COALS OF THE CLARION QUADRANGLE, CLARION COUNTY, PA.

By EDWIN F. LINES.

LOCATION AND AREA.

The Clarion quadrangle is in the southeast corner of Clarion County, Pa. Its area is approximately 225 square miles, or a little more than one-third of the area of the county.

TOPOGRAPHY.

The most striking topographic feature of the area consists of the gorgelike valleys of Clarion River and its tributaries, cut 400 feet below the comparatively flat top of the general upland region. This drainage system occupies approximately the northern two-thirds of the quadrangle. The remainder of the drainage is tributary to Redbank Creek. The latter area is made up of broader valleys and gentle slopes, except in the southwest, where the valleys are again deep and narrow. Altitudes in the quadrangle range from about 1,000 feet at water level on Clarion River to 1,700 feet in the highest part of the Clarion-Redbank divide.

STRATIGRAPHY.

The formations exposed in the quadrangle extend from the upper portion of the Pocono to the lower portion of the Conemaugh. Over most of the quadrangle, however, the rocks at the surface belong to the Allegheny formation, and in this formation occur, with one possible exception, all the workable coal beds of the quadrangle. A generalized section showing the position of the coals of this formation is as follows:

General section of Allegheny formation in Clarion quadrangle.

	Feet.
Coal, Upper Freeport	3½ – 5½
Clay, plastic, Limestone, Clay, flint, Shale	25 – 45

	Feet.
Coal, Lower Freeport	3½ – 7½
Clay, plastic Limestone (locally developed) Sandstone and sandy shale	50 – 90
Coal, Upper Kittanning	2 – 4
Clay, plastic Sandstone and shale Coal Clay, plastic Shale Coal, Middle Kittanning Clay, plastic Shale	70 – 130
Coal, Lower Kittanning	2 – 4½
Sandstone and shale	10 – 45
Iron ore	0 – 1½
Limestone, Vanport	3 – 8
Sandstone and shale	20 – 35
Coal, Clarion	1 – 2
Shale Coal (?) Shale, sandy	20 – 40
Coal, Brookville	1 – 3

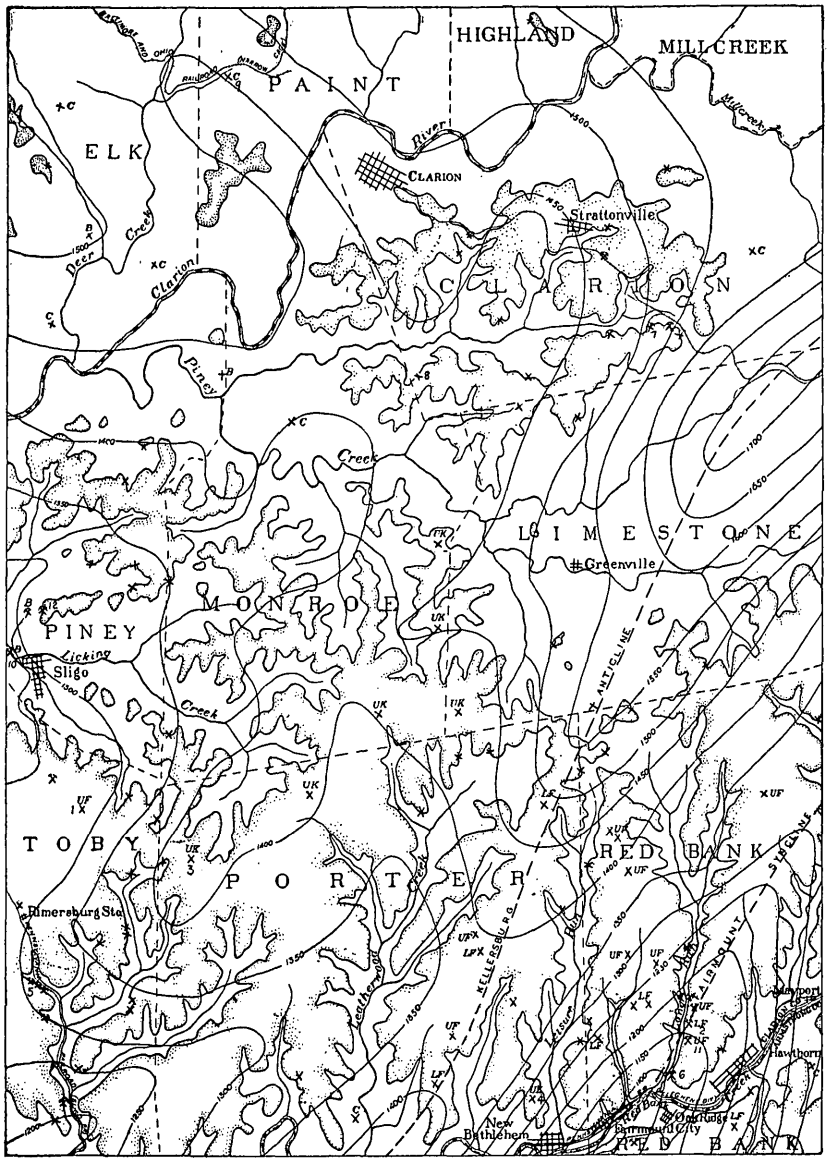
The above general section applies to the rocks over about two-thirds of the quadrangle. In the remaining third, which occupies the northwest corner, the rocks below the Lower Kittanning coal are radically different, the succession being as follows:

Section of rocks below Lower Kittanning coal in northwestern third of Clarion quadrangle.

	Feet.
Clay, plastic	5 – 15
Coal	½– 2
Clay, plastic	5 – 10
Clay, flint	0 – 4
Sandstone	45 – 60
Coal, Clarion	2 – 4
Sandstone and shale	55 – 60
Coal, Brookville	1 – 2½

STRUCTURE.

Reference to the map (Pl. I) shows that the leading structural feature of the quadrangle is the Kellersburg anticline. The rocks on the east flank of this fold dip strongly into the Fairmount syncline, but west of the anticline the dips are slight and irregular, so that in the western and northern parts of the quadrangle there are no prominent anticlines or synclines. The dip of the rocks as a whole is a little west of south and amounts to about 300 feet in the length of the quadrangle, so that the Lower Kittanning coal, which is just above drainage level in the south, occupies the hilltops in the north. The dips range from 25 feet to the mile in the western portion of the quadrangle to 175 feet to the mile in the eastern portion.



MAP OF CLARION QUADRANGLE, PENNSYLVANIA.

Names of the coal beds on which openings have been made are indicated as follows: U F = Upper Freeport; L F = Lower Freeport; U K = Upper Kittanning; C = Clarion; B = Brookville; no mark = Lower Kittanning.

COALS.

FREEPORT COALS.

The Upper Freeport coal bed is the uppermost member of the Allegheny formation, and the Lower Freeport coal lies about 40 feet lower. These coals are present in small areas on some of the higher hills in the southern half of the quadrangle. With the exception of a few isolated hilltops in which country banks have been opened, the only commercial development of these coals is in the vicinity of New Bethlehem. The Freeport coals are of excellent quality and good thickness, but are of comparatively small extent and have been largely worked out.

On a hilltop 1½ miles south of Rimersburg, on the Painter farm, is an old opening on a coal 4 feet 4 inches thick, which the writer at present refers doubtfully to the Upper Freeport, although it is possibly the Brush Creek coal. As a rule the roof of the Upper Freeport is sandstone, and the roof of the Lower Freeport is shale. The following are typical sections:

Section of Upper Freeport coal in W. R. Saylor bank, 2 miles south of Sligo (No. 1[a]).

	Ft.	in.
Sandstone.		
Coal, bony		7
Coal	3	3
Clay.		
	3	10

Section of Lower Freeport coal in mine No. 11 of the Fairmount Coal Company, 3 miles north of New Bethlehem (No. 2).

	Ft.	in.
Clay.		
Coal	2	2½
Sulphur parting		½
Coal	1	1
Sulphur parting		½
Coal		10
Clay.		
	4	2½

KITTANNING COALS.

The Kittanning group of coals is usually described as consisting of three members, Lower, Middle, and Upper, but in this quadrangle there appear to be four or five coal beds in the interval between the Lower Freeport coal and the Vanport ("Ferriferous") limestone. The uppermost coal bed, designated Upper Kittanning in the general section, is fairly persistent and where opened averages 2½ feet in thickness except in the vicinity of New Bethlehem, where two sec-

[a] Numbers refer to corresponding numbers on Pl. I.

tions of 3 and 4 feet were measured. The following are typical sections:

Section of Upper Kittanning coal in John Mohney bank, 5 miles southeast of Sligo (No. 3).

	Ft.	in.
Shale.		
Coal	1	11
Clay parting		½
Coal		3½
Clay.		
	2	3

Section of Upper Kittanning coal in Sam Shankel bank, 1 mile northwest of New Bethlehem (No. 4).

	Ft.	in.
Coal, bony		6
Coal	1	1
Coal, bony		½
Coal	1	11
Coal, bony		6
	4	½

The next two coal beds in descending order, the lower of which is designated Middle Kittanning in the general section, are difficult to trace. Both coals were observed in the same vertical section only once, but the relation of the blossoms to adjacent rocks and the intervals between them and other coal beds that are more readily identified indicate their presence in many localities. In no place where either of these coals was identified with certainty was it possible to obtain a measured section. Neither promises anything more than a possible local value.

The Lower Kittanning coal is the most important in the quadrangle. It is persistent, uniform in thickness, and widely distributed. Its horizontal position is indicated on the accompanying map by its line of outcrop, and its elevation by the structure contours. The average thickness of 66 measured sections is 3 feet. Of the total number of measurements nine were under 2½ feet and eight over 3½ feet. No regular partings occur in the coal and the irregular ones are thin, few of them being over one-half inch in thickness. In about half the sections measured no partings were noted. From 6 to 12 inches below the top of the coal, however, occurs a binder of splinty character, from half an inch to 2½ inches thick, which is readily distinguished on fresh faces of the coal and which probably persists nearly everywhere. No attention is paid to this binder in mining. In many places the upper portion of the bed consists of 2 to 12 inches of bony coal, thus making the average thickness of clean coal 1 or 2 inches less than 3 feet. In all the openings examined the roof is shale and the floor clay. It is reported that this coal was coked for use in some of the old natural-draft iron furnaces which formerly existed in Clarion County, but a recent attempt to coke it in some

experimental ovens near Rimersburg was reported to be unsuccessful. The analyses show that the coal is rather high in sulphur and moderately high in ash. The following are typical sections of the Lower Kittanning coal:

Section of coal in mine of Acme Mining Company, 1 mile south of Rimersburg station (No. 5).

	Ft.	in.
Shale.		
Coal	1	
Binder		½
Coal	2	7
Clay.		
	3	7½

Section of coal in mine No. 1 of the Alcola Coal Company, 1 mile north of Oak Ridge (No. 6).

	Ft.	in.
Shale.		
Coal		7
Coal, bony		½
Coal	1	9
Sulphur parting		¾
Coal		11½
Clay.		
	3	4¾

Section at Baldauf mine No. 1, 2 miles southeast of Strattonville (No. 7).

	Ft.	in.
Shale.		
Coal		4½
Binder		2½
Coal	2	7½
Clay.		
	3	2½

At a distance ranging from 5 to 15 feet below the Lower Kittanning coal occurs a lower bed which is developed only in the northern half of the quadrangle. This is either a split from the Lower Kittanning or a separate bed. In favor of the theory that it is a split is the fact that in general the measurements show smaller intervals in the western than in the eastern part of the area. On the other hand, the inconsistencies in the variation and the fact that the thickness of the upper coal is not affected by the presence of the lower is in favor of the hypothesis that there are two beds. A more detailed study of the problem should be made before attempting to settle the question definitely. The thickness of the coal varies between 20 and 24 inches, except in a road section near the west edge of the quadrangle, where the beds show in one place 4 inches and in another place 9 inches thick. On the J. H. Strickler farm, 3 miles south of Clarion, an opening has been made on what appears

to be this coal. Its thickness is 24 inches. The following section was exposed at the mouth of the opening:

Section of Lower Kittanning (?) coal on farm of J. H. Strickler, 3 miles south of Clarion (No. 8).

	Ft.	in.
Coal		4
Shale		5
Coal		7
Clay	5	6
Coal, worked	1	10
	8	8

CLARION COAL.

According to the Second Geological Survey of Pennsylvania,[a] the Clarion coal in this county is split into two beds, but in this quadrangle the evidences of two coals at this horizon are not conclusive. Many sections suggest their presence, but in most of these the indications consist of coal fragments so scattered as to make the determination of the horizon uncertain. In the southern half of the quadrangle the Clarion coal is of little commercial importance. Openings have been made on it 1 mile south of Mayport and 3 miles west of New Bethlehem, and in these openings the coal measures 26 and 27 inches, respectively. In the northern half of the quadrangle the coal is much thicker, the average of four sections being 3½ feet. An 18-inch bed is reported about 5 feet below the bed that is being worked, but this coal was not seen by the writer. The Clarion coal in this region lies immmediately below the pinkish, massive sandstone which makes many flats and benches in the vicinity of Clarion River. The coal is known locally as the "Sulphur vein." The following is a sample section:

Section in coal bank on George Cook farm, one-half mile northeast of Clarion (No. 9).

	Ft.	in.
Sandstone.		
Clay	1	
Coal	2	11½
Clay.		
	3	11½

BROOKVILLE COAL.

The Brookville coal lies usually about 90 feet below the Lower Kittanning. The few sections seen indicate that it is thin and dirty over most of the quadrangle. At Sligo, however, there are two commercial mines on this coal—the Mineral Run mine, owned by J. B. Miller, and the mine of the Sligo Coal and Coke Company. The bed is about 3 feet thick and, although high in sulphur, the coal has a ready sale for steam purposes. The extent of coal having this thickness and quality is at present not definitely known. A good blossom of the coal shows in the road running south from

[a] Rept. VV, 1880, pp. 49, 50.

Curllsville, 3½ miles east of Sligo, and 3 feet or more is said to have been uncovered on Leatherwood Creek on the George Lee farm, 2½ miles northeast of New Bethlehem.

Section of coal bed in mine of Sligo Coal and Coke Company, Sligo (No. 10).

	Ft.	in.
Sandstone.		
Coal	1	9
Sulphur parting		¾
Coal		7
Sulphur parting		½
Coal		6
Clay.		
	2	11¼

OTHER COALS.

In the northwest corner of the quadrangle there is an unusual succession of coal beds below the Lower Kittanning. A road section 1½ miles southwest of Shippensville contains seven beds ranging from 2 inches to 1 foot in thickness in a vertical distance of 140 feet. These coal beds are of small extent within the quadrangle and are probably of no commercial value. The horizon of the Mercer coals of the Pottsville formation is above drainage level in portions of the quadrangle, but these coals are not commercially important.

COAL ANALYSES.

The following analyses of coals of the Clarion quadrangle were made at the United States Geological Survey 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.		Lower Freeport.	Upper Kittanning.		Lower Kittanning.				Clarion.	Brookville.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
Laboratory No	4111.	4171.	4172.	4176.	4177.	4116.	4170.	4055.	3951.	4173.	3953.
Analysis of sample as received:											
Moisture	3.98	5.56	3.30	5.89	4.09	2.87	2.73	4.09	3.36	4.84	2.35
Volatile matter	33.70	30.72	33.79	30.46	30.24	34.51	34.77	34.79	35.94	37.86	37.47
Fixed carbon	54.50	57.14	56.83	48.66	57.37	54.31	52.20	55.32	52.05	50.28	49.01
Ash	7.82	6.58	6.08	14.99	8.30	8.31	10.30	5.80	8.65	7.02	11.17
Sulphur	2.18	1.10	2.73	1.60	1.01	1.36	3.66	2.39	2.30	3.98	4.04
Loss of moisture on air drying	2.30	3.30	1.80	3.90	2.10	1.00	1.30	2.60	1.70	3.20	1.10
Analysis of air-dried sample:											
Moisture	1.72	2.34	1.53	2.07	2.03	1.89	1.45	1.53	1.69	1.69	1.26
Volatile matter	34.49	31.76	34.41	31.70	30.89	34.86	35.23	35.72	36.56	39.11	37.89
Fixed carbon	55.79	59.09	57.87	50.63	58.60	54.86	52.89	56.80	52.95	51.95	49.56
Ash	8.00	6.81	6.19	15.60	8.48	8.39	10.43	5.95	8.80	7.25	11.29
Sulphur	2.23	1.13	2.78	1.66	1.03	1.37	3.71	2.45	2.43	4.11	4.08

A. Two miles south of Sligo.
B. Three miles northeast of New Bethlehem.
C. Three miles northeast of New Bethlehem.
D. Five miles southeast of Sligo.
E. One mile northwest of New Bethlehem.
F. Two miles southeast of Strattonville.
G. One mile north 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.

COAL RESOURCES OF JOHNSTOWN, PA., AND VICINITY.[a]

By W. C. PHALEN.

INTRODUCTION.

Location.—The area here considered is the Johnstown quadrangle, which comprises an area of 228 square miles. It lies mostly in Cambria County, Pa., but includes small parts of Somerset, Indiana, and Westmoreland counties. (See Pl. II.)

Commercial geography.—This quadrangle lies in the plateau region west of the Allegheny Front and the streams that flow through it have cut deep valleys, exposing valuable coal and clay beds. The most important streams are Conemaugh River, formed by the union of Stony Creek and Little Conemaugh River at Johnstown; Blacklick Creek, and South Fork. Conemaugh River has long been one of the most available highways of communication across the region from the coast to the Middle West; the first railroad, the old Portage and Canal Route, and the main line of the Pennsylvania Railroad have both used its valley. Thus the early development of the iron resources of the region was stimulated, and, in turn, an impetus was given to the development of its coal resources, until, at the present time, Johnstown and the towns lying in this area are among the leading coal and iron centers of western Pennsylvania. The value of the coal for 1905 was nearly $5,000,000, representing an output of about as many tons.

GEOLOGY.

STRATIGRAPHY.

The rocks outcropping in this district belong mostly in the Carboniferous system, but a few hundred feet (400 ±) of Devonian rocks are represented. Of the Carboniferous rocks only those in the Pennsylvanian series are of interest in this connection, since all the coal beds are confined to this series. As developed in this area, the Pennsylvanian comprises the Conemaugh, Allegheny, and Pottsville forma-

[a] In the field work on which these notes are based the writer was assisted by Lawrence Martin. This preliminary statement will be followed by a detailed report on the same region, which will be published as a bulletin of the Survey.

tions, in all about 1,200 feet of beds. These formations correspond, respectively, with the "Lower Barren Coal Measures," the "Lower Productive Coal Measures," and the "Millstone grit" or "Pottsville conglomerate" of the Second Geological Survey of Pennsylvania. The important coals of the area are included in the Allegheny formation, though the Conemaugh and Pottsville both contain beds that are locally workable, but probably not valuable commercially. The Allegheny formation contains at least six coal beds which at various points are thick enough to be of commercial value. Of these, not more than four, and in most places not more than two or three, are persistently valuable. The highest of these beds is the Upper Freeport or E coal. It is known about Johnstown as the Coke Yard coal and at South Fork as the Lemon or Four-foot coal. It occurs at the top of the Allegheny formation, almost directly below the usually massive Mahoning sandstone, and from 230 to 300 feet above the top of the Pottsville, or as it is locally called, the "conglomerate rock." The Lower Freeport, or D coal, is known about Johnstown as the Limestone bed, from a 2 or 3 foot layer of limestone occurring within a foot of its base. It ranges from 45 to 70 feet below the Upper Freeport coal.

The next lower coal is known as the Upper Kittanning, or C′ coal, and about Johnstown it is frequently called the Cement bed. Like the Lower Freeport coal, it is in general closely underlain by a bed of ferruginous limestone known as the Johnstown cement bed. The Upper Kittanning is an important coal about Johnstown and Windber, and is one of the most persistent and valuable coals in the quadrangle. It occurs from 80 to 105 feet below the Upper Freeport coal, though at some points, as about South Fork, this interval is slightly less. The Middle Kittanning, or C coal, is the next lower coal, but is usually not workable in this area. The next lower coal, known as the Lower Kittanning, Miller, White Ash, or B bed, is the most persistent and valuable bed in the area. It usually lies 180 to 200 feet below the Upper Freeport coal, and from 65 to 110 feet above the top of the Pottsville.

Between the Lower Kittanning coal and the top of the Pottsville there are usually at least two coal beds. One of these, occurring about 65 feet below the Miller bed, is worked at South Fork. It probably corresponds to the Brookville or A coal of the Allegheny Valley. The other bed, known as the Clarion or A′ coal, lies at a small distance above the Brookville. The upper coal showing at the roadside just opposite the pumping station of the Cambria Steel Company, west of Coopersdale, may correspond to the Clarion. It is separated by 10 feet of dark shale or clay from the lower or Brookville coal. The Mercer coal, occurring in the Pottsville formation, is as a rule not workable in this quadrangle.

STRUCTURE.

The details of the structure of this area have been only partially worked out, and it will be understood that the statements made in the following paragraphs, relating to structure, are subject to revision when the data have been studied in greater detail.

The beds which have been described above are involved in a series of nearly parallel folds, having a general northeast-southwest trend, which extend completely across the area in a series of waves from the southeast to the northwest corner. In the southeast corner the beds dip to the northwest away from the Allegheny Front into the Wilmore basin, the dips ranging as high as 300 to 350 feet to the mile. The Wilmore basin, as its name suggests, passes through the town of Wilmore, situated to the east of Summerhill and outside this quadrangle, and after crossing the reservoir site on South Fork of Little Conemaugh River passes to the southwest near the town of Elton, and from this point onward coincides very closely in position with the South Fork branch of the Pennsylvania Railroad. It is estimated that along the axis of this basin the beds rise between 800 and 900 feet in crossing from the eastern to the southern border of the quadrangle. From the Wilmore basin the beds rise northwestward to the summit of the Ebensburg (Viaduct) anticline. About South Fork the rise is comparatively sharp, at many points exceeding 400 feet to the mile. It is probable that south of Little Conemaugh River this anticlinal axis swerves slightly to the southeast and then returns to its regular southwest course. The point where it leaves the southern edge of the quadrangle is in the vicinity of Eureka No. 37 mine of the Berwind-White Coal Mining Company, but the structure of this region is not simple, the mine maps showing many slight irregularities. The Johnstown syncline is the next prominent structural feature to the west. Where it enters the quadrangle near its northeast corner, this synclinal axis lies very near the Ebensburg anticlinal axis, but farther southwest it diverges and at Johnstown curves in somewhat the same manner as the Ebensburg anticline. The next structural feature to the west is the most pronounced in the area. It is known as the Laurel Ridge anticline. This is the "first grand axis" of the Second Geological Survey of Pennsylvania. It crosses Conemaugh River about midway between Conemaugh Furnace and Coopersdale and passes to the northeast, crossing South Fork of Blacklick Creek a little over a mile southeast of Twin Rocks. Where the axis of the fold crosses the valley of Conemaugh River the lowest beds in the area are exposed. These are the red shales and sandstones of the Catskill formation, aggregating 400 feet or more above drainage level. This fold pitches

sharply to the northeast, and the Pocono sandstone, which caps the hills where the axis crosses Conemaugh River, is below drainage level where it crosses South Fork of Blacklick Creek near Twin Rocks, dropping in this distance at least 1,000 feet. The basin west of the Laurel Ridge anticline is known as the Westover basin in the Pennsylvania Geological Survey reports. More recently it has been called the Barnesboro basin by the United States Geological Survey. The course of this basin has not been very definitely determined as yet, but it is believed to enter the quadrangle near the boundary between Indiana and Cambria counties and to pass southwestward near Wehrum, crossing Blacklick Creek about a mile west of Buffington post-office. West of this basin the beds rise northwestward to the axis of the Nolo anticline, which lies very close to the northwest corner of the quadrangle. Thus it is evident that the beds in the quadrangle are involved in three broad, low waves, a condition of great practical importance in the distribution and working of the coals, fire clays, and other bedded deposits of economic importance.

