Discussion

of the Records of Some Very Deep Wells in the Appalachian Oil Fields of Pennsylvania and West Virginia

By
I. C. WHITE, State Geologist,
With
TEMPERATURE MEASUREMENTS
By
C. E. VAN ORSTRAND.

DISCUSSION OF THE RECORDS OF SOME VERY DEEP WELLS IN THE APPALACHIAN OIL FIELDS OF PENNSYLVANIA, OHIO, AND WEST VIRGINIA,

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R. A. GEARY NO. 770 WELL RECORD.

Previous Publication.

At the annual meeting of the Geological Society of America December 30th, 1912, the writer presented a "Note of the Peoples Natural Gas Company and Capt. L. F. Barger of the same city was General Manager and in immediate charge of field operations during the period in which the Geary well was drilled, and to their courtesy and liberal views Company, of Pittsburgh, Pennsylvania, an organization along with the Hope Natural Gas Company and the Carter Oil Company which the Supreme Court permitted the Standard Oil Company of New Jersey to retain in the order for its dissolution. Mr. John G. Pew of Pittsburgh is President same was published in Volume XXIV, pages 275 to 282, under date of June 10th, 1913. At that time the well in question, which is located on the R. A. Geary farm, about 5 miles northwest from McDonald, Pennsylvania, near the line between Allegheny and Washington Counties, had attained a depth of 6299 feet, and was still drilling. As related in the former "Note", the boring was executed by the Peoples Natural Gas on a Very Deep Well near McDonald, Pennsylvania", and the

in their attitude toward geologic science, we are indebted for the record of this very deep boring.

As stated in the previous publication, this well is located on the Candor Dome described in the Burgettstown Folio of the U. S. Geological Survey by E. W. Shaw and M. J. Munn, a structural feature in the rocks of the region where the several sands of the lower Pennsylvanian, Mississippian, and upper Devonian beds had produced large quantities of natural gas, but in the course of 20-odd years of production had become practically exhausted on account of the great decline in rock pressures through continued use of the gas. It was in hopes of developing still deeper and virgin horizons of natural gas that the drilling of the Geary well was undertaken on the summit of the Candor Dome where several successive gas sands had already furnished large quantities of this matchless fuel.

After overcoming many difficulties, including the loss of a bailer and many hundred feet of steel line in the hole, pulling casing and reaming, to shut off additional water found at 6520 feet, as also the loss of two strings of drilling tools, only one of which could be recovered from a depth of nearly 7000 feet, the lower string of tools was left at the side of the hole which was drilled past them and the tools cased off with 7214 feet of 4½-inch casing welded into one continuous tube by the oxy-acetylene flame, and constituting probably the longest string of casing ever set in any boring anywhere in the world. After the salt water struck at 6520 to 6530 feet had been successfully shut off at 7214 feet and the missing set of tools safely sidetracked into the wall of the well, the lower joints of this very long casing tube under a water pressure of nearly 3000 pounds to the square inch collapsed around the drilling tools, and as there was of course a curve in the bore hole opposite the lost tools, the drilling set could not be withdrawn, and thus the second deepest hole ever yet sunk in the new world (and exceeded only by the Czuchow well—7349 feet—in the old world) was plugged beyond hope of recovery at a depth of 7248 feet, in the Summer of 1917, after more than 6 years of continuous work, and the expenditure of very many thousands of dollars in an effort to reach the "Clinton" oil and gas zone

of Ohio which has proved gas-bearing and petroliferous practically from the Ohio River in Scioto County northward to Lake Erie in Cuyahoga County. This gas horizon was termed "Clinton" by Dr. Edward Orton, Sr., when it was first discovered, and it will probably continue to retain the original name, but the writer has always regarded it as more probably the equivalent of the White Medina Sandstone horizon immediately below the true Clinton of the New York Series, and in this conclusion Prof. J. A. Bownocker, the present State Geologist of Ohio, concurs.

The record of this second deepest well in America and third deepest in the world affords so much of geologic and stratigraphic interest that it is here given in full with the kind permission of Messrs. Pew and Barger. It reads as follows:

R. A. Geary Well Record, No. 770 of the Peoples Natural Gas Company.

Located 5 miles northwest from McDonald, Pennsylvania; beginning 130 feet below the crop of the Pittsburgh Coal; well mouth approximately 1050 feet above tide.

	Thickness. Feet.	Total. Feet.
Conductor	16	16
Unrecorded (13" casing set at 232')	434	450
Lime	20	470
Slate	125	595
Middle Kittanning Coal (water at 600')	5	600
Unrecorded	134	734
Salt Sand (gas at 760' and 912')	216	950
Pencil Cave (10" casing set at 953')	3	953
Big Lime	29	982
Big Injun Sand (gas at 1052')	259	1241
Unrecorded	137	1378
Squaw Sand (gas at 1379')	14	1392
Unrecorded	218	1610
Sand (Berea)	12	1622
Unrecorded	172	1794
Hundred-Foot Sand (gas at 1797')	23	1817
Unrecorded	93	1910
Thirty-Foot Sand (gas at 1912')	15	1925
Unrecorded	43	1968
Gordon Stray Sand (8¼" casing set at 1969')	3	1971
White slate	1019	2990
Lime	220	3210
White slate	230	3440
Lime	10	3450

	Thickness. Feet.		Total. Feet.
White slate	650		4100
Sand and lime (Benson, Bradford?)	70		4170
White slate	350		4520
Black slate	30		4550
White slate	650		5200
Black slate	120		5320
Black shale	200		5520
White slate	140		5660
Limestone 20′ / Black lime 108	128	Selinsgrove?	5788
Black slate (Marcellus)	220		6008
Black lime 15′ / Flint 22	37	Corniferous	6045
Gray sand (6⅝″ casing, 6053′) (water and gas, 6045′) 155′ / Brown sand 60 / White sand (water, 6260-6265′) 10 / Brown sand 45	270	Oriskany	6315
Black lime 80′ / Sand and black flint 10 / Black lime 110 / White sand, Stormville Conglomerate (Coeymans) (gas,, 6522′; water, 6520 to 6530 feet) 15 / Black limestone 80′ / Gray limestone (Bossardville) 90	385	Helderberg	6700
Rock salt 8′ / Lime and sand 67 / Rock salt 10 / Limestone 45 / Rock salt 10 / Lime and sand 20 / Rock salt 5 / Limestone 5 / Rock salt 5 / Limestone 20 / Rock salt 5 / Limestone (tools lost) 25 / Limestone and sand 95 / Salt and lime shells 20	340	Salina Salt Series	7040
Sand and lime, Salina and Niagara, to bottom	208		7248

Casing Record:

16″ hole to 232′; cased to that point with 13″ casing;
13″ hole to 953′; to that point 10″ casing;
10″ hole to 1969′; 8¼″ casing to that point;
8¼″ hole to 6053′; 6⅝″ casing to that point, weight 68 tons;
6⅝″ hole to 6315′; 4½″ casing to that point, weight 46 tons;
Then pulled 4½″ casing and reamed, and drilled hole to 7214′ when 7214 feet of 4½″ welded casing was set.

This detailed record may be summarized as follows, beginning at the base of the Pittsburgh Coal 130 feet above the derrick floor:

		Thickness. Feet.	Total. Feet.
Conemaugh Series.....580'			
Allegheny Series.....284	Pennsylvanian..	1080	1080
Pottsville Series.....216			
Mauch Chunk..... 3'			
Big Lime ("Mountain, Greenbrier") 29	Mississippian..	672	1752
"Big Injun," "Squaw," and "Berea" Sands.....640			
Catskill, (including Venango Oil Sand Group), Chemung, Portage, Hamilton, and Marcellus beds		4386	6138
Corniferous Limestone.....		37	6175
Oriskany Sandstone.....		270	6445
Helderberg		385	6830
Salina Salt Series.....		340	7170
Salina Shales and Niagara (Clinton?).....		208	7378

It is regrettable that this boring could not have been sunk a few hundred feet deeper, since the horizon of the "Clinton" oil and gas zone could not have been more than 100 to 300 feet below where the tools were so successfully imprisoned, and reluctantly abandoned by Mr. Pew and his associates.

The demonstration of the existence of commercial deposits of rock salt in the Salina Series extending in unbroken sheets from Cleveland past Akron (where its presence had already been demonstrated) to the vicinity of Pittsburgh and probably many miles southward, is an accomplishment well worth all of the cost of the boring, to say nothing of the great addition to the sum of stratigraphic and geologic knowledge otherwise forever to remain a sealed book except for the labor and money expended thereon by the men of broad vision and ample means who had at their command the unlimited resources of the Standard Oil Company of New Jersey. To Mr. A. C. Bedford, Chairman, and the other officers of this great corporation, geologic science is indebted for this rich contribution to the sum of human knowledge. It is barely possible that in addition to the vast quantity of common salt, or sodium chloride, in these great underground deposits, some

of the potash salts, potassium chloride and potassium sulphate, may also exist and will be found interbedded among these other saline products.

Opportunity was afforded the experts of the U. S. Geological Survey to test this deep well for temperature observations and the Peoples Natural Gas Company also made some temperature tests on its own account, these latter being given in the Geological Society of America publication referred to above.

The temperature measurements of C. E. Van Orstrand, Physical Geologist of the U. S. Geological Survey, have been courteously submitted by him to the writer by the kind permission of the Director of the U. S. Geological Survey, for publication in connection herewith, and they will be given later in this Report in connection with other deep well temperatures.

Mr. Van Orstrand, with improved temperature reading and recording devices, was to have been given an opportunity to make other temperature tests before the boring was abandoned, but the unhappy accident mentioned above prevented this very desirable accomplishment.

The water found at 6,260 feet rose in the hole to a height of 5560 feet, or to 700 feet below the top of the well. Its chemical composition is as follows, according to an analysis of a sample made by the Pittsburgh Testing Laboratory—H. H. Craver, Chief Chemist:

Specific gravity at 60° Fahrenheit	1.1085
Oil	Trace
	Parts per 100,000
Alkalinity as calcium carbonate	5.50
Calcium chloride	4,421.40
Magnesium chloride	251.60
Sodium chloride	5,018.20
Sulphuric anhydride	Trace
Iron oxide	Trace
Sediment (rock powder)	224.60
Total solids	9,921.30
Total solids exclusive of pulverized rock sediment	9,696.70

This analysis looks as though we had here a case of fossil ocean water imprisoned since mid-Paleozoic time.

