

there are no openings on the Lower Kittanning, and in this region the coal is probably not thick enough to be mined profitably. On the J. H. Strickler farm, 3 miles south of Clarion, an opening has been made on a coal which appears to be the lower of the two beds assigned to the Lower Kittanning horizon in the geologic section.

From Sligo northward to Clarion River there appears to be nothing but clay between the two beds, but in the northeast corner of the Foxburg quadrangle there are two coal beds separated by shale and sandstone near the position of the Lower Kittanning. The upper one is the more valuable and shows very unusual local dips. Near Wentlings Corners there is said to be a drop of 30 feet in a distance of 40 rods.

Much of the coal that is shipped from these quadrangles is taken from the Lower Kittanning bed. It is used as a domestic and steam coal in northwestern Pennsylvania and western New York, and a small amount goes to Canada.

MIDDLE KITTANNING COALS.

As already stated, there are in the Clarion quadrangle two coals between the Lower and Upper Kittanning, and a few local mines are opened on each of them. In these mines the coal is from 2 feet to 2 feet 4 inches in thickness, except in a bank on the upper coal about 1 mile north of New Bethlehem, where it is 4 feet thick and of excellent quality. In the central and southwestern part of the Foxburg quadrangle the Middle Kittanning is 12 to 30 inches thick, averaging about 16 inches. It is commonly held as a reserve supply by farmers when they sell the Lower Kittanning. There are several small country banks on this coal.

UPPER KITTANNING COAL.

The Upper Kittanning coal is variable in thickness and quality and is worthy of the name "Pot vein," by which it is also known. Except for one or two banks this coal is found only in the southern half of the quadrangle. In most of the few openings it is thin and dirty, but in a bank 2 miles north of New Bethlehem it is 3 feet thick. Near Petrolia also it is minable, but in one place its thickness decreases in 200 yards from 5 feet 6 inches to 7 inches.

LOWER FREEPORT COAL.

The Lower Freeport coal has been worked commercially only in the vicinity of New Bethlehem but has been opened in a number of country banks. This coal is absent from large areas and where present it is generally too thin to be mined. In the New Bethlehem region the coal ranges in thickness from 3½ to 7½ feet and is of good quality, but it is nearly worked out.

About 3 miles southeast of West Freedom the Lower Freeport coal is known as the "Willcott vein." It is mined here in several country banks and its quality is, as usual, very good, but a parting of shale about 2 feet thick separates the coal into two benches, each about 2 feet thick.

UPPER FREEPORT COAL.

Next to the Lower Kittanning and Clarion coals the Upper Freeport is the most valuable in the Foxburg quadrangle. It is persistent and is of minable thickness in perhaps half of the area in which it occurs. There are no shipping mines on this coal, but in the vicinity of Redbank, just south of the area, it has been mined extensively for the last fifty years, and much of it has been coked. The coke was not of superior quality but was used in iron smelting. The Upper Freeport is found near the tops of the hills; consequently it occurs in many isolated areas and its outcrop is long and irregular. It is extensively worked in the vicinity of Rimersburg and near Baldwin.

In the Clarion quadrangle the Upper Freeport coal, besides being worked in approximately the same areas as the Lower, is also opened in the hill 2 miles north by east from Truittsburg; in the ridge 2 miles west of this town; on the Clarion-Redbank divide, 1½ miles west of Sloan Gap; and in Myers Hill, 2½ miles south by east from Sligo. All the openings are on small bodies of coal, near the hilltops. The thickness ranges from 3½ to 5½ feet.

MAHONING COAL.

The Mahoning coal seems to be unworkable in these quadrangles. It has been prospected near Queenstown and 3 miles southeast of West Freedom, where it is known as the "Second Summit vein." But the coal lies under light cover and scarcely reaches workable thickness. It is, however, reported to be of very good quality.

COAL ANALYSES.

The following analyses of coals were made at the United States Geological Survey's fuel-testing plant at St. Louis, Mo., from samples properly cut and quartered in accordance with the practice of the Survey, and shipped in air-tight cans.

Analyses of coal samples from Clarion quadrangle, Pennsylvania.