Besides the principal folds there are many minor folds in these rocks. A small arch or anticline is exposed along Little Conemaugh River about a mile east of Conemaugh station. From this point westward to Johnstown depot there are many minor fluctuations, all exposed along the main line of the Pennsylvania Railroad. Between Millville and Coopersdale there is a distinct anticline. Thus it will be seen that the main broad Johnstown syncline has been subjected to many minor plications. It has been thought by some mining men that these lesser folds about Franklin and along Clapboard Run have been responsible for the so-called "faulting" which the coal exhibits in this region. The erratic behavior of the Lower Kittanning coal may possibly be due in part to this cause, but the irregularities seen by the writer are not faults, as this term is used in the geologic sense, but rather broad rolls, which seem to have pinched out the coal.

COALS.

CHEMISTRY AND USES.

In the following descriptions no attempt is made to present detailed information. This will be reserved for a future economic bulletin on this area. It is the aim here to present general facts only, chiefly additional to those heretofore published in the various volumes of the geological surveys of Pennsylvania.

The coals in this district are of the soft, lustrous, semibituminous variety. They are best adapted for steaming and domestic purposes and to a less extent for coking. They are regarded as smokeless coals owing to their small content of volatile hydrocarbons. They

are uniformly high in carbon and contain small amounts of volatile matter and moisture. The ash and sulphur contents are variable, but in general terms high as compared with other Appalachian coals—for instance, those of West Virginia and eastern Kentucky. Some analyses of samples collected according to present Survey methods are listed below:

Analyses of coal samples from Johnstown quadrangle, Pennsylvania.[a]

	Upper Freeport (E).			Lower Freeport (D).	Upper Kittanning (C').					
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Analysis of sample as received:										
Moisture	2.65	2.82	3.04	4.73	2.81	1.67	2.60	1.94	2.93	3.51
Volatile matter	14.86	15.61	16.27	13.78	15.07	18.52	14.10	15.81	13.47	17.16
Fixed carbon	72.38	70.32	73.47	72.27	72.64	69.14	72.05	70.77	74.06	69.04
Ash	10.11	11.25	7.22	9.22	9.48	10.67	11.25	11.48	9.54	10.29
Sulphur	2.06	2.42	2.18	1.09	1.92	3.46	2.79	3.73	1.88	2.01
Loss of moisture on air drying	2.00	2.10	2.50	4.00	2.20	1.00	2.00	1.20	2.20	2.30
Analysis of air-dried sample:										
Moisture	.66	.74	.55	.76	.62	.68	.61	.75	.75	1.24
Volatile matter	15.16	15.94	16.69	14.35	15.41	18.71	14.39	16.00	13.77	17.56
Fixed carbon	73.86	71.83	75.35	75.28	74.28	69.84	73.52	71.63	75.73	70.67
Ash	10.32	11.49	7.41	9.61	9.69	10.77	11.48	11.62	9.75	10.53
Sulphur	2.10	2.47	2.24	1.14	1.96	3.49	2.85	3.78	1.92	2.06

	Lower Kittanning (B).									
	K.	L.	M.	N.	O.	P.	Q.	R.	S.	T.
Analysis of sample as received:										
Prox. Moisture	2.70	2.03	2.81	1.78	2.21	2.24	2.63	2.79	3.12	3.07
Prox. Volatile matter	15.64	14.47	14.66	15.19	14.32	15.70	17.85	17.76	17.89	17.64
Prox. Fixed carbon	74.03	75.31	75.75	73.25	78.16	78.37	73.24	73.20	70.85	72.85
Prox. Ash	7.63	8.19	6.78	9.78	5.31	3.69	6.28	6.25	8.14	6.44
Ult. Sulphur	1.93	2.26	1.33	4.50	.47	.77	1.49	1.88	2.74	1.38
Ult. Hydrogen	.....	4.14	.....	4.16	.....	.....	.....	.....	.....	.....
Ult. Carbon	.....	79.97	.....	77.10	.....	.....	.....	.....	.....	.....
Ult. Nitrogen	.....	1.26	.....	1.41	.....	.....	.....	.....	.....	.....
Ult. Oxygen	.....	4.18	.....	3.05	.....	.....	.....	.....	.....	.....
Calorific value determined:										
Calories	.....	7,823	.....	7,612	.....	.....	.....	.....	.....	.....
British thermal units	.....	14,081	.....	13,702	.....	.....	.....	.....	.....	.....
Loss of moisture on air drying	1.80	1.40	1.90	1.10	1.60	1.60	2.00	2.10	2.50	2.50
Analysis of air-dried sample:										
Prox. Moisture	.91	.64	.93	.69	.62	.65	.64	.71	.64	.58
Prox. Volatile matter	15.93	14.67	14.94	15.36	14.55	15.95	18.21	18.14	18.35	18.09
Prox. Fixed carbon	75.39	76.38	77.22	74.06	79.43	79.65	74.74	74.77	72.67	74.72
Prox. Ash	7.77	8.31	6.91	9.89	5.40	3.75	6.41	6.38	8.34	6.61
Ult. Sulphur	1.97	2.29	1.36	4.55	.48	.78	1.52	1.92	2.81	1.42
Ult. Hydrogen	.....	4.04	.....	4.08	.....	.....	.....	.....	.....	.....
Ult. Carbon	.....	81.10	.....	77.95	.....	.....	.....	.....	.....	.....
Ult. Nitrogen	.....	1.27	.....	1.43	.....	.....	.....	.....	.....	.....
Ult. Oxygen	.....	2.99	.....	2.10	.....	.....	.....	.....	.....	.....
Calorific value determined:										
Calories	.....	7,934	.....	7,697	.....	.....	.....	.....	.....	.....
British thermal units	.....	14,281	.....	13,854	.....	.....	.....	.....	.....	.....

[a] All analyses given in this paper, unless otherwise stated, were made at the fuel-testing plant of the United States Geological Survey at St. Louis, Mo.; J. A. Holmes, in charge; F. M. Stanton, chemist.

Analyses of coal samples from Johnstown quadrangle, Pennsylvania—Continued.

	Lower Kittanning (B).								Brookville. (A).
	U.	V.	W.	X.	Y.	Z.	AA.	BB.	CC.
Analysis of sample as received:									
Prox. Moisture	2.80	3.45	2.59	3.49	3.09	2.31	1.10	0.59	2.35
Prox. Volatile matter	17.30	18.82	18.91	16.12	16.66	13.99	15.80	16.61	14.30
Prox. Fixed carbon	73.28	71.18	70.33	74.68	74.79	76.69	75.69	76.76	71.40
Prox. Ash	6.62	6.55	8.17	5.71	5.46	7.01	7.41	6.04	11.95
Ult. Sulphur	2.46	2.01	4.04	.95	1.18	1.19	1.49	.91	3.30
Ult. Hydrogen	.....	.....	.....	.....	.....	.....	.....	.....	4.22
Ult. Carbon	.....	.....	.....	.....	.....	.....	.....	.....	75.16
Ult. Nitrogen	.....	.....	.....	.....	.....	.....	.....	.....	1.13
Ult. Oxygen	.....	.....	.....	.....	.....	.....	.....	.....	4.24
Calorific value determined:									
Calories	.....	.....	.....	.....	.....	.....	.....	.....	7,382
British thermal units	.....	.....	.....	.....	.....	.....	.....	.....	13,288
Loss of moisture on air drying	2.00	3.00	2.00	2.80	2.20	1.60	.....	.....	1.80
Analysis of air-dried sample:									
Prox. Moisture	.82	.46	.60	.71	.91	.72	.....	.....	.56
Prox. Volatile matter	17.65	19.40	19.30	16.58	17.03	14.22	.....	.....	14.56
Prox. Fixed carbon	74.77	73.38	71.77	76.83	76.47	77.94	.....	.....	72.71
Prox. Ash	6.76	6.76	8.33	5.88	5.59	7.12	.....	.....	12.17
Ult. Sulphur	2.51	2.07	4.12	.98	1.21	1.21	.....	.....	3.36
Ult. Hydrogen	.....	.....	.....	.....	.....	.....	.....	.....	4.09
Ult. Carbon	.....	.....	.....	.....	.....	.....	.....	.....	76.53
Ult. Nitrogen	.....	.....	.....	.....	.....	.....	.....	.....	1.15
Ult. Oxygen	.....	.....	.....	.....	.....	.....	.....	.....	2.71
Calorific value determined:									
Calories	.....	.....	.....	.....	.....	.....	.....	.....	7,517
British thermal units	.....	.....	.....	.....	.....	.....	.....	.....	13,532

A. Conemaugh.
B. Johnstown.
C. South Fork.
D. Stony Creek near trolley bridge between Moxham and Ferndale, south of Johnstown.
E. South Fork.
F. Franklin.
G. Dale.
H. Johnstown.
I. Moxham.
J. Solomons Run, southeast of Johnstown.
K. Franklin.
L. Johnstown.
M. Near Walsall.
N. Stony Creek, Somerset County, south of quadrangle.
O. South Fork.
P. South Fork.
Q. Nant-y-Glo.
R. Nant-y-Glo.
S. Vintondale.
T. Twin Rocks.
U. Near Weber station, Black Lick Creek.
V. Twin Rocks.
W. Wehrum.
X. Ehrenfeld.[a]
Y. Ehrenfeld.[a]
Z. Scalp Level.
AA. Windber.[b]
BB. Windber.[b]
CC. South Fork.

[a] J. S. Burrows, collector. See Bull. U. S. Geol. Survey No. 290, 1906, p. 179.
[b] Analyses of sample of carload shipped by operators to St. Louis. See Bull. U. S. Geol. Survey No. 261, 1905, p. 51.

CHARACTER OF THE COAL.

UPPER FREEPORT COAL.

The highest important coal is known as the Upper Freeport coal. It is used as a domestic and steam fuel about Johnstown and South Fork, supplying also some of the brick plants at the former city. The coal from this bed is used almost exclusively for steaming purposes. It gives satisfactory results, particularly when used for generating steam in locomotives. It is not used for coking purposes in this area, though at Cresson, Gallitzin, and Bennington it is coked with satisfactory results in beehive ovens. In the by-product ovens of the Cambria Steel Company at Franklin, near Johnstown, it was found to be unsuitable owing to expansion, which quickly ruined the ovens and made it very difficult to force out the charge after it was coked. The

analyses of this coal as given on page 24 show it to be a high-carbon coal with very low moisture. The ash, especially in the first two samples collected in the Johnstown basin, is high. Its sulphur content, ranging from 2 to 2½ per cent, is also rather high.

LOWER FREEPORT COAL.

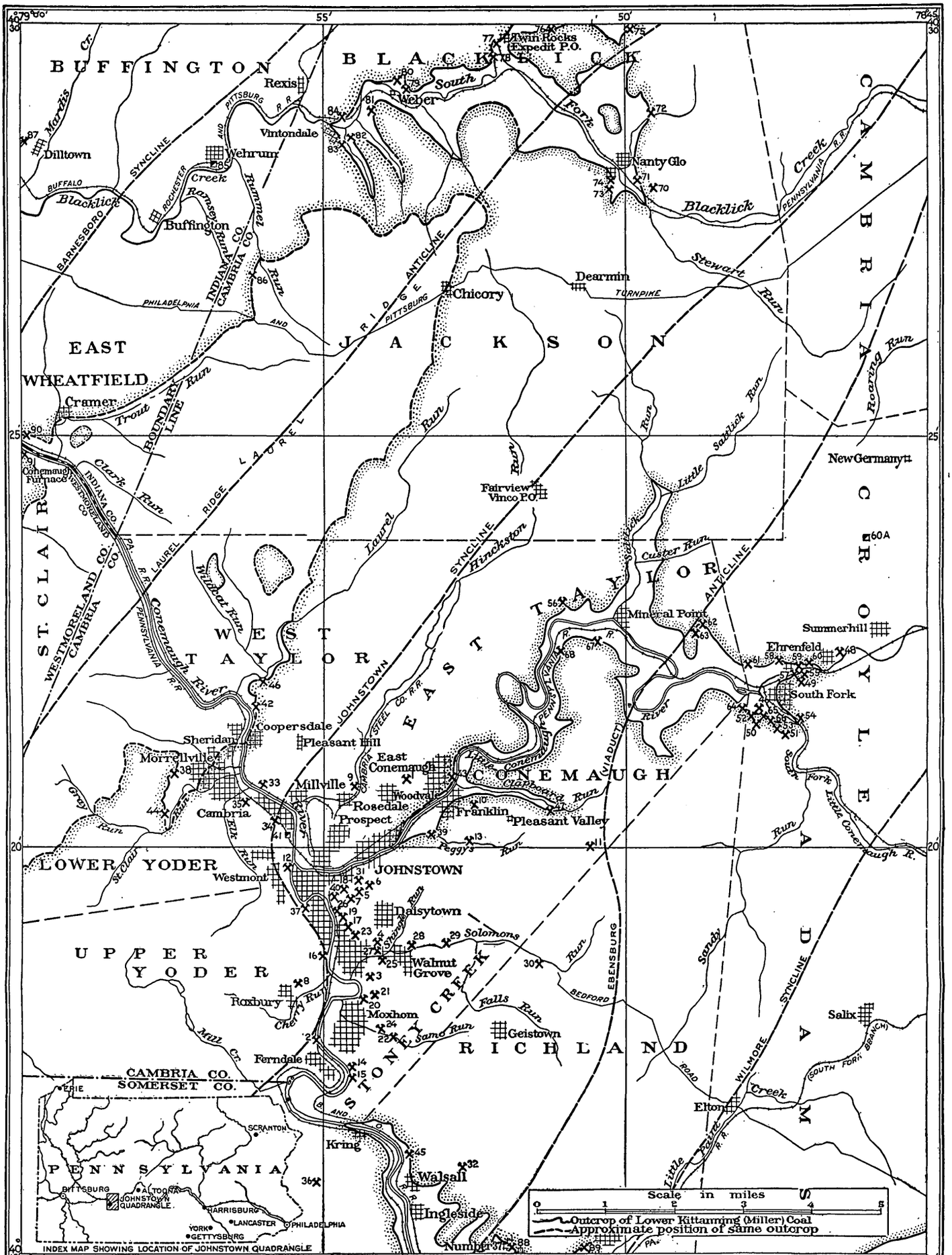
The Lower Freeport or D coal is of workable thickness about Johnstown and, though not exploited at the present time, will probably be one of the important coals of the future in this district. In the sample collected south of the city, the analysis of which is given on page 24, the clay partings were not included, as these will be discarded when this bed is worked on a commercial scale. The percentage of carbon is high and comparable with this constituent in other coals in this district. The moisture is not representative, as the material was procured near the outcrop. The ash runs rather high, but not above the average of the coals of the area. The coal from this bed is not considered good in the region about Johnstown, but the analysis of the sample collected near Stony Creek indicates that in this locality, where the coal is persistent and of workable thickness, it may be of some commercial importance.

UPPER KITTANNING COAL.

The Upper Kittanning or C′ coal is one of the most valuable beds about Johnstown and its suburbs, where it is known as the "cement seam." To the south, about Windber, recent prospecting has shown it to be even thicker than about Johnstown. As a steaming coal it is probably equal if not superior to any other coal in the Johnstown basin, and the recent demand for it in the market has been greater than the supply. The six analyses (p. 24) show a high-carbon coal with correspondingly low volatile matter. The moisture is low, but the ash and sulphur are rather high. The coal mined from this bed at Franklin mine No. 1 of the Cambria Steel Company is washed and coked at the Franklin plant. It makes a good grade of coke, but, owing to its low volatile matter, it is not considered so well adapted for beehive ovens as some of the richer gas coals of the districts farther west. When the cost of shipping coke from the region about Connellsville and Pittsburg is considered, it is found cheaper to wash and coke this coal on the ground.

LOWER KITTANNING COAL.

The next lower coal of importance in this area is the Lower Kittanning or B coal. It is widely known also as the "Miller seam." This is the most persistent of the valuable coals in the area. From the analyses given on pages 24–25, it will be seen that its fixed carbon



OUTLINE MAP OF JOHNSTOWN QUADRANGLE, PENNSYLVANIA.

Crossed hammers and appended numbers indicate coal openings.

ranges from 70 per cent in the sample collected at Wehrum to 78 per cent in a sample collected at South Fork. Its volatile matter ranges from 14 to 19 per cent. The moisture is low, and only in a few analyses do the figures show more than 3 per cent. The ash and sulphur exhibit considerable variation, as might naturally be expected in view of the wide extent of the territory from which the samples were collected. The samples from South Fork have the lowest content both in sulphur and ash and show the excellent character of the Miller bed in this part of the Wilmore basin. As a steam coal it ranks among the very best of western Pennsylvania, the coal mined about South Fork probably equaling any other steam coal in this part of the State. As bearing on this point the following table has been prepared, showing its position among the 120-odd coals tested at the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., since the summer of 1904.[a] The column recording the number of pounds of water evaporated by 1 pound of dry coal from and at a temperature of 212° F. gives the comparative results of the coals tested, so far as these relate to their commercial values.

Chemical composition and steaming values of typical Appalachian coals.

Location.	Number of tests made.	Average chemical composition.					Average pounds of water evaporated from and at 212° F. per pound of dry coal.
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	
Page, Fayette County, W. Va	2	4.06	30.35	61.54	4.05	0.90	10.545
Do	1	2.85	30.13	64.78	2.24	1.06	10.52
McDonald, Fayette County, W. Va	2	2.75	20.59	70.05	6.61	.98	10.36
Big Black Mountain, Harlan County, Ky	2	5.06	34.77	56.31	3.86	.56	10.26
Rush Run, Fayette County, W. Va	2	2.12	21.91	70.73	5.24	.67	10.195
Ehrenfeld, Cambria County, Pa	5	2.38	16.53	74.47	6.62	.95	10.186
Winifrede, Kanawha County, W. Va	4	3.79	35.33	55.76	5.12	1.11	10.16
Acme, Kanawha County, W. Va	4	2.93	32.66	57.64	6.77	1.23	10.115
Powellton, Fayette County, W. Va	1	3.42	31.11	59.47	6.00	.82	10.09
Near Bretz, Preston County, W. Va	3	4.20	28.05	60.86	6.89	1.28	10.07

The results of tests on the Ehrenfeld samples, although showing a range of 9.75 to 10.42 pounds of water evaporated per pound of dry coal used, are yet when averaged among the very best made at the testing plant. Each sample submitted to the steaming test was analyzed and the accompanying analyses represent averages of the total number made, as do the figures representing the efficiency of the coals as steam producers. It is of interest to note that the Ehrenfeld coal contains the largest percentage of fixed carbon and the lowest amount of volatile matter of all the samples. For the details of the conditions of these steaming tests the reader is referred to the publications cited above.

[a] Bull. U. S. Geol. Survey Nos. 261, 1905, and 290, 1906.

This coal is coked, but it does not rank so high as a coking coal as it does as a steam producer. A test was made on a sample of this coal with the following results:[a]

Coking test of Lower Kittanning coal from Ehrenfeld, Pa.

[Coal finely crushed. Duration of test, 51 hours.]

Coal charged	pounds..	10,000
Coke produced	do....	5,223
Breeze produced	do....	1,600
Coke produced	per cent..	52.23
Breeze produced	do....	16.00
		68.23

The coke was dull gray in color, and was soft and dense. It was broken into large and small chunks, had a heavy black butt, and was hard to burn.

Analyses of coal and coke from Ehrenfeld, Pa.

	Coal.	Coke.
Moisture	3.32	0.91
Volatile matter	15.56	2.16
Fixed carbon	74.29	88.99
Ash	6.83	7.94
Sulphur	1.12	.91

The yield of coke from this test is comparatively high, but the poor quality of the coke shows that this coal does not belong among the best coking coals of western Pennsylvania and West Virginia. The coal mined at Franklin (analysis K, p. 24) is coked by the Cambria Steel Company in by-product ovens for use in the company's plant near Johnstown, and gives satisfactory results, but before coking the coal is washed, thereby adding to the cost of the coke. Even with this additional item of cost, it is found cheaper to coke this coal on the ground than to buy coke of better quality from the Connellsville region. Tests have been made by the Cambria Steel Company with the coal mined from this bed about Ehrenfeld, and the resulting coke proved well adapted to metallurgical purposes. The yield also was satisfactory. The coal mined at Nant-y-Glo from this bed has been tested in beehive ovens at Gallitzin. It produced coke of good structure, but of a rather dull appearance. As was to be expected, an insufficient amount of sulphur was volatilized. At Bennington this coal, like the Upper Freeport, shows a higher content in volatile matter than it does about South Fork and Johnstown. The Lackawanna Coal and Coke Company has experimented with it about Wehrum, but the washeries are now shut down and the results of the coking tests were not learned. The Vinton Colliery Company

[a] Bull. U. S. Geol. Survey No. 290, 1906, p. 181.

is now building a large by-product plant at Vintondale and the results will be awaited with great interest by the operators along Blacklick Creek.

LOWER COALS.

The coals below the Lower Kittanning bed have not been extensively developed in this area. At South Fork a bed lying about 60 feet below the Miller coal and known locally as the "dirty A" or "6-foot seam" has been opened. It is possible that this corresponds to the Brookville or coal A of the Allegheny Valley. It has a composition indicated by analysis CC on page 25, and from the high ash and sulphur content, aggregating more than 15 per cent, deserves the name which is often applied to it. It other respects the analysis corresponds with those of other coals of the area, being relatively high in fixed carbon and low in volatile matter.

PHYSICAL CHARACTER OF THE COALS.

The characteristics of these coal beds in addition to those already outlined are presented in the following paragraphs, and for this purpose the area may be divided into the following districts: Johnstown, South Fork, Black Lick Creek, Windber, Conemaugh Furnace.