DERRICK CITY DEEP WELL, 4 MILES EAST OF BRADFORD, PENNSYLVANIA.

Although the Geary well failed to penetrate to the "Clinton" (Medina) oil and gas horizon of Ohio, another deep boring about 140 miles northeast from the Geary location did reach and pass below that horizon. This well was drilled by the United Natural Gas Company of Oil City, Pennsylvania. It is located near Derrick City, 4 miles east from Bradford, in McKean County, Pennsylvania, and the record of the boring, as transmitted through Capt. L. F. Barger by Mr. W. P. Craig, of Oil City, Superintendent of the United Natural Gas Company, is as follows:

Record of Derrick City Deep Well.

Four miles east of Bradford, Pennsylvania, as given by W. P. Craig, Superintendent, United Natural Gas Company; mouth of well about 1585 feet above tide, and 815 feet below the Olean Conglomerate, the basal member of the Pennsylvanian.

	Thickness. Feet.	Total. Feet.
Unrecorded	1120	1120
Sand, Bradford	78	1198
Interval, unrecorded	32	1230
Slate, light, soft	90	1320
Slate, black, soft	95	1415
Slate, black, soft	15	1430
Slate, light, soft	37	1467
Sand, gray, hard 12′ / Slate 1 / Sand, gray, hard 10 — **Kane Sand**	23	1490
Shale, dark, soft	60	1550
Sand shells, dark, hard	20	1570
Shale, light, soft	54	1624
Slate, light, soft	16	1640
Sand shell, dark, hard	10	1650
Shale, dark, soft	30	1680
Sand shells, dark, hard	40	1720
Slate, light, soft	10	1730
Shale, brown, soft	10	1740
Sand shell, brown, hard	10	1750
Lime shells, light, hard	50	1800
Slate, light, soft	30	1830
Slate, white, soft	40	1870
Shale, brown, soft	30	1900
Slate and lime shell, light, hard	50	1950
Slate and lime shell, light, hard	40	1990
Slate and lime shell, brown, hard	40	2030
Slate and lime shell, light, hard	20	2050

	Thickness. Feet.	Total. Feet.
Slate and lime shell, light, hard	20	2070
Slate and lime shell, dark, hard	30	2100
Lime, light, hard	20	2120
Lime, light, very hard	30	2150
Slate and lime, light, medium	20	2170
Slate and lime, light, medium	30	2200
Slate and lime, dark, medium	30	2230
Slate, light, soft	35	2265
Slate and shells, light, medium	35	2300
Lime and slate, light, hard	43	2343
Slate, light, soft	32	2375
Slate, light, soft	25	2400
Shells, dark, hard	30	2430
Shells, dark, hard	16	2446
Shells and slate, light, hard	24	2470
Shale, brown, soft	20	2490
Sand shells, brown, hard	25	2515
Slate, dark, soft	25	2540
Slate, black, soft	90	2630
Shale, brown, soft	30	2660
Slate shells, light, medium	25	2685
Slate, black, soft	43	2728
Sand shells, black, hard	22	2750
Slate shells, brown, soft	50	2800
Shale, brown, soft	33	2833
Sand shells, brown, hard	12	2845
Shale, brown, soft	155	3000
Slate, black, soft	100	3100
Slate, white, soft	50	3150
Slate, black, soft	66	3216
Slate, black, soft	184	3400
Shale, black-brown, soft	20	3420
Sand, shell, black-brown, soft	155	3575
Slate shale, black, soft	45	3620
Shale, black, soft	30	3650
Shale, brown, soft	19	3669
Pencil Cave, black (caved very badly; dumped water with bailer)...31′ Shale, black, soft.....80 Shale, brown, soft.....20 Lime shells, dark, hard...30 Shale, brown, soft.....70 Shale, black, soft.....165	Marcellus 396	4065
Sand, black, hard, pebbly (gas showing).....30′ Lime, black, hard.....20 Flint, dark, very hard.... 5 Flint, light, very hard....15	Corniferous 70	4135

	Thickness. Feet.		Total. Feet.
Sand, white, very hard, Oriskany (showing of oil)	20		4155
Lime, dark, very hard.....10′			
Sandy lime, light, very hard 10			
Lime, dark, very hard...25			
Lime, light, very hard...15			
Sandy lime, dark, very hard 10			
Sandy lime, (Coeymans, Stormville) dark, very hard (pocket of gas from 4225′ to 4235′)..10			
Lime, dark, very hard....30			
Brick shale, dark, soft (sample lost)..... 5		Helderberg	335	4490
Lime and gypsum, medium, (sample lost).....10			
Lime, dark, hard.....20			
Lime, dark, hard.....30			
Lime, dark, hard.....20			
Lime, dark, hard.....20			
Lime, dark, hard.....30			
Lime, dark, hard.....20			
Lime, light, hard.....20			
Lime, dark, hard.....15			
Lime, light-brown, hard...10			
Lime, light, hard.....15			
Lime, dark, hard.....10			
Pure salt, white, soft.....30′			
Sandy lime, white, fairly soft, (showing of black oil) 15			
Lime and slate, white, fairly soft..... 5			
Lime, dark, very hard....25			
Lime, brown, hard.....31		Salina Salt Group..	223	4713
Salt, white, soft (caving considerably) 10			
Lime, brown, hard.....20			
Lime, gray, very hard.....12			
Salt, white, soft.....47			
Lime, brown, hard..... 8			
Salt and "lava,"* white, soft 20			

*Most probably "lava" means anhydrite or sulphate of lime, a common mineral interstratified with salt beds.

		Thickness. Feet.	Total. Feet.
Slate "lava," gray, soft (caved very badly from 4723′ to 4780′. Cemented this cave with good results, using 5 tons of cement and sand).....20′			
Slate-"lava," gray, soft...47			
Slate-"lava," gray, soft (bad cave 4785′ to 4840′; did not cement this cave).....60	Salina Shales.....	297	5010
Slate, white, soft, (not caving) 20			
Slate shells, dark, hard (standing up nicely)..40			
Lime shells, dark, hard...30			
Lime, dark, hard.....15			
Slate shells, dark, fair drilling 5			
Slate, light and dark, soft (caving slightly).....15			
Shale, dark-brown, soft (not caving) 45			
Lime, dark-gray, very hard.10′			
Lime, dark-gray, very hard.10			
Lime, dark, very hard....20			
Lime, gray, hard.....25			
Lime and shells, black, (fair drilling).....10	Niagara	145	5155
Lime, black, hard.....15			
Lime, gray, hard.....10			
Lime, black, very hard....40			
Lime, gray, very hard..... 5			
Shale, black, (fair drilling).15′			
Sand, gray, very hard.....15			
Lime, black, very hard....15			
Sand, gray, very hard (small show of oil)...46			
Lime, dark, hard..... 4	Clinton Shales.....	165	5320
Lime, brown, hard.....10			
Lime, dark, hard.....10			
Lime, brown, hard.....10			
Lime, gray, hard.....20			
Lime, dark-gray, hard.....20			

		Thickness. Feet.	Total. Feet.
Sand, light-gray, hard.....15′ Sand, dark-gray, hard.... 2 Sand, light-gray, hard..... 3 Sand, light-gray, hard..... 2 Sand, dark, soft..... 3 Sand, dark, shells..... 5 Shells, dark, fair..... 4 Sand, gray, hard..... 6 Sand, dark, soft.....20 Sand, dark, soft..... 5 Shale, dark, soft.....15 Shale, dark, fair.....10 Shale, dark, fair.....10 Shale, blue, soft.....20 Shale, black, soft.....20 Sand, dark-gray, hard.....35 Slate, light-gray, soft (caved considerably).35 Slate, gray, soft.....20 Sand, gray, hard.....10	White Medina.... (“Clinton Sand”)	240	5560
Sand, red, hard..... 3′ Sand, red, hard..... 2 Sand, red, hard..... 5 Sand, red, hard..... 2 Sand, red, hard, (some white shells)..... 2 Sand, red, hard (softened up slightly)..... 4 Sand, red, hard..... 2 Sand, red, hard..... 5 Sand, red, hard, (more white shells)..... 5 Sand, red, hard..... 5 Sand, red, hard..... 5 Sand, red, softer (shells and broken sand).... 5 Sand, gray, softer (red predominating) ..... 5 Sand, gray, very hard (white predominating) 5 Sand, gray, very hard (white predominating) 7 Sand, red, softer (pure red) 3 Sand, red, hard, (pure red) .....11 Sand, red, hard (gray predominating) ..... 4 Sand, red, softer, sand coarse and shelly.... 2	Red Medina.....	82	5642

		Thickness. Feet.	Total. Feet.
Sand, gray, hard, almost white ..... 2′ Sand, light-gray, hard..... 2 Sand, white, hard..... 2 Sand, white, hard..... 2 Sand, gray, hard (slightly sprinkled red)..... 5 Sand, gray, hard..... 2 Sand, dark-gray, hard.... 2 Sand, light-gray, hard....16 Sand ..... 5 Sand, very dark, very hard 4 Sand, light-gray, softer... 4 Sand, dark-gray, very hard 4 Sand, light-gray, very hard. 3 Sand, dark-gray, very hard (hardest stratum found) ..... 5 Brown sand shale, softer, fair drilling.....10 Red sand and coarse, hard shells to bottom, where well was abandoned February 2, 1914.....50	Gray or Lower Medina	118	5760

This detailed record may be summarized as follows, beginning with the missing intervals up to the Pittsburgh Coal horizon, approximately 1900 feet above the top of the boring:

	Thickness.	Depth Below Pittsburgh Coal.
Pittsburgh Coal.....	...	....
Pennsylvanian { Conemaugh .....600′ Allegheny .....250 Pottsville .....250 }	1100	1100
Mississippian, estimated to base of Berea Sand horizon	530	1630
Catskill and Chemung Oil Sand Groups, to bottom of Kane Sand.....1775′	4350	5980
Chemung, Portage, Hamilton, and Marcellus 2575		
Corniferous { Sand, dark, hard, pebbly.30′ Limestone .....20 Flint .....20 } 70′		
Oriskany Sandstone..... 20	1090	7070
Helderberg 335		
Salina (Salt Zone).....223		
Salina Shales.....297		
Niagara Limestone.....145		
Clinton Shales, Sandstones, and Limestones.....	165	7235
Medina White Sandstones ("Clinton" Oil Sand of Ohio)	240	7475
Medina Red Sandstones and Shales.....	82	7557
Medina Gray Sandstones, to bottom.....	118	7675

No temperature observations were made in this well so far as known to the writer.

