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STRUCTURE OF THE BEREA OIL SAND IN THE FLUSHING QUADRANGLE

HARRISON, BELMONT, AND GUERNSEY COUNTIES, OHIO

BY

W. T. GRISWOLD

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STRUCTURE OF THE BEREA OIL SAND IN THE FLUSHING QUADRANGLE, HARRISON, BELMONT. AND GUERNSEY COUNTIES, OHIO.

By W. T. Griswold.

INTRODUCTION.

The United States Geological Survey has undertaken detailed mapping of the geologic structure of the oil sands in certain parts of the Appalachian oil field in eastern Ohio and western Pennsylvania. The first report describing work of this kind is contained in Bulletin No. 198, which deals with the Cadiz quadrangle in Harrison County, Ohio. The second bulletin is No. 318, which describes the conditions existing in the Steubenville quadrangle in Ohio and West Virginia and in the Burgettstown and Claysville quadrangles in Pennsylvania. The present report, which is the third of the series, treats of the Flushing quadrangle in Harrison, Belmont, and Guernsey counties, Ohio.

The object of this work is to determine accurately the geologic structure of the surface rocks and of the Berea sand (which is the principal oil-bearing stratum of this part of the field), and from this structure to determine, if possible, where the conditions are favorable for the accumulation of oil and gas. The first step in the work is to ascertain the structure or lay of the surface rocks. Then it is necessary to determine what degree of parallelism exists between the rocks that outcrop at the surface and those that lie from 1,000 to 2,000 feet below the surface, and by means of this parallelism to construct a map of the oil sand as if all the geologic formations above it had been removed and the upper surface of the sandstone were open to view.

Previous work of this kind has been carried on in areas in which a considerable amount of oil and gas territory had been developed prior to the survey. In such regions it was possible by means of wells already drilled to check the degree of exactness to which the oil sands could be plotted, and by a study of the conditions under which the oil and gas had accumulated to formulate general laws governing such accumulations.

In the Flushing quadrangle very little oil or gas has been found. It was for this reason that the area was selected for a practical test of the principles which had been determined in the previous surveys. The Berea sand, which is the principal oil sand of this part of Ohio, was known to be present in this quadrangle. The surface conditions were also known to be favorable for accurate geologic work. By selecting such an area and carefully plotting the structure it was hoped that the areas which are most favorable for the accumulation of oil and gas could be determined, and that thus the economic development of the field would be assisted. The result of the work shows a regularity in the structure which is not favorable for large oil accumulations. There are, however, minor structural features which doubtless have exercised an influence on the location of deposits of oil and gas, and which may be regarded as indicating favorable territory.

The field work in the Flushing quadrangle was performed during the field season of 1906 by B. J. Green and F. M. Hutchinson under the supervision of the writer.

LOCATION, DRAINAGE, AND CULTURE.

The Flushing quadrangle is situated in eastern Ohio and includes parts of Harrison, Belmont, and Guernsey counties. It is limited by meridians 81° and 81° 15′ and by parallels 40° and 40° 15′. The area of the quadrangle is about 227 square miles. It contains no large towns, but there are a number of small places, such as Flushing, Piedmont, Morristown, Belmont, and Bethesda, within it. The city of Barnesville is a little over 1 mile south of the quadrangle, near the southwest corner.

The entire surface of the quadrangle is deeply dissected. The divide separating the waters of Muskingum River from those flowing directly into Ohio River enters the quadrangle in the northeast corner, and extends southward through the eastern third of the quadrangle, passing through the towns of Flushing, Morristown, and Bethesda. East of this divide the topographic features differ materially from those on the west. The streams flowing to the east have a gradual slope at a nearly uniform rate to the eastern edge of the quadrangle; the streams flowing to the west have cut deep canyons nearly to their heads, thus descending to the general valley levels within a very short distance from their sources. Once at those levels they flow westward with very little fall. Between the streams are oval-shaped hills with steep sides. Throughout most of the area the rocks underlying the region are exposed through a vertical section from 300 to 400 feet thick. The surface is in a high state of cultivation and is traversed by roads in all directions.

The Cleveland, Lorain and Wheeling Railway (of the Baltimore and Ohio system) crosses the area from the center of the eastern margin to the northwest corner, and the main Baltimore and Ohio Railroad line passes through the southeast corner.

GEOLOGY.

ROCKS SHOWING AT THE SURFACE.

The rocks which outcrop at the surface of the Flushing quadrangle are included in the Washington, Monongahela, and Conemaugh formations of the Carboniferous system. From the highest to the lowest strata exposed the vertical distance is 740 feet. The base of the Pittsburg coal is accepted as a datum plane from which to commence descriptions and measure intervals. This well-known coal bed is constant over an area covering many square miles and therefore makes a desirable plane from which to reckon. The other members of the formations will be considered from this base, first the overlying and then the underlying beds, the peculiarities of each member being described and the areal distribution of its outcrop given.

MONONGAHELA FORMATION.

The Monongahela formation includes the rocks from the base of the Pittsburg coal to the top of the Waynesburg coal. The principal strata are the Pittsburg, Meigs Creek, Uniontown, and Waynesburg coal beds.

Pittsburg coal.—In this region the Pittsburg coal ranges in thickness from 40 to 62 inches, with an average of about 50 inches in the Flushing quadrangle. The bed is usually divided into three or four benches by small partings of half an inch or less in thickness. One parting is from 14 to 21 inches above the bottom and another about 4 inches higher. The coal is of good quality and generally mined both at local banks and commercial mines. This coal bed is present in most of the quadrangle. In Nottingham Township, Harrison County, it extends westward along the ridge to Prospect Hill. In Moorefield Township the last outcrop to the west is close to the village of Moorefield. In Flushing Township the most westerly outcrops are found on the ridge between Boggs Fork and Stillwater Creek half a mile west of Compher, and to the west of Stillwater Creek in the hills south and east of Oakgrove. Northwest of these last-named outcrops the coal dips to the southeast. It outcrops along the hillsides above Stillwater Creek to a point within a mile of Badgertown. On Boggs Fork and Trail Run the coal remains above water level to a point within a mile of the town of Flushing. East of the main dividing ridge this coal does not come to the surface except for about 2 miles on Crabapple Creek in Wheeling Township, Belmont County. At Laferty, on Wheeling Creek, the coal is about 80 feet below the surface.

Rocks between Pittsburg coal and Meigs Creek coal.—The lower portion of the interval between the Pittsburg coal and the Meigs Creek coal differs greatly in different localities. Normally, the Pittsburg coal is overlain by a few feet of shale extending to a hard blue limestone usually about 1 foot in thickness. Above the limestone is shale to the Pittsburg Rider coal, which is a small bed from 8 inches to 1 foot in thickness and from 24 to 30 feet above the base of the Pittsburg bed; it is, however, absent over the greater portion of the Flushing quadrangle. Above the Rider coal a second limestone stratum about 1 foot thick is found in many places. Above this is shale for 25 feet or more to a bed of smooth, light cream-colored limestone, from 1 to 2 feet thick, which is especially prominent in the southwest corner of Union, the northwest corner of Goshen, and the eastern side of Warren townships in Belmont County. From this limestone up to the Meigs Creek coal is sandy shale, in places merging into flaggy sandstone.