JOHNSTOWN DISTRICT.

The Johnstown district includes the territory lying about the city of Johnstown, including its suburbs. It produced during 1905 about 1,750,000 tons of coal, valued at about $1,750,000. The important operations in this district extend from Franklin and East Conemaugh westward to Coopersdale along the main line of the Pennsylvania Railroad, and southward from the city along the Baltimore and Ohio Railroad beyond Moxhom. Important operations, though small, are also conducted on Clapboard, Hinckston, Peggys, Solomons, St. Clairs, and Samo runs. The commercial coals in this area are confined entirely to the Allegheny formation.

There are four and in places five coals of workable thickness in this district—the Upper Freeport or Coke Yard bed, the Lower Freeport or Limestone bed, the Upper Kittanning or Cement bed, and the Lower Kittanning or Miller bed. The Middle Kittanning is of workable thickness, so far as known, at only a few points and can not be classed among the commercial coals of this district. The coals, except the Lower Kittanning, lie at convenient intervals above drainage level in all the hills surrounding the city and most of its suburbs and are extensively worked.

Upper Freeport coal.—The largest operation on the Upper Freeport bed is that of the Cambria Steel Company at the Conemaugh slope, which produces yearly about 60,000 tons. The Ferndale Coal Company also operates on an extensive scale, producing about 30,000 tons yearly. There are many smaller mines worked the year round,

and many smaller banks worked only during the winter season. These small operations are more in the nature of country banks and have not been indicated on the map.

To give a fair idea of the thickness of this bed in the district, the following sections selected from well-scattered points are given:

Sections of Upper Freeport coal near Johnstown.

	Roof.	Main bench.	Parting.	Lower bench.	Floor.
		Inches	*Inches.*	*Inches.*	
Kerndale Coal Co	Shale	38	5–6	4–6	
Cambria Steel Co., Conemaugh slope	Bone	38	1	4	Clay.
Berkebile Coal Co	Sandy shale	38	3	.....	Clay.
William Davis	Shale and bone	39	4	3–4	
Davis mine, Grubtown	Shale	42	2	½–2	
George Heidingsfelder, Solomons Run	Shale	36	.....	.....	Clay.

These are average sections. They show a main bench 3 to 3½ feet thick, with a lower bench half an inch to 6 inches, separated by a bone and shale parting 1 to 6 inches in thickness. The lower bench is not invariably present and in places it is bony in character. Only the main bench is worked and the bone and shale below it may be regarded as a floor. As a rule no partings were noted in the main bench in this district. It thus differs markedly from the equivalent bed about South Fork. The maximum thickness does not exceed 4 feet; the minimum is about 2 feet and is caused by rolls, but these are extremely rare and the coal is characterized by marked uniformity. There are few or no clay veins. The roof is usually shaly in character, but is firm and little or no typical draw slate was reported. At one or two abandoned banks gas was reported and also in some of the older workings in one of the larger mines; it is nonexplosive and may be carbon dioxide.

Lower Freeport coal.—The Lower Freeport coal is known as the Limestone coal about Johnstown. It has been prospected at many points about the city and its suburbs, but it is not mined at the present time. The most promising outcrops were observed along Stony Creek from the vicinity of the Valley Coal and Stone Company's mine northward to Grubtown. In this region the following sections were measured:

Sections of Lower Freeport coal near Johnstown.

	Roof.	Top bench.	Parting (bone or shale).	Middle bench.	Parting (bone or shale).	Lower bench.	Floor.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	
Stony Creek near trolley bridge.	Massive sandstone	12	1	22	1	4	Clay.
On Baltimore and Ohio R. R., west of Loraine Steel Co.'s plant.	Sandstone or shaly sandstone.	10½–12	1½	21	1	5	Clay.
South of Kernville near Citizens' Coal Co.'s Eighth Ward mine.	Sandstone	14	1–2	24	½	4	Clay.

The coal lies in three distinct benches, separated by thin shale and bone partings. The upper bench averages about a foot thick and the middle bench about 2 feet. It is possible that in the commercial development of this bed only these two benches will be worked, and the underlying coal and bone will serve as a floor. It may be said, therefore, that from 2½ to 3 feet of good coal are present. Immediately over the coal are usually a few inches of bone and black shale, overlain by either sandy shale or massive sandstone.

On Peggys Run, near Franklin, this coal has been prospected by the Cambria Steel Company. It is reported 4 feet thick, but so badly broken up by partings that it is not commercially valuable.

Upper Kittanning (Cement) bed.—The Upper Kittanning coal outcrops at a height above drainage level that is convenient for exploitation at practically all points about Johnstown. West of the city the operations of the Cambria Steel Company in the Rolling Mill mine have been pushed westward in Upper Yoder Township beyond Mill Creek, and the coal has showed no indication of becoming too thin to work. Where observed along Bens Creek in Somerset County it is also of workable thickness. The westward dips toward the Johnstown basin carry this bed below drainage level less than a mile east of the Baltimore and Ohio tunnel south of Moxhom.

This coal is the most extensively exploited of all the beds in this district. It is worked on a commercial scale from Franklin as far west as Coopersdale and to the south beyond Moxham. Many operations, though small, are conducted along Solomons and Samo runs. The mines in operation about the city may be seen from the accompanying map (Pl. II, p. 20). One of these mines, the Rolling Mill mine of the Cambria Steel Company, is the largest in the area and one of the largest in the State, having a daily output of about 3,000 tons. The thickness of this coal may be seen from the following sections, selected from well-scattered points:

Sections of Upper Kittanning coal in Johnstown district.

	Roof.	Main bench.	Floor.
		Inches.	
Cambria Steel Co., Rolling Mill mine..	Shale or sandstone underlain by 4 to 8 inches of bone.	36–39	Shale underlain by limestone.
Valley Coal and Stone Co.....	Sandstone underlain by 8 to 10 inches of bone.	54	Shale.
Kelso Smokeless Coal Co.....	Shale.....	62	Shale.
Suppes Coal Co.....	Shale.....	42	Shale.
Natural exposure near East Conemaugh.	Sandstone.....	35½	Limestone.
Samuel Fuge, Cambria City.....	Shale underlain by 1 inch of bone..	32	Shale.

This bed varies somewhat in thickness about Johnstown, but averages between 3 and 3½ feet of coal. Rarely does it exceed 4 feet, and

at a few mines less than 3 feet has been measured. South of the city it is thicker, and along Stony Creek, on the Baltimore and Ohio Railroad, the sections average about 5 feet of coal. This thick coal continues southward to the Windber district. There is usually a thin bony streak at the top of this bed which is discarded in mining, and locally a few inches of bone at the bottom; but the rest of the bed is good, clean coal, generally of uniform quality throughout. In a few mines the upper foot is reported soft and the lower harder than the average. The roof of the coal is either very dense shale or sandy shale and sandstone and gives no trouble whatever. The floor is usually a few inches of firm shale, closely underlain by the cement bed. The coal is remarkably uniform and few rolls are reported. Clay veins are, however, rather numerous and occasionally considerable annoyance is caused by gas, necessitating the use of safety lamps.

Middle Kittanning coal.—As a rule the Middle Kittanning coal is not workable in this district, though it is very persistent and hence serves as an additional check on the identity of the beds above and below. It has been opened at Coopersdale, where it is about 25 feet above the Lower Kittanning coal, at the brick plant of A. J. Hawes & Sons (Limited), and shows a thickness of 30 inches, with more concealed. It is also of workable thickness at the head of Solomons Run. Though it is locally workable, it can not be classed among the commercial coals of the district.

Lower Kittanning coal.—Immediately about Johnstown the Lower Kittanning coal is below drainage level and the mines working it are either slopes or shafts. The rise of the beds brings the coal above drainage level east of the city, and it is worked by drifts at Franklin and East Conemaugh and on Clapboard Run. It is also above drainage level west of the city, and is worked near Coopersdale, west of Morrellville, and on St. Clair and Laurel runs. It has been opened on Stony Creek south of Kring.

This coal is of importance in all parts of the quadrangle. The developments on it are important and extensive, as will be seen from the map (Pl. II, p. 20). A few of the representative sections in the region about Johnstown are as follows:

Sections of Lower Kittanning coal ("Miller seam") near Johnstown.

	Roof.	Main bench.	Parting.	Lower bench.	Floor.
		Inches.	*Inches.*	*Inches.*	
W. J. Williams, Kernville	Sandstone or shale	36–42	.....	.....	Shale.
Citizens' Coal Co., Adams street	Shale	42	.....	.....	Fire clay.
A. J. Hawes & Sons (Limited) shaft.	Shale or sandstone	37	14	4½	Do.
A. J. Hawes & Sons (Limited), Coopersdale.	do	43	7	11	Do.
Cambria Steel Co., Franklin No. 2	Sandstone or shale	42–44	.....	.....	Fire clay and shale.
Keystone Coal and Coke Co., Conemaugh mine.	Shale	46	6–10	8–14	Clay.

The workable coal is present in a single bench ranging mainly from 3 to 3½ feet in thickness, though locally it reaches 4 feet. Below the main bench and separated from it by a few inches of shale and bone there is commonly a lower bench from 3 inches to a foot thick. This lower coal is usually not worked. Below the lower bench or, in its absence, below the main bench, there is uniformly a thick bed of fire clay. In nearly all the coal mines about Johnstown the under clay is mined in addition to the coal, though, of course, not on anything like the same scale. The roof of the coal is hard and firm and gives no trouble whatever. There are few or no clay veins. The floor is irregular, and numerous rolls are reported which in many places cut out the coal. At Franklin and along Clapboard Run much difficulty has been experienced on account of the irregular character of the floor. These irregularities have led to much expensive dead work near Franklin and have caused the abandonment of large operations along Clapboard Run.

Lower coals.—Coals lower than the Lower Kittanning are exposed in this district. At Coopersdale the Pottsville sandstone appears at road level just west of the brick plant of A. J. Hawes & Sons (Limited). Just above the top of the Pottsville there are two small coal beds exposed, separated by about 10 feet of dark shale. The section is as follows:

Section above Pottsville formation near A. J. Hawes & Sons' brick plant, Coopersdale.

	Ft.	in.
Shale, dark	10+	
Coal	1	0–4
Shale, black, with siliceous limestone concretions	10	
Coal		5½
Shale and bone		4
Coal	1	0–5
Shale and bone		0–10
Sandstone, massive, top of Pottsville.		

The coals are each less than 1½ feet thick. The lower and upper probably correspond with the Brookville (A) and Clarion (A′) coals, respectively, of the Allegheny Valley. One of these coals at least is exposed on Clapboard Run, but is so badly broken by partings as to be of no value commercially. South of Moxhom on Stony Creek the horizon of these lower coals is also brought above drainage level, but the data on the coals are so meager that it is uncertain whether they will be generally workable in this vicinity or not.

SOUTH FORK DISTRICT.

The South Fork district includes the territory about the towns of South Fork and Mineral Point. In 1905 it produced about 1,400,000 tons of coal, valued at $1,500,000.

The important coals are all included in the Allegheny formation, though higher coals have been worked, but without success. The coals rise above drainage level just east of Ehrenfeld station and on South Fork of Little Conemaugh River just at the southern part of the town of South Fork. They are present in the hills along Little Conemaugh River to the west beyond Mineral Point.

Upper Freeport coal.—The highest workable coal in this district is the Upper Freeport. It has been opened by the Pennsylvania, Beech Creek and Eastern Coal Company at Ehrenfeld, and by the South Fork Coal Company and H. C. and O. M. Stineman west of South Fork. Its character is indicated by the following sections:

Sections of Upper Freeport coal near South Fork.

	Roof.	Top bench.	Parting.	Middle bench.	Parting.	Lower bench.	Floor.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	
South Fork Coal Co	Shale	2	4–12	18	½–2	18	Clay.
H. C. Stineman, No. 5	Shale	3	¾	10	2	20	
Pennsylvania, Beech Creek and Eastern Coal Co., No. 8, Ehrenfeld	Shale			24	2	22½	
O. M. Stineman, No. 3		3	½	11	2	22	Clay.
Cut near Ehrenfeld station	Shale			23½	2	20	Clay.

The bed may consist of either two benches or of three of which only the two lower are workable, and in this respect it differs essentially from the same coal about Johnstown. About Ehrenfeld only two benches were observed. The upper of the workable benches ranges in thickness from 1 foot to 2 feet and the lower from 1½ to 2 feet. The bone or shale parting between the two main benches ranges from one-half inch to 2 inches. It is very persistent in this district and is usually also present in this bed along the southeast margin of the Wilmore basin.

Upper Kittanning coal.—The coal known as the Cement bed about South Fork probably corresponds to the Cement bed of Johnstown. It has been opened by H. C. Stineman and O. M. Stineman west of the town, and by Charles Hutzel and Robert A. Giles in the town itself. The coal ranges from 3 to 3½ feet in thickness, usually without any partings, and has a hard shale roof which gives no trouble. A few inches below the base of the coal lie 3 feet or more of limestone. The sections given below show the character of this coal.

Sections of Upper Kittanning coal at South Fork.

	Roof.	Main bench.	Clay or shale.	Limestone.
		Inches.	*Inches.*	*Feet.*
Robert A. Giles	Shale	36	9	2½
Charles Hutzel	Shale and bone	34	8	3½–4
H. C. Stineman, No. 6	Shale and bone	42		
O. M. Stineman, No. 3½	Shale	36		

The coal is bright, lustrous, and of good quality, and though the single analysis (E, p. 24) shows it to be on a par with the Cement bed in the Johnstown basin its general reputation is not so good.

Lower Kittanning coal.—This coal occurs at a distance of 160 feet below the Upper Freeport coal immediately about South Fork. It is the most extensively worked coal in this district, there being no less than thirteen large and active operations on it at the present time. These operations are conducted immediately about the town, but include also two small mines near Mineral Point. All the mines are situated near the main line of the Pennsylvania Railroad. The coal makes its appearance above drainage level in the town and is exposed in the valley of Little Conemaugh River westward most of the distance to the Johnstown district. The Miller bed in the South Fork district maintains its usual section, as follows:

Sections of Lower Kittanning coal ("Miller bed") near South Fork.

	Roof.	Main bench.	Parting.	Lower bench.	Floor.
		Inches.	*Inches.*	*Inches.*	
Valley Smokeless, No. 3 (Radnor mine).	Shale or sandstone....	54	1	21-24	Fire clay.
Pennsylvania, Beech Creek and Eastern Coal Co., No. 3.	Shale with bone, 3 inches.	46	2-3	4	Fire clay.
South Fork Coal Mining Co., No. 1....	Shale.....	48	3-12	2-8	Fire clay.
Stineman Coal and Coke Co., No. 2....	Shale.....	48	3-15	15-36	Fire clay.
Argyle Coal Co., No. 3.....	Shale.....	48	6-12	4-24	Fire clay.
Stineman Coal Mining Co., No. 1.....	Shale or sandstone....	42	12	2-9	Fire clay.

Its main bench averages nearly 4 feet and in some places is 5 feet in thickness, with no partings. The double structure which is fairly persistent in the Johnstown district is even more apparent about South Fork. Some of the mines, however, show it only here and there. In other physical aspects this coal resembles the Miller bed about Johnstown. Its roof of dense shale or sandstone, the general absence of draw slate or clay veins, and the irregular floor are all common to the bed in both districts. The top few inches are usually bony and have to be discarded. In appearance the coal is lustrous, much of it iridescent, and its columnar cleavage is one of its more characteristic features. Its chemical composition and uses are indicated by the analyses given on page 24 and the descriptions given on pages 26–29.

Lower coals.—A coal 60 to 70 feet lower than the Miller bed has been opened at a few points about South Fork and Mineral Point. This coal probably corresponds with the Brookville or A coal. Most of the openings are fallen shut, but it is mined at one bank at South Fork to supply the local brick company. It is better known locally as the "6-foot coal," or "dirty A," but where seen measured only 3½ feet of coal, as indicated in the section below:

Section of Brookville (A) coal at South Fork.

Shale.	Ft.	in.
Coal	2	6
Bone		1
Coal	1	
Total coal	3	6

The analysis given on page 25 shows a large content of ash and sulphur, but fixed carbon and volatile matter about the average for coals in this quadrangle. It is possible that the coal may be valuable in this district, but the fact that it has not been developed on any extensive scale and apparently has not come into competition with the other coals of the district is strong presumptive evidence that in quality it is not up to the standard of the other coals mined about South Fork.

BLACKLICK CREEK DISTRICT.

In the territory lying along Blacklick Creek and its south fork mining operations are confined exclusively to the creek valley, the principal mining towns being Nant-y-Glo, Twin Rocks, Weber, Vintondale, and Wehrum. The production of the district was about 5,000 tons in 1894, but had increased to 1,045,802 tons, valued at $1,019,617, in 1905.

The coals along Blacklick Creek outcrop from the town of Nant-y-Glo westward to Vintondale. Just west of the latter town the highest coal that is workable disappears below drainage level and farther west, at the town of Wehrum, mining operations are conducted by means of a shaft. West of Wehrum the rise of the beds brings the coal-bearing formation above drainage level just at the west edge of the quadrangle, near Dilltown, and a few country banks have been opened on Mardis Run.

Upper Freeport coal.—In this district a coal bed of workable thickness is present about 150 feet above the Lower Kittanning coal. The interval between these two coals has been found exceptionally constant. It has been measured at Nant-y-Glo and Vintondale and reported the same at Twin Rocks by the engineer of the collieries situated at that point. At Wehrum certain of the diamond-drill records show a coal at about the same interval above the Lower Kittanning bed. A few sections of this upper coal, which is presumably the upper Freeport, are as follows:

Sections of Upper Freeport coal along Blacklick Creek.

	Roof.	Upper bench.	Parting (bone).	Lower bench.	Floor.
		Inches.	*Inches.*	*In.*	
Near Vintondale	Shale...	18	1	Coal..16 Bone . 7	Clay.
Twin Rocks	Shale...	25½	½–2	Coal..15 Bone . 6	Clay.
Ivory Hill Coal Mining Co., Nant-y-Glo	Shale...	22	2½–3	Coal..15½ Bone . 3½	Clay.

The bed has two benches, separated by a small bone parting, and the coal aggregates in thickness from 3 to 3½ feet. The presence of the parting has been a drawback to operations on this bed, but it

is quite probable that in the future the coal will be worked. If proper care is exercised in separating the thin bony parting, it should be readily marketed. The resemblance of its section to that of the Upper Freeport coal about South Fork is rather marked and it is probable that they occur at the same horizon.

Middle Kittanning coal (?).—A little more than 100 feet below this upper coal and about 50 feet above the main Blacklick bed occurs a coal which is fairly persistent. It has been called the Middle Kittanning, simply because it is the first bed above the Lower Kittanning coal. It has been seen about Twin Rocks, Nant-y-Glo, and Vintondale and at the latter point a section measured 33 inches of coal with a thin parting of shale near its base.

Lower Kittanning coal.—The next lower coal is the main bed of the Blacklick Creek district. There has been some question as to its identity. It has been regarded by some as the equivalent of the Cement bed of the Johnstown basin, and by others as the equivalent of the Miller or Lower Kittanning coal. The writer is inclined to take the latter view. Certainly the physical character of the bed, as mined along Blacklick Creek, strongly resembles the main features of the Lower Kittanning coal in the districts to the south, as the following sections will show:

Sections of Lower Kittanning coal along Blacklick Creek.

	Roof.	Main bench.	Parting.	Coal.	Parting.	Coal.	Floor.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	
Vinton Colliery Co., No. 5	Shale	42	6	12–14	.....	.....	Clay.
Pennsylvania, Beech Creek and Eastern Coal Co., No. 14.	Sandstone or shale	45	14	6	.....	.....	Clay.
Lincoln Coal Co	Sandstone or shale	45	3	0–6	.....	.....	Clay.
H. R. Dill, Dilltown	Shale	48	8	2–3	.....	.....	Clay.
Ivory Hill Coal Mining Co	Sandstone or shale	43	1½	2½	4	6	
Cardiff Coal Co	Shale	45	3	6	3	3	

The coal is made up of a main bench from 3½ to 4 feet thick. Below this there occur either one or two thinner benches, but in places both lower benches are absent. The second lower bench was not observed about South Fork or Johnstown, but is rather persistent along Blacklick Creek. Below the lowermost bench occurs a good body of clay not exploited in this district. The roof of the coal is either very firm shale or sandstone. This fact, in connection with an irregular floor, the general absence of clay veins, and the fact that it is nongaseous, are points in which it is similar to the Miller bed in the Conemaugh Valley. The coal is bright and lustrous, with a marked tendency to columnar cleavage. Analyses of this coal are given on pages 24–25.

Lower coals.—Along Blacklick Creek other coals outcrop which are below the main Blacklick bed. In the railroad cut near Twin Rocks two representatives at least of these lower coals appear, but

they are so badly broken that they are not of commercial value. Attempts to work one of these coals at Twin Rocks have resulted in failure. They are tentatively correlated with the group lying directly above the Pottsville formation.

WINDBER DISTRICT.

The Windber district includes the territory about the town of Windber situated within the Johnstown quadrangle. This district is among the more recently developed in this part of the State. It is first mentioned in the State mine inspector's report in 1897, with two mines belonging to the Berwind-White Coal Mining Company, having an annual output of about 50,000 tons. Since that year the developments have expanded rapidly, and in 1905 there were ten mines in the district, with a total annual output of more than 3,000,000 tons of coal.

All the workable coals in the district belong in the Allegheny formation, which is above drainage level in all the hills surrounding the town. Of these coals only the Lower Kittanning coal is now worked, but higher coals are known to be valuable. All the operations on the Lower Kittanning bed are controlled by the Berwind-White Coal Mining Company, and of their ten collieries two—namely, Eureka Nos. 37 and 40—are located just within the southern boundary of the quadrangle, and the underground workings of two others—Eureka Nos. 35 and 36—just touch the southeast edge.

Upper coals.—The highest of the coals outcrops in all the hills surrounding Windber. It lies about 170 to 180 feet above the Lower Kittanning coal in the hills near No. 37 mine, and this interval remains fairly constant as far east as Elton, where drillings show it to be about 175 feet. Still farther northeast, approaching South Fork of Little Conemaugh River, the interval increases to 200 feet. Little definite information regarding this coal was obtainable in this district, as no openings were located. It is, however, persistent and may be of workable thickness.

About 40 to 50 feet below the Upper Freeport coal is the Lower Freeport. It also is fairly persistent in this district, but little is known about it, except from data furnished by drillings. Some of the records from points northeast of Windber show it to be in places 3 feet thick, while others show less promising sections. It is possible that this bed may be valuable in the future, but the data obtained are insufficient to afford a basis for a positive opinion.