The top of the White Medina, struck at 5320 feet, and 1255 feet below the top of the Corniferous Limestone, most probably correlates with the "Clinton Oil Sand" horizon of Ohio, although it is barely possible that the 46 feet of gray sand with "showing of oil" 74 feet higher might represent that petroliferous level.

The estimate of 1100 feet at Derrick City from the base of the Olean Conglomerate up to the Pittsburgh Coal horizon is only approximately correct, since it may be 100 feet in error, but the average interval from the coal in question to the base of the Pottsville in the Pittsburgh region has been used in this estimate, while the interval of 815 feet from the mouth of the well to the base of the Olean Conglomerate (Pennsylvanian) is that furnished by Mr. W. P. Craig, who had it specially determined, presumably by aneroid measurement.

The interval from the Pittsburgh Coal horizon to the base of the famous Bradford Sand would be at Bradford according to these figures approximately only 3113 feet, and 3405 feet to the base of the Kane Sand, since in northern Pennsylvania the upper portion of the Mississippian suffered much from erosion before the Olean Conglomerate (the beginning of the Pennsylvanian deposits) was laid down. The proof of this is attested by the fact that the Olean Conglomerate contains many Mississippian fossils as pebbles while the conglomerate itself rests unconformably upon the remnants of the Pocono Shales and Sandstones, the Mauch Chunk Shale and the underlying Mountain or Greenbrier Limestone having been entirely eroded before the deposition of the Olean Conglomerate. Hence in figuring the thickness of the Devonian Shales at the Derrick City well the amount of Mississippian sediments has been assumed as 530 feet down to the base of the Berea Grit horizon, which corresponds closely with that (509′) found for these beds in the Bradys Bend well.

This erosion extended southward practically to the latitude of Pittsburgh as we learn from other drill hole records, but beyond there to the south, the Mauch Chunk Red Shale

and the Mountain Limestone both make their appearance in the section.

In order to show the thickening of the Upper Devonian beds southward, the record of a boring from Bradys Bend on the Allegheny River, about 85 miles southwest from Bradford, is here given on the authority of Emmet Queen, the oil and gas operator, of Pittsburgh, Pa., as follows:

RECORD OF BRADYS BEND WELL.

	Thickness. Feet.	Total. Feet.
Interval above top of well to Pittsburgh Coal horizon (estimated by I. C. W.)	815	815
Conductor and unrecorded	35	850
Ferriferous (Vanport) Limestone	20	870
Fire clay	15	885
Coal, Clarion	4	889
Slate and shale	156	1045
Mountain Sand (Pottsville and Big Injun)	243	1288
Slate and shale	162	1450
Sand, "Squaw"	38	1488
Slate and shale	185	1673
"Gas Sand" (Berea)	24	1697
Slate and shale	102	1799
"Hundred-Foot" Sand (Gantz and 50-Foot)	84	1883
Slate and shale	57	1940
"Thirty-Foot" Sand	30	1970
Slate and shale	105	2075
"Third" or Gordon Sand	20	2095
Slate	10	2105
"Boulder" Sand	10	2115
Slate and shale	40	2155
Fourth Sand	17	2172
Slate and shale (No Fifth nor Bayard Sands)	503	2675
Beatty Sand (Warren or Tiona)	25	2700
Slate and shale	335	3035
"Speechley" Sand, top 15 feet gray and full of pebbles (gas)	60	3095
Slate and shale	1020	4115
"Bradford" Sand, (possibly "Kane") top 15 feet pebbly, the balance "honeycomb," brownish and showing dark oil	80	4195
Slate and red ? rock to bottom	137	4332

This record reveals a thickening of approximately (4115—3035) 1080 feet between the Pittsburgh Coal horizon and the Bradford Sand in the 85 miles between Bradford and Bradys Bend, unless the Sand identified here as "Bradford" should really represent the "Kane", which would appear probable

with the Bradford absent, since the usual interval between the Speechley and Bradford Sands is only 600-700′ and not 1020′ as given in this record, and which would be about the correct interval from the "Speechley" to the "Kane".

This Bradys Bend record is quite important, since it reveals most of the Appalachian field oil and gas sands in a vertical range, and exhibits their stratigraphic relationships to the famous Pittsburgh Coal, whose horizon belongs at an approximate interval of 850 feet above the Vanport Limestone. It is quite probable that the "red rock" noted in the last 137 feet of the boring had fallen into the hole from the caving walls of the well much higher up since other deep borings find no "reds" below the "Elizabeth" Sand.

AKRON, OHIO, DEEP WELL.

This Bradys Bend well penetrated only through the upper portion of the Devonian Shales, but a boring near Akron, Ohio, approximately 100 miles nearly due west from Bradys Bend, starting near the base of the Pottsville Series, was drilled below the "Clinton" (Medina) Sand. The record of this well furnished by Capt. L. F. Barger, of the Peoples Natural Gas Company, and not heretofore published, reads as follows:

Record of Seiberling Well.

Located south of Akron, Ohio; began, May 12th, 1905; completed, August 1st, 1905; authority, Capt. L. F. Barger, General Superintendent, Peoples Natural Gas Company, Pittsburgh, Pennsylvania.

	Thickness. Feet.	Total. Feet.
Drive pipe (10″) (Glacial Drift)	139	139
Unrecorded	161	300
Berea Grit	85	385
Shales, Devonian (8¼″ casing at 455′)	1775	2160
Hard limestone, (Corniferous, Oriskany, Helderbery, &c)	640	2800

		Thickness. Feet.	Total. Feet.
Rock salt....14'			
Limestone 16			
Rock salt....40			
Limestone 10			
Rock salt....38			
Limestone 15			
Rock salt....45			
Limestone 5			
Rock salt....32	Salina Salt Series.	420	3220
Limestone 30	(Thickness of		
Rock salt....40	rock salt 304')		
Limestone 5			
Rock salt....40			
Limestone 25			
Rock salt....30			
Limestone 10			
Rock salt....25			
Limestone		20	3240
Slate		40	3280
Limestone, Niagara and Clinton....		321	3601
Sand, "Clinton" (Medina), (little oil, gas, and water)		5	3606
Limestone		143	3749
Slaty limestone to bottom....		40	3789

The enormous thickness of **Rock Salt** (304') found in the Akron boring, compared to about 100 feet in the Derrick City well, and 60 feet in the R. A. Geary deep boring, shows that the vicinity of Akron was probably near the center of the ancient sea which becoming isolated from oceanic waters by crustal movement gave origin through evaporation of its saline waters to these extensive salt deposits. These we now know extended from the vicinity of Pittsburgh, Pennsylvania, northward beyond Cleveland under Lake Erie and far northward into Canada, and central Michigan, a distance of 300 to 400 miles, thus covering an area of many thousand square miles and constituting an inexhaustible supply of saline minerals, since a thickness of 550 and 600 feet of rock salt is reported from the Dearborn and Royal Oak wells, respectively, in 870 and 932 feet of Salina Beds, near Detroit, Wayne County, Michigan, according to R. C. Allen, State Geologist.*

The thickness (1775') of the Upper Devonian Shales in the Seiberling boring is so much less than in the Derrick City

*Publication 24, Series 20, 1916, p. 247, Michigan Geol. and Biol. Survey.

well (4350′) that it reveals a very rapid westward thinning of these particular measures. As a gauge on this westward thinning or eastward thickening, as the case may be, we fortunately have access to another measurement of these Upper Devonian Shales, near West Middlesex, Mercer County, Pennsylvania, about 5 miles south from Sharon, and about 55 miles nearly due east from Akron. Here the No. 2 well of the Wheatland Iron Company found the bottom of the Berea Grit at 351 feet, and the top of the Corniferous Limestone at 3377 feet, thus giving a thickness of 3026 feet for the Devonian Shales at that locality which represents (3026—1775=1245′) an eastward thickening or a westward thinning of 22.63 feet per mile in the 55 miles between Akron and West Middlesex, and if the same rate were continued eastward 45 miles farther to the latitude of Bradys Bend, would make an additional increase of 1018 feet, and thus give these Upper Devonian Shales an approximate thickness of 4044 feet in the Bradys Bend well. Hence, the top of the Corniferous Limestone in that boring would lie about 1400 feet below the bottom of the same and would have required a well of nearly (4917′) 5000 feet in depth to penetrate to the base of these Upper Devonian Shales at Bradys Bend.

The Peoples Natural Gas Company and others have developed a deep sand gas field in the Bradford and higher sand horizons in Westmoreland County, Pennsylvania. Since none of these deep well records has yet been published, and as they furnish most interesting data for correlation purposes, two of them are here given through the courtesy of Mr. John G. Pew, President of the Peoples Natural Gas Company, of Pittsburgh, Pennsylvania. The first one is Well No. 1099 of the Peoples Natural Gas Company's series, and is located on the land of John Hamilton Heirs, Franklin Township, Westmoreland County, Pennsylvania. Its record reads as follows:

JOHN HAMILTON HEIRS WELL NO. 1099.

Located in Franklin Township, Westmoreland County, Pa.; drilling commenced February 3, 1916; completed, April 20, 1916; Contractor, Geo. M. Evans.

