dolomite, sandy.....	85	2240
Limestone.....	45	455	Sandstone and sandy dolomite.....	45	2285
			Gasconade and Van Buren dolomites.....	210	2495
			Gunter sandstone and sandy dolomite.....	35	2530
			Cambrian system		
			St. Croix series		
			Eminence dolomite.....	234	2764
			Potosi dolomite.....	140	2904

## 6. Waterloo pool, Monroe County

Hughes Petroleum Corp.—*Wm. Myer No. 1, 295 feet from N. line, 358 feet from E. line of SW. ¼ SE. ¼ sec. 28, T. 2 S., R. 10 W., Monroe County.*

Surface elevation 575 feet. Drilled 1939.

Formation	Thick- ness Ft.	Depth Ft.
Pleistocene system		
Glacial drift.....	28	28
Mississippian system		
Iowa series		
Meramec group		
St. Louis limestone.....	162	190
Salem limestone.....	170	360
Osage group		
Warsaw shale and lime- stone.....	115	475
Keokuk and Burlington limestones.....	103	578
Fern Glen limestone.....	107	685
Silurian system		
Limestone.....	27	712
Ordovician system		
Cincinnatian series		
Maquoketa formation		
Shale, gray.....	83	795
Sandstone.....	25	820
Limestone and shale...	35	855
Mohawkian-Chazyan series		
Kimmswick-Plattin lime- stones and Joachim dolomite.....	485	1340
Chazyan series		
St. Peter (and Joachim?) sandstones.....	147	1487
Prairie du Chien series		
Powell and Cotter dolo- mites.....	88	1575

*Eugene Hoffer—J. H. Boyer No. 2, 329 feet from S. line, 1262 feet from W. line, SE. ¼ sec. 19, T. 1 S., R. 10 W., Monroe County.*

Surface elevation 405 feet. Drilled 1940.

Formation	Thick- ness Ft.	Depth Ft.
No record.....	155	155
Mississippian system		
Iowa series		
Meramec group		
Salem limestone.....	83	238
Osage group		
Warsaw limestone, dolo- mite, and some shale.	128	366
Keokuk and Burlington limestones.....	189	555
Fern Glen limestone.....	69	624
Silurian system		
Limestone.....	29	653
Ordovician system		
Cincinnatian series		
Maquoketa shale		
Shale, gray.....	75	728
Limestone and shale...	65	793
Mohawkian series		
Kimmswick limestone....	86	879
Plattin limestone.....	221	1100
Chazyan series		
Joachim dolomite.....	145	1245
St. Peter (and Joachim?) formation		
Sandstone, incoherent..	98	1343
Dolomite, sandy; sand- stone, partly dolomitic	47	1390
Sandstone, incoherent..	17	1407
Prairie du Chien series		
Powell and Cotter dolo- mites.....	286	1693
Jefferson City dolomite...	202	1895
Roubidoux sandstone and sandy dolomite.....	170	2065
Gasconade and Van Buren dolomites.....	155	2220