The Upper Kittanning or C′ coal in the Windber district lies practically midway between the Upper Freeport and Lower Kittanning beds. This is one of the valuable coals about Windber, and, though not worked commercially as yet, it promises to rival in importance the Lower Kittanning or Miller bed. It is stated in the description of this coal in the Johnstown basin (p. 32) that on Stony

Creek, south of Moxham, it increases in thickness. The unusual thickness of 5 to 6 feet prevails generally to the north of Windber, as the following sections will show:

Sections of Upper Kittanning coal north of Windber.

	Roof.	Coal.
		Ft. in.
One-half mile north of No. 37	Black shale...	6
One mile north of No. 37	Black shale...	5 5
One mile southeast of Walsall	Shale.....	4 8

The coal where measured shows a clean face, ranging from 4½ to 6 feet in thickness, with a firm shale roof. To judge from the appearance of the coal, its quality is equal to that of the coal mined from this bed about Johnstown.

Lower Kittanning coal.—The Lower Kittanning coal is worked on a large scale in all the hills about Windber, and the large operations conducted by the Berwind-White Coal Mining Company have drawn to the town between 4,000 and 5,000 employees of all classes. The coal outcrops well down in the hills about the town, enabling the operations to be conducted from the outcrop by drifts. Of the large mines now working only two are situated in the Johnstown quadrangle, namely, Eureka Nos. 37 and 40, but the character of the coal at these mines and as seen at some of the country banks to the northwest near Walsall may be regarded as typical of the coal in this district.

Sections of Lower Kittanning coal near Windber.

	Roof.	Main bench.	Parting.	Lower bench.	Floor.
		Inches.	*Inches.*	*Inches.*	
Eureka No. 37	Sandy shale..	42	3-24	3-18	Clay.
Country bank, near Walsall	Sandstone....	41	.....	.....	

Little need be said regarding the physical character of this coal about Windber. The above sections are typical as to the thickness of the main bench. The under coal is usually present, and in some of the mines is remarkably uniform. There is also present a small rider, averaging 3 to 4 inches in thickness and lying from 3½ to 4 feet above the main bench. In other respects the coal resembles the Lower Kittanning along Conemaugh River.

The analyses of this coal given on page 25 show its carbon content to be among the highest in the area, with a comparatively low amount of sulphur and ash. Two tests on samples selected by the operators showed an evaporative power of 9.04 and 9.79 pounds of water per pound of dry coal, thus indicating its high standing as a steam fuel.

CONEMAUGH FURNACE DISTRICT.

Along the west edge of the quadrangle, in the valley of Conemaugh River, the lower part of the Allegheny formation is brought down to drainage level by the steep dips along the western flanks of the Laurel Ridge anticline. There are two commercial mines on the Lower Kittanning coal in this district, operated by the Nineveh Coal Company and the Johnstown Coal Company. The coal at these two mines is strictly comparable in every way with the corresponding coal as mined farther east near Johnstown and South Fork. It averages about 3½ feet in thickness and has the characteristic under coal and a valuable under clay which has not been worked. Its roof is strong, and there are the usual rolls in the floor.

Higher coals exist in the hills about Cramer and in East Wheatfield Township, but little is known about them.

LIST OF MINES IN THE JOHNSTOWN QUADRANGLE.[a]

JOHNSTOWN DISTRICT.

UPPER FREEPORT (COKE YARD) COAL.

1. Cambria Steel Company, Conemaugh slope.
2. Ferndale Coal Company.
3. Berkebile Coal Company.
4. William Schaeffer.
5. William Davis.
6. William Cover.
7. Johnstown Press Brick Company.
8. Davis mine, Grubtown.
9. Lewis Epply.
10. L. J. Mitchell.
11. Charles Umbarger.

UPPER KITTANNING (CEMENT) COAL.

12. Cambria Steel Company, Rolling Mill mine.
13. Cambria Steel Company, Franklin No. 1.
14. Valley Coal and Stone Company, No. 1.
15. Valley Coal and Stone Company, No. 2.
16. Citizens' Coal Company, Eighth Ward mine.
17. Citizens' Coal Company, Dale mine.
18. Suppes Coal Company, No. 1.
19. Suppes Coal Company, Dale mine.
20. Sunnyside Coal Company, No. 2.
21. Llewellyn mine.
22. Highland Coal and Coke Company.
23. Caddy Coal Company.
24. Caufield mine.
25. Fyock mine.
26. Livergood mine.
27. Jacoby mine.
28. Wertz & Miller.
29. Edward Litsinger.
30. George Heidingsfelder.
31. John F. Griffith.
32. J. J. Orris.
33. Lewis Prosser.
34. E. W. Fuge.
35. Samuel Fuge.
36. Kelso Smokeless Coal Company.

LOWER KITTANNING (MILLER) COAL.

37. W. J. Williams, Kernville slope.
38. W. J. Williams, Morrellville mine.
39. Cambria Steel Company, Franklin slope, No. 2.
40. Citizens' Coal Company, Green Hill slope.
41. A. J. Hawes & Sons (Limited), shaft.
42. A. J. Hawes & Sons (Limited), Coopersdale mine.
43. Keystone Coal Company, Conemaugh mine.
44. Robertson & Griffith.
45. Ingleside Coal Company.
46. John Adams.
47. J. L. Custer.

SOUTH FORK DISTRICT.

UPPER FREEPORT (LEMON) COAL.

48. Pennsylvania, Beech Creek and Eastern Coal Company, No. 8.
49. South Fork Coal Company, No. 2.
50. H. C. Stineman, No. 5.
51. O. M. Stineman, No. 3.

UPPER KITTANNING (CEMENT) COAL.

52. H. C. Stineman, No. 6.
53. O. M. Stineman, No. 3½.
54. Charles Hutzel.
55. Robert A. Giles.
56. H. W. Gillan.

[a] See Pl. II.

LOWER KITTANNING (MILLER) COAL.

57. South Fork Coal Company, No. 1.
58. Priscilla Coal Company.
59. Pennsylvania, Beech Creek and Eastern Coal Company, No. 3.
60. Pennsylvania, Beech Creek and Eastern Coal Company, No. 5.
60a. Pennsylvania, Beech Creek and Eastern Coal Company, shaft.
61. Argyle Coal Company, Argyle No. 1.
62. Argyle Coal Company, Argyle No. 2.
63. Argyle Coal Company, Argyle No. 3.
64. Stineman Coal and Coke Company, No. 2.
65. Stineman Coal and Coke Company, No. 4.
66. Stineman Coal Mining Company, No. 1.
67. Page-Reighard Mining Company, Juniper mine.
68. Valley Smokeless, No. 3 (Radnor mine).

BROOKVILLE (?) ("DIRTY A") COAL.

69. J. H. Wickes (omitted on map owing to lack of space).

BLACKLICK CREEK DISTRICT.

UPPER FREEPORT COAL.

70. Ivory Hill Coal Mining Company.

LOWER KITTANNING (MILLER) COAL.

71. Ivory Hill Coal Mining Company.
72. Lincoln Coal Company.
73. Pennsylvania, Beech Creek and Eastern Coal Company, No. 14.
74. Nant-y-Glo Coal Mining Company.
75. Cardiff Coal Company.
76. Blacklick Coal Mining Company, Colliery No. 2.
77. Big Bend Coal Mining Company, Nonpareil No. 1.
78. Commercial Coal Mining Company, No. 3.
79. Commercial Coal Mining Company, No. 4.
80. Vinton Colliery Company, No. 5.
81. Vinton Colliery Company, No. 3.
82. Vinton Colliery Company, No. 2.
83. Vinton Colliery Company, No. 1.
84. Vinton Colliery Company, No. 6.
85. Lackawanna Coal and Coke Company, No. 4.
86. Amos Rager.
87. H. R. Dill.

WINDBER DISTRICT.[a]

LOWER KITTANNING (MILLER) COAL.

88. Berwind-White Coal Mining Company, Eureka No. 37.
89. Berwind-White Coal Mining Company, Eureka No. 40.

CONEMAUGH FURNACE DISTRICT.

LOWER KITTANNING (MILLER) COAL.

90. Johnstown Coal Company, Cramer mine.
91. Nineveh Coal Company.

[a] Only those mines which lie in the Johnstown quadrangle are given.

THE ELKHORN COAL FIELD, KENTUCKY.

By RALPH W. STONE.

INTRODUCTION.

For many years the region around the heads of Elkhorn and Shelby creeks and of Boone Fork in Pike and Letcher counties, Ky., has had a good reputation among investors as a source of coal in great quantity and of excellent quality. In order to make this field available, a branch of the Chesapeake and Ohio Railway was extended into Pike County in 1906, and mines were opened at once on Marrowbone Creek, about 20 miles above Pikeville. Because of the prospective importance of the region, a reconnaissance survey of the coal field lying in the drainage basin of Russell Fork of Big Sandy River was undertaken by the Geological Survey. The area covered by this survey is triangular in shape, having its base along Pine Mountain from Pound Gap to Grassy Creek, and its apex at Millard.

Very little has been published concerning the resources of this district, the descriptions in reports of the Kentucky Geological Survey and of the State inspector of mines aggregating only a few pages. Detailed maps of the region furnished by the Big Sandy Company and the Northern Coal and Coke Company were compiled to make the accompanying map (Pl. III). The outlines of the coal outcrops shown are mostly the work of E. V. d'Invilliers, who prepared an extensive report on this field for the Big Sandy Company. All sections given herewith were measured by the writer.

TOPOGRAPHY.

The topography of this region is rugged, almost mountainous. The elevation of the main streams is between 700 and 900 feet, while the summits of the ridges are over 1,500 feet above tide. Between the heads of Shelby and Elkhorn creeks an area known as the Flatwoods exceeds 2,500 feet in elevation, and the crest of Pine Mountain, which marks the southern boundary of the field, averages 3,000 feet high.

The valleys are narrow and steep walled, rising abruptly several hundred feet to narrow ridge tops. There is practically no level land except the narrow valley floors, to which settlement is confined.

The area here described is divided into two unequal parts by Russell Fork, which enters Kentucky around the north end of Pine Moun-

tain, through "The Breaks." The elevation of the river at the State line is about 900 feet, and at Millard 680 feet. This difference of 220 feet in 14½ miles gives an average fall of a little more than 15 feet to the mile. The principal tributaries on the east are Powell Creek, Road Creek, and Ferrell, Beaver, and Grassy creeks, and on the west Marrowbone, Pond, and Elkhorn creeks. Marrowbone Creek has a fall of less than 50 feet to the mile in the lower 6 miles of its course; Elkhorn Creek falls 760 feet from head to mouth, an average of 38 feet for 20 miles.

ACCESSIBILITY.

Pine Mountain, which limits the coal field on the east, has been a barrier to ready access from Virginia. There are no low gaps in the ridge, and The Breaks, at the north end of the mountain, through which the river flows, is an impassable box canyon 1,000 feet deep. Practically all approach to the region, therefore, is from the north, by way of the valley of Big Sandy River.

Until 1906 Pike County was accessible only by wagon, except at infrequent intervals when flood stages made it possible for steamers to ascend the river to Pikeville. Wagon roads are few and follow only the main streams. In June, 1906, the Big Sandy branch of the Chesapeake and Ohio Railway was completed from Pikeville to Elkhorn City (Praise post-office), at the mouth of Elkhorn Creek, 21 miles above Pikeville, and to Hellier, near the head of Marrowbone Creek. The completion of the railroad brought about the opening of several mines and also increased interest in the field.

HISTORY OF DEVELOPMENT.

Small coal banks were opened in this field during the civil war, to get fuel for blacksmithing and for locomotives used in logging, but the heavily forested condition of the whole region makes wood so cheap that there has been little or no incentive on the part of the native population to develop or use the coal, which in many places is at their very doors. About 1885 capitalists began buying up blocks of coal land, partly for development and partly for speculative purposes. The control of much of this land has lately come into the hands of three companies, and in 1906 five mines, the first in the field, were opened by lessees of the Big Sandy Company, namely, the Greenough, Henry Clay, Edgewater, Marrowbone, and Pike Coal and Coke companies. Development commenced early in the year, and regular shipments of coal began in July.

All these mines are using the room and pillar system, and the coal is shot from the solid. At present ventilation is by furnace, and haulage by mules. Natural drainage is obtained. The capacity of the mines (January, 1907) is about a thousand tons daily, but the difficulty of getting cars retards delivery.

GENERAL GEOLOGY.

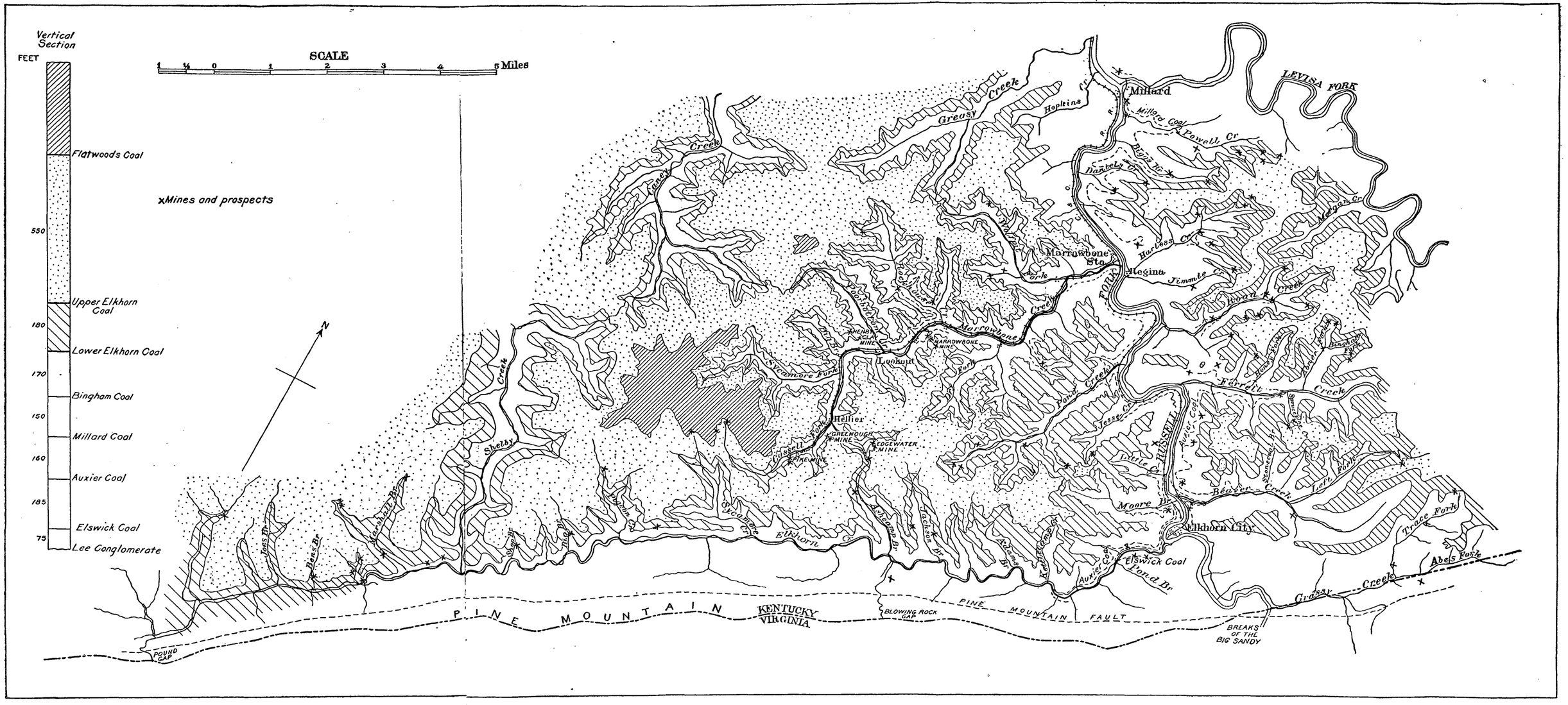
STRATIGRAPHY.

The formations exposed in this field are the Newman limestone, Pennington shale, Lee conglomerate, and a series of strata more than 1,500 feet thick carrying numerous beds of coal. The Newman limestone and the Pennington shale are several hundred feet thick and are exposed only on the west flank and crest of Pine Mountain, east of the fault which terminates the Kentucky coal field in this locality. The Lee conglomerate, which lies above the Pennington shale, is at least 1,000 feet thick. It is so elevated by the fault that its base lies along the crest of Pine Mountain, and it forms the east flank of the mountain in Virginia. The Lee makes the walls of the canyon at The Breaks, in which the fault is plainly shown. East of the fault, at the mouth of Grassy Creek, the top of the Lee is at least 700 feet above water; west of the fault it is only about 100 feet. The westerly dip of the rocks brings the top of the Lee to water level a little below Elkhorn City. This formation is composed largely of coarse, massive sandstone and fine conglomerate carrying white quartz pebbles. It contains some shale beds and may carry one or two small coal beds.

The coal-bearing rocks, which are from 1,500 to 2,000 feet thick, are composed of sandstones, shales, and coal beds. The sandstones and shales range from massive to thin bedded and from coarse to fine grained. There are no limestones in the section. The generalized section, omitting all details, is as follows:

Section of coal-bearing rocks in Elkhorn field, Kentucky.

	Feet.
Coal	4
Interval	530
Coal, Flatwoods	18
Interval	550
Coal, Upper Elkhorn	6 (4–8)
Interval	180
Coal, Lower Elkhorn	4
Interval	170
Coal, Bingham	2½
Interval	150
Coal, Millard	2
Interval	160
Coal, Auxier	3
Interval	185
Coal, Elswick	2½
Interval	75
Conglomerate, Lee.	
	2,042



MAP OF ELKHORN COAL FIELD, KENTUCKY.

STRUCTURE.

The Elkhorn coal field is bounded on the south by the Pine Mountain fault, which parallels the crest of the mountain. This fault causes a displacement of 2,000 feet in the vicinity of Pound Gap, but to the northeast, on Grassy Creek, it decreases rapidly and probably becomes an anticlinal fold. So far as observed, there are no other faults in the field. The coal beds, which originally were deposited in a flat position, now have a slight and general tilt to the northwest. The dip is not continuous, however, but is formed of a series of low, gentle folds or waves in the strata. The dip in few places exceeds 125 feet to the mile, and in most of the area it is still more gentle. A basin, or syncline, extends from the head of Cassell Fork in a north-northwest direction to Daniels Creek, and parallel with it there is a fold or anticline that can be traced easily from Shelby Gap to the head of Wolfpit Fork. The relation of Marrowbone Creek to this anticline is such as to facilitate mining operations on both sides of the creek, giving natural drainage and easy grade for haulage in the mines. On Elkhorn Creek the relation of the structure to the outcrop is for the most part less favorable.

ECONOMIC GEOLOGY.

COAL BEDS.

Under this heading is given, in ascending order, a brief description of the stratigraphic position and extent of each of the coal beds.

Elswick coal.—From 50 to 75 feet above the top of the Lee conglomerate is a coal bed which averages 30 inches in thickness and is known locally as the Elswick coal. This bed, being the lowest, has the shortest outcrop of any in the field. It rises above the waters of Russell Fork at the mouth of Little Creek, about a mile below Elkhorn City, and keeps above the river to Grassy Creek, a distance of 4 miles. It passes below the level of Elkhorn Creek between the mouths of Big Branch and Pond Branch 1 mile above Elkhorn City.

Auxier coal.—At a distance of 250 feet above the Lee conglomerate is the Auxier coal, which usually rests upon a 30-foot bed of massive sandstone. The coal bed ranges in thickness from 18 to 54 inches, with an average of 33 inches. It rises above the bed of Russell Fork at the mouth of Biggs Branch and can be found from that point to Trace Fork of Grassy Creek. It goes below the level of Elkhorn Creek a few rods below the mouth of Kettlecamp Creek.

Millard coal.—This coal is 400 feet above the base of the coal-bearing rocks, and because it has been opened at a number of places near Millard post-office, it is given this name to facilitate description. The bed has an average thickness of 3 feet, but includes several part-

ings. It has been prospected in each of the eastern tributaries of Russell Fork from Powell Creek to Ferrell Creek. There is a good opening on this coal near the tipple of the Marrowbone mine, about 60 feet above creek level, and at Coleman's, opposite Marrowbone station.

Bingham coal.—This coal is 590 feet above the top of the Lee conglomerate and 180 feet below the Lower Elkhorn coal. It was first noted at E. B. Bingham's, on Ferrell Creek, where a prospect is reported to have shown the bed 30 inches thick. It was discovered also under the incline at the Marrowbone mine. In four sections of the bed it was found to range from 30 to 53 inches in thickness.

Lower Elkhorn coal.—This bed has been thoroughly prospected throughout the field, and its location is well known. It is from 750 to 800 feet above the Lee conglomerate, and usually overlies a more or less massive sandstone. It will be seen by the accompanying map (Pl. III) that the Lower Elkhorn coal outcrop delineates every valley and is found throughout the field, except on the south side of Elkhorn Creek. It is everywhere of workable thickness, averaging more than 4 feet. Its value for commercial mining, however, is greatly reduced by the fact that commonly at least one-quarter of the bed is laminated coal—that is, coal so crushed that it breaks into small chips when mined. Many of the chips are slickensided or have smooth, polished surfaces. Schistosity may be developed in the laminated coal, parallel or oblique to the normal bedding, and in some places this coal is rolled and twisted into a rumpled mass which is strikingly different from a normal bed of bituminous coal. It ignites quickly and burns readily under a strong draft, but it is high in ash, and for that reason, and also because it breaks down to slack on handling, it does not meet with a ready sale, and consequently is more or less of a loss to the operator. The laminated coal usually forms the upper part of the bed, but it may be in the middle and overlain by solid block coal. It appears to have been produced by crushing between laterally moving surfaces, and in that respect resembles the Widow Kennedy coal bed at Dante and other places in Virginia.

Upper Elkhorn coal.—This bed is from 160 to 190 feet above the Lower Elkhorn, or 900 to 1,000 feet above the Lee conglomerate. Geographically it is located in the high land, being from 700 to 900 feet above Russell Fork, and therefore near the tops of the ridges. It can be found throughout the entire region where the hills are high enough.

East of Russell Fork, in the vicinity of Ferrell Creek, the Upper Elkhorn coal ranges from 5 to 7 feet in thickness, with only 4 to 8 inches of waste. On Marrowbone Creek the average thickness is 3 feet 10 inches, and 3 feet 2 inches of this is marketable. At the head of Elkhorn Creek, where the bed attains an extraordinary development, the thickness of the entire bed ranges from 7 feet 8 inches to 9 feet

4 inches, with an average of 8 feet 7 inches. The amount of marketable coal in this bed, around the head of Elkhorn Creek, averages 7 feet 9 inches.

Flatwoods coal.—The Flatwoods coal is approximately 1,500 feet above the Lee conglomerate. It occupies only two small areas of the greatest elevation in the field. The larger area lies between the heads of Shelby, Elkhorn, and Marrowbone creeks, and the smaller is at the head of Poorbottom Creek. The thickness of the bed ranges from 14 to 18 feet, but only the upper 7 feet of it can be mined advantageously.