		Top. Feet.	Bottom. Feet.
Slate and shells		0	265
Coal, Upper Freeport		265	273
Lime, Upper Freeport		273	290
Slate		290	615
Sand	Pottsville	615	650
Slate		650	700
Sand		700	755
Slate		755	830
Sand, Big Injun		830	1230
Slate		1230	1510
Sand, Murrysville		1510	1585
Slate		1585	1590
Sand, "Hundred-Foot"		1590	1700
Slate and shells		1700	2010
Sand		2010	2030
Slate and shells		2030	2070
Sand, Fifth		2070	2120
Slate and shells		2120	2826
Sand, Speechley (gas, 2826', steel-line measurement, 6/10" water in 2" opening, included in open flow given for Bradford Sand)		2826	2840
Slate		2840	2865
Sand		2865	2885
Sand, Tiona		2885	2930
Slate		2930	3000
Sand, Sheffield		3000	3012
Slate and shells		3012	3426
Sand, Bradford		3426	3446
Slate and shells		3446	3505
Sand, Bradford (gas, 3515', steel-line measurement, 1-6/10" water in 3" opening, 428,110 cubic feet daily)		3505	3535
Slate, to bottom (steel-line measurement)		3535	3541

Casing Record: 12½", 19' 7"; 10", 100' 3"; 8¼", 801' 11"; 6⅝", 1721' 0"; 4", 2107' 4". 12½" casing used to shut off loose sand. 10" casing used to shut off surface water. 4" tubing used on account of high rock pressure.

Well shot April 21, 1916, with 40 quarts. Top of shell, 3515'; bottom of shell, 3525'; length, 10'; diameter, 5 inches. Shot in Bradford Sand by West Penn Torpedo Company. Open flow test before shooting, 1-3/10" water in 3" opening.

Minute Pressure Taken in 4" Tubing:

1	2	3	4	5	6	7	8	9	10	30	60	4 hrs.
10—	18—	22—	28—	30—	32—	36—	40—	44—	48—	112—	220	540

The record of another deep sand well drilled by the Peoples Natural Gas Company in Westmoreland County, Pennsylvania, is as follows:

W. F. AND R. N. CROOKS WELL NO. 1212

Located in Upper Burrell Township, Westworeland County, Pennsylvania; drilling commenced January 12, 1917; completed, February 14, 1917; Contractor, Geo. M. Evans.

	Top. Feet.	Bottom. Feet.
Coal, (Upper Freeport)	320	
Lime	330	
Sand, 60′	725	780
Sand, 70′	820	
Sand, Big Injun	990	
Sand, Murrysville	1530	1640
Sand, 100-Foot (gas at 1701′, steel-line measurement, 1″ water in 6⅝″ casing)	1640	1770
Red rock	1780	1810
Slate and shell	1810	2060
Sand, Fifth	2060	2161
Slate and shell	2161	2871
Sand, "Stray" (probably top of Speechley—I. C. W.) (gas at 2873′, 12/10″ water in 2″ opening)	2871	2900
Slate and shell	2900	2956
Sand, Speechley	2956	2982
Slate and shell	2982	3265
Sand, Sheffield	3265	3280
Slate and shell	3280	3561
Sand, Bradford (little gas at 3563′)	3561	3579
Slate to bottom (steel-line measurement)	3579	3609

Minute Pressure in 6⅝″ tubing:

1	2	3	4	5	6	7	8	9	10	30	60 minutes.
0	0	2	5	8	11	13	15	17	19	41	80 pounds.

The Pittsburgh Coal horizon lies above the tops of both wells, but the coal found at 265 feet in well No. 1099 and at 320 feet in well No. 1212 appears to represent the Upper Freeport bed, which in this region belongs at 600 to 650 feet below the famous Pittsburgh seam. This correlation puts the bottom of the Bradford Sand in well No. 1099 at 3262 feet below the Upper Freeport Coal, while in well No. 1212, the same horizons are separated by a vertical interval of 3259 feet, or say 3900 feet, in round numbers, below the Pittsburgh Coal bed, while the interval below the top of the Big Injun Sand is 2675 feet in well No. 1099 where the top of the Big Injun is clearly defined.

DEEP DRILLING IN WEST VIRGINIA.

Quite recently the Hope Natural Gas Company and the Reserve Gas Company have inaugurated a deep drilling campaign in West Virginia, and have succeeded in finding a gas horizon furnishing wells of 300,000 to 1,000,000 cubic feet daily in what appears to be the representative of the "Bradford Sand" of Westmoreland County, Pennsylvania. This deep sand horizon, which was first developed on the farm of J. C. Benson in western Barbour County, found gas at a depth of 4090 feet, about 4300 feet below the horizon of the Pittsburgh Coal, and 2765 feet below the top of the Big Injun Sand. At this well the detailed record of which is given on pages 85-86 of this volume, a rock pressure of 1800 pounds to the square inch was recorded from this Benson Sand, and it is not certain that the total pressure was registered, owing to the considerable leakage from joints and couplings at such high pressures.

A boring made on the M. D. Reiley farm, 5 to 6 miles west from Philippi, Barbour County, by the Hope Natural Gas Company, gives an interesting record, and also reveals the presence of a gas-bearing sand at 327 feet above the Benson Sand horizon. This valuable record is here given through the courtesy of John G. Pew and J. B. Corrin, of Pittsburgh, Pennsylvania:

M. D. REILEY WELL NO. 5048.

Located 5 to 6 miles west from Philippi, Barbour County; drilled by the Hope Natural Gas Co.; commenced drilling, December 14, 1917; completed, April 4, 1918.

	Top. Feet.	Bottom. Feet.
Yellow clay	0	16
Red rock	16	30
Bluff Sand (2 bailers water per hour at 58')	30	85
Coal	85	88
White slate	88	90
White lime	90	115
Red rock	115	125
Lime	125	135
Red rock	135	150
White slate	150	165
White lime	165	180

	Top. Feet.	Bottom. Feet.
White slate	180	210
Red rock	210	225
White slate	225	280
Dark lime	280	320
White slate	320	330
White lime	330	350
Sand (Big Dunkard) (water at 360′ (10″ casing at 371′)	350	385
Slate	385	391
Lime	391	430
Black slate	430	455
Dark lime	455	475
First Gas Sand	475	515
White slate	515	530
Gas Sand	530	550
Coal	550	553
Second Gas Sand	553	700
White slate	700	740
Black slate	740	780
First Salt Sand	780	790
Black slate	790	810
Coal	810	817
Second Salt Sand	817	885
Dark lime	885	920
Gritty lime	920	955
Third Salt Sand	955	990
Black slate	990	1080
Lime	1080	1150
Maxton Sand	1150	1180
Slate and shells	1180	1210
Red rock	1210	1285
Lime	1285	1312
Red rock	1312	1415
White slate	1415	1453
Little Lime	1453	1470
Pencil Cave	1470	1495
Big Lime	1495	1565
Big Injun Sand	1565	1590
Red rock	1590	1592
Big Injun Sand	1592	1690
White slate	1690	1697
Squaw Sand	1697	1707
Slate	1707	1725
Dark lime	1725	1820
Dark slate	1820	1823
Dark lime	1823	1833
Dark slate	1833	1843
Gantz Sand (gas at 1861′)	1843	1965
White slate	1965	1975
Lime	1975	1987
White slate	1987	2005
Fifty-Foot Sand	2005	2025
White slate	2025	2033
Thirty-Foot Sand	2033	2045
Red rock	2045	2052

	Top. Feet.	Bottom. Feet.
Dark lime	2052	2064
Slate and shells	2064	2100
Red rock	2100	2117
Dark slate	2117	2127
Sand	2127	2138
Red rock	2138	2315
Gordon Sand (oil show)	2315	2373
White slate	2373	2392
Fourth Sand	2392	2417
Red rock	2417	2425
White sand	2425	2437
Slate	2437	2463
Sand, Fifth (oil show, 2465')	2463	2514
White slate	2514	2550
Lime	2550	2565
White slate	2565	2600
Lime	2600	2615
White slate	2615	2633
White lime	2633	2640
Slate	2640	2657
White sand	2657	2672
White slate	2672	2830
Lime	2950	2964
Slate and shells	2964	3105
Lime	3105	3140
Slate and shells	3140	3270
Lime	3270	3285
Slate and shells	3285	3307
Slate	3307	3340
Lime	3340	3350
Slate	3350	3370
Sand	3370	3375
Lime	3375	3396
White, hard lime	3396	3425
Hard lime	3425	3436
White slate	3436	3446
Hard lime	3446	3455
Dark slate	3455	3470
Hard lime	3470	3480
Lime shells	3480	3490
Slate and shells	3490	3525
Hard lime	3525	3545
Lime	3545	3550
Dark slate	3550	3565
Hard gritty lime	3565	3575
Dark slate	3575	3585
Hard gritty lime	3585	3600
Dark slate	3600	3625
Soft slate	3625	3645
Hard lime	3645	3660
Slate	3660	3690
Dark slate	3690	3700
Lime	3700	3740
Hard lime	3740	3775
Dark slate	3775	3793

	Top. Feet.	Bottom. Feet.
Soft lime	3793	3800
Dark, soft slate	3800	3820
Dark lime	3820	3860
Soft lime	3860	3900
Slate and shells	3900	3950
Hard lime	3950	3970
Soft sand	3970	3975
Gray slate	3975	4020
Soft lime	4020	4050
Slate and shells	4050	4077
Soft sand (gas, at 4077'; 10/10" mercury through 2" opening=552,000 cu. ft. daily)	4077	4079
Hard lime	4079	4100
Dark slate	4100	4125
Soft sand	4125	4135
Lime	4135	4170
Slate and shells	4170	4230
Hard lime	4230	4270
Shells	4270	4320
Slate and shells	4320	4355
Soft lime	4355	4390
Slate	4390	4403
Benson Sand (gas at 4404', 50/10" water through 2" opening=336,000 cu. ft.)	4403	4409
Lime shells, to bottom	4409	4448

The presence of a gas horizon 327 feet above the Benson Sand in this well makes it possible that this upper sand may represent the **Bradford Sand** horizon, while the **Benson** might be the **Kane Sand** horizon, the lowest gas-bearing zone yet developed in the Devonian beds of northern Pennsylvania, since the Kane Sand, as shown by the record of the Derrick City well on a previous page, comes approximately 300 feet below the Bradford Sand. This Reiley well starts about 200 feet below the Pittsburgh Coal, and thus reveals a considerable thickening in the measures between this coal bed and the top of the Big Injun Sand due principally to the increase in the Mauch Chunk Red Beds, and the Pottsville Series immediately above, thus increasing considerably the interval between the Pittsburgh Coal and the Benson Sand. If this "Reiley" Sand at 327 feet above the "Benson" should finally prove to be at the "Bradford" Sand horizon, then the one called "Sheffield" in the Westmoreland County deep wells would most probably represent the "Bradford" Sand of Pennsylvania, while the one called "Bradford" in these records would most probably represent the "Kane" Sand of northern

Pennsylvania. This interpretation is held by James N. Pew, General Manager of the Peoples Natural Gas Company.