In a large part of the Flushing quadrangle the lower part of this interval, from the Pittsburg coal to the top of the limestone overlying the Rider coal, is represented by a massive buff sandstone of medium coarseness known as the Pittsburg sandstone. This bed generally commences on top of the coal and in some localities has replaced part of the coal bed. The sandstone is present in the western part of Cadiz Township, through Nottingham Township, and in the eastern part of Moorefield Township, in Harrison County; in the western part of Flushing Township, in Kirkwood Township to the west of Hendrysburg, and through the western part of Warren Township, in Belmont County.

Meigs Creek coal.—The Meigs Creek coal is equivalent to the Sewickley coal bed of Pennsylvania. Throughout a large part of the Flushing quadrangle this coal is of commercial importance, maintaining a thickness of about 4 feet. As a rule the coal is overlain by clay which is flinty in places and ranges in thickness from 8 inches to 2 feet. The clay is locally overlain by a small coal from 6 to 8 inches thick. The Meigs Creek coal maintains a commercial thickness through Athens Township, Harrison County; and in the eastern part of Flushing, the whole of Union, Goshen, Warren, and the southern part of Kirkwood townships, Belmont County.

The interval between the base of the Pittsburg coal and the top of the Meigs Creek coal was measured in 55 different places in the quadrangle, with the results shown in the following table:

Distance between base of Pittsburg coal and top of Meigs Creek coal.

Township.	Number of measurements.	Minimum interval.	Maximum interval.	Average interval.
Harrison County:		*Feet.*	*Feet.*	*Feet.*
Cadiz	4	86	100	94
Athens	7	86	106	96
Belmont County:				
East part of Flushing and Wheeling	7	85	96	91
Union	8	85	101	94
Goshen	1	95	95	95
West part of Flushing	4	99	101	100
North half of Kirkwood	8	95	102	101
South half of Kirkwood	8	94	113	103
Warren	8	101	109	105

Rocks between Meigs Creek coal and Uniontown coal.—The interval between the Meigs Creek and Uniontown coals is occupied by calcareous shale. In places the lower portion contains thin beds of a slabby white limestone which is the equivalent of that portion of the Benwood limestone known as the Dinsmore. Near the center of the interval is often found a bed of hard limestone about 1 foot thick. This bed is not constant enough, however, to make a good reference stratum. The rocks in the upper portion of the interval consist of shale, with here and there a bed of limestone a short distance below the Uniontown coal. In the vicinity and to the east of the town of Flushing the separate limestone beds are better developed than in other parts of the quadrangle.

Uniontown coal.—This coal, which is known as No. 11 of the Ohio series, has a thickness of 8 to 30 inches. It is best developed on Bend Fork south of Bethesda, where it has been mined in a small way. It is here 30 inches thick, with a 2-inch parting of shale 10 inches from the bottom and 1 inch of clay 24 inches from the bottom. The Uniontown coal appears in the high hills in the north part of Athens Township and thence south along the main dividing ridge. On the ridge south of Trail Run it extends westward to Rock Hill. It is generally present in Union, Goshen, Warren, and southern Kirkwood townships in Belmont County.

The distance from the Meigs Creek coal to the Uniontown coal was measured in 19 different places in the quadrangle, with results as shown in the following table:

Distance from top of Uniontown coal to top of Meigs Creek coal and to base of Pittsburg coal.

Township.	Number of measurements.	Meigs Creek coal.			Pittsburg coal—average interval.
		Minimum interval.	Maximum interval.	Average interval.	
		Feet.	*Feet.*	*Feet.*	*Feet.*
Harrison County:					
Cadiz	1	82	82	82	176
Athens	3	80	100	92	188
Belmont County:					
Flushing	4	89	99	95	[a] 186 [b] 195
Union	4	98	108	103	197
Goshen	1	96	96	96	196
Kirkwood	3	90	105	97	199
Warren	3	91	105	98	203

[a] East part. [b] West part.

Rocks between Uniontown coal and Waynesburg coal.—The section between the Uniontown coal and the Waynesburg coal is composed mostly of shale, which is sandy in the upper portion. Below the Waynesburg coal in many places is a limestone, above which is fire clay extending to the bottom of the coal.

Waynesburg coal.—The Waynesburg coal ranges from 20 to 40 inches in thickness and is best developed in the southeast corner of

Union Township and in Goshen Township. This coal is mined in a small way northwest and south of Belmont, where it has a thickness of about 40 inches, with a half-inch parting of shale 19 inches from the bottom.

The distance from the Uniontown coal to the Waynesburg coal was measured in 27 different places in the quadrangle, as shown in the following table:

Distance from top of Waynesburg coal to top of Uniontown coal and to base of Pittsburg coal.

Township.	Number of measurements.	Uniontown coal.			Pittsburg coal—average interval.
		Minimum interval.	Maximum interval.	Average interval.	
		Feet.	*Feet.*	*Feet.*	*Feet.*
Harrison County:					
Athens	2	35	40	37	225
Flushing	4	38	51	43	[a] 229 [b] 238
Belmont County:					
Union	7	36	61	49	246
Goshen	9	37	56	46	242
Kirkwood	1	38	....	(c)	245
Warren	4	47	63	59	262

a East part. b West part. c Goshen average used.

WASHINGTON FORMATION.

The Washington formation includes the rocks from the top of the Waynesburg coal to the top of the Upper Washington limestone. The well-marked strata which occupy this interval in Pennsylvania are not sufficiently developed in the Flushing quadrangle to be easily recognized. The only members positively identified are the Washington coal and the Upper Washington limestone.

Rocks between Waynesburg coal and Washington coal.—Overlying the Waynesburg coal is from 1 to 6 feet of shale, above which is the Waynesburg sandstone. This sandstone, which is of a light-brown color, occurs in layers from 6 inches to 2 feet thick, the combined layers having a total thickness of 15 to 20 feet. Above this is a sandy shale which extends to a bed of easily disintegrated limestone, with 6 to 8 inches of dark-colored fire clay above. The average distance of this clay above the Waynesburg coal is about 52 feet. It probably represents the horizon of the Waynesburg B coal of Pennsylvania. From the clay to the Washington coal is shale, with no distinctive features.

Washington coal.—The Washington coal is present in the southeast corner of the quadrangle, with a thickness of 1½ to 2 feet of solid coal underlain by 6 feet of very black shale. The northernmost outcrop in the quadrangle is in the hill at the crossroads 1½ miles northeast of Morristown. From this place it is found in the higher hills to the southeast and along the main dividing ridge as far west as Speidel, The distance between the Waynesburg and Washington coals was measured in seven different places in the quadrangle, with the results shown in the following table:

Distance from Washington coal to top of Waynesburg coal and to base of Pittsburg coal.