Higher coal.—Nothing is known of any coals higher in the section except a 4-foot bed which is reported in a few hills on the top of the Flatwoods area, more than 500 feet above the Flatwoods coal.

DISTRIBUTION OF THE COALS.

The occurrence of the coals in this region will be described briefly, with only sufficient detail to give a general idea of the field. The description of the coals is arranged by creek valleys, beginning with the left or east side of Russell Fork.

Powell Creek.—In the vicinity of Millard post-office and on Powell Creek the Millard coal has been opened in a number of places, in less than half of which the coal is now exposed. It ranges in thickness from 1 foot 6 inches to 2 feet 4 inches, and can be seen at an opening near the schoolhouse below Powell Creek. The Bingham coal shows a thickness of 3 feet in a drift near Hunter's, on Powell Creek. The Lower Elkhorn coal is exposed in pits on Mead Fork and on the main stream three-fourths of a mile above Widow Mead's. It is composed of two benches, the lower consisting of 2 feet of solid coal and the upper of 15 inches of laminated coal. The Upper Elkhorn is present at the head of the creek, where it is about 3 feet thick.

Biggs Branch.—One mile up Biggs Branch the Millard coal has been dug near creek level, and shows a bed 1 foot 9 inches thick. Near Isaac Lee's, at the forks 2 miles up the creek, the Lower Elkhorn is a doubled bed having the following section:

Section of Lower Elkhorn coal on Biggs Branch.

	Ft.	in.
Coal, soft, dirty	1	4
Coal, block	2	2
Shale	6	
Coal, solid	2	
Coal, bony	2	3
	13	9

Higher coals ranging from 2 feet 6 inches to 5 feet in thickness occur on the opposite hillside.

Daniels Creek.—The Millard coal opened by Mose Coleman on the right fork of Daniels Creek is 21 inches thick, and the Lower Elkhorn opened by Elijah Anderson at the head of the left fork is more than 4 feet thick, with 12 inches of laminated coal at the top.

Harless Creek.—The lowest coal on Harless Creek is the Auxier, which was mined at the mouth of Lower Lick thirty years ago to provide fuel for a locomotive hauling saw logs. This bed is 5 feet thick, but contains 18 inches of shale. A quarter of a mile below Harless Creek, at H. E. Coleman's, the Millard coal has been mined for ten years to supply a few families. The bed is 4 feet 4 inches thick, and is divided into three benches by 10 inches of clay and 4 inches of bone. Four openings on the Lower Elkhorn were seen on Harless Creek. It is 5 feet thick on Lower Lick, 3 feet 3 inches in Corn Hollow and Mose Coleman Hollow, and 5 feet 3 inches at David Coleman's, on Right Hand Fork. The upper part, 1 foot 3 inches thick, is laminated. The Upper Elkhorn in Mose Coleman Hollow is a 5-foot bed with one thick parting.

Jimmie Creek.—The Millard coal shows unusual thickness at an opening 1¼ miles up Jimmie Creek. The bed measures 4 feet 4 inches, but is so broken by bone and clay bands as to be practically valueless. The Elkhorn coals have not been prospected in this creek.

Road Creek.—The Auxier coal is 3 feet thick at Joe Looney's, 1 mile up Road Creek, and the Millard coal near the mouth of Isam Fork and at the mouth of Middle Fork has a thickness of 2 feet 2 inches, including 3 inches of clay. Pits on the Lower Elkhorn coal have been opened in Coalbank Hollow, Cotton Patch Hollow, Middle Fork, and Isam Fork. Robert Martin's bank near the mouth of Road Creek has the typical section of 1 foot 3 inches laminated coal and 4 feet 1 inch of solid coal. The Lower Elkhorn ranges in thickness from 5 feet to 5 feet 10 inches, but the upper part, 1 foot 3 inches thick, is laminated. No openings were seen on the Upper Elkhorn coal.

Ferrell Creek.—The Auxier coal at the schoolhouse below Sprucepine Creek is 1 foot 10 inches to 2 feet thick, and on Board Fork and Shop Branch, above Ferrell Creek, it is reported to be 3 feet thick. The Millard coal is 2 feet thick in the first hollow on the left above Belcher's store at the mouth of Ferrell Creek, 2 feet 6 inches in Hoggston Hollow, and 1 foot 10 inches at water level at the mouth of Bingham Fork. The Bingham coal is reported to be 2 feet 6 inches thick at water level half a mile up Bingham Fork. The Lower Elkhorn in Middle Field Fork is a bed consisting of 1 foot 2 inches of laminated coal and 3 feet 11 inches of solid coal. On Sprucepine Creek the same bed is 8 feet 4½ inches thick, but it includes a 20-inch clay seam. It is 5 feet 9 inches thick at the

head of the creek, near Richard Epling's, and in several openings on Abner Fork it is more than 6 feet thick, including about 15 inches of laminated coal and 3 to 6 inches of clay. Two openings on the Upper Elkhorn show 6 feet 3 inches and 7 feet of coal, with scarcely any parting.

Beaver Creek.—The Elswick coal is exposed at the schoolhouse near the mouth of Beaver Creek. It is in two benches, the upper one carrying 2 feet 4 inches to 2 feet 6 inches of coal and the lower one 7 inches, with an 8 to 9 inch shale parting between them. The Auxier coal is 3 feet thick on this creek. The Lower Elkhorn was not seen here, but is reported from 2 to 6 feet thick. The Upper Elkhorn was seen only at Miles Potter's, at the head of Left Fork, where it is a 6-foot 9-inch bed, with less than 2 inches of partings.

Grassy Creek.—The bloom of the Elswick coal occurs in the road north of Big Hollow. The Auxier coal opened near Riley Cavin's, on Trace Fork, is 1 foot 8 inches thick, and on the right side of Abes Fork 2 feet 6 inches thick. A coal bed opened by the Yellow Poplar Company on the right of Abes Fork, near Old House Branch, ranges in three openings from 4 feet 2 inches to 6 feet in thickness, and carries one 7-inch clay band. These openings are close to the Pine Mountain fault. Coal supposed to be the Millard, prospected at the foot of Greasy Spur, 1½ miles up Trace Fork, is 5 feet 8 inches to 6 feet 1 inch thick, with 15 inches of clay in three partings. A 3-foot bed of coal, found 200 feet higher in the hill, is probably the Bingham coal. The only opening on the Elkhorn coals on Grassy Creek is at the head of Trace Fork, and is reported to show the Lower Elkhorn 4 feet 10 inches thick.

Marrowbone Creek.—The Auxier coal is insignificant on Marrowbone Creek, as can be seen by an outcrop at Marrowbone station.

The Millard coal is 240 feet above the railroad at the mouth of the creek, where it is 2 feet 6 inches thick. It maintains this thickness at John Coleman's, on Wolfpit Fork, and at Dan Stewart's, in Laurel Hollow. In a pit 370 feet below the Lower Elkhorn coal at the Marrowbone mine, this bed shows 2 feet 4 inches of coal, and on Rockhouse Creek it varies from 2 feet 2 inches to 2 feet 6 inches.

The Bingham coal is exposed under the incline at the Marrowbone mine, 190 feet below the Lower Elkhorn. It consists of a lower bench 2 feet 9 inches thick, overlain by 1 foot 2 inches of clay, and an upper bench of 6 inches of coal. At Alec Ratliff's, on Wolfpit Fork, it is 2 feet 6 inches thick.

The Lower Elkhorn coal at the heads of Wolfpit Fork and of Deadening Fork of Rockhouse Creek consists of 3 feet to 3 feet 4 inches of solid coal, overlain by 4 to 9 inches of bony coal. The bed has no partings and no laminated coal, as is usual elsewhere. In the five mines on Marrowbone Creek and in numerous other openings the

Lower Elkhorn consists typically of 2 feet 6 inches to 3 feet of solid coal, overlain by 1 foot to 1 foot 8 inches of laminated coal. At a few places the laminated coal is thin and overlain by several inches of solid coal.

The Upper Elkhorn bed is opened at a number of places on this creek, and shows thicknesses ranging from 3 to 5 feet, with the upper 5 to 10 inches laminated. A notable exception is the occurrence at the Marrowbone mine, where the bed is 3 feet 10 inches thick, but includes a clay parting 1 foot 5 inches thick near the bottom.

The Flatwoods coal is shown by three trenches near the head of Cassell Fork to be from 14 feet to 18 feet 9 inches thick. Two-thirds of the bed is practically worthless, on account of clay partings.

Pond Creek.—The Lower Elkhorn coal has been opened by Sanford Moore, N. A. Ramey, William Ramey, and Grant Hawkins, and at each pit shows approximately 3 feet of solid coal, overlain by 1 foot of laminated coal.

Jesse Creek.—The Lower Elkhorn coal has been dug in a hollow off Left Branch of Jesse Creek above Frank Owen's house, and shows the same character as on Pond Creek, being 4 feet thick with the upper part laminated.

Little Creek and Moore Branch.—The Elswick coal is 3 feet to 3 feet 4 inches thick along the railroad below the mouth of Moore Branch. The Auxier coal is 3 feet 8 inches thick on Little Creek, and 3 feet 1 inch in the hollow back of Calvin Ramey's, half a mile farther down the river. At Moore Branch the Auxier is thicker than elsewhere in the field, measuring 4 feet 6 inches with a 2-inch clay parting near the floor.

Elkhorn Creek.—The Elswick coal is dug in two or three places within a mile of Praise and shows from 2 feet 6 inches to 2 feet 9 inches of coal.

The outcrop of the Auxier was traced by its bloom to the point where the coal falls below creek level near the mouth of Kettlecamp Creek, but a section of the bed was not obtained.

The Lower Elkhorn coal is a little over 4 feet thick at Jackson Branch, but the upper third or half is laminated. Near the head of Ashcamp Branch the bed is composed of 10 inches of solid coal, 9 inches of laminated coal, and a main bench of solid coal at least 2 feet 6 inches thick. An opening at Harry Bentley's, below Pigeon Creek, shows a 4-foot bed, only the upper 2 inches being laminated; but at the Childers opening on Big Branch there is 2 feet 6 inches of laminated coal and only 13 inches of solid coal. On Shop Branch and at the head of Shelby Creek the Lower Elkhorn is 3 to 4 feet thick, and has from 12 to 20 inches of laminated coal in the middle instead of at the top of the bed. At J. D. Bentley's and at Esau Moore's, on Elkhorn Creek between Shelby Gap and Marshall Branch; at William

Isom's, on Marshall Branch; and at the mouth of Peaks Branch, the Lower Elkhorn bed has a thickness of 3 feet. In each place the lower half of the bed is solid coal and the upper half ranges from 7 to 13 inches of laminated coal, overlain by 6 to 10 inches of solid coal.

The Upper Elkhorn coal is 2 feet 10 inches thick at Ashcamp Gap, and on the longest fork of Pigeon Creek it is 3 feet 3 inches thick, including 4 inches of laminated coal. On Marshall Branch the Upper Elkhorn begins to assume the proportions that have made it famous in this region. At the head of the right fork 4 feet 3 inches of coal is seen in two benches, separated by 14 inches of shale; while in two openings at the head of the left fork the bed is 8 feet and 8 feet 9 inches thick, and contains only from 4 to 9 inches of partings. On Peaks Branch the bed is at least 10 feet thick, with one 10-inch parting. On Bens Branch the Upper Elkhorn measures 8 feet 10 inches, with a 10-inch parting in the middle, and on Joes Branch 9 feet 1½ inches, with only a 2½-inch parting. The Mullins opening at the head of Elkhorn Creek shows this bed 7 feet 7 inches thick, with 3 inches of clay in the middle. The coal bed maintains an average thickness of 8 feet over a large area around the heads of Boone Fork of Kentucky River and of Shelby Creek.

Coal has been found in several places on the flank of Pine Mountain. A bed on William Potter's land above Joes Branch is reported 9 feet 6 inches thick. Ten feet of clean, solid coal outcrops 1 mile up Pigeonroost Creek, and a bed 9 feet thick is reported on the road to Blowing Rock Gap.

SUMMARY.

It will be seen from the foregoing description of the field that it contains six coal beds which are of workable thickness. Two or three other beds are of unknown thickness. The following table shows the range in thickness of the workable beds:

Thickness of workable beds in Elkhorn field, Kentucky.

Coal bed.	Number of sections.	Maximum.	Minimum.	Average.
		Ft. in.	*Ft. in.*	*Ft. in.*
Elswick	5	3 10	2 6	3 1
Auxier	8	4 11	1 8	3 1
Millard	20	4 4	1 6	2 5
Bingham	4	4 5	2 6	3 1
Lower Elkhorn	34	6 11	2 9	4 3
Upper Elkhorn	17	8 10	3 3	5 2

It should be borne in mind that this table is based on the total thickness of the beds, and does not represent the amount of marketable coal contained in each bed, which is considerably less than these figures.

ANALYSES OF COAL.

Few bituminous coals in the Appalachian field are of higher grade than those described in this report. The following table shows the chemical character as determined at the United States Geological Survey fuel-testing plant at St. Louis, from mine samples taken by the writer:

Analyses of coal samples from Elkhorn field, Kentucky.

[F. M. Stanton, analyst.]

	Millard.	Lower Elkhorn.					Upper Elkhorn.		Flatwoods.
Laboratory No.	3662.	3705.	3706.	3702.	3663.	3661.	3708.	3828.	3829.
Analysis of sample as received:									
Moisture	3.00	2.90	3.35	3.19	4.73	5.27	4.03	3.96	3.45
Volatile matter	32.22	28.59	31.76	25.83	31.62	27.74	32.46	32.37	33.69
Fixed carbon	56.59	53.70	60.81	48.61	61.57	59.75	58.73	61.10	54.61
Ash	8.19	14.81	4.08	22.37	2.08	7.24	4.78	2.57	8.25
Sulphur	1.06	.49	.54	.40	.71	.50	.74	.56	.82
Loss of moisture on air drying	1.40	1.30	1.70	1.80	3.20	3.40	2.80	1.90	1.70
Analysis of air-dried sample:									
Moisture	1.62	1.62	1.68	1.42	1.58	1.93	1.26	2.10	1.78
Volatile matter	32.68	28.97	32.31	26.30	32.66	28.72	33.40	33.00	34.27
Fixed carbon	57.39	54.41	61.86	49.50	63.61	61.85	60.42	62.28	55.55
Ash	8.31	15.00	4.15	22.78	2.15	7.50	4.92	2.62	8.40
Sulphur	1.07	.50	.55	.41	.73	.52	.76	.57	.83

The following table contains analyses of samples taken by E. V. d'Invilliers for a private report:

Analyses of coals in the Elkhorn field, Kentucky.

[A. S. McCreath, analyst.]

Coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
Elswick [a]	0.65	30.55	59.239	8.18	1.381	.....
Auxier [b]	.65	29.96	58.98	9.72	.69	.....
Lower Elkhorn [c]	1.441	31.804	56.837	9.538	.558	0.0028
Upper Elkhorn [d]	1.538	34.985	58.367	4.499	.587	.0022

[a] Mouth of Moore Branch.
[b] Mouth of Elkhorn Creek.
[c] Average of 9 samples from entire field.
[d] Average of 19 samples from entire field.

The following table is given for the purpose of comparing the Elkhorn coals with well-known eastern bituminous coals:

Average analyses of eastern bituminous coals.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Pocahontas, semibituminous (average of 38) [a]	0.73	17.43	77.71	4.63	0.62
New River (Quinnemont), semibituminous (average of 17) [b]	.60	19.93	75.20	4.27	.67
Pittsburg (Connellsville), coking (average of 20) [c]	1.130	29.812	60.420	7.949	.689
Lower Elkhorn (average of 22)	1.425	32.105	58.435	7.459	.574
Upper Elkhorn (average of 19)	1.538	34.985	58.367	4.499	.587
Clinch Valley gas coal [d]	1.180	37.398	56.732	5.602	.619
Westmoreland gas coal [d]	1.427	37.521	54.921	5.418	.713
Pennsylvania gas coal [d]	1.280	38.105	54.383	5.440	.792

[a] White, I. C., Geol. Survey West Virginia, vol. 2, 1903, pp. 695, 696, 700.
[b] White, I. C., op. cit., p. 670.
[c] H. C. Frick Coke Company.
[d] McCreath, A. S., and D'Invilliers, E. V., Mineral Resources of Upper Cumberland Valley, 1888, p. 145.

COKE.

Analyses and tests of coke made at several different laboratories and plants for the Northern Coal and Coke Company show that the Upper Elkhorn coal around the head of Elkhorn Creek is an excellent coking coal. The coke produced from it is equal to the standard cokes made in this country to-day and is superior to some in its very low percentage of sulphur and phosphorus.

Analyses of five samples of 48-hour coke and four samples of 72-hour coke made from coal taken from the Ben Potter and William Mullins banks in beehive ovens built by the Northern Coal and Coke Company, on Elkhorn Creek, average as follows:

Analyses of Elkhorn coke.

[A. S. McCreath, analyst.]

	48-hour.	72-hour.
Moisture	0.187	0.151
Volatile matter	1.265	1.147
Fixed carbon	90.140	91.072
Ash	7.891	7.082
Sulphur	.517	.546

Phosphorus to the amount of 0.003 per cent was found in two samples.

A sample of 48-hour coke from the coal at Ben Potter's gave the following results in a physical test by John Fulton, of Johnstown, Pa.:

Physical test of Elkhorn coke.

Percentage by volume of coke		59.84
Percentage by volume of cells		40.26
Compressive strength of cubic inch, one-fourth ultimate strength	lbs.	279
Height of furnace charge without crushing	feet	111
Order in cellular space		1.25
Hardness		2.95
Specific gravity		1.75

TONNAGE.

Any estimate of the amount of coal in this field necessarily is only approximate. It is not known absolutely how far the beds extend beneath the surface or whether the average thicknesses shown in the outcrops are maintained for any distance under cover. It is assumed that a bed 2 feet thick is workable, because beds carrying less than 2 feet of good bituminous coal are being mined in the United States to-day.

The tonnage of the Elswick and Bingham coals is estimated on an area only one-quarter that of the field, because so little is known of the character of these beds. The Auxier and Millard beds are better known and are assumed to be of workable thickness under at least 50

square miles of the 130 which constitute the field. The acreage of the Elkhorn and Flatwoods coals was obtained by planimeter from the accompanying map, the divide at the head of Russell Fork drainage being taken for the boundary of the field.

The subjoined figures are an estimate of the coal now in the ground. They do not include the 3- or 4-foot bed said to occur above the Upper Elkhorn coal or the 4-foot bed 500 feet above the Flatwoods coal. This estimate is based on a specific gravity of 1.3, or 1,800 tons per acre for every foot of coal.

Estimated gross tonnage in Elkhorn coal field, Kentucky.

Coal.	Area.	Thickness.	Amount.
	Sq. miles.	*Feet.*	*Short tons.*
Elswick	30	2½	86,400,000
Auxier	50	2½	144,000,000
Millard	50	2	115,200,000
Bingham	30	3	103,680,000
Lower Elkhorn:	*Acres.*		
East of Russell Fork	12,140	5	109,260,000
Russell Fork to Shelby Gap	33,825	4	243,540,000
Shelby Gap to head of Elkhorn Creek	9,150	3	49,410,000
Upper Elkhorn:			
East of Russell Fork	4,000	6	43,200,000
Russell Fork to Shelby Gap	20,720	3½	130,536,000
Shelby Gap to head of Elkhorn Creek	6,425	8	92,520,000
Flatwoods	2,300	7	28,980,000
			1,146,726,000

These figures are so inconceivable that the amount of coal estimated to be in this field can be grasped only when expressed in other terms than millions of tons. The total amount is nearly three times as much as all the coal mined in the United States in 1905. It would make a solid bed of coal 8 feet thick over the area shown on the accompanying map, or 1 foot thick over nearly 1,000 square miles. The amount of coal in the Upper Elkhorn bed between Shelby Gap and the head of Elkhorn Creek, if loaded in 40-foot coal cars carrying 40 tons each, would make a train 17,522 miles long. The total amount of coal in this field, over a billion tons, if loaded in the same way, would make a train 217,183 miles long, or eight trains extending around the world, with enough left over to make more than five solid trains reaching from New York to San Francisco. On the assumption that 30 per cent of this coal will be wasted in mining, there remains a possible output of 800,000,000 tons.

THE RUSSELL FORK COAL FIELD, VIRGINIA.

By RALPH W. STONE.

INTRODUCTION.

In Dickenson County and adjacent portions of Buchanan and Wise counties, Va., there is an area of 550 square miles in the midst of the Appalachian coal field in which the coal has not been extensively prospected and concerning which no reports have been published. The field to be described is that part of the drainage basin of Russell Fork of Big Sandy River which lies in Virginia.

Projects for the construction of a railroad through Dickenson County led to a reconnaissance survey of this field, which was made by the writer during six weeks in the fall of 1906, assisted by C. W. Dodge, jr., for two weeks.

GEOGRAPHY.

This field includes all of Dickenson County, the western part of Buchanan County, and the northern part of Wise County (Pl. IV). It is a heavily wooded, thinly populated, mountainous district. Sandy Ridge, which has a general elevation of 3,000 feet, forms the southeastern boundary of the field, and Pine Mountain, of equal elevation, on the dividing line between Virginia and Kentucky, forms the northern and western boundaries. The divide between Russell Fork and Levisa Fork is from 2,000 to 2,500 feet above sea level. The general elevation of the main streams is 1,500 feet, and the lowest point, where Russell Fork passes through The Breaks at the north end of Pine Mountain, is approximately 900 feet above tide at the State line.

For the most part the country is made up of steep-sided, narrow-topped ridges. There is no level land of any extent in this section of the State, the nearest approximation being some of the flat tops of the ridges, which may be comparatively level for a mile or more, but not over a hundred yards wide. The valley bottoms are narrow, many of them affording little more than room for a road beside the stream.

DRAINAGE.

All the drainage of the area here described passes into Kentucky through The Breaks, at the end of Pine Mountain, in the northeast corner of Dickenson County. The principal streams tributary to Russell Fork are Pound River, McClure Creek, and Fryingpan Creek. Pound River is the largest branch, rising at Black Mountain, on Stateline Spur, and flowing northeastward, parallel with Pine Mountain, for 25 miles. Cranes Nest River, a fork of Pound River, is about equal in size to the main stream.

SETTLEMENT.

The area of the Russell Fork basin in Virginia is 550 square miles, and the population probably does not exceed 10,000. Dickenson County has an area of 324 square miles and a population of 7,747. Settlements are confined to the valleys and are all very small, the only one having a population of more than 100 being the county seat, Clintwood, which numbers 255.

ACCESSIBILITY.

There is no ready access to this country except on horseback or by wagon road through some gap in the surrounding mountains. Pine Mountain, State-line Spur, and Sandy Ridge form a continuous barrier on three sides, with a general elevation of 3,000 feet, while the ridge on the fourth side is but little less of a barrier. Wagon roads are few and follow the main streams or the long, fairly level ridge tops.