In addition to the deep sands shown in the Reiley well, the Hope Natural Gas Company has also found another deep gas horizon in the same general region not hitherto known to be productive in West Virginia. It comes at 1500 to 1600 feet below the top of the "Big Injun" Sand, near Good Hope, Harrison County, on the border of Lewis. The initial output was over a million cubic feet. This horizon would belong at about 3100 feet below the Pittsburgh Coal at the locality in question and would appear to represent either the Warren or Tiona Sand of western Pennsylvania which in the deep well drilled at Bradys Bend, Armstrong County, Pennsylvania, the record of which is given on page xxxix, lies about 1500 feet below the top of the Big Injun Sand, and 1000 feet below the top of the Berea Grit, or 2675 feet below the horizon of the Pittsburgh Coal.

The following record of the W. C. Burnside deep well, located in Grant District, near Good Hope, Harrison County, West Virginia, being well No. 2073 (5008) of the Hope Natural Gas Company, reveals the stratigraphic relations of this new deep sand horizon both to the Benson Sand below and to the other well-known sands above. It is given here through the courtesy of John B. Corrin and John G. Pew, Vice-Presidents of the Hope Company:

W. C. BURNSIDE NO. 2073 (5008) WELL RECORD.

	Top. Feet.	Bottom. Feet.
Little Dunkard Sand	280	320
Second Salt Sand	870	930
Little Lime	1172	1184
Pencil Cave	1184	1202
Big Lime (water, 1245')	1202	1279
Big Injun Sand (gas, 1373')	1279	1388
Fifty-Foot Sand (gas, 1725')	1720	1758
Thirty-Foot Sand	1772	1797
Gordon Stray Sand	1997	2007
Gordon Sand	2010	2037
Fifth Sand (gas, 2143')	2142	2160
Limestone	2651	2750
Slate	2750	2850
Sand, Burnside (Warren or Tiona) (gas, 2852')	2850	2855

	Top. Feet.	Bottom. Feet.
Slate	2855	2983
Lime	2983	2997
Slate	2997	3520
Lime	3520	3540
Slate	3540	4205
Benson Sand	4205	4220
Slate (light) to bottom	4220	4515

6⅝" casing, 1279'; 5 3/16", 2172'; 2", 2797"; 3", 44' 8"; 3" Perf., 22' 6"; all left in well.

The K. M. Patton well No. 745 of the Reserve Gas Company, drilled a few hundred feet distant from the one on the Burnside farm reveals other sands not given in the latter and reads as follows, according to Messrs. Corrin and Pew:

K. M. PATTON WELL NO. 745 OF RESERVE GAS COMPANY.

	Top. Feet.	Bottom. Feet.
Little Dunkard Sand	550	585
Gas Sand	705	775
Maxton Sand	1170	1245
Shells	1245	1310
Big Lime	1340	1414
Big Injun Sand	1414	1535
Squaw Sand	1605	1635
Berea Sand	1725	1745
Gantz Sand	1760	1785
Fifty-Foot Sand	1865	1950
Thirty-Foot Sand (gas at 1980')	1975	1990
Gordon Stray Sand	2095	2110
Gordon Sand	2115	....
Fourth Sand	....	2180
Fifth Sand (gas at 2217')	2215	2227
Bayard Sand (gas at 2295')	2293	2300
Sand	2630	2645
Sand	2835	2910
Sand, Burnside (Warren or Tiona) (gas at 2989')	2987	2990
Unrecorded to bottom	2990	3011

Gas tests: 30', 5th, Bayard, 134,400 cu. ft.—255 lbs. rock pressure; Burnside, 304,320 cu. ft.,—1428 lbs. rock pressure.

This Patton record reveals the presence of all the regular oil and gas sands from the top of the "Big Injun" down to and including the Bayard Sand at 2293-2300', at 879 feet below the top of the Big Injun, and about 2350 feet below the horizon of the Pittsburgh Coal which crops about 60 feet above the derrick floor. Two other sand horizons are reported in

this well at depths of 2630 feet and 2835 feet, respectively, and this latter might represent the Elizabeth Sand of the deep well near West Elizabeth, Pennsylvania, on the Wm. Bedell farm, since the latter comes at 1397 feet below the top of the Big Injun Sand, while the one at 2835 feet in the Patton well comes 1421 feet below the same horizon.

The sand producing gas struck at 2987 feet, 3047 feet below the Pittsburgh Coal and 1573 feet below the top of the Big Injun Sand in the Patton well, and at 1571 feet below the same horizon in the Burnside well near by, can not represent the Speechley Sand of the Pennsylvania series, since in the Burnside well it comes considerably farther above (1355') the Benson Sand than it does above what has been identified as the Bradford Sand horizon in western Pennsylvania, where the "Speechley" Sand as identified in the records of two borings given on pages xliii and xliv of this discussion comes only 600 feet above the top of the "Bradford" of those wells, and 2000 feet in round numbers below the top of the Big Injun Sand. Then, too, in the record of the Bradys Bend well on page xxxix, the interval from the top of the Big Injun Sand (about 1200') to the top of the "Speechley" is 1835 feet, which corresponds closely to the same in the two records given from Westmoreland County, and thus renders it probable that the **Burnside Sand** may represent either the Warren or Tiona Sand of the western Pennsylvania series, 300 to 400 feet above the true **Speechley** gas horizon.

The Hope Natural Gas Company has also developed a still deeper oil and gas horizon in West Virginia than the **"Benson" Sand** of the Reiley and other wells just described. This is on the great Burning Springs or Volcano Arch near the line between Wood and Ritchie Counties, a few miles northeast from Petroleum Station on the Baltimore and Ohio Railroad.

The record of this well, as given through the courtesy of the officers of the Hope Natural Gas Company, is as follows:

RECORD OF WELL NO. 4670 OF HOPE NATURAL GAS COMPANY.

Drilled on lease of Volcanic Oil and Coal Company, near crest of Burning Springs Anticlinal, Wood County, West Virginia; began drilling April 1, 1917.

	Thickness. Feet.	Total. Feet.
Unrecorded (mostly sandstone)	500	500
Sand	12	512
Unrecorded	3	515
Sand	73	588
Hard lime, "Big Lime"	12	600
Sand, Big Injun	40	640
Slate and shells to bottom of Berea Sand	260	900
Slate and shells	1700	2600
Very hard "lime" and shells and slate	1100	3700
White "lime" and shells	270	3970
Slate, soft, white	85	4055
Slate, white and shells	57	4112
Slate, white, and brown	48	4160
Slate, hard	10	4170
Slate, soft, chocolate-colored	33	4203
Shells, hard	62	4265
Shale, brown	15	4280
Lime shells	7	4287
Shale, brown, mixed with light, sandy layers	59	4346
Shells, soft, limy	14	4360
Shell, hard	2	4362
Shale, soft, chocolate-colored	18	4380
Shale, very soft, cinnamon-brown	50	4430
Shell, gray, hard	2	4432
Shale, cinnamon-colored, soft	38	4470
Shell, hard, gray	2	4472
Shell, light-brown	18	4490
Shell, gray	4	4494
Shale, chocolate-coloced	10	4504
Shell	1	4505
Slate, soft	7	4512
Shells	2	4514
Slate, soft, dark	13	4527
*Hard lime and sand, with nuggets of iron pyrites (gas and oil at 4531')	4	4531

The "hard lime and sand" with oil and gas struck at 4527 feet may possibly represent the pebbly stratum struck just above the Corniferous Limestone at 4065 feet in the Derrick City well, or it may represent the Corniferous Limestone and Oriskany horizon with the flint absent. In any event, it lies geologically far below the "Benson" Sand horizon of Barbour, Harrison, and Lewis Counties, since the Devonian Shales thin rapidly westward, and at the longitude of Lancaster, Ohio, approximately 73 miles north 67½° west

*Since the above record was closed the well has been drilled a few feet deeper into a gray sand (Oriskany), getting some water and a much larger amount of gas, the total being estimated at not less than 2,000,000 cubic feet.

from the Volcano deep well, the Upper Devonian Shales between the Berea Sand and the Corniferous Limestone, which already measure 3627 feet at the Volcano well, have thinned down to only 805 feet, a northwestward thinning of 38.6 feet to the mile, as shown by the Federal Fuel and Gas Company's well No. 1 drilled near Lancaster, the record of which is published in Bulletin No. 1, Fourth Series, Ohio Geological Survey, pages 117-118, and given herewith:

LANCASTER, OHIO, WELL.

The record of Federal Fuel and Gas Company's Well No. 1, drilled in the bed of the old canal, 4 miles below Lancaster, Ohio, as recorded on pages 118 and 119, Bulletin No. 1, Fourth Series, Ohio Geological Survey, reads as follows:

	Thickness. Feet.	Total. Feet.
Drive pipe (Glacial Drift)	54	54
Shale	91	145
White sand, water	20	165
Sandy shale	135	300
Gray shale	90	390
Shale (Sunbury, Orangeville)	52	442
Berea Sand (8¼" casing)	25	467
Red Shale, (Bedford), Catskill	103	570
Black shale..560' } Chemung, Hamilton, and Mar- White shale..142 } cellus	702	1272
Corniferous, Helderberg, Salina, and Niagara Limestones, (water at 1407' and 1682', cased 6⅝" at 1944')	687	1959
White slate.....66' }		
Red rock (shales).....18 }		
Limestone shell..... 8 } Clinton Shales....	116	2075
Blue slate..... 4 }		
Shells .....15 }		
Blue slate..... 5 }		
Sand, "Clinton" (Medina White) to bottom.....	13	2088

Here these Upper Devonian Shales, including Catskill, Chemung, Portage, Hamilton, and Marcellus, total only 805 feet between the Berea Grit and the top of the Corniferous Limestone, and westward from Lancaster, they still continue to thin away until a thickness of only 30 to 40 feet remains just east of the Cincinnati Arch.