Township.	Number of measurements.	Waynesburg coal.			Pittsburg coal—average interval.
		Minimum interval.	Maximum interval.	Average interval.	
		Feet.	*Feet.*	*Feet.*	*Feet.*
Belmont County:					
Union	2	99	101	100	345
Goshen	5	89	98	92	334

Rocks between Washington coal and Upper Washington limestone.—The rocks lying between the Washington coal and the Upper Washington limestone are present in the Flushing quadrangle only in the high ridges to the south of the Baltimore and Ohio Railroad. They consist mostly of shale, with one or two limestone beds which could not be identified owing to their poor development and their small area of outcrop.

Upper Washington limestone.—The Upper Washington limestone occurs in the tops of the high ridge in the southeast corner of the quadrangle. It is a double bed, each section of which is about 1 foot thick. Two measurements of the distance of this bed above the Washington coal were obtained, both of which show the interval to be 160 feet. This makes the Upper Washington limestone 494 feet above the base of the Pittsburg coal. This limestone is the highest reference stratum in the quadrangle.

CONEMAUGH FORMATION.

The Conemaugh formation lies below the Pittsburg coal, extending from the base of that bed to the top of the Upper Freeport coal. It contains the Pittsburg, Ames, and Cambridge limestones, all of which are easily identified and can be used as reference strata. Besides these are some local coal and limestone beds, which are available as guides to the geology over small areas. In describing the members of the Conemaugh formation the order of considering the members is reversed, the highest or those nearest the Pittsburg coal being considered first. The distances are computed from the same datum plane (the base of the Pittsburg coal), being, however, down instead of up.

Pittsburg limestone.—The Pittsburg limestone ranges from 1 to 4 feet in thickness. Where the greater thickness is present it is divided into two beds. Its position ranges from a few inches to 25 feet below the base of the Pittsburg coal. Normally there is a foot of fire clay under the coal, with the limestone next below. In many places, however, the limestone is next to the coal and the fire clay below the limestone.

Where the interval between the coal and limestone is 20 feet or more, it is occupied by fire clay and shale.

The distance from the base of the Pittsburg coal to the top of the Pittsburg limestone was measured in 12 different places in the quadrangle, with the results shown in the following table:

Distance from top of Pittsburg limestone to base of Pittsburg coal.

Township.	Number of measurements.	Minimum interval.	Maximum interval.	Average interval.
Harrison County:		*Feet.*	*Feet.*	*Feet.*
Cadiz	3	14	20	17
Belmont County:				
Flushing	1	16	16	16
Kirkwood	6	0	29	14
Moorefield	2	0	1	1

Rocks between Pittsburg limestone and Ames limestone.—The rocks between the Pittsburg limestone and the Ames limestone consist mostly of sandy shale and sandstone. In the vicinity of Cassville, in the western part of Cadiz Township, Harrison County, is a bed of hard limestone with a rough surface, showing on fracture a conglomerate of small particles of limestone, ranging in color from light buff through brown to red. This rock carries a small percentage of iron, which gives a red color to the mud formed when the rock is disintegrated. By two measurements in Cadiz Township this rock was found to be 79 and 96 feet below the Pittsburg coal; two in Nottingham Township gave 72 and 74 feet below the coal; and two in the western part of Flushing Township gave 44 and 58 feet below the coal. The average of all measurements is 70 feet, but the result is not satisfactory, owing to the great variation of the measurements in the different sections.

In Cadiz and Athens townships a coal or black shale 1 foot thick occurs in the interval of 145 feet below the Pittsburg coal. In Moorefield and western Flushing townships this interval is only 115 feet, as determined by the average of five measurements.

In the lower part of the interval between the Pittsburg limestone and the Ames limestone is a massive sandstone from 15 to 30 feet thick. Its base is usually from 10 to 12 feet above the Ames limestone, but in many places the sandstone lies directly above the limestone or has entirely replaced it.

Ames limestone.—The Ames limestone is a bed of hard, green limestone from 1 to 3 feet thick. It contains many fossil crinoid stems and brachiopods, these fossils being most plentiful in the upper portion of the bed. The distance from the base of the Pittsburg coal to the Ames limestone was measured in 13 different places in Flushing, Moorefield, and Kirkwood townships. Eleven of these measurements show an interval ranging from 161 to 176 feet, with an average of 171 feet. Two other measurements show distances of 185 and 147 feet. The average of all measurements is 168 feet.

Rocks between Ames limestone and Cambridge limestone.—The rocks between the Ames limestone and the Cambridge limestone are fully exposed only in the northwest corner of the quadrangle. In order to measure the distance between these two beds of limestone, levels were run a mile or so west of the quadrangle, where outcrops of both beds were crossed. The result of these measurements shows a distance of 74 feet between the two limestones, with a coal 18 feet above the Cambridge. This coal is from a few inches to 2 feet in thickness, and it has been mined in a small way in the northwest quarter of the quadrangle.

Cambridge limestone.—The Cambridge is a dark-gray limestone, weathering to a light yellow. It contains many fossil brachiopods and a few crinoid stems. The distances from the Cambridge coal and the Cambridge limestone to the Pittsburg coal are accepted as 227 and 245 feet, respectively.

Mahoning sandstone.—The top of the Mahoning sandstone, a coarse, buff, massive rock, appears in the northwest corner of the quadrangle. It attains a thickness of about 40 feet just west of the quadrangle boundary. Directly under the Mahoning sandstone is the Upper Freeport coal, which is not exposed in this quadrangle, but is worked along Stillwater Valley just beyond the west side.

ROCKS WHOLLY BELOW THE SURFACE.

The subsurface rocks to be considered are those extending down to and including the Berea sandstone. Knowledge of these rocks is obtained only from the logs of wells. Only a few detailed records were obtained from the wells in the Flushing quadrangle, and these few do not agree with each other closely enough to furnish a description of the rocks. The following are some of the best records obtained:

Log of well[a] (No. 13) on the Margaret Dunlap farm, in Moorefield Township, Harrison County.

	Thickness.	Distance below mouth of well.	Distance below base of Pittsburg coal.
	Feet.	*Feet.*	*Feet.*
Shale, red	61	0	140
Shale, gray	119	61	201
Coal, small bed	2	180	320
Shale	395	205	345
Sand (filled with water)	60	600	740
Shale, soft, dark	140	660	800
Sand, Big Injun	235	800	940
Shale	357	1,035	1,175
Sand, hard, Berea (water)	24	1,392	1,532

[a] Mouth of well, 943 feet above sea. Base of Pittsburg coal at well, 1,083 feet above sea.