The railroads nearest to the area are the Clinch Valley division of the Norfolk and Western Railway on the south, and the Big Sandy branch of the Chesapeake and Ohio Railway at Elkhorn City, Ky., on the north. The Chesapeake and Ohio branch could be extended into the region from the north through The Breaks with no great difficulty other than considerable expense. The South and Western Railway has surveyed a route from Elkhorn City to the mouth of Cranes Nest River, with a maximum compensated grade of less than 1 per cent. The proposed route which would connect the railroad at Dante with the Chesapeake and Ohio at Elkhorn City is to pass through Sandy Ridge by a long tunnel under Trammel Gap, and thence down McClure Creek. Another feasible route would be up Dump Creek, under Kisers Gap by a tunnel, and down Fryingpan Creek.

GEOLOGY.

STRATIGRAPHY.

The rocks of this field all belong to the Pottsville group of Carboniferous age. Three formations of this group are represented in whole or in part. The lowest is the Lee conglomerate. This is over-

lain by the Norton formation, which underlies the surface of the greater part of the area. The lower members of the Wise formation cap some of the high ridges which form the southern and eastern boundaries of the region. The Lee conglomerate is nearly 1,000 feet thick, the Norton approaches 1,000 feet, and 200 or 300 feet of the Wise formation may be present, making a total stratigraphic section of about 2,400 feet.

The Lee conglomerate is composed largely of massive cross-bedded sandstone, but may contain some thin sandy or shaly beds. Two or three coal beds have been found in it at various places. The name "conglomerate" comes from the fact that some portions of the formation, particularly the top and bottom, carry considerable quantities of small white quartz pebbles. The conglomerate as a whole is coarse grained, weathers to a grayish white, and makes conspicuous ledges or strews the surface with large blocks. It is exposed along the east side of Pine Mountain and makes cliffs several hundred feet high at The Breaks. The base of the formation is seen at Pound Gap and Osborn Gap, and a dip of 25° E. carries it below the surface close to Pound River. On Russell Fork, above the mouth of Indian Creek, a massive sandstone which carries white quartz pebbles and is believed to be the top of the Lee is exposed for several miles. At the mouths of Indian and Hurricane creeks it forms cliffs nearly 100 feet high. It rises gradually to the east and keeps above water nearly to the heads of the streams. The top of the Lee, according to a hurried field correlation, is but a few feet above Council post-office on Russell Fork.

The Norton formation is a series of sandstone, shale, and coal beds having a thickness of 1,000 feet or more and lying above the Lee conglomerate. Its upper limit is the base of the Gladeville sandstone. The position of this sandstone at Dante, the only place where a complete section could be measured, is uncertain, but on the assumption that a pebble-bearing sandstone exposed in Trammel Gap is the Gladeville and that the top of a heavy sandstone found 257 feet below the surface in a drill hole at Dante is the top of the Lee, the thickness of the Norton formation is 1,060 feet.

The relative position of the coal beds in the Norton formation in this area is as follows:

Generalized section of Norton formation in Russell Fork coal field, Kentucky.

	Feet.
Sandstone, Gladeville.	
Coal	3
Interval	140
Coal	Small.
Interval	100
Coal, Upper Banner	5
Interval	100

	Feet.
Coal, Lower Banner	4
Interval	50
Coal	2
Interval	190
Coal, Widow Kennedy	6
Interval	120
Coal	Small.
Interval	140
Coal	Small.
Interval	180
Coal	3–15
Interval	10–30
Conglomerate, Lee.	

The Gladeville sandstone is massive, coarse grained, and about 100 feet thick. It is found only in the ridge tops, except at Clintwood, where a structural basin brings it down to an elevation of 1,800 feet.

The Wise formation caps the highest ridges. It is composed of sandstone, shale, and coal, like the Norton formation. Its lower portion only is exposed in this area. A coal bed lying at or near the base has a local thickness of 8 feet on Georges and Lick creeks near Clintwood.

STRUCTURE.

The rocks in this area for the most part lie comparatively flat. So far as could be discovered in a reconnaissance trip, the dip between Sandy Ridge and Cranes Nest River is generally to the north and northwest. From the crest of Pine Mountain to Pound River and along Russell Fork below the mouth of Pound River the rocks dip to the southeast at angles decreasing in intensity as the mountain is descended. The base of the Lee on the top of the mountain dips 25° SE., but near Pound River the beds at the top of the Lee dip less than 10°. These strong dips carry the conglomerate below the surface, so that little of it is found east of Pound River.

In the triangle between Pound River, Cranes Nest River, and the county line, the rocks dip toward Brush Creek, or a point on Pound River north of Clintwood. This syncline, which is parallel with the mountain, is recognized farther upstream in Wise County, where the axis seems to lie between the north and south forks of Pound River. Structurally, the lowest point in the section of Wise County included here is near Pound post-office, for the rocks dip down South Fork and Indian, Bowlecamp, and Mill creeks.

The great fault which extends along the west side of Pine Mountain in Kentucky for many miles crosses the State line near The Breaks, and on Grassy Creek is in Virginia. It makes an escarpment several hundred feet high at the mouth of Grassy Creek, but this

decreases in height to the north until on Cow Fork it is inconspicuous. It is possible that the fault terminates in a northward-plunging anticline on Levisa Fork.

Parallel faults 75 yards apart and trending N. 40° W. were found at the mouth of Pound River. The amount of displacement was not ascertained. One of these faults crosses Pound River at the dam, directly under the grist mill, and the other extends along the left bank of Russell Fork, crossing Pound River at its mouth.

A small fault causing a displacement of about 20 feet is noticeable at the ford just below Colley post-office, near the mouth of Fryingpan Creek. A possible continuation of this fault was seen on Priest Fork, a quarter of a mile from the mouth, in a cliff above John Kiser's house. In line with these two points and possibly having some relation to them is a sharp little fold at the third bend in Russell Fork above Murphy post-office.

On Russell Fork, about 1 mile above the mouth of Hurricane Creek, near Spencer Ball's house, the massive sandstone, supposed to be the top of the Lee, abruptly disappears, and shale standing at high angles is seen at the same elevation. It is believed that there is a fault at this point, and it is possible that there is a continuation of the fault on Indian Creek, a short distance below the mouth of Cany Fork.

At Haysi, a few rods both east and west of Heyter's store, exposures in the road show coals and shales standing vertical, and in the head of a ravine a short distance farther west the rocks are greatly disturbed and indicate proximity to a fault. It is possible that other minor faults or sharp folds of small extent may be found on closer investigation of the field.

COAL RESOURCES.

INTRODUCTION.

On account of the undeveloped condition of the coal resources of the region and the reconnaissance character of the survey, it is not possible in this paper to name and describe the extent of the various coal beds occurring in this field. Many of the coal outcrops are several miles apart, and in the wooded condition of the country it was impossible to carry correlation over such distances. Some idea of the character and abundance of the coals can be obtained, however, by a description of the exposures seen at prospect trenches, coal banks, and natural outcrops. The Widow Kennedy and Banner coals of the Toms Creek field in Virginia have been recognized at many points in the area.

To facilitate description, the field may be divided into four parts, equivalent to the main drainage basins. These are Russell Fork, McClure Creek, Cranes Nest River, and Pound River.

RUSSELL FORK.

The Russell Fork district includes all the tributary drainage of Russell Fork on the east, from its head to Grassy Creek at the State line, and Fryingpan and Lick creeks on the west. Most of this region is very thinly settled, and little or no prospecting has been done for coal except on Indian Creek, where there is an unusually thick bed, and on Fryingpan Creek near Bucu.

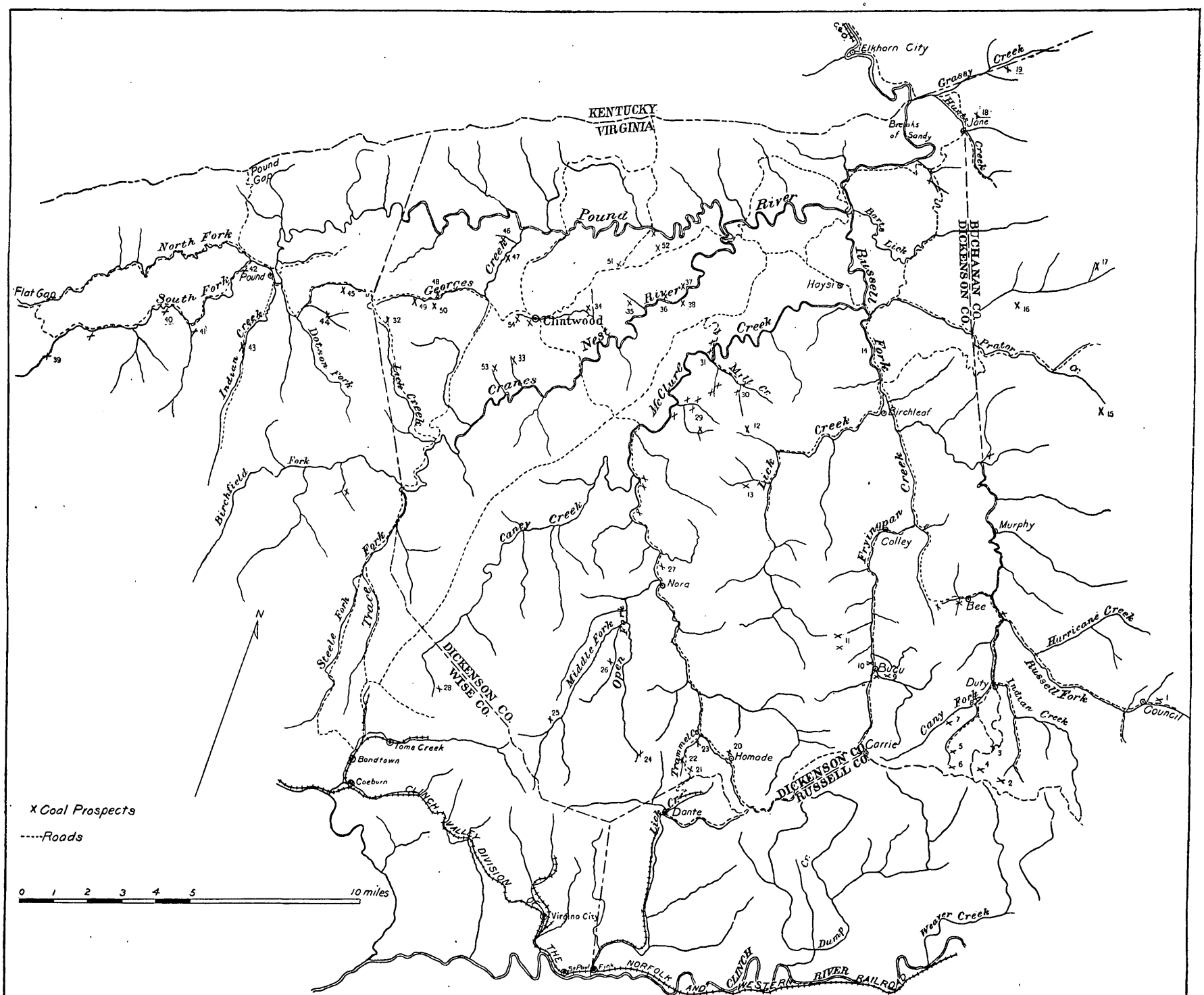
The first coal seen at the head of Russell Fork is one-third of a mile above Council post-office. It is exposed beside the road, only a few feet above the level of the creek, at an opening known as the Isaac J. Hurt bank (No. 1[a]). An entry has been driven for 100 feet and shows the bed 5½ feet thick. This includes 2 inches of clay and 30 to 36 inches of laminated coal in the middle. It has a sandstone roof and floor, and from the fact that the underlying sandstone, well exposed a few rods farther upstream, carries abundant quartz pebbles, it is concluded that this bed is on top of the Lee conglomerate.

This same coal has been opened at a number of points on Indian Creek and shows everywhere a considerable thickness. On the Van Sutherland tract, at the head of the right fork of Indian Creek, an opening (No. 2) exposes a bed 12 feet 5 inches thick. The thickest parting is 18 inches, but much of the coal is inferior. At another opening on this fork it is reported 12 feet thick, but contains two shale partings which are 22 and 33 inches thick. In Cane Gap a 30-foot drift (No. 3) shows 15 feet 4 inches of coal. The bottom bench of this section is solid coal 4 feet 10 inches thick and the remaining 10 feet contains 4 feet of clay and shale. Near Elijah Rasnick's house, below Cane Gap, a 50-foot drift (No. 4) shows a section 6 feet 2 inches thick similar to the lower part of the bed in Cane Gap.

At the head of the left fork of Cany Fork, above S. J. Tiller's house, an entry (No. 5) driven 120 feet to obtain fuel for a locomotive used in logging developed 5 feet 6 inches of fairly clean coal and left 19 inches of laminated coal in the roof. At the head of the fork (No. 6) Hiram Tiller has cleared the outcrop and exposed more than 11 feet of coal bed. Over 2 feet of this is sandy clay parting, but the upper part of the section shows 5½ feet of solid coal.

At N. B. Sutherland's (No. 7), on Cany Fork, this coal bed is 11 feet thick, and one-half mile farther downstream it is a trifle less than 8 feet. One mile above the mouth of Cany Fork the bed is 8 feet thick, but carries three partings in the middle which aggregate 17 inches of shale. The Pitzer & Lind- -y opening (No. 8), below the forks of Cany, which once supplied the fuel for a logging locomotive, is reported to have shown a 14-foot bed of coal. There is a top bench of 34 inches of coal separated by 6½ feet of shale, coal, and

[a] Figures in parentheses refer to location of coal prospects on accompanying map (Pl. IV).



MAP OF RUSSELL FORK COAL FIELD, VIRGINIA.

bone from another bench 2 feet thick. The thick partings make it of little value for mining.

No coal beds of any value were seen for several miles down Russell Fork, but it is probable that some will be discovered if the region is prospected. Among the unimportant exposures is a 22-inch coal at the mouth of Indian Creek, an 18-inch coal in the hollow back of Bee post-office, and a 17-inch coal in the gap between Abners Fork and Priest Fork. A 2-foot bed is reported near Murphy post-office, and a 15-inch coal was seen on Little Pawpaw Branch. Prospecting has revealed several coals on Fryingpan Creek in the vicinity of Bucu post-office. Among these is a 32-inch bed at the mouth of Left Fork and a 5-foot bed one-third of a mile farther upstream (No. 9) close to the road. A quarter of a mile below Bucu, in the east bank of the creek, there is an opening which shows 46 inches of coal with only a half-inch parting, and 25 feet above it there is a 20-inch bed. On the opposite side of the creek, at Z. T. Sutherland's, an opening (No. 10) shows a bed 5 feet 10 inches thick, which is peculiar in that the lower 27 inches is a mixture of clay and laminated coal standing on edge. A road opening farther downstream shows a coal reported to be 5 feet 7 inches thick which has a marked curly laminated structure.

The Upper Banner coal has been opened in the head of the hollow back of Havre Powers's, about 500 feet above the creek (No. 11). It lies under a 50-foot ledge of sandstone and is more than 6 feet thick. On the left side of the same branch another opening shows the Upper Banner nearly 7 feet thick, with less than 20 inches of clay or bone parting. The Upper Banner has also been opened (No. 12) at the head of Beech Branch of Lick Creek, on John Deel's land. The bed is only 4 feet 2 inches thick, but is fairly clean coal. On Dog Branch, half a mile above Lick Creek, a pit (No. 13) shows a highly contorted mixture of clay and coal, which is practically worthless on account of its irregularity. The appearance of the coal suggests that this may be the Widow Kennedy bed. An opening (No. 14) at T. K. Colley's, at the mouth of Duty Branch, half a mile below Birchleaf post-office, showed about 4 feet of crushed and rolled coal under a roof of badly jointed sandstone which is so treacherous that the pit can not be kept open. The general appearance of the coal suggests that this also may be the Widow Kennedy bed.

Very little prospecting has been done on Prator Creek, and only two beds of any account were seen. One of these (No. 15) is at the head of War Fork, 2½ miles above Prator post-office, 130 feet above Larkins Owen's house, and close to the top of the ridge. The opening shows a bed 4 feet 8 inches thick, containing only one-half inch of clay. This probably is the Upper Banner coal. On Greenbrier Fork, 2 miles above the mouth and 400 feet above the creek, there is an opening (No. 16), made by Albert and Wiley O'Quinn, on

a bed which is over 5 feet thick, but which has several thin partings. At the head of Greenbrier Fork there is 2 feet 5 inches of coal on Z. T. Raines's land (No. 17), and about 2 feet of coal, probably the same bed, at Joshua O'Quinn's. On the road from the mouth of McClure Creek to Jane post-office a number of coal blooms are exposed, and a 1-foot bed has been stripped on the fork of Bart Lick. On Bart Lick, 1 mile from the road, there is a 2-foot bed opened at three places below Dr. J. W. Wright's house, and at the crook of the road on the right fork of Camp Branch there is an opening on a coal bed nearly 5 feet thick, which has a 12-inch clay parting. On Hunts Creek, the main right fork of Grassy Creek, there are three openings between Jane post-office and the divide on the road to Grundy which show from 2 to 3 feet of coal. On the right of Hunts Creek, half a mile below the gap leading to Bull Creek, an opening shows 4 feet 1 inch of very clean coal.

On the branch which joins Hunts Creek from the east at Jane post-office an opening back of T. L. Owen's house shows a 35-inch bed (No. 18), containing a 7-inch parting, and another on the Stiltner farm shows a 2-foot bed. One mile above Jane, on Noah Mullens's land, coal is taken every winter from a pit containing 28 to 30 inches of coal. On the right of Abes Fork of Grassy Creek, in Old House Branch, there are three openings (No. 19), made by the Yellow Poplar Company, which show a bed from 4 to 6 feet thick, containing a 7-inch clay band near the bottom. These openings are close to the Pine Mountain fault.

McCLURE CREEK.

Back of Homade post-office, on the head of McClure Creek, Reuben Owens has faced up a coal bed (No. 20), probably the Lower Banner, and found nearly 4 feet of solid coal. Blossoms of higher coals occur in the road between Homade and Flint Gap.

At the head of Trammel Creek the Upper Banner coal has been opened on the Brooks farm (No. 21), where it is 4 feet 11 inches thick. A 1-inch sandstone parting, 21 inches below the roof, is practically the only waste in the bed. The Lower Banner coal has been opened on Laban Phillips's place (No. 22) and shows 4 feet of coal underlain by 3 inches of clay and 4 inches of bone. In the Clinchfield mine No. 2, at Dante, on the other side of Sandy Ridge, the Lower Banner coal averages about 3½ feet in thickness. A pit (No. 23) opposite the schoolhouse near the mouth of Trammel Creek shows the Widow Kennedy coal 7 feet thick, but decreasing rapidly with depth. The record of a diamond-drill hole 150 feet away shows only 1 foot of coal at this horizon.

The Grizzle opening (No. 24), at the head of Open Fork of McClure Creek, shows the Upper Banner coal nearly 7 feet thick. The middle bench, 4 feet thick, can be profitably mined, leaving 8 inches of fire clay and 11 inches of coal in the floor and 3 inches of coal in the roof.

The Milton Carico opening (No. 25) on the Upper Banner coal at the head of Middle Fork has the same partings as the Grizzle opening, but the total thickness of the bed is less, measuring from 6 feet 3 inches to 6 feet 5 inches. Three-fourths of a mile above this point the Upper Banner is less than 5 feet thick, but has thinner partings. On Coon Branch of Open Fork the Rasnick opening (No. 26) on the Upper Banner coal shows a 9-foot bed, but it contains a 35-inch fire-clay parting. The Lower Banner coal opened farther down the branch is 6 feet thick, with 30 inches of fire clay in two partings of equal thickness. The Widow Kennedy coal is reported 5 feet thick near the mouth of this branch. Three openings (No. 27) on the Widow Kennedy coal at the Rasnick mill, below Nora post-office, show a bed about 6 feet thick, but the disturbed condition of the coal makes it of questionable value.

The Upper Banner coal has been opened at the head of Caney Creek on Alec Odle's land (No. 28) by a drift 100 feet long. The bed is 8 feet 10 inches thick, and contains a number of very thin partings. At Samuel Horn's place on the head of this creek the Upper Banner has the same number of thin partings, and is 7 feet 5 inches thick. The Lower Banner coal has a thickness of 21 inches in this vicinity.

On McClure Creek, just above the mouth of Caney Creek, there are three openings close to the road, showing a coal bed believed to be the Widow Kennedy, which ranges in thickness from 2 feet 1 inch to 5 feet.

On Squirrelcamp Branch there are five openings (No. 29) on the Upper Banner coal, showing a range in thickness from 4 feet 8 inches to 6 feet 9 inches. The thickest bed includes 15 inches of shale near the top.

In the vicinity of Mill Creek the Upper Banner coal has been extensively prospected and wherever found the bed maintains the same character, having two thin fire-clay partings and a band of sandstone from 1 to 2 inches thick. Four openings on the W. J. Ring tract, three on the right fork of Mill Creek, and two near Eli Wright's on Mill Creek (No. 30) all have an average thickness of about 5 feet. The partings in the bed are so small as to offer no difficulty in the mining of this coal.

Below the mouth of Mill Creek there is an opening back of Paris Colley's house (No. 31) and another on Low Gap Branch, both of which show the same three thin partings in a bed having a thickness of a little over 5 feet. So far as learned, there are no coal openings on the lower 5 miles of McClure Creek.

CRANES NEST RIVER.

The most extensive prospecting on Cranes Nest River is at the extreme heads of Steele and Trace forks. A number of openings have been made on both sides of these forks, and the position and character of the Upper Banner coal have been thoroughly investigated.

This coal bed for the most part is in two benches which range from 1 to 2 feet in thickness, separated by 1 inch of sandstone, the average thickness of the whole bed being 3 feet.

Several openings on the right side of Steele Fork apparently have discovered only the lower bench of this coal, for the bed measures less than 2 feet thick. At a point about a mile and a quarter above the mouth of the creek, however, a prospect shows the bed 9 feet 4 inches thick, but this contains 5 feet 9 inches of shale and fire clay in two benches, making it nearly worthless for mining.

On Trace Fork of Cranes Nest River, the Upper Banner has been opened in many places, and shows thicknesses ranging from 2 to 4 feet. A sandstone parting 1 inch thick is found in all the openings about one-third of the distance below the top of the bed, and in a few places 1 inch of fire clay appears within a few inches of the roof; but these two thin partings were the only ones encountered.

So far as learned there is only one opening on Birchfield Fork, and aside from this opening the only guide to the thickness of the coal beds in this vicinity is an average section of the coal mined at Glamorgan, on the opposite side of the ridge from the head of Birchfield Fork. In this mine the bed averages 4 feet 6 inches in thickness and contains two very thin partings, but the writer was not able to correlate it with any of the coals seen in Dickenson County. On Plummer Branch, which is 2 miles above the mouth of Birchfield Fork, the Upper Banner coal is between 5 and 6 feet thick.