The greatest thickening of these Upper Devonian beds appears to be southeastward toward the Alleghany Mountains, since in the Central City deep well on the Ohio River near

Huntington, West Virginia, S. 4° E. 85 miles from Lancaster, they have increased only 200 feet to 1005 feet, a rate of only 2-1/3 feet to the mile, while in the Edwards deep well on Slaughter Creek, Kanawha County, S. 29½° E. 115 miles, the record of which is published on page XVIII, Kanawha County Report, W. Va. Geological Survey, they have increased to 2840 feet, or at the rate of slightly more than 16 feet to the mile.

The northeastward thickening of the Devonian Shales from the vicinity of Lancaster to 6 miles east from Zanesville as also the character of the formations there is shown by the record of a well published on pages 36 and 37, Bulletin No. 12, Fourth Series, Ohio Geological Survey, as follows:

RECORD OF ZANESVILLE OIL AND GAS COMPANY'S WELL.

On land of George Handchsy, 6 miles east of Zanesville, Section 25, Perry Township, Muskingum County, Ohio:

		Thickness. Feet.	Total Depth Feet.
Unrecorded			0 to 1010
Berea Sand			23 to 1033
Devonian (Ohio) Shales	Bedford red shales	15′	
	Limestone	15	
	Shale and lime shells	1312	
	Lime shells	265	
			1607 to 2640
"Big Lime"	Corniferous, Helderberg, Salina, Niagara		1005 to 3645
Clinton Shales	Black shales	5′	
	Lime shells	3	
	Shales	16	
	Sand shells	3	
	Shales	18	
	Red sandstone	4	
	Black shale	15	
			64 to 3709
Clinton (Medina) Sand			38 to 3747
Shales to bottom			58 to 3805

This record reveals a considerable thickening in both the Devonian Shales and the underlying limestone formations, Corniferous to Niagara, inclusive, in a direction from Lancaster, N. 71½° E., the Devonian Shales having a thickness of 1607 feet in the Zanesville well, or practically double

that (805') in the Lancaster test, while the "Big Lime" has also increased from 687 feet at Lancaster to 1005 feet in the Zanesville Oil and Gas Company's well, or a thickening of 318 feet.

THE DEEPEST WELL IN THE WORLD.

The deepest well in the world is the one put down by the Hope Natural Gas Company on the Martha O. Goff farm about 8 miles northeast from Clarksburg, Harrison County, West Virginia. Through the courtesy of Messrs. John B. Corrin and John G. Pew, Vice-Presidents of the Hope Company, and John H. Williams, Superintendent of the drilling department, the record of this deepest well of all borings (Hope No. 4190), together with a sketch map (figure 23) showing its location, photos of the derrick, cable, drilling crew, etc., are given herewith. The well was begun with the idea of testing for deeper oil or gas horizons than any hitherto encountered in West Virginia, the intention being to drive it to the horizon of the "Clinton" (Medina) petroliferous Sand of Ohio, if possible. The Devonian Shales, however, having thickened over a thousand feet more than expected, this boring will most probably be stopped after penetrating and testing the Oriskany Sandstone, now only a few feet (probably not more than 20 to 30) below the present bottom (7386') of the well where it is temporarily delayed with a fishing job, the steel cable having parted over 5000 feet down, thus leaving the tools and 2000 feet of cable in the hole. Mr. John H. Williams (to whose great skill and accomplishments in the art of drilling, aided by the splendid work of his resourceful crew, geology is indebted for the deepest well ever drilled) thinks that he can clear the well of the broken cable and tools, and then sink the same several hundred feet deeper, even to 8000 feet or more, the only trouble being to find a cable of the right strength and quality, some of them having parted with only a few hours' use. The complete history of this remarkable well is given in the following summary and record prepared by John B. Corrin and John H. Williams:

Statistics Concerning Deep Well Drilled By Hope Natural Gas Company.

LOCATION: On the Martha O. Goff farm of 620 acres in Simpson District, Harrison County, West Virginia, on the waters of Owens Fork of Booths Creek, 4½ miles northeast of the town of Bridgeport, on the the main highway from Fairmont to Clarksburg, W. Va. Well accurately located on the accompanying topographic sheet.

ELEVATION: Location made for well March 3rd, 1916, at a point 1164 feet above sea-level, and 200 feet below the level of the Pittsburgh seam of coal.

SUMMARY OF DRILLING: Drilling was commenced April 19, 1916, and on March 4, 1918, a depth of 7386 feet had been reached, thus exceeding by 37 feet the depth of the well hitherto known as "the deepest well in the world," located at Czuchow in Germany. Approximately 400 days have been spent in actual drilling, the remainder of the time the well has been shut down for repairs to rig, boilers, cables, etc., waiting for materials, minor fishing jobs, taking of temperatures, cleaning out cavings from the hole, etc. Fortunately, no serious fishing jobs have been encountered. The last known sand passed in the well was the Bayard Sand, at depth of 2300 to 2310 feet. Following is record of the various formations, and the dates showing progress of the work.

RECORD:

	Top. Feet.	Bottom. Feet.	
Native Coal (Elk Lick)	83	86	
Little Dunkard Sand	170	186	
Big Dunkard Sand	305	336	
Gas Sand	436	446	
First Salt Sand	690	815	
Second Salt Sand	860	880	
Maxton Sand	1025	1040	
Little Lime	1183	1194	
Pencil Cave	1194	1210	
Big Lime	1210	1275	Gas at 1253'
Big Injun Sand	1275	1394	Water at 1304'
Squaw Sand	1410	1428	
Berea Sand	1512	1540	
Gantz Sand consolidated with Fifty-Foot	....	....	
Fifty-Foot Sand	1748	1885	Gas at 1749' and 1757'
Thirty-Foot Sand	1900	1980	
Gordon Stray Sand	2090	2097	
Gordon Sand	2130	2142	
Fourth Sand	None		
Fifth Sand	None		

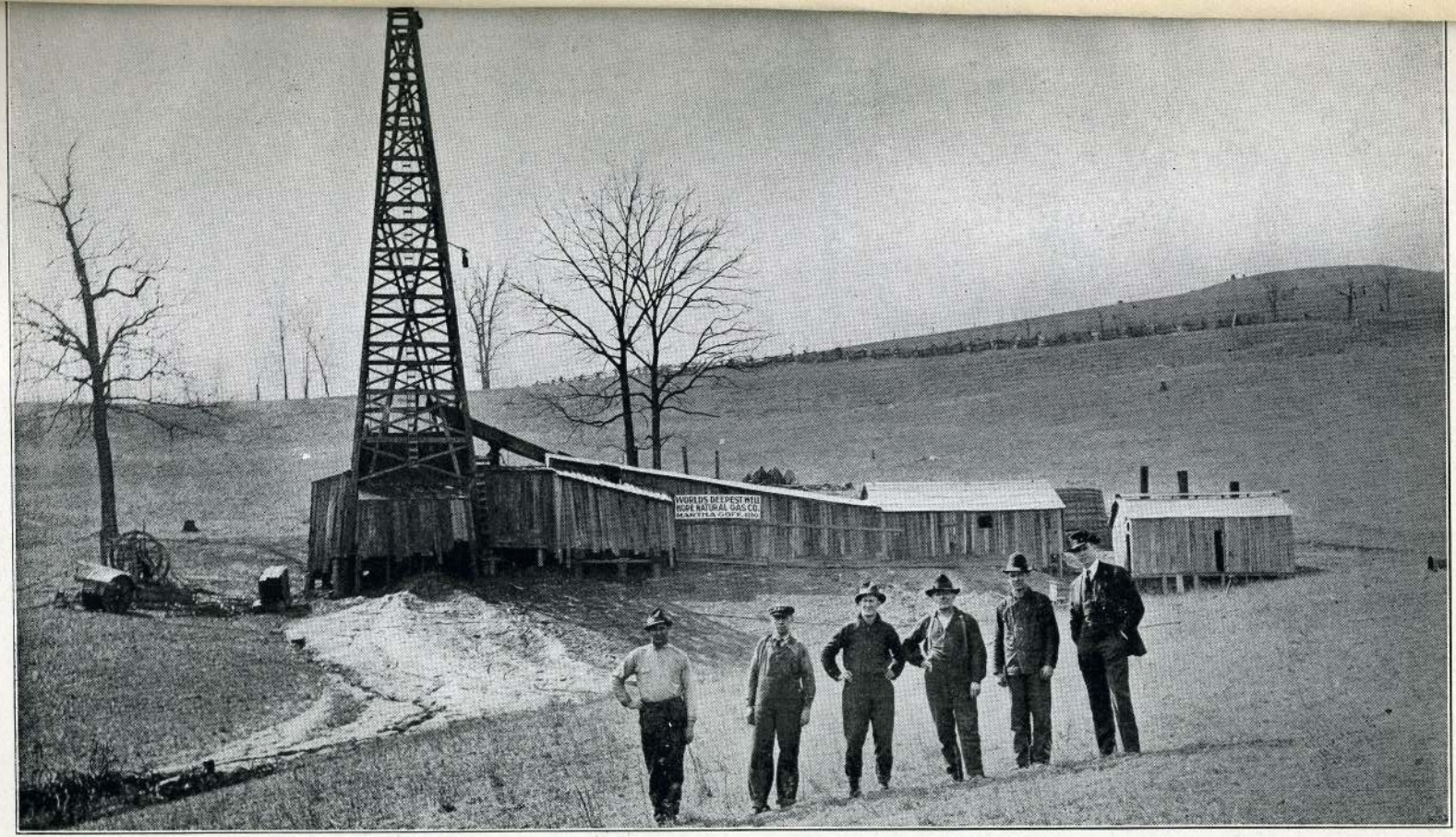

PLATE XLV.—Deepest Well in the World, Martha O. Goff, No. 4190 of the Hope Natural Gas Company, 8 miles northeast of Clarksburg, Harrison County, W. Va., and the men who drilled it; namely, (from left to right): James B. Wells, Tool Dresser; Charles Welch, Foreman; F. C. Davis, Tool Dresser; A. L. Rawlins, Driller; E. C. Rummage, Driller; and John H. Williams, Superintendent.