Log of well[a] *(No. 42) on the Abner Lodge farm in Union Township, Belmont County.*

	Thickness.	Distance below mouth of well.	Distance below base of Pittsburg coal.
	Feet.	*Feet.*	*Feet.*
Coal, Meigs Creek	4	25	[b] 97
Limestone	87	29	[b] 93
Coal, Pittsburg	5	117	[b] 5
Shale	5	112	0
Limestone	113	127	5
Sand	45	240	118
Shale	375	285	163
Coal, Upper Freeport	6	660	538
Shale	66	666	444
Coal	10	726	604
Shale	104	736	614
Sand	50	840	718
Shale	50	890	768
Sand, Salt sand	60	940	818
Shale	25	1,010	888
Sand and broken shells	20	1,035	913
Shale, black	10	1,055	933
Sand, Big Injun	225	1,065	943
Shale	59	1,290	1,168
Limestone	240	1,349	1,227
Shale	35	1,589	1,467
Shale, brown	11	1,624	1,502
Sand, Berea	35	1,635	1,513

[a] Mouth of well, 1,106 feet above sea. Base of Pittsburg coal at well, 984 feet above sea.
[b] Above base of Pittsburg coal.

Log of well[a] *(No. 53) on the Albert Romans farm in Londonderry Township, Guernsey County.*

	Thickness.	Distance below mouth of well.	Distance below base of Pittsburg coal.
	Feet.	*Feet.*	*Feet.*
Limestone, Ames	3	23	171
Coal	6	226	374
Sand, white	6	320	468
Coal	4	332	480
Sand, white	35	336	484
Coal	3	446	594
Sand (with salt water)	12	458	606
Coal	5	485	633
Sand, gray	20	490	638
Sand, Hurry-up	40	545	697
Sand (show of oil; water at 720 feet)	66	654	802
Sand	20	840	988
Shale	37	860	1,008
Sand, gray (show of oil)	20	897	1,045
Shale, black	39	917	1,065
Sand, Big Injun	89	956	1,104
Sand, Berea	37	1,407	1,555

[a] Mouth of well, 1,164 feet above sea. Base of Pittsburg coal at well, 1,312 feet above sea.

Log of well[a] *(No. 67) on the P. E. Calhoun farm in Londonderry Township, Guernsey County.*

	Thickness.	Distance below mouth of well.	Distance below base of Pittsburg coal.
	Feet.	*Feet.*	*Feet.*
Sand	15	10	214
Shale, red	10	25	229
Shale, white	15	35	239
Shale, red	5	50	254
Limestone, blue	41	55	259
Coal	2	96	300
Limestone, white	27	98	302
Shale, red	20	125	329
Limestone	30	145	349
Shale, black	50	175	379
Limestone, white	25	225	429
Coal	3	250	454
Shale, white	25	253	457
Sand	10	278	482
Shale, black	12	288	492
Shale, white	15	300	504
Limestone, white	30	315	519
Sand, white	25	345	549
Shale, black	15	370	574
Limestone, black	15	385	589
Sand, white	20	400	604
Shale, black	10	420	624
Limestone	50	430	634
Shale, black	15	480	684
Sand, white	45	495	699
Shale, black	47	540	744
Limestone	53	587	791
Sand, white, Keener	90	640	844
Shale	30	730	934
Sand, Big Injun	200	760	964
Shale	40	960	1,164
Limestone	65	1,000	1,204
Shale	110	1,065	1,269
Sand and shale	37	1,240	1,444
Shale, black	33	1,277	1,481
Sand, Berea	19	1,310	1,514

[a] Mouth of well, 1,025 feet above sea. Base of Pittsburg coal at well, 1,229 feet above sea.

Log of well[a] *(No. 98) on the F. M. Taggert farm in Union Township, Belmont County.*

	Thickness.	Distance below mouth of well.	Distance below base of Pittsburg coal.
	Feet.	*Feet.*	*Feet.*
Shale	89	21	[b] 188
Coal, Meigs Creek	5	110	[b] 99
Limestone and shale	90	115	[b] 94
Coal, Pittsburg	4	205	[b] 4
Limestone and red shale	430	209	0
Shale, white and black	60	639	430
Shale, brown	40	699	490
Sand, gray, First Cow Run	55	739	530
Shale	112	794	585
Sand, Second Cow Run	107	906	697
Shale, black	12	1,013	804
Sand	40	1,025	816
Limestone and shale	61	1,065	856
Sand, Keener (show of oil and gas)	40	1,126	917
Shale, white	5	1,166	957
Sand, Big Injun	237	1,171	962
Shale	60	1,408	1,199
Limestone and shale	272	1,468	1,259
Sand, Berea (salt water)	28	1,740	1,531

[a] Mouth of well, 1,193 feet above sea. Base of Pittsburg coal at well, 984 feet above sea.
[b] Above base of Pittsburg coal.

RESULTS OF THE WORK.

OBJECT.

The object of the work in the Flushing quadrangle was to produce a map of the Berea oil sand with as great a degree of accuracy as was possible from the geologic conditions, and with sufficient detail to make it of value to the practical oil man in the location and development of oil and gas territory.

In work of this character there are two conditions which govern the accuracy of the final result. These are (1) the degree of parallelism that exists between the outcropping strata and the oil sand, and (2) the regularity of the variation in the distance between these beds.

SUBSURFACE MAPPING.

GENERAL STATEMENT.

The mapping of a subsurface stratum consists of three distinct steps: First, it is necessary to find the elevations of the outcrops of different known strata; then, having determined the average distance and the variations in this distance between these strata, by combining these data to prepare a contour map showing the geologic structure of some prominent stratum called a key rock.

Second, by means of the measured depth to the oil sand from the mouths of test wells already drilled, to determine by leveling to these wells the distances in different parts of the area between the key rock and the oil sand it is proposed to map.

Third, by means of a mechanical drawing called a convergence sheet to correct for the variations in distances between the key stratum and the oil sand in different parts of the area, and then to project the elevations obtained upon the key horizon, thereby determining the correct elevation of the oil sand.

BASE MAP.

The first requisite in this work is a good topographic base map upon which to indicate the horizontal locations of the outcrops of different strata. The base map of the Flushing quadrangle is the topographic atlas sheet surveyed in 1903 by the United States Geological Survey. On this map were located in horizontal position the outcrops of the different strata. The elevation of the outcrops at each of these points was obtained by a spirit level which was run from permanent bench marks established by the topographic engineers. For this work the level lines were carried over all roads, up a great many streams, and along a number of ridges. In this way the elevations of the outcrops all over the quadrangle were obtained.

MEASUREMENT OF INTERVALS.