At the head of Lick Creek, 4 miles southwest of Clintwood, the Cranes Nest Coal and Coke Company opened a coal bed which probably lies on top of the Gladeville sandstone and which has a considerable thickness. At this opening (No. 32) the bed measures 10 feet 5 inches and contains only 5 inches of shale. The same bed has been opened in two places on the head of Keel Branch, about 1 mile from Clintwood; in one place it is 6 feet 5 inches thick and in the other 10 feet 4 inches. There is very little waste in this bed, considering its thickness. The same bed has been opened on Georges Creek and near Clintwood, to supply the local demand for fuel, but is not quite so thick at the village coal banks as it is on Keel Branch.

Several small beds of coal have been opened along the banks of Cranes Nest River and on its smaller tributaries between Clintwood and the mouth on Pound River. The Upper Banner coal has been recognized at an elevation of 100 to 200 feet above the creek. It is 3 feet 4 inches thick where opened on Holly Creek (No. 34), 1 mile above the mouth, and nearly 4 feet thick on Levi Bartley Branch (No. 35). The Hawkins opening (No. 36), on the right of Cranes Nest River, below Nickels Gap, shows the Upper Banner 4 feet 1 inch thick, with only one thin parting, and at C. G. Rake's (No. 37), about a mile farther downstream, the same coal is 4 feet 3 inches thick, with

a 6-inch clay parting about 2 feet above the floor and two or three other very thin shale partings. In this same vicinity on Cranes Nest River, just opposite Delaney's mill (No. 38) and also opposite Delaney's house, the Upper Banner coal is over 4 feet thick. It has four partings, the thickest of which measures three-fourths of an inch. These openings, together with those in the vicinity of Mill Creek, on McClure Creek, lead to the assumption that the Upper Banner coal is fairly profitable for mining in this part of Big Ridge, which separates the two streams. The bed is several hundred feet below the top of the ridge and lies in a body several miles long, averaging over 1 mile wide.

POUND RIVER.

No coal openings were found on North Fork of Pound River. At the head of South Fork Reuben Boling has a bank (No. 39) at the water's edge which shows a bed 4 feet 3 inches thick, including a 10-inch seam of clay. At the mouth of Fox Gap Hollow there is a 28-inch coal, and near Bond Mill a 2-foot coal is reported. Farther down South Fork, at Thurston Banner's (No. 40), there are two openings which show 23 and 27 inches of coal, and at the mouth of Glady Fork (No. 41) there is a 3-foot bed without partings. At the mouth of South Fork (No. 42) openings made by Milburn Guillam show a bed which has a total thickness of 4 feet 4 inches. This, however, includes a 12-inch clay seam and 3 inches of bone.

On Indian Creek there is an old mine belonging to the Tidewater Company, in which 3 feet 4 inches of coal is visible, but water covers the bottom of the pit. Farther downstream, at J. H. Blair's (No. 43), a bed has been opened which is reported to be 5 feet thick, including one 8-inch parting. This is about 2 miles above the mouth of the creek. At the mouth a 16-inch coal is exposed near the road.

At the head of Dotson Fork of Bowlecamp Creek an opening on the George L. Baker place shows a bed of coal 8 feet 3 inches thick. The upper 5 feet of this bed is clean solid coal. Near the forks of McFalls Fork (No. 44), a coal reported to be 6 feet 6 inches thick is exposed in the bed of the creek, and on Hamilton Fork a pit back of Grant Mead's house (No. 45) has been opened on a coal bed which measures 4 feet 8 inches and contains one clay parting 6 inches thick.

A little over half a mile above the mouth of Georges Creek an opening (No. 46) at water level on the right-hand fork, made by John Trivitt, reveals a 4-foot coal containing 8 inches of clay in two partings. About a mile above the mouth, on the main creek, at J. C. Willis's (No. 47), this same coal is reported to be 2 feet 7 inches thick.

Near the head of Georges Creek, the coal which lies above the Gladeville sandstone and which has a considerable thickness on the head of Keel Branch and Lick Creek, tributaries of Cranes Nest River, has been prospected at several points and found to have considerable thickness.

At Samuel Elkins's (No. 48) this coal bed measures 5 feet 10 inches, and at Baumgardner's (No. 49), a little farther up the creek, 9 feet 8 inches. At the latter point it contains 16 inches of waste. The thickest section of this bed known to the writer is the Manuel Mullens opening (No. 50), three-fourths of a mile below Baumgardner's, where the thickness is 11 feet 3 inches, including an aggregate of 13 inches of waste in five partings.

Very few exposures of coal were seen on Pound River below the mouth of Georges Creek. There is a 16-inch bed of coal at the spring 30 feet below Nickels Gap (No. 51), and a 15-inch bed in the bank of Pound River directly below Nickels Gap.

In a hollow on the left of Pound River, 2 miles above the mouth of Cranes Nest River, at J. Sypherd's, a small pit reveals a coal bed probably just below the Gladeville sandstone, which has a thickness of 5 feet 2 inches and contains 11 inches of clay in two partings.

Coal was seen in two or three places on the right of Pound River on the flank of Pine Mountain, but in no case is the outcrop of commercial importance, the thickest being a 20-inch coal found about 50 feet below the top of the Lee conglomerate, on one of the forks of Skeet Rock Branch.

QUALITY OF THE COALS.

The following 16 analyses of coal from the Russell Fork basin in Virginia are from private reports, and show the chemical character of the principal coal beds in this field. The average of these analyses is 29 per cent volatile matter, 62 per cent fixed carbon, less than 1 per cent moisture, about 6 per cent ash, and 0.015 per cent phosphorus. The quality of the coals in this field is equivalent to that of the Pittsburg coking coal.

Analyses of bituminous coals from Dickenson County, Va.

	Opening.	Location.	Name of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Thickness.
										Ft. in.
1	Baumgardner (No. 49).	Georges Creek..	Clintwood..	2.44	33.26	58.682	4.90	0.718	0.007	9
2	Beverley (No. 53)..	Honeycamp Branch.	....do.....	.62	33.63	60.951	3.95	.849	.01	6 9
3				.....	33.96	62.02	4.02	.77	.....	6 9
4	John Lane (No. 54)	Clintwood.....	.....do.....	.59	33.60	62.239	2.86	.711	.008	4 6
5	C. C. Kilgore.....	.....do.....	.....do.....	.55	32.11	60.721	6.01	.609	.005	4
6	Keel (No. 33).....	.....do.....	.....do.....	.70	33.60	60.90	4.80	.....	.....	.....
7	Keel, upper bench .	.....do.....	.....do.....	.63	32.44	61.662	4.53	.738	.016	6 6
8	Keel, lower bench..	.....do.....	.....do.....	.46	33.12	60.752	4.78	.888	.023	2
9	Viers.....	McClure Creek..	Upper Banner.	.438	29.862	63.355	5.44	.905	.005	5 9
10	Harden Branch (No. 11).	Fryingpan Creek.	.....do.....	1.56	28.62	61.35	8.47	.....	.....	.....
11	Cany Fork.....	Indian Creek...	Tiller.....	.90	27.33	67.74	4.03	.....	.....	10
12	Barnett, upper bench.	Duty.....	.....do.....	.304	25.436	64.594	8.88	.786	.021	4
13	Barnett, lower bench.	.....do.....	.....do.....	.404	26.306	69.522	3.29	.478	.023	5
14	Taylor Sutherland (No. 10).	Bucu.....	Widow Kennedy?	.95	23.36	61.43	14.26	.....	.....	5 6
15	Taylor Sutherland	.....do.....	.....do.....	.428	23.022	63.735	12.15	.665	.013	6
16	Sutherland.....	.....do.....	.....do.....	.378	22.292	61.601	15.21	.519	.033	3

Analysts: 1, 2, 4, 5, 7–9, 12, 13, 15, 16, A. S. McCreath; 3, 6, Wuth & Stafford; 10, 11, 14, C. C. Tutwiler
Authority: 1–9, 12, 13, 15, 16, James T. Gardner; 10, 11, 14, Jansen Haines.

COKE.

The coals of this field duplicate in physical properties and chemical composition the coking coals on Toms Creek, and it is believed that for the most part they will be found to be good coking coals.

Car samples of the Clintwood coal taken from the Beverley opening (No. 53) on Honeycamp Branch and shipped to Chattanooga and Connellsville made coke of the following character, according to a private report of F. A. Stratton:

Analyses of Dickenson County coke.

	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Analyst.
72-hour	0.45	90.153	8.575	0.775	0.047	Wuth & Stafford.
48-hour	.031	91.224	7.695	.736	.035	Do.
72-hour	.....	90.91	8.34	.75	.....	Schoenberger Steel Co.
48-hour	.....	92.03	7.22	.75	.....	Do.
Do	1.50	92.30	6.30	.69	.032	Do.
Do	1.03	92.76	4.373	.841	.026	P. D. Langdon.

SUMMARY.

The evidence in the foregoing descriptions shows conclusively that the area between Sandy Ridge and Pound River is a valuable field of bituminous coal, in all parts of which there is at least one coal bed of minable dimensions. Doubtless further prospecting will reveal two or more coal beds of workable thickness above drainage level in many parts of the field. It is shown in the above notes that a coal bed having an average thickness of 8 feet is commercially minable around the head of Russell Fork; that the Upper Banner coal, averaging 4 feet in thickness, is present throughout a great part of the region; and that a bed approximating 7 feet in thickness underlies a small area near Clintwood. There is no known coal of value between Pound River and the crest of Pine Mountain. The chemical analyses show that these are high-grade bituminous coals and have only small percentages of impurities. There is evidence that some if not all of these coals will coke.

COAL MINING AT DANTE, VA.

By RALPH W. STONE.

INTRODUCTION.

Early in October, 1906, while making a reconnaissance survey of Dickenson County, Va., the writer was detained for a few days at Flint Gap on Sandy Ridge, 2 miles from the coal mines at Dante. The notes on which this paper is based were made at that time.

Dante, formerly known as Turkey Foot, is at the forks of Lick Creek, in the west corner of Russell County, Va., at the foot of the eastern slope of Sandy Ridge below Trammel Gap. It is near the north edge of the Bristol quadrangle, about 8 miles from Fink and St. Paul on the Norfolk and Western Railway, and is connected with Fink by a branch line known as the Lick Creek and Lake Erie Railroad, which is a part of the South and Western Railway. This gives an outlet for the coal to markets north, east, and south. Dante is 10 miles east of Toms Creek, where there are large coal mines and banks of coke ovens. A number of small mines are operating between these places.

Dante is in a mountainous country, its elevation above sea level being 1,770 feet, and the top of Sandy Ridge, 2 or 3 miles distant, averaging 3,000 feet. The hill slopes are steep and the ridges and valleys are narrow.

GEOLOGY.

STRATIGRAPHY.

The east edge of the coal field of Virginia is marked by a great fault which extends for many miles in a northeast-southwest direction across this part of the State. This fault brings Silurian limestone up above Carboniferous rocks. At Fink the limestone is seen abutting the overturned edge of the Lee conglomerate, which lies stratigraphically next below the coal-bearing formation. Dante is 7 miles west of this fault.

According to M. R. Campbell,[a] the Lee conglomerate lies nearly flat beyond the zone of disturbance at the fault, perhaps dipping slightly westward, and should be barely 300 feet below the sur-

[a] Geologic Atlas U. S., Bristol folio (No. 59), U. S. Geol. Survey, 1899.

face at Dante. A diamond-drill hole near the Dante schoolhouse encountered massive sandstone 257 feet below the surface, and conglomerate carrying small quartz pebbles at a depth of 299 feet. These appeared to the writer to be the same as the rocks seen at the top of the Lee formation in Pine Mountain, and to sustain Campbell's interpretation of the structure.

Above the Lee, and forming all of the surface in the vicinity of Dante, is the coal-bearing series of rocks known as the Norton formation. According to Campbell, this formation at Big Stone Gap is 1,280 feet thick and is overlain by the Gladeville sandstone, a coarse-grained, massive bed 100 feet thick. This sandstone is found near the top of Sandy Ridge, the highest points of which are occupied by the Wise formation, another series of sandstones and shales carrying a few beds of coal.

If the writer's interpretation of the top of the Lee in the above-mentioned drill hole is correct, there is a 60-foot bed of massive gray sandstone near the base of the Norton formation, or 190 feet below creek level. Two coal beds in the lower part of the formation were found in the midst of thin-bedded sandstone and shales within 150 feet of the surface.

A coal bed about 18 inches thick outcrops just above the creek at Dante, and the Widow Kennedy coal is 196 feet above water at the forks. The position of this coal is about 400 feet above the conglomerate and 125 feet above the 18-inch coal. It is succeeded by 240 feet of sandstones and shales, above which lies the Lower Banner coal, and 100 feet higher the Upper Banner coal. Just below Trammel Gap, or 250 feet above the Upper Banner, the bloom of a small coal occurs in the road at the base of a sandstone carrying white quartz pebbles. This may be the Gladeville sandstone. If so, the thickness of the Norton formation at this place is about 1,060 feet. From the gap to the top of Sandy Ridge the section is made up of sandstones and shales, with possibly two or three thin coal beds. Blocks of massive gray sandstone were seen at the top of the ridge and if these represent the Gladeville the thickness of the Norton formation is close to 1,300 feet.

STRUCTURE.

The rocks in this field have a fairly regular dip to the northwest at a low angle. This rather hinders natural drainage of the mines until they have been cut through to the far side of the hill.

COAL RESOURCES.

Introduction.—All mining at Dante is being done by the Clinchfield Coal Corporation, of Johnson City, Tenn. At this company's plant, which is known as the Clinchfield colliery, three beds are being worked by four mines, as follows: Widow Kennedy coal, mines Nos. 1 and 4;

Lower Banner coal, mine No. 2; Upper Banner coal, mine No. 3. The Widow Kennedy mines are at the foot of the Trammel Gap road on opposite sides of the creek, half a mile above Dante. Farther up on the left is the Lower Banner mine, and the Upper Banner is worked from several entries at the head of the creek. A brief description of these coal beds as found in each of the mines is given below.

Widow Kennedy coal, mine No. 1.—The Widow Kennedy coal outcrops nearly 200 feet above the creek at Dante, but the steep grade

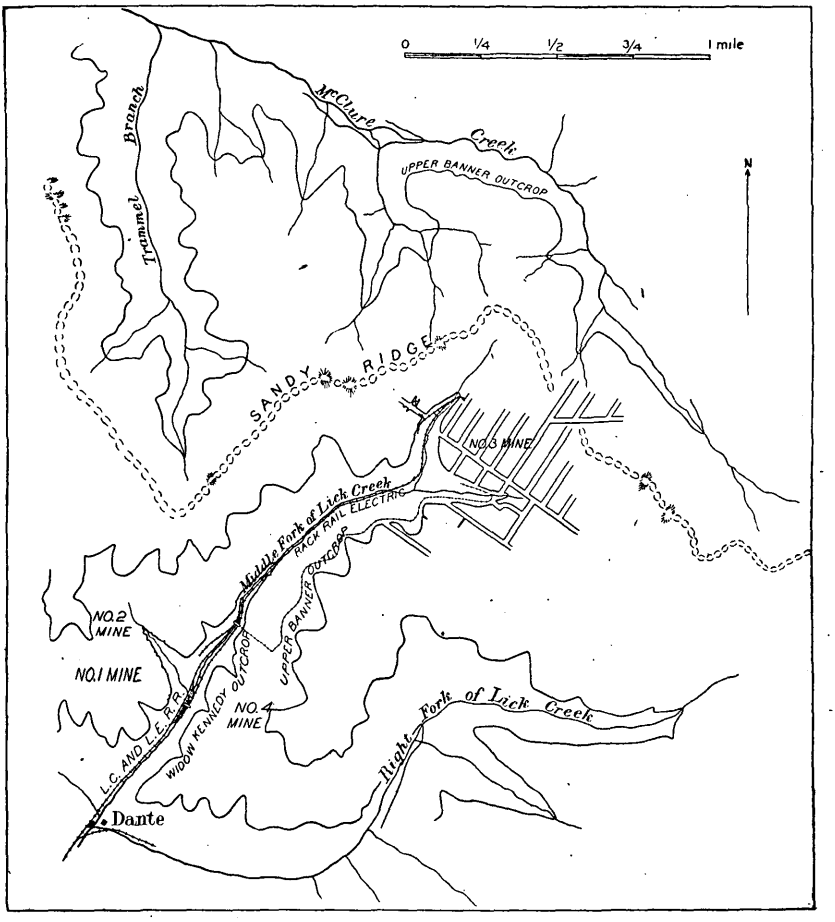


FIG. 1.—Map showing location of coal mines at Dante, Va.

of the stream and the opposing dip of the coal bring it somewhat nearer creek level at the point where it is mined. This is a curious bed, showing abrupt variations in thickness and character. In mine No. 1, which covers 15 or 20 acres on the left of the creek, the bed averages 7 feet in thickness, but in one heading it pinches out entirely and at other points it is from 12 to 14 feet thick. In parts of the mine it shows from 4 to 6 feet of clean coal without apparent bedding or

cleavage. This condition, however, is not persistent, for a peculiarity of the Widow Kennedy coal is that in many places it is crushed, and slickensided as if it had been subjected to squeezing and lateral movement. Slick faces dipping in all directions are encountered and streaks and balls of clay are included in the coal bed. The coal under these conditions is laminated or flaky, and the thin layers of clay in it show the movement by their curved and contorted outline. One heading in this mine passes through 20 feet of alternate thin layers of coal and clay standing vertical. Much of the badly shattered coal is so dirty as to be unmarketable, but in some places the clay balls are so easily separated that the coal can be cleaned by hand.

The floor in mine No. 1 is sandstone, and the roof is also, but is separated from the coal in places by a foot or less of draw slate. The roof holds well. Here and there thin lenses of sandstone separate 1 inch or 2 inches of flat coal next the roof from the top of the main bed.

Widow Kennedy coal, mine No. 4.—In mine No. 4 on the opposite side of the creek the average thickness of the Widow Kennedy coal is from 3 to 3½ feet. The coal is not badly crushed, but the top 2 inches is dirty and lies in thin flat plates or layers. Throughout the mine the floor is sandstone, which is fairly regular with only minor unevennesses like ripple marks. Draw slate usually separates the coal from the sandstone in the roof. This draw slate, however, is of variable thickness, ranging from a few inches up to 4 feet. In room No. 2 off the main heading, within a distance of 65 feet, the draw slate pinches down from 2 feet until the sandstone rests upon the coal. A thin layer of plastic clay lies between the coal and the roof.

The main heading in mine No. 4 shows 6 feet of coal with two diagonal clay streaks and 1 foot of draw slate. About 300 feet farther in the draw slate thickens to nearly 4 feet and the coal thins to 2 feet, the upper half of which is soft, dirty, laminated coal, or "rash." In room No. 2 from the main heading there is from 6 to 7 feet of solid coal with almost no clay balls, but the top 2 inches in spots is laminated. The face of No. 6 right crosscut shows 50 inches of coal with two diagonal or inclined clay streaks 1 inch thick. In one place the upper 10 inches of the coal is contorted and so mashed that it breaks to slack when mined. In the face of No. 5 crosscut the bed has a hard draw-slate roof and a sandstone floor; it is 4 feet thick but contains 6 inches of clay about a foot above the floor. In crosscut No. 4 the face of room 1 shows 4 feet to 4 feet 2 inches of coal with 2 inches of clay between coal and draw slate. The coal here is free from dirt and fairly hard, but it contains some soft crushed streaks and diagonal cleavage. In room No. 2 of the same crosscut there is 5 feet of solid coal with 2 inches of clay on top. Room No. 3 has 3 feet 4 inches of coal, with one-half inch of clay between it and the draw slate, which is 6 inches thick. Much of this coal shows hard slick faces that

appear to have been produced by movement in the bed. The writer took a sample of the entire bed in No. 2 crossheading, where there is 3 feet 9 inches of solid coal. The analysis is given with others on page 74.

Lower Banner coal, mine No. 2.—The Lower Banner bed is worked at what is known as mine No. 2, on the left of the creek, 200 yards north of mine No. 1. The thickness of the bed averages from 3 to 3½ feet in the main heading, but increases toward the outcrop on the far side of the hill. This heading has been driven through for drainage. In the furnace heading the coal measures 6 feet 2 inches, but thins to 5 feet 10 inches farther under the hill. A sample, the analysis of which is given on page 74, was taken in room No. 4 off the left entry, where the section is as follows:

Section of Lower Banner coal in mine No. 2, Dante, Va.

	Inches.
Coal, alternate bright and dull bands	19
Coal, laminated	3
Coal, solid	17
Fire clay	6
Coal, bright	2
	47

The fire clay and bottom coal were not included in this sample.

In the face of the third left heading and of a cross entry the following sections were measured between the shale roof and the clay floor:

Sections of Lower Banner coal in mine No. 2, Dante, Va.

		Third left heading.	Cross entry.
		Inches.	*Inches.*
Coal	Mined	24	4
Bone or rash	Mined	1	2
Coal	Mined	18	20
Coal, sticks to clay	Left in floor	1	1
Fire clay	Left in floor	1	2
Coal	Left in floor	2	3
Fire clay	Left in floor	6	.....
Coal	Left in floor	2	.....
		55	32

The bed is mined down to the 1 inch of coal which is left on top of the fire clay. In one heading the bed thins down to 18 inches of coal, with a thin laminated streak 4 inches from the top, then to a minimum of 16 inches of solid coal. Beyond this point the solid coal increases to 17 inches, with 10 inches of laminated coal on top, and farther on 1½ inches of good coal appear above the laminated.

Upper Banner coal, mine No. 3.—The Upper Banner coal has been mined more extensively than either of the others. The entries, of

which there are nine, are at the head of the creek under Trammel Gap and around to the right of the head. Mine No. 3 is working on a 1,160-acre tract. The main tunnel, when completed, will be about 3,200 feet long and No. 2 crosscut about 2,400 feet. The coal averages 5 feet in thickness, with more at 5 feet 6 inches or 5 feet 10 inches than at 4 feet. Draw slate from 6 to 10 inches thick lies on top of the coal and becomes plastic when wet. This is usually overlain by 1 inch to 6 inches of coal, which hangs to the sandstone roof. In some places the sandstone cuts out the draw slate, and where this happens the coal bed is thin. The slate floor is from 4 to 19 inches thick, over sandstone.

The following sections were measured at different points in the mine:

Sections of Upper Banner coal in mine No. 3, Dante, Va.

[Inches.]

Coal	21	22	23
Sandstone	1	1	1½
Coal	10	10	10
Shale, gritty	½	½	1
Coal	30	33	36
	62½	66½	71½

At No. 9 opening a 10-inch coal bed lies 7 feet below the Upper Banner. The intervening rocks are sandstone and shale.