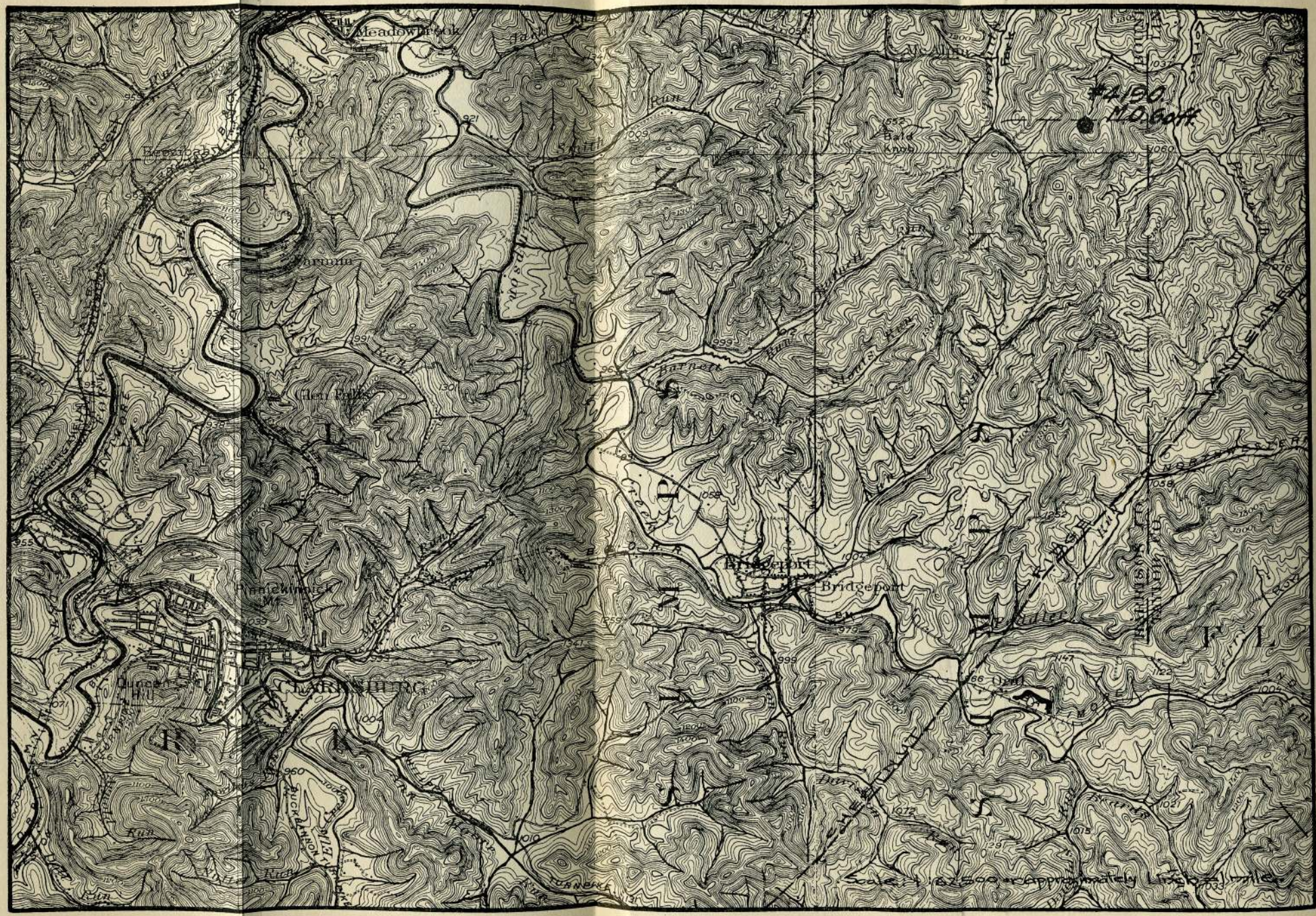

Figure 23.—Map Showing Location of Martha O. Goff No. 4190 Well.

	Top. Feet.	Bottom. Feet.	
Bayard Sand	2300	2310	June 23, 1916
Slate shells	2310	2830	
Hard lime	2830	2893	
Slate and lime shells	2892	3125	
Hard lime	3125	3145	
Slate shells	3145	3222	
Hard lime	3222	3240	
Slate shells	3240	3480	
Hard sand	3480	3505	
Slate	3505	4166	
Lime shells (Benson Sand)	4166	4167	With puff of air (gas)
Slate	4167	4425	
Lime	4425	4500	Sept. 8, 1916
Slate and shells	4500	4790	
Lime	4790	4850	
Slate shells	4850	5200	
Slate shells at		5700	December 23, 1916
Slate shells at		5775	January 6, 1917
Dark slate	5840	5995	
Lime shells	5995	5998	
Dark slate	5998	6210	
Light slate	6210	6235	February 16, 1917
Lime	6235	6265	
Dark slate	6265	6272	
Lime	6272	6280	
Dark slate	6280	6294	
Lime	6294	6304	
Dark slate	6304	6318	
Lime	6318	6330	
Dark slate	6330	6360	March 23, 1917
Lime	6360	6380	
Dark slate	6380	6385	
Lime	6385	6395	
Dark slate	6395	6420	
Lime	6420	6426	
Dark slate	6426	6438	
Lime	6438	6447	
Dark slate	6447	6465	
Lime	6465	6470	
Dark slate	6470	6500	April 13, 1917
Black slate	6500	6505	Shut down 2 months,
Black lime	6505	6510	repairs to rig, sand
Black slate	6510	6532	reels, waiting for ca-
Dark slate	6532	6580	ble, etc.
Dark slate	6580	6625	
Hard shells	6625	6627	
Brown shale	6627	6640	
Hard shells	6640	6645	
Black slate	6645	6660	June 29, 1917
Black shale	6660	6676	
Black sand	6676	6680	
Hard lime	6680	6690	
Dark slate	6690	6714	
Dark lime	6714	6747	
Hard shell	6747	6750	

	Top. Feet.	Bottom. Feet.	
Slate	6750	6755	July 7, 1917
Dark slate	6755	6775	
Hard sand shells	6775	6780	
Black shale	6780	6800	
Black slate	6800	6823	
Hard lime	6823	6865	July 13, 1917
Slate and shells	6865	6950	
Hard lime	6950	7057	
Lime shells	7057	7069	Shut down 1½ months
Hard sand	7069	7071	
Hard lime	7069	7075	November 2, 1917
Lime	7081	7093	November 16, 1917
Hard lime	7093	7097	
Hard lime	7097	7110	
Slate and shells	7110	7150	December 21, 1917
Slate	7150	7160	
Hard lime	7160	7162	
Lime shells	7162	7176	
Gritty shells	7176	7190	
Slate	7190	7225	January 4, 1918
Slate	7225	7232	
Hard shell	7232	7245	
Black slate	7245	7251	
Slate and shells	7251	7256	
Hard lime	7256	7261	
Dark hard lime	7261	7266	
Black slate	7266	7280	
Hard shells	7280	7282	
Slate	7282	7290	
Soft slate	7290	7295	
Soft black slate	7295	7300	January 18, 1918
Black slate	7300	7345	
Gritty lime	7345	7363	Feb. 1 to Mar. 1, 1918, shut down taking temperatures and repairing rig.
Hard flinty limestone, **Corniferous**, to bottom	7363	7386	March 1-4, 1918. March 4, 1918, cable parted 2000′ above bottom.

SIZE OF HOLE:
16″ in diameter to depth of 217′.
13″ in diameter from 217′ to 1238′.
10″ in diameter from 1238′ to 2307′.
8″ in diameter from 2307′ to 7071′.
6′ in diameter from 7071′ to present depth.

CASING:
217 feet of 13-inch casing, set in slate.
1238 feet of 10-inch casing, set in Big Lime.
2307 feet of 8¼-inch casing, set in Bayard Sand.
1666 feet of 6-inch liner, set in well at 5405′ to 7071′, to protect hole from cavings.