The intervals between the different surface strata were obtained by comparing the elevation of outcrops of different strata where they are near together and where the elevation of the outcrop of one stratum could be compared with the elevation of two outcrops of another stratum on different sides of the first. In this way a great many comparisons were made, and the average distance between the beds in the different townships was obtained. The results of this work have been given under the heading "Geology." In considering these results with a view to determining what degree of accuracy can reasonably be expected in the structure map of the key horizon, it is found that out of 51 measurements of the distance between the Meigs Creek coal and the Pittsburg coal, when averaged by townships, the minimum and maximum in each township are within 10 feet of the average, and that the range is usually nearly 20 feet when a number of measurements are taken. The same condition holds for the distances between the prominent beds above the Meigs Creek coal. The Pittsburg limestone, whose distance below the Pittsburg coal is from a few inches to 29 feet, has the same range of variation as the strata at distances of 200 or 300 feet from the Pittsburg coal. This indicates that there is a local divergence from parallelism between the different strata of about 20 feet, that the average distance between strata over small areas will give results that are probably correct within 10 feet, and closer accuracy than this is not to be looked for.

The distance of 171 feet between the Pittsburg coal and the Ames limestone in the northwest quarter of the Flushing quadrangle is believed to be very nearly correct. This probably diminishes from the south and east toward the northwest. The measurements of this interval made in the central and western parts of the Cadiz quadrangle ranged from 205 to 230 feet. The determination of the distance from the limestone bed lying between the Pittsburg limestone and the Ames limestone to the Pittsburg coal is poor. All measurements show this interval to vary abruptly from east to west. The position of the Cambridge limestone and the coal above it with reference to the Ames limestone was determined at only a few places, but the measurements so obtained are believed to be good.

SURFACE STRUCTURE MAP.

As the Pittsburg coal is the most prominent outcropping stratum in the quadrangle, its base is accepted as the key horizon by which the structure of the surface rocks is represented. The elevation of the outcrops of this horizon were determined wherever possible directly with a spirit level. To the determined elevation of every other outcropping horizon was added or subtracted the average distance of that particular horizon below or above the base of the Pittsburg coal in that township. This resulted in establishing the elevation of the Pittsburg coal at nearly 900 locations. The points of equal elevation were connected by lines, thus forming a contour map of the bottom surface of the Pittsburg coal (Pl. I). Data for making the surface structural map are plentiful in all parts of the Flushing quadrangle, except in a portion of Moorefield and Freeport townships, Harrison County. In the area to the north and west of the village of Piedmont the Ames limstone seems to be absent. It is probable that the sandstone whose base is normally from 10 to 12 feet above the Ames limestone has descended and cut out the limestone. The absence of this important stratum leaves the limestone between the Pittsburg limestone and the Ames limestone and a few outcrops of what is believed to be the Cambridge coal as the only beds from which to determine the structure. The scarcity of information has made it impossible to draw contours with any degree of accuracy in this area.

STRUCTURAL FEATURES.

The structural features represented on Pl. I are not pronounced but rather monotonous. The dip of the rocks is to the southeast with but little irregularity. The most prominent feature is the structural dome at Smyrna. Here the Pittsburg coal if it had not been eroded would lie at an elevation of about 1,300 feet, or 60 feet above the surface. Due east from this dome is a steep dip of about 160 feet. This is the steepest dip found for any considerable distance in the quadrangle. From the Smyrna dome an anticlinal ridge extends to the southeast, falling away at a steep angle into a synclinal trough on the south. A second dome of lesser magnitude exists just north of the town of Fairview.

A structural feature that is important, though not prominent, is the anticlinal ridge which commences in the northwest corner of the quadrangle, swings a little to the south and thence trends northeast, leaving the quadrangle a little east of the center of the northern boundary. The western portion of this ridge shows a drop of about 60 feet to the northeast into a basin on the north edge of the quadrangle. The geologic evidence regarding the depth of this basin is not of the best, as nothing but outcrops of what is believed to be the Cambridge coal were found within the area. This coal is known to dip as represented by the contours. This dip, however, may not coincide with the dip of the adjacent rocks. The northern dip from the anticlinal ridge farther to the east is more positively established by elevations on the Ames limestone and the Pittsburg coal, some of which are north af the quadrangle. The dip is slight, however, being in all not over 20 feet. In Athens Township, Harrison County, a secondary fold exists to the south of the main anticlinal ridge. The northward dip from this fold is very slight, being in places less than one contour interval.

The remaining noticeable feature of the quadrangle is a slight dome 2 miles northeast of Flushing, whose northwesterly dip is over 20 feet. The existence of this feature is established by elevation on both the Meigs Creek and the Uniontown coal.

CONVERGENCE SHEET.

With the surface structure defined by the elevations of the Pittsburg coal as shown on Pl. I, the next step was to determine the amount to be subtracted from each elevation to make it equivalent to an elevation on the top of the Berea sand. This information was gained from wells already drilled within the area. The quadrangle was carefully searched for any existing wells or previously drilled dry holes and it is believed that all the test wells drilled prior to the date of the survey are represented on the map of the Berea sand. The elevation of the mouth of each well was obtained by spirit level. With this information the position of the key horizon with reference to the mouth of the well is obtained from Pl. I, and by a slight calculation the distance from the key horizon to the oil sand is obtained from the record of the well. The records of 28 wells on or adjacent to the quadrangle were obtained. From these records was built up the convergence sheet, which is constructed by connecting the positions of the different test wells by straight lines and then dividing these lines so that each subdivision represents the horizontal distance in which the vertical interval between the Pittsburg coal and the Berea sand decreases or increases 10 feet. The distance from the base of the Pittsburg coal to the top of the Berea sand was found to range from 1,464 feet to 1,613 feet, the lesser interval being along the north edge and the greater near the southwest corner of the quadrangle The interval does not increase regularly, however, but ranges from 1,464 to about 1,540 feet in the north third of the quadrangle, decreases to a little over 1,500 feet in the central part, and then increases at a uniform rate to the maximum distance at the south edge. A large area in the center of the quadrangle is devoid of any drilled well from which a record could be obtained. The assumption of an even increase or decrease over distances as great as those between some of the wells from which the convergence sheet of the Flushing quadrangle is made up is undesirable, but could not be avoided.

MAP OF THE BEREA OIL SAND.

With the previously described work performed, the construction of the map of the oil sand is very simple. The convergence sheet shows the amount to be subtracted from each elevation of the key horizon.

This amount in the Flushing quadrangle was in all cases greater than the elevation of the key horizon, showing the oil sand to be everywhere below sea level. To avoid the use of the minus sign in numbering the contours of the oil sand, 2,000 feet were added to each elevation of the key horizon. This is equivalent to assuming a datum plane 2,000 feet below sea level for the map of the oil sand. After subtracting the amount shown in the convergence sheet from each elevation of the key horizon, the points of equal elevation were connected by lines. The result is a contour map of the Berea oil sand as shown in Pl. II, on which the upper surface of the limestone cap of the Berea sandstone is represented by contours printed in red. The elevations of these contours are shown by numbers figured from a datum plane 2,000 feet below sea level. All wells known to have been drilled prior to the date of survey are also shown in red with accepted symbols for dry holes, gas wells, and oil wells. Wells known to have been drilled only to some of the upper sands are marked with a cross to the left of the well symbol.