In a part of mine No. 3 known as Hylton No. 1 a sandstone lens cuts the coal down to 16 inches. This sandstone, however, does not show in Hylton No. 2, about 60 feet away. In the left butt entries off the main tunnel the floor dips about 10 feet in 60 feet, then rises again, making a sag in which water collects. In one entry the water touches the roof.

A sample of the Upper Banner was taken at butt entry No. 6, off the main gangway, where the section of the bed is as follows:

Section of Upper Banner coal in mine No. 3, Dante, Va.

Sandstone roof.	Inches.
Draw slate	8
Coal	22
Sandstone	1
Coal	10
Shale, gritty	½
Coal	24
Parting.	
Coal	5
Shale floor.	
	70½

The 24-inch bench contains 4 inches of dull, hard splint coal.

ANALYSES.

Samples of these three coals were taken by the writer. Each sample was crushed and quartered in the mine and sealed in an air-tight can. They were analyzed at the fuel-testing plant of the United States Geological Survey at St. Louis as received, without loss of moisture. These analyses have been recalculated on an air-dried basis to give analyses representing the condition of the coals as delivered to the consumer and to make them more readily comparable with analyses of other coals made from air-dried samples.

Analyses of coals mined at Dante, Va.

[F. M. Stanton, analyst.]

	Widow Kennedy.	Lower Banner.	Upper Banner.
Laboratory No.	3947.	4057.	3942.
Loss of moisture on air drying	0.80	1.80	1.30
Moisture	1.90	2.79	2.36
Volatile matter	31.54	32.11	32.40
Fixed carbon	60.87	59.30	57.92
Ash	5.69	5.80	7.32
Sulphur	1.47	.84	.66
Recalculated on air-dried basis:			
Moisture	1.11	1.01	1.07
Volatile matter	31.79	32.70	32.83
Fixed carbon	61.36	60.39	58.68
Ash	5.74	5.90	7.42
Sulphur	1.48	.85	.67

Analyses of the Widow Kennedy and Lower Banner coals at the Dante mines, furnished by the Clinchfield Coal Corporation, are as follows:

Analyses of coals mined at Dante, Va.

	Widow Kennedy.		Lower Banner.
Moisture	0.90	0.85	0.95
Volatile matter	38.46	35.25	37.61
Fixed carbon	56.26	58.14	55.62
Ash	4.38	5.76	5.82
Sulphur	1.12	1.13	.82

These results show that they are all high-grade bituminous coals. The sample of the Widow Kennedy coal taken by the writer represents that bed in its best condition, and the low percentage of ash in the other analyses of the Widow Kennedy coal suggests that the samples were taken at particularly favorable points. A sample including the crushed or laminated coal, called "rash" at Dante, which is so common in this bed, probably would show a much higher percentage of ash. The sulphur content is so low as to be unobjectionable.

It is presumed that these coals would make a high-grade coke, for the coal mined from the same beds at Toms Creek is coked successfully on a large scale. The Dante and Toms Creek coals are identical in physical structure and chemical character.

METHOD OF MINING.

The room and pillar method of mining is used at Dante—in the old workings rooms 24 feet wide with 50-foot centers, and more recently 30-foot rooms with 60-foot centers. Practically all the mining is pick work, and the coal is shot from the solid. Two Goodman electric undercutting machines have been used in mine No. 3 since September, 1906.

At mines Nos. 1, 2, and 4 all haulage is done by mules. Cars are lowered from the mines by a gravity incline to tipples on the railroad. At mine No. 3 cars are gathered and hauled out by mules in all entries west of No. 5. At entry No. 5 and those farther east this work is done by motors. Five 4-ton gathering motors are in use, besides which there are one 20-ton, one 15-ton, and one 8-ton motor. These are all the Goodman type of motor, except the 8-ton, which is a Jeffrey. The trips of mine cars are hauled by a small steam locomotive about a mile along the mountain side to a gravity incline which connects with a tipple 300 feet below.

A rack rail electric-motor system is being installed between the main gangway of mine No. 3 and a new tipple which is to serve mines Nos. 3 and 4. When the new tipple is completed the Upper Banner coal will be shipped as mine-run, and the Widow Kennedy from mine No. 4 will be screened for slack and lump. The coal from mines Nos. 1 and 2 is screened now, but is only a small part of the output because there are only 10 or 12 miners working in the two mines.

Ventilation is by furnace in mines Nos. 1, 2, and 4, and in entries 1, 2, and 3 of mine No. 3. The remainder of mine No. 3 is ventilated by a 12-foot suction fan.

Natural drainage is obtained in mines Nos. 1 and 2, which are driven down the dip to the outcrop on the far side of the ridge. Mine No. 4 is skillfully managed and drains out the main entry. No. 3 can not have natural drainage until it is driven through to Trammel Creek. Then, on account of rolls or sags, it may be necessary to do some ditching. At present the water is hand pumped, siphoned, and bailed onto cars. Two electric centrifugal pumps will soon be installed at this mine.

MARKET.

Most of the output of the mines at Dante goes to the Atlantic Coast Line and the Southern Railway for railroad use. Some of the Widow Kennedy coal is used for domestic purposes. The Clinchfield colliery produces about 15,000 tons of coal a month, and the output is being slowly increased.

THE NORTHERN PART OF THE CAHABA COAL FIELD, ALABAMA.

By CHARLES BUTTS.

INTRODUCTION.

The Cahaba coal field, named from Cahaba River, has been studied for many years by Joseph Squire, whose excellent report, with detailed map, was published by the Geological Survey of Alabama in 1890. This report has been a valuable guide to the field, and, although the present results differ in some particulars from those published by Mr. Squire, the writer testifies to the general worth of his report and acknowledges indebtedness to it for much information. Much help has been derived from other sources also. Mr. W. B. Allen, of the Tennessee Coal, Iron and Railroad Company, kindly furnished maps of parts of the field, showing coal outcrops and locations of prospect pits, which were of great assistance, and many others contributed information. All such help is gratefully acknowledged.

The survey on which the present report is based was made in 1906 by Mr. Chester W. Washburne, Dr. William F. Prouty, assistant State geologist of Alabama, and the writer. To the loyal and efficient assistance of Messrs. Washburne and Prouty is due much of whatever value this report may possess. Mr. T. E. Williard also rendered valuable aid by his collection of fossil plants.

The geology of the Cahaba field is rather difficult, and, especially in the southern half of the area here included, there are obscure and still unsolved problems of stratigraphy and structure which it is hoped will be cleared up by further study. This report and the accompanying map are therefore provisional only and subject to change in a more complete and final report to be made at a later date.

LOCATION AND EXTENT.

The Cahaba coal field is relatively long and narrow and trends N. 45° E. The part under discussion lies in general along the boundary lines between Jefferson County on the northwest and Shelby and St. Clair counties on the southeast. (See Pl. V, p. 80.) Its length is about 40 miles, its greatest width nearly 6 miles, and its least width a little more than 3 miles. Its total area is 150 square miles.

TOPOGRAPHY.

SURFACE RELIEF.

The altitude of the area mapped ranges from 360 feet above the sea on Cahaba River at its southern margin to 1,100 feet on the crest of Shades Mountain near Oxmoor. The most salient features of the

surface are the long parallel ridges following the general direction of the field. At intervals the continuity of these ridges is broken by transverse valleys that have been eroded by streams finding an outlet in Cahaba River, which flows along the middle of the field. As is shown in the section on structure (pp. 80–82), this conspicuous linear and parallel arrangement of the ridges and valleys is an expression of the character and attitude of the rocks underlying the surface.

DRAINAGE.

Cahaba River, the main stream, follows the middle of the field for nearly its whole length and receives the waters from both sides through the generally small lateral streams. Shades Creek is a good-sized stream flowing parallel to the west side of the area, from which it receives a few small tributaries.

ACCESSIBILITY.

The transverse streams, as well as the Cahaba itself, have cut deep gaps through the ridges at many points, and at other points there are low wind gaps through which shallow cutting only is needed for railroad construction. The valley of Stinking Creek through Blackjack Ridge, followed by the Seaboard Air Line Railway, and that of Abes Creek through Blackjack, Grassy, and Chestnut ridges, followed by the Southern and the Central of Georgia railways, are examples of the stream-cut gaps. The low place in Shades Mountain, known as Brock Gap, followed by the Louisville and Nashville Railroad, and that through the same ridge 2 miles farther south, known as Genery Gap, crossed by the Southern Railway, are wind gaps. The longitudinal valleys separating the ridges offer easy access to the mines by spurs from the main lines of railroads which cross the field. The spur of the Central of Georgia Railway that leaves the main line at Henryellen and runs northward along the outcrop, first of the Mammoth bed and then of the Harkness bed, to the Margaret mine, which is beyond the limits of the area mapped, is an example of the possibilities of railroad building to points favorable for opening the various coal beds.

GEOLOGY.

STRATIGRAPHY.

The rocks of this coal field are shale and sandstone, interstratified with beds of coal. They are of Pottsville age and constitute the lower subdivision of the rocks known as the Pennsylvanian series.

In the Birmingham district there is doubt as to what shall be regarded as the lower limit of the Pennsylvanian series. Mr. Squire, in the cross sections accompanying his report on the Cahaba field, has placed the bottom of the "Coal Measures" 200 to 400 feet below the Brock coal bed, and that limit appears to have the sanction of the Alabama Geological Survey. It has been the custom of the geologists of the United States Geological Survey, however, to extend

the lower limit of the Pennsylvanian series downward to the top of the Bangor limestone, but, for the reasons stated below, that custom is not warranted in this region. Along the west side of the Cahaba field there are, between the Brock coal bed and the Bangor limestone or equivalent horizon, 1,200 to 2,200 feet of gray shale and sandstone which are apparently identical in character with the coal-bearing rocks. A very few fossils have been collected from these rocks, however, that have Mississippian affinities and indicate the "Lower Carboniferous" age of the beds. These rocks are a lithologic unit and, in the writer's judgment, should not be divided. They are therefore regarded as Mississippian, and the upper limit of this series is fixed at the bottom of the Brock coal bed. This interpretation involves the recognition of a great unconformity between the Pennsylvanian and the Mississippian series in this region.

The sandstone strata of the coal-bearing rocks do not commonly exceed 100 feet in thickness, and they are generally made up of layers from 6 inches to 2 feet thick.

If we take the bottom of the Brock bed as its lower limit, the total average thickness of the Pennsylvanian series is more than 6,000 feet. The following is a generalized section:

Generalized section of the coal-bearing rocks of the Cahaba coal field.

		Minimum.	Maximum.	Average.[a]
		Feet.	*Feet.*	*Feet.*
Shale and sandstone with coal beds at intervals from top of section		.....	1,300	1,300
Coal, Mammoth-Helena bed		.....	.....	10
Shale and sandstone		100	140	118
Conglomerate		10	80	45
Coal, Thompson or Conglomerate bed		.....	.....	4
Shale and sandstone with thin coal beds		200	270	223
Coal, Little Pittsburg bed		.....	.....	2
Shale and sandstone, Moyle coal bed at top and other thin coals in some sections		130	380	292
Coal, Black Shale bed		.....	.....	2
Shale and sandstone		100	150	125
Coal, Buck bed		.....	.....	2
Shale and sandstone with coal beds, including Squire's Coke, Atkins, and Schute beds, etc., in the Henryellen basin		125	775	500
Shale and sandstone		375	950	660
Coal, Wadsworth bed		1	3	2
Shale and sandstone		250	750	410
Coal, Harkness bed		1	8	4
Shale and sandstone with thin coals; sandstone of Owen Mountain at base		325	600	440
Shale and sandstone with Nunnally group of coals, two to six beds		50	400	250
Shale and sandstone; includes sandstone of Chestnut Ridge at base	"Millstone grit," probable equivalent of Lookout formation.	425	1,000	618
Shale and sandstone with Gould group of coals		50	275	180
Shale and sandstone; includes two white, siliceous, in places conglomeratic, sandstones, making two ridges, one known in different parts as Grassy Ridge, Flat Ridge, or Pine Mountain, and the other as Blackjack Ridge or Shades Mountain; one to three thin coals between the sandstones		800	1,200	918
Coal, Brock bed		½	1½	1
		.....	.....	6,105

[a] The averages in the last column are not derived alone from the maximum and minimum measurements here given, but from those and a number of others from the individual vertical sections on Pl. VI.

The preceding section differs from that of Squire[a] in its greater detail. It has been compiled from the vertical sections on Pl. VI, which are themselves derived from horizontal sections across the field at intervals from Black Creek on the north to the Louisville and Nashville Railroad on the south. (See Pl. V.)

A great variation in the thickness of the subdivisions in the generalized section is shown by the maximum and minimum measurements. These irregularities become still more apparent on the study of the individual vertical sections (Pl. VI). Two explanations can be given. The first is that great irregularities probably exist in the rocks themselves, and the second that the variations are in part due to errors of measurement.

According to David White, who has studied the fossil plants collected in the Cahaba field, the Helena bed, near the top of the section in the area under discussion, does not lie at a higher horizon than the middle of the Sewell formation of West Virginia. The interval from this horizon to the bottom of the Pottsville in West Virginia is approximately 1,500 feet. During lower and middle Pottsville time, therefore, about three times as great a thickness of sediment was deposited in the Cahaba field as in the Pottsville of West Virginia, or, in other words, the rate of deposition was three times as great in the former as in the latter field. Great inequalities in the thickness of sediments within comparatively short distances probably resulted from such rapid deposition.

Errors of measurement are inevitable where, as in this field, thicknesses have to be determined from the dip of the rocks and horizontal distance between the outcrops of observed beds. The number of observations is often insufficient because of lack of exposures, and many dip measurements are inaccurate on account of the deceptive appearance of the beds, so that when the exposure is small, it is nearly impossible to determine the true dip. As is well known, dips vary constantly from place to place, and unless there are many observations the average dip as determined may be several degrees in error.

The sections also show great variations in the number of coal beds in some of the groups, more particularly in the Nunnally and Gould groups. Thus in the section along the road from Birmingham to Leeds no less than six thin beds of coal are shown in the Nunnally group; in the Louisville and Nashville Railroad sections there are but two beds to be seen in this group, with possibly a third lower down but not exposed; and in the section along the road eastward from Trussville there are three thin coals showing close together. These variations are doubtless due partly to actual differences in the number of beds in the different sections and partly to the fact that all the coals of a group are not exposed in most of the sections.

[a] Rept. on Cahaba coal field, 1890, p. 14.

STRUCTURE.

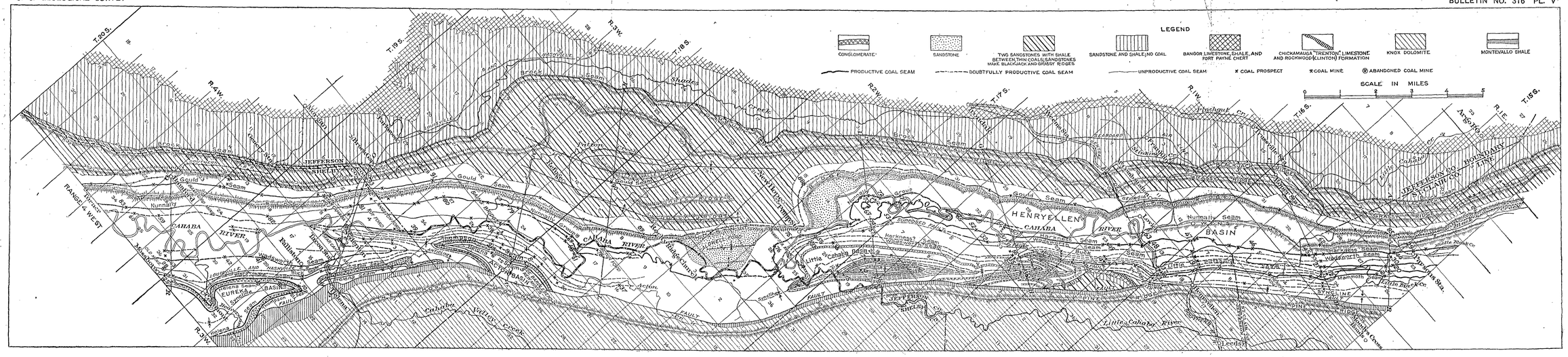
The Cahaba coal field is a structural trough or syncline which is unsymmetrical, being deepest near the southeast margin. The trough is bounded on the southeast by a fault, known as the boundary fault, along which much lower and older rocks of Cambrian age are in contact with the coal-bearing rocks. In the northwestern half of the field the rocks generally dip to the southeast at angles ranging from 10° to 15°; nearer the axis of the trough the dip reaches 25° to 45° SE., while on the southeast side of the axis the dip is reversed and the rocks are abruptly bent upward to a vertical or nearly vertical attitude, as shown by the cross sections on Pl. V.

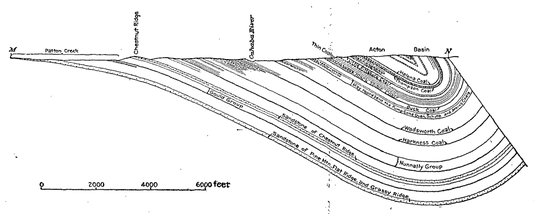
As noted above, the general structure of the field is comparatively simple, but there are a number of minor features which tend to complicate it. These consist of strike faults and of subordinate folds either following the strike or running transversely or obliquely across the main trough and creating thus a number of small independent basins. These basins are described below, and in following this description the reader should constantly refer to the map (Pl. V).

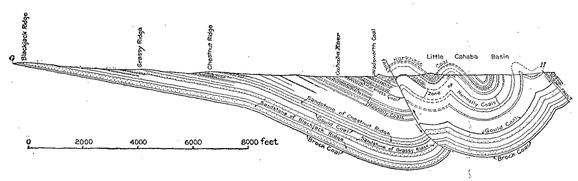
Simple but unsymmetrical structure prevails in this field north of Henryellen. About 1 mile south of that place a subordinate fault diverges from the boundary fault and follows a more westward course to Hogpen Branch, in the northeast corner of sec. 26, T. 17 S., R. 1 W., where it in turn seems to divide into eastern and western faults. The eastern one of these last-mentioned faults runs southward and rejoins the main fault near the point where the Birmingham-Leeds highway strikes the base of Pine Ridge. The western fault follows Hogpen Branch southwestward nearly to its mouth, whence it is supposed to continue along a southwesterly course and to connect with a fault encountered in an old mine west of the pumping station of the Birmingham waterworks.

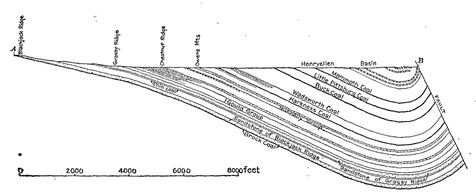
As a result of the movement which produced the faults described above, the lenticular area of rocks, beginning 1 mile southwest of Henryellen and including, in order from north to south, all formations from the Knox dolomite to the lower part of the coal-bearing rocks, was thrust up as a block between the main boundary fault on the east and the faults on the west.

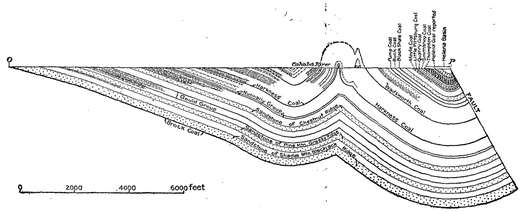
Squire mapped and described the Henryellen basin as a regular trough extending from the north end of the Cahaba field to the vicinity of the pumping station named above. It was found, however, that a subordinate basin, extending from Hogpen Branch to the pumping station, forms the south third of Squire's Henryellen basin. This is here named the Little Cahaba basin on account of its proximity to Little Cahaba River, which crosses its south end. This subordinate basin or trough is narrow and deep, with steeply dipping rocks on

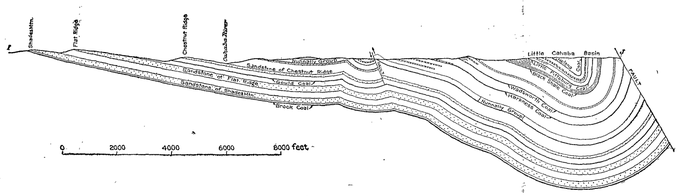


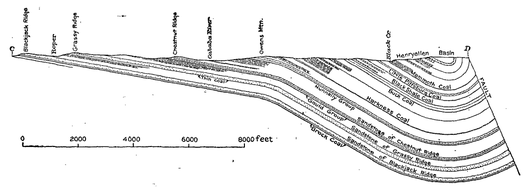


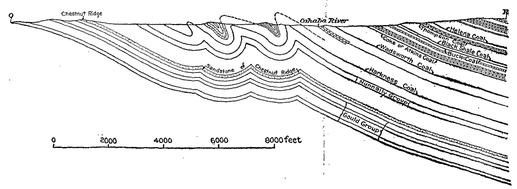


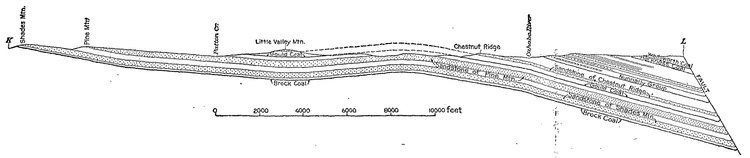


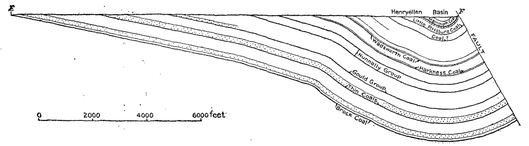












MAP AND SECTIONS OF THE NORTHERN PART OF THE CAHABA COAL FIELD, ALABAMA.

each side. The north end of the Little Cahaba basin is closely folded into a number of narrow anticlines and synclines that are shown on the map (Pl. V) by the lines indicating the outcrop of a number of beds of sandstone which, standing nearly vertical, make prominent ridges. These outcrops were actually followed out in the field, and the main features of the structure were determined beyond a doubt.

Between the basin just described and the Acton basin next on the south is an area in which sufficient geologic work has not yet been done to permit mapping and description. It seems probable that the structure is synclinal in the northern part. The location, form, and extent of the Acton, Helena, and Eureka basins are shown on the map. The anticline separating the Acton and Helena basins is clearly the continuation of that shown along the Louisville and Nashville Railroad between the Cahaba River bridge and Tacoa station. The fold between the Helena and Eureka basins appears to be a low swell transverse to the general strike.

The anticline just mentioned is to all appearances a closed and upright fold. In the cut at Tacoa there is, on the limb of the main fold, a subordinate fold, which is also closed and upright. These features are exhibited in the Louisville and Nashville Railroad section, on Pl. V.

Along the natural continuation of the anticlinal belt, southwest of the Louisville and Nashville