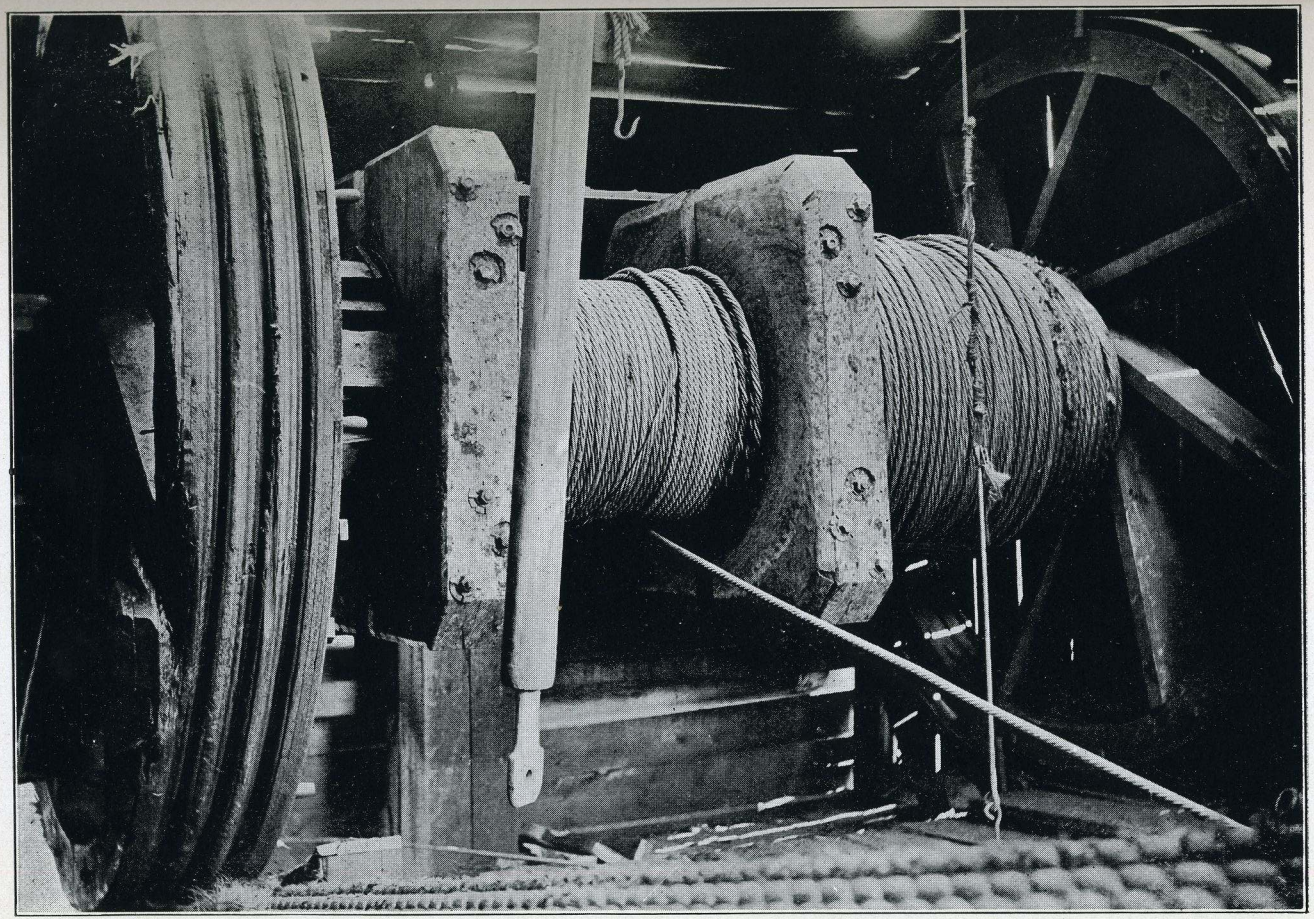

PLATE XLVI.—Bull Wheel and Cable at Goff Well.

PLATE XLVII.—Walking Beam at Goff Well.

RIG: Standard (wood), 96 feet high, with 22-ft. base of extra heavy timbers, Bull wheel shaft 24" in diameter, with Bull wheels 10' in diameter, triple tug, having two 10' brake wheels, with 14" brake band on one side, 10" on other side; three sets of bull wheels have been used. Band wheel is 14' in diameter with 13" face, triple tug, carrying belt 18" wide. 150' in length. Sand reel has 6" steel shaft, with 16" friction and brake wheel, and weighs approximately 8000 lbs., two of these sand reels having been used. Walking Beam is probably the heaviest and largest piece of timber ever used for this purpose, with Pitman, connected to the walking beam, also of unusual size and weight. Crown Pulley (top of rig) has 7" steel shaft, and weighs 1200 lbs. 4½ Standard rig irons were used to depth of 4500 feet, then replaced by special extra heavy rig irons (7½") which have been used to present depth. Rig has been reinforced and repaired from time to time. All work of erecting and repairing rig has been under the direction of George H. Stanfield, of Clarksburg, W. Va., Superintendent of Rig Building for the Hope Natural Gas Company.

BOILERS: One 25 hp. Acme, used from top hole to 4500 feet.

On 25 hp. Brennen, coupled with the Acme at 4500', the two boilers then being used from 4500' to 7300'.

One 25 hp. Acme, put on at 7300', the three boilers then being used from 7300' to the present depth.

ENGINES: One 12x12 Acme, 25 hp. used from top to 4500'.

One 16x16 Oil Well Supply, 80 hp., replaced the Acme at 4500' and has been used from that depth to present time.

CABLES: One second-hand Manilla, 2¼x700', drilled to 150'.

One second-hand Manilla, 2¼x700', drilled 150' to 615'.

One new Manilla, 2¼x2800', drilled 665' to 2290'.

One new Wire, ⅞"x4000', drilled 1070'.

One new tapered Wire, ⅞x1x1⅛x1¼x10,000' drilled 1220'.

One new tapered Wire, ⅞x1x1⅛x1¼x10,000', drilled, 525'.

One new tapered Wire, ⅞x1x1⅛"x7350', drilled 790'.

One new Wire, 1"x7000', drilled 32 feet, then used 48 days on cleaning out work.

One new Wire tapered, ⅞x1x1⅛x10,000', used one day, broke, and was fished out of well.

One second-hand Wire, 1"x5000', used one day.

One second-hand Wire, 1"x7000', used one day.

TOOLS: Drilled to 6500′ with string tools containing Stem 34′ in length, 5½-inch diameter.

Drilled from 6500′ to 7071′ with string tools containing Stem 40′ in length, 4½-inch diameter.

Drilled from 7071′ to 7386′ with string tools containing Stem 40′ in length, 4¼-inch diameter.

TO WHOM CREDIT IS DUE: John H. Williams, Clarksburg, W. Va., Supt. of Drilling Department of Hope Natural Gas Co., who has directed the work since its commencement, and still has charge.

A. L. Rawlins, Driller, at well since same was commenced.

L. P. Williams, Driller, from 175′ to 6500′.

John L. Richey, Driller, from 6500′ to present depth.

George Groves, Driller, from top to 175′.

Summary of Record.

This long column of deposits might be summarized as follows, beginning at the base of the Pittsburgh Coal, 200 feet above the mouth of the boring:

		Thickness. Feet.	Total. Feet.
Pittsburgh Coal, base of Monongahela Series.....			
Conemaugh Series.....600′ Allegheny .....290 Pottsville 260	Pennsylvanian	1150	1150
Mauch Chunk.....260′ Mountain (Greenbrier) Limestone ..... 65 "Big Injun," "Squaw," and "Berea" Sand Group.265	Mississippian	 590	1740
Catskill, containing Venango Oil Sand Group, to base of "Bayard" Oil Sand..... 770′ Chemung Shales, containing "Elizabeth," Speechley, Bradford (Benson) and Kane Oil Sand horizons..2190 Portage beds.....1207 Genesee Slate..... 288 Hamilton and Marcellus.1368	Upper Devonian Shales	5823	7563
Corniferous Limestone to present bottom.....		23	7586

The great thickness (5823′) of the Upper Devonian beds, or the measures lying between the Berea Sand and the top of the Corniferous Limestone in the Goff well reveals an un-

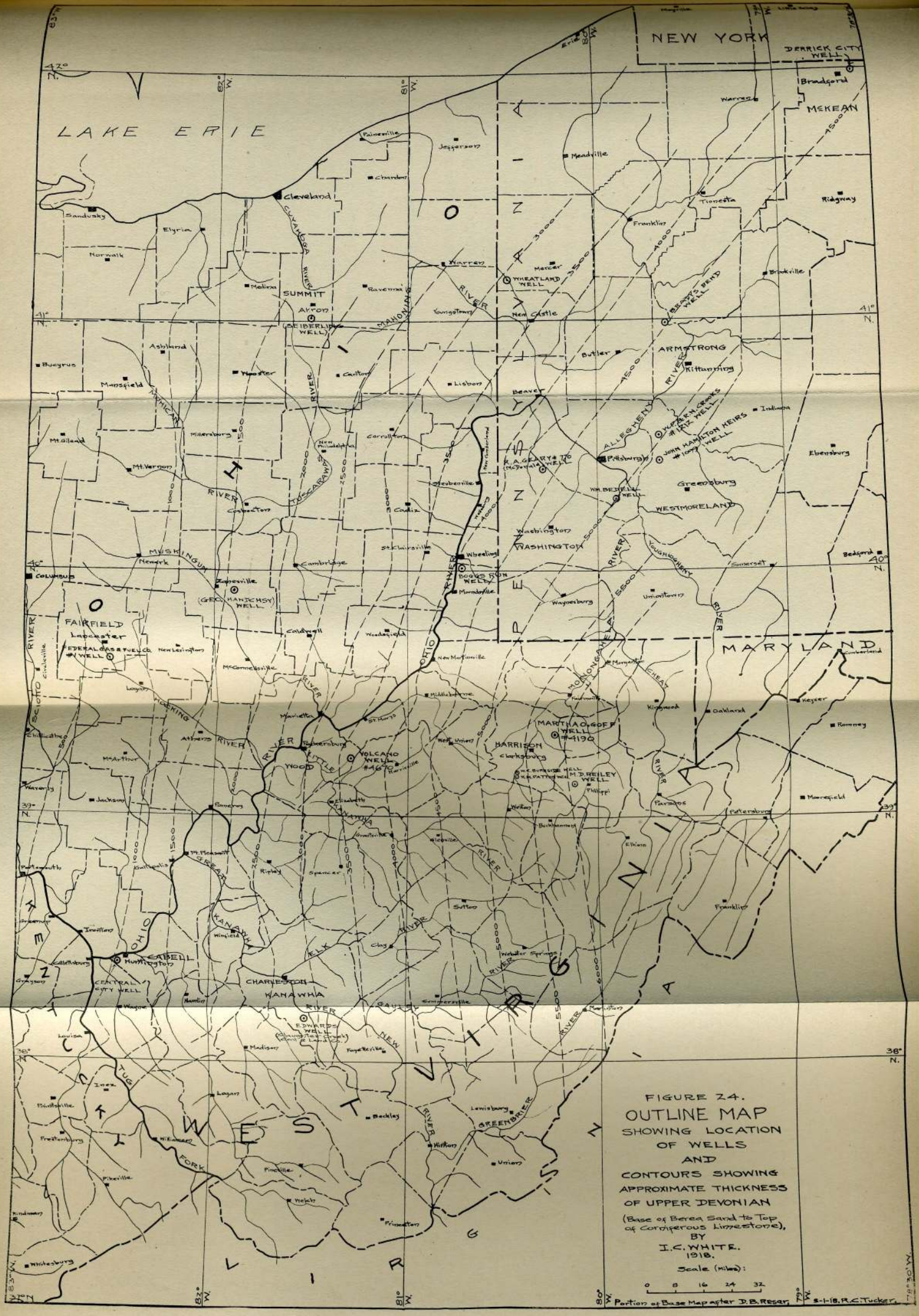

FIGURE 24.

OUTLINE MAP SHOWING LOCATION OF WELLS AND CONTOURS SHOWING APPROXIMATE THICKNESS OF UPPER DEVONIAN

(Base of Berea Sand to Top of Coniferous Limestone),

BY

I. C. WHITE.

1918.

Portion of Base Map after J. B. Reger.

S-1-18. R. C. Tucker.