FACTORS GOVERNING THE ACCUMULATION OF OIL AND GAS.

Previous work of this kind has demonstrated that there are three primary factors which govern the accumulation of oil in the rocks. These are (1) the condition of the rocks as to porosity, (2) the area of complete saturation by water of the oil-bearing stratum, and (3) the geologic structure of the rocks.

POROSITY.

The condition of many of the sands changes within short distances from loose and porous sands to closely cemented hard rocks entirely impervious to oil and water in large quantities. Some sandstone beds are of the same texture over large areas, both as to the size of the solid particles forming them and as to the matrix which combines the separate grains. In others, although the size of the separate grains remains relatively the same, the cementing material changes from place to place and in this way the relative porosity of the rock is changed. Some sandstone beds contain lenses of conglomerate in which the separate particles are of considerable size, loosely held together, thus forming a condition of great porosity. A knowledge of the general characteristics of a particular sandstone bed is gained only by test wells. In the Appalachian oil field the peculiarities of the principal oil-bearing sands are pretty well known.

SATURATION.

The condition of saturation with water is not the same in different sands. Experience has shown that the older or lower beds in the Appalachian field contain a smaller area of completely saturated rock than the upper or younger sands. The lowest sands seem to be almost entirely dry, only the very lowest points in the center of a structural basin showing any considerable quantity of salt water. Above these lower rocks each succeeding stratum of sandstone has a larger area in which it is saturated with water. In regions where the sand rock is not entirely saturated there may be separate areas of saturated rock in each structural basin, the upper limits of which are at the same elevation in any one basin but at different elevations in different structural basins.

STRUCTURE.

The effect of geologic structure on the accumulation of oil depends on the condition of saturation of the oil-bearing stratum.

If small quantities of oil and gas are in a dry, porous rock at different points the oil will move down as long as the slope is sufficient to overcome friction and capillary attraction. The gas will diffuse with the air or water vapor contained in the pores of the rock.

Oil and gas in a porous rock that is completely saturated with water will first be forced up to the top of the porous stratum by the difference in the specific gravity of the oil and the water. The oil and gas will accumulate in the upper part of the rock if the porous stratum is level, but if it dips sufficiently to overcome friction the particles of oil and gas will gradually be forced up the slope, the gas with its much lower specific gravity occupying the higher places.

In places where the porous rocks are only in part completely saturated a combination of these two actions will take place. The oil above the line of complete saturation will run down to that line and the oil below will be forced up to the top of the completely saturated portion.

The sand spoken of as porous may not be so at all points. If in some areas it is impervious, those areas will tend to limit the movement of the oil and gas through the rock. Although a short distance away the same stratum may be porous, it must from an oil standpoint be considered a separate and distinct porous body, unless the area of impervious rocks is so situated that the oil can readily move laterally around it.

PLACES OF ACCUMULATION.

In dry, porous rocks the principal points of accumulation of oil are at the bottom or near the bottom of the synclines, at the lowest points of the porous medium, or at any points where the slope of the rock is not sufficient to overcome capillary attraction and friction, such as structural terraces or benches. In porous rocks that are completely saturated the accumulation of both oil and gas will be in the anticlines or along level portions of the structure. In completely saturated rocks of small area the accumulation should occur at the highest point of the porous medium, and where stops or dams of impervious rocks exist in a generally porous stratum the accumulation should occur below such impervious stop, which is really the top limit of the porous rock. In porous rocks that are only partly filled with water the oil accumulates at the top limit of the saturated area. This point may be anywhere with reference to the anticlines and synclines.

The condition most generally found is that the rocks are saturated only in a portion of their volume, in which case accumulations of oil may occur anywhere with reference to the geologic structure, though they are more likely to be on terraces or levels, as these points are favorable to accumulation in both dry and saturated rocks.

Under all conditions the most probable location for the accumulation of gas is in an anticline, though small folds along the side of a syncline may capture and hold a supply of gas, or the rocks may be so close-grained that gas can not travel to the anticline, but must remain in greatest volume close to the oil accumulation.

CONDITIONS IN THE FLUSHING QUADRANGLE.

SATURATION OF BEREA SAND.

In the Flushing quadrangle the Berea sand lies in the same structural basin as in the southeastern half of the Cadiz quadrangle. In that portion of the Cadiz quadrangle it was found to be completely saturated to an elevation of about 270 to 280 feet below sea level. This is equivalent to an elevation of 1,720 to 1,730 feet, as the contours on the Flushing quadrangle are numbered. This is higher than any portion of the sand in the Flushing quadrangle, except a very small area on top of the Smyrna anticline. The conditions, therefore, to be considered in this area are those of complete saturation. Under these conditions the oil should accumulate just below the gas on the crest of the anticlinal ridges and upon terraces at the top of steep breaks.

EXISTING OIL POOLS.

Only three oil pools have been discovered in the Flushing quadrangle. The Uniontown pool, in Wheeling Township, on the east edge of the quadrangle, extends eastward into the St. Clairsville quadrangle for a short distance. This pool is located on a large structural flat or terrace, only a small portion of which is covered by it. The pool appears to be well defined within the quadrangle by dry holes. To the southeast the structure shows a descent of about 40 feet. This is not favorable for the accumulation of oil unless a steep slope of some magnitude exists in the St. Clairsville quadrangle.

In the southwestern portion of the quadrangle is the north end of the Barnesville pool. This accumulation is on a slope as shown by the contours. From the separate well records, however, a very narrow terrace can be recognized. The direction of the pool is along the strike of the rocks for 1 to 2 miles to the south and then to the west, the elevations of the sand differing by only a few feet in all wells where oil was found.

The third pool in the quadrangle is at Oakgrove. This is the only accumulation so far discovered in the quadrangle that could have been foretold by a knowledge of the structure prior to the drilling of the wells. The location of the pool is upon a flat near the top of the Smyrna anticline. All wells so far developed are small, and a number of dry holes are close to the producing wells. The wells are not in the best theoretical location for large production. The eastern side of the anticline along the Guernsey-Belmont county line in secs. 32 and 33 appears to be the most favorable territory from a structural standpoint. From this point to the east is a strong dip of 160 feet. Near the top of this slope is the theoretical location for oil accumulation. The flat on the structural nose in the southern part of sec. 31, Flushing Township, Belmont County, looks favorable and is certainly worthy of a test well.

TERRITORY FAVORABLE FOR NEW DEVELOPMENT.

North of the village of Fairview, in the northern part of sec. 2, Oxford Township, Guernsey County, is a structural dome in which there is probably an accumulation of both oil and gas.

North of Morristown is a very low dome, including all of sec. 21, Union Township, Belmont County. The position of this dome is established by elevations on a number of the upper coal beds. It is probable that this feature extends down to the Berea sand. If the map is a true representation of the oil sand, this dome is a favorable point for both oil and gas. On its western side a number of wells have been drilled which produced gas from the upper sands. Wells Nos. 81 and 98 were drilled to the Berea sand and reported dry. They should not, however, condemn the entire area.