	Upper Freeport			Upper Kittanning			Lower Kittanning					Clarion	Black vein
	A	B	C	D	E	F	G	H	I	J	K		
Laboratory No.	4115	4075	4125	4108	4177	4118	4176	4086	4061	4173	4064		
Analyses of samples as received													
Moisture	8.18	5.96	6.36	5.99	4.99	5.87	5.73	4.99	3.38	4.54	5.35		
Volatile matter	36.55	46.52	46.79	39.46	36.51	34.51	34.77	34.71	36.58	37.86	37.57		
Fixed carbon	55.26	47.51	46.85	54.55	57.57	59.31	59.50	59.37	55.10	56.29	56.07		
Ash	7.52	6.28	6.58	14.00	8.59	5.31	10.30	5.96	8.65	7.26	11.17		
Sulfur	5.18	1.15	2.55	1.59	1.05	1.96	3.95	7.28	5.36	5.51	4.64		
Loss of moisture on air drying	2.46	3.30	1.99	1.39	2.35	1.30	7.36	3.50	1.59	3.30	1.19		
Analyses of air-dried samples													
Moisture	1.59	2.34	1.08	2.59	2.08	1.36	1.45	1.36	1.99	1.98	1.36		
Volatile matter	39.49	47.70	46.41	37.29	39.99	41.96	42.33	42.35	39.59	40.11	42.89		
Fixed carbon	56.79	50.30	53.47	59.85	58.60	58.64	57.66	57.70	59.39	57.92	57.59		
Ash	8.91	5.56	4.15	13.60	8.49	4.95	10.85	5.67	8.86	7.28	11.59		
Sulfur	2.88	1.13	2.78	1.06	1.08	1.27	3.75	5.45	2.45	4.11	4.09		

A. Two miles south of Sligo.
B. Three miles northwest of New Bethlehem.
C. Three miles northwest of New Bethlehem.
D. Five miles east of West of Sligo.
E. One mile northwest of New Bethlehem.
F. Two miles southeast of Truittsburg.
G. One mile south of Oak Ridge.
H. One mile south of Rimersburg station.
I. At Sligo.
J. One and one-half miles northwest of Clarion.
K. At Sligo.

PETROLEUM AND NATURAL GAS.

The Clarion and Foxburg quadrangles lie within the great petroleum and natural gas region of western Pennsylvania, and from this area enormous quantities of both of these products have been obtained. Drilling was begun here as early as 1865, when a well was sunk on Clarion River at the mouth of Deer Creek, in which oil was found. Between 1865 and 1870 a number of wells were drilled at that point, some of which flowed oil in small quantities. Several hundred barrels of this oil were shipped by barges to Pittsburg. The wells were not cased and much trouble was experienced with salt water; the wells produced only for a short time, until the gas pressure was relieved, and were then drowned out. The development of the larger pools began at Foxburg in 1869, when the first well in the great Petrolia-Elk City field was completed. Soon after this well was brought in another was drilled at the head of Armstrong Run, in Perry Township, Armstrong County, which began flowing at the rate of 2000 barrels per day. These wells initiated one of the great oil excitements, which have frequently occurred in Pennsylvania since Drake's discovery at Oil Creek in 1859. Development work was so rapid that as early as 1875 the great Petrolia-Elk City and the Cross Belt fields were fairly well outlined, and more than 1700 wells had been drilled having a total daily production of more than 20,000 barrels. Since that time thousands of deep wells have been sunk in these quadrangles, both in search of new pools and in retesting areas partly depleted during the early oil excitement. This drilling has thoroughly tested most of this territory, though there still remain a number of small isolated areas which may be found to contain pools of considerable value.

The oil and gas is found in greater or less quantities in nearly all of the sandstones from the base of the Burgoon down to and including the oil sands at the top of the Fortage (?) formation, which are believed to represent the Bradford oil sands.

Practically all of the oil and most of the gas found in commercial quantities occur, however, in the Venango oil sands of the Catskill (?) formation and the lower Pocono. Named in the order of their productiveness these are the Third or Gordon, Fourth, Hundred-foot, Third Stray or Gordon Stray, Murrysville, Bowlder, Nineveh Thirty-foot, Fifth, and First sands. The Speechley, Tiona, and Bradford (?) sands are exclusively gas producers in these quadrangles, though an oil pool of considerable value occurs in the Speechley just beyond the western border of the Foxburg quadrangle in the vicinity of Baldwin. From the maps showing the oil and gas pools, it may be seen that most of the great oil pools are confined to the Foxburg quadrangle and that the largest distinct gas pools occur toward the eastern border of the Clarion quadrangle, where the folding is more pronounced. In a general way the tendency of the oil pools to lie west of and apart from the great gas producing areas is characteristic of these accumulations throughout the entire Appalachian region and especially in Pennsylvania. The geologic reasons for this tendency are not apparent.

POOLS IN THE BRADFORD (?) SANDS.