In the northern part of sec. 10 and southern part of sec. 11, Athens Township, Harrison County, is represented an anticlinal dome whose northern dip is 20 feet or more. This feature is established by levels on the Meigs Creek coal. The conditions as represented should be favorable for both oil and gas.

Along the north edge of the quadrangle, in secs. 1, 3, and 8 of Nottingham Township, Harrison County, is an anticline, and to the south of this ridge near Cassville is a second anticlinal fold. These features, are not prominent, but they are important owing to the slight northward dip of the formation. This northward dip is well established by levels on the Pittsburg and Meigs Creek coals. The main or northern anticline is a direct extension from the Moholland oil pool, which lies 1 mile to the northeast in the Scio quadrangle. This pool was discovered and partly developed during the summer of 1906. The crest of the anticline through the sections mentioned is favorable territory. The secondary anticline to the south is detrimental to the chances of oil on the main ridge, as its own dome may have trapped the oil.

WELLS IN THE FLUSHING QUADRANGLE.

The following table sets forth such information as was procured about the wells drilled in the Flushing quadrangle. It states in concise form the owner of the land on which the wells were drilled; the number of them; the person by whom they were drilled; the elevations of their mouths above sea level; the distance from their mouths to the top of the Berea sand, and their total depths. The reference numbers of the wells correspond to those given on the map (Pl. II).

List of wells in the Flushing quadrangle:

No. on Pl. II.	Owner of land.	Number of wells.	Well drilled by—	Elevation of mouth.	Depth to Berea sand.	Total depth.	Remarks.
				Feet.	*Feet.*	*Feet.*	
1	H. S. Barricklow	1	Rankin Gas Co	1,015	1,415	1,480	Gas and small show of oil in Berea sand.
2	....do	2	....do	1,035			Gas in Cow Run sand.
3	....do	1	Rich Oil and Gas Co	1,074	1,470	1,524	Dry.
4	W. K. Scott	1	Rankin Gas Co	1,004		704	Gas in Cow Run sand.
5	Mary Rankin	1	....do	979	1,376	1,417	Gas in Berea sand.
6	R. K. Dunlap	2	....do	981	1,372		
7	W. F. Dunlap	1	....do	1,020	1,416	1,477	Little gas.
8	J. F. Dickerson	1	....do	971	1,388		Dry (no water).
9	John D. Barricklow	1	Hedge & Holmes	1,096			Dry.
10	S. M. McDowell	1	W. D. Black & Co	1,054	1,447	1,499	Dry (no water).
11	M. A. Johnson	1	....do	1,011	1,432	1,478	Dry (no water); show of oil.
12	S. M. McDowell	2	....do	1,062	1,488		Dry.
13	Margaret Dunlap	1	....do	943	1,392	1,437	Little water.
14	Samuel Richey	1	Charles Schoenfield	1,068			Small show of oil and gas.
15	W. F. Dunlap	1	W. D. Black & Co	1,077	1,517	1,562	Salt water.
16	R. N. Birney	1		1,131			
19	Sarah J. Lyle	2	National Oil Co	1,200	1,718	1,742	Producer.
20	Josiah Beall	3	....do	1,216	1,728	1,758	Do.
21	....do	2	....do	1,226	1,738	1,765	Do.
22	....do	4	....do	1,170	1,690	1,712	Do.
23	Sarah J. Lyle	1	....do	1,145	1,657	1,680	Do.
24	Josiah Beall	1	....do	1,181	1,691	1,721	Do.
25	Clark Boyd	1	....do	1,120	1,637	1,661	Do.
26	—— Lee	9	....do	1,175	1,678	1,706	Do.
27	M. L. Richey	4	....do	1,129	1,658	1,672	Small producer.
28	....do	2	....do	1,157	1,670	1,691	Producer.
29	....do	1	....do		1,598	1,611	Do.
30	....do	3	....do	1,235	1,749	1,795	Salt water.
31	Sarah Lee	8	....do	1,077			Producer.
32	....do	7	....do	1,041	1,568	1,590	Do.
33	....do	3	....do	1,060	1,589	1,608	Do.
37	....do	6	....do	1,006	1,530	1,549	Do.
41	James Lyle	1	....do	1,125	1,650	1,677	Salt water.
42	Abner Lodge	1	....do	1,106	1,635	1,700	Do.
43	Elizabeth Lyle	1	R. D. Gillespie	1,223	1,742	1,770	Do.
44	....do	1	Russell & Bush	1,125	1,653	1,687	Salt water; show of oil.
45	William Walker	1		1,099			Dry.
46	Robert Campbell	1		1,110		1,680	Salt water.
47	John Hazen	1	Freehold Oil and Gas Co	1,123	1,660	1,699	
48	John Brokaw, sr	1		1,128	1,635		Do.
49	Byron Cochran	1		1,044			

List of wells in the Flushing quadrangle—Continued.

No. on Pl. II.	Owner of land.	Number of wells.	Well drilled by—	Elevation of mouth.	Depth to Berea sand.	Total depth.	Remarks.
				Feet.	*Feet.*	*Feet.*	
50	Jane Moore		Gilbert & Co	992	1,370	1,408	Salt water.
51	Harrison Howell	1	do	952	1,352	1,400	Do.
52	R. W. Scott	1		896			Do.
53	Albert Romans		Piedmont Oil and Gas Co	1,164	1,407	1,444	Do.
54	William Greenfield	1	Elk Creek Oil and Gas Co				Show of oil.
55	do	1	Piedmont Oil and Gas Co				Do.
56	O. B. Hibbs	1	do	1,018	1,274	1,296	Small well.
57	do	1	D. F. Conley	1,139	1,391	1,410	Do.
58	do	2	do				Small well; show of oil.
59	do	1	Oak Grove Oil Co	1,085	1,336	1,352	Producer.
60	do	2	do	1,135	1,385	1,405	Do.
61	C. J. Hibbs	1	Piedmont Oil and Gas Co				Salt water.
62	do	1	Davis & Goodman		1,410	1,436	Do.
63	William Kirk	1	Allegheny Oil and Gas Co				Do.
64	William Greenfield	1	do				
65	William Kirk	1	Oak Grove Oil Co	1,006	1,260	1,282	Producer.
66	George Clay	1	Piedmont Oil and Gas Co				Salt water.
67	Jobe Reynolds	1	P. E. Calhoun	1,025	1,310	1,369	Little salt water.
68	Harrison Mills	1	H. G. Twiker	941	1,460	1,504	Salt water (record poor).
69	L. B. Bethel	1		884			Salt water.
70	Jos. Barclay	1		906	1,230	1,264	Do.
71	Ellis Fulton	1	J. S. Wilson	906			Do.
72	Eliza Wilson	1	American Oil and Development Co	1,164	1,521	1,545	Small amount of salt water.
73	W. W. McKebben	1	New York Oil and Gas Co	998	1,365	1,414	
75	R. K. Dunlap	1		1,020	1,427	1,482	
76	A. J. Rea	1	W. D. Black & Co	993	1,338	1,402	Dry.
77	Rebecca White	1	Flushing Co	1,082			Salt water.
80	William Sheppard	2	Rich Gas Co				Gas in Big Injun sand (shallow well).
81	do	1	do				Salt water in Berea sand.
82	Albert Schlentz	1	do				Gas in Keener sand.
83	J. H. Majors	3	do				Gas in Big Injun sand (shallow well).
84	do	1	do	1,143			Gas in Keener sand (shallow well).
85	do	2	do				Gas in Salt sand (shallow well).
86	Jos. Sheppard	1	do			1,022	Gas in Keener sand (shallow well).
87	do	2	do				Salt water in Keener sand (shallow well).
88	James Barber	1	do				Gas in Salt sand (shallow well).
89	do	2	do				Salt water in Big Injun sand (shallow well).
90	do	3	do				Gas in Salt sand (shallow well).
91	Jos. Easton	1	Morristown Oil and Gas Co	1,157			Salt water in Berea sand; gas in Keener sand.
92	do	1	St. Clair Oil and Gas Co	1,159			Gas in Keener sand.
93	Arthur Brown	1	do	1,100			Salt water in Keener sand.