So far as known the two sands that are called by the drillers in this region the First and Second Bradford sands contain no commercial oil pools in the Clarion and Foxburg quadrangles, though small quantities of oil have been reported in them in several wells. The principal gas pools in these sands are in the central part of Monroe Township, Clarion County, and in the Greenville field, which is located along the crest of the Kellersburg anticline in Limestone Township. In these areas a number of good gas wells are producing from each of the Bradford (?) sands. Where productive the sands range from 15 to 60 feet in thickness. The initial closed pressure of the gas generally ranges from about 300 to more than 400 pounds

per square inch. Some of the better wells had an initial daily capacity of probably more than 1,000,000 cubic feet.

In addition to these pools a number of wells, widely scattered over both quadrangles, produce more or less gas from these sands. Of these wells a number occur in the eastern and central portions of Clarion Township and a few others in the Bittenbender and Piolett fields of Porter Township. In the Foxburg quadrangle a few wells get small quantities of gas from the Bradford (?) sands, but these wells are of little importance.

POOLS IN TIONA SANDS.

The first well recognized sand above the Bradford (?) oil sand group is called the Tiona sand. The distance between them is about 150 feet. In northwestern Pennsylvania this sand has produced enormous quantities of both oil and gas, but in the Foxburg and Clarion quadrangles it is barren except in two or three small gas wells in Limestone Township, Clarion County. Small quantities of gas have been found in this sand at a number of other places in both quadrangles, but so far as known the amount was too small to be utilized. The Tiona sand is fairly continuous throughout both quadrangles, though generally too fine grained and hard to afford a good reservoir for either oil or gas.

POOLS IN THE SPEECHLEY SAND.

The Speechley sand, which lies about 100 feet above the Tiona, does not furnish oil in paying quantities in these quadrangles. It is, however, an important source of gas throughout the whole area, though nearly all the larger pools have been found in the Clarion quadrangle. Most of this gas comes from a depth of 2000 feet to 2400 feet and has a closed pressure ranging from 400 to more than 900 pounds per square inch. The initial daily production of some of these wells is reported to have been more than 10,000,000 cubic feet.

The Greenville field on the crest of the Kellersburg anticline is the largest pool in this sand. The Kifer pool in Monroe Township, the Leatherwood field of Porter Township, and a number of wells in Paint Township have furnished considerable quantities of gas from this sand. In the Foxburg quadrangle numerous small pools of gas under high pressure have furnished many good wells at a number of places throughout the area. The sand is almost invariably found to carry gas in greater or less quantities, the amount depending on its thickness and porosity.

POOLS IN THE FIFTH SAND.

There is some doubt as to the correct identification of the Fifth sand by drillers in most of the wells where it is recorded. This sand is generally thin and of little importance for either oil or gas. The Exley oil pool, in the northwest corner of Beaver Township, Clarion County, is the only oil reported in this sand, though it is highly probable that several other small pools have been overlooked in areas where better pools occur in other sands. Gas is found in small quantities in the Fifth sand at several points, but the total production from that source is small.

POOLS IN THE FOURTH SAND.

With a single exception the Fourth sand is the most prolific source of oil and gas in this area. From it came most of the tremendous flow of oil yielded by the great "Cross Belt" pool of Armstrong and Butler counties, in the southwestern part of the Foxburg quadrangle. Many of these wells produced from 1000 to 2000 barrels of oil per day, the maximum daily output of a single well being about 3000 barrels. In the Petrolia-Elk City oil field are a number of important oil-bearing areas in the Fourth sand which are so closely associated with the Third sand pools that they can not now be accurately outlined. One of these is the Triangle pool, which furnished wells with an initial daily production of 100 to 400 barrels. Some Fourth sand oil is also found in the Emlenton-Richey Run field. The Miola pool, in Paint and Highland townships, Clarion County, is said to furnish oil exclusively from the Fourth sand. In this instance the writer doubts the correctness of the drillers' correlation. In this pool and in the Clarion pool the Fourth sand is said to be separated from the Third sand above by only a few feet of shale, and in places drillers report that the sands are united. Taking all the available stratigraphic evidence into account it seems probable that these two sands represent more nearly the Third sand and Third Stray sand. Oil was discovered in the Miola pool in December, 1906, when a well which had been producing gas for eight years from the upper of the two sands mentioned above, which is probably the Third Stray, was drilled 10 feet deeper, through 2 feet of shale into the so-called Fourth sand. This well began flowing at the rate of 80 barrels per day. Aside from this questionable Fourth sand production, no oil has come from this sand in the Clarion quadrangle, except in a few small wells in the Shamburg field, Piney Township, where the same doubt exists as to the correct identification of the sands. Gas in paying quantities has been found