94	....do	1	Ann Oil Co	1,251			Salt water in Berea sand.
95	E. Pratt	1	St. Clair Oil and Gas Co	1,215			Gas in Keener sand.
96	Sarah Jeffrey	1	Ann Oil Co	1,087			Small show of oil and water in Keener sand.
97	Lincoln Lynn	1	St. Clair Oil and Gas Co	1,265			Salt water (shallow well).
98	F. M. Taggert	1	Morristown Oil and Gas Co	1,193	1,740	1,768	Salt water.
99	George Dallas	1	Rich Gas Co				Salt water in Keener sand (shallow well).
100	J. D. Sheppard	1	St. Clair Oil and Gas Co	934			Do.
101	David Majors	1	....do				Salt water in Salt sand (shallow well).
102	I. N. Roby	1	....do	932			Gas in Keener sand; salt water in Berea sand.
103	O. C. Ayers	1	....do	933			Gas in Salt sand (shallow well).
104	James Taggert	1	....do	1,002		744	Gas in Salt sand.
105	Theo. Burgess	1	Haycock & Co	973			
106	Willard Hyde	1	Ann Oil Co	1,010	1,582	1,610	Dry.
107	T. Y. Johnson	1	....do	1,142			
108	L. K. Russell	1		1,011			Show of oil in Berea sand.
109	John Walker	1	Ann Oil Co	1,119	1,702	1,750	Dry.
110	Jos. Patterson	1	....do	1,231	1,720	1,730	
111	Martha Brown	1	....do	1,237		1,234	Keener sand at 1,219 feet; salt water.
112	Ann Tidball	1	Hughes & Guffey	948			
113	Henderson Griffin	2	N. D. Goe	1,089			Salt water.
114	J. D. Saltsgaver	3	P. E. Calhoun	1,092		1,598	Do.
115	Benjamin Giffie	1	Andy Crowl	952			
116	....do	2	N. D. Goe	943			
117	....do	3	Andy Crowl	1,002			
118	A. J. Wheaton	1	P. E. Calhoun	1,201			Salt water in Berea sand.
119	John McCormick	1	Husband & Inskep	1,072			Do.
120	James Wilkin	1	P. E. Calhoun	1,163			Dry in Berea sand.
121	Charles Rice	1		1,089			Shallow well.
122	Louis Palmer	1	St. Clair Oil and Gas Co	1,085			Shallow well (water).
123	Jos. Heed	1	Wm. Beadling	1,043			Salt water in Berea sand.
124	Elmer Irwin	1		1,080			Do.
125	Joshua Hogue	1		1,067			
126	Wood Bentley	1	Wm. Beadling	1,054			Do.
129	William H. White	1	St. Clair Oil and Gas Co				Shallow well.
131	John Moran	1	J. B. Knots	927		1,248	Very little salt water in Berea sand.
132	Clark Wells	1	St. Clair Oil and Gas Co	1,064			
133	Jos. Bernard	1	Quaker Oil Co	1,059	1,750		Salt water.
134	Bradfield Bros	1	Hughes & Guffey	1,192			Do.
135	Marion Ault	1	American Oil and Development Co	1,041			Small well.
136	George Gibson	1	Ohio Fuel and Supply Co	1,037	1,613	1,623	Producer.
137	F. S. Walton	1	American Oil and Development Co	1,175	1,748	1,763	Do.
138	John Hayes	1	....do	1,082	1,652	1,671	Do.
139	Jos. Cannon	1	....do	1,068			Do.
140	Margaret Septer	1	....do	1,100	1,668	1,685	Do.
141	James Gill	1	....do	1,052			Do.
142	Amanda Dyer	1	....do	1,089	1,660	1,668	Do.
143	C. Gill	1	....do	1,052	1,624	1,638	Do.
144	Valentine Ault	2	....do	1,208	1,781	1,798	Do.
145	F. S. Walton	2	....do	1,160	1,740	1,754	
147	Jos. Duglass	1	Warren Oil and Gas Co				Dry.
148	Kate Maldon	1	American Oil and Development Co	1,203	1,776	1,790	Producer.

List of wells in the Flushing quadrangle—Continued.

No. on Pl. II.	Owner of land.	Number of wells.	Well drilled by—	Elevation of mouth.	Depth to Berea sand.	Total depth.	Remarks.
				Feet.	*Feet.*	*Feet.*	
149	Kate Maldon	2	American Oil and Development Co	1,090	1,664	1,679	Producer.
151	....do	4	....do	1,269			Do.
152	Curtis Smith	2	T. N. Barnsdall	1,220			Do.
172	John Laughlin	3	Ohio Fuel and Supply Co		1,758	1,768	Gas.
175	Campbell Bros	1	Warren Oil and Gas Co	1,668			
176	W. O. Dunbar	1	C. K. O'Hara	951	1,278	1,300	Salt water.
183	W. S. Parker (heirs)	1	Ohio Fuel and Supply Co	1,075	1,601	1,633	Dry.
184	Jos. Kirk	1	Lick Run Oil and Gas Co	1,104	1,363	1,378	Producer.
185	James Rowland	1		940	1,289	1,319	Salt water.
186	W. A. Fulton	1	A. J. Wallace	1,159			Drilling.
187	Jos. Kirk	2	Lick Run Oil and Gas Co	1,145	1,403	1,420	Producer.
188	Miller Greenfield	1	McMath & Kelly				Gas in Salt sand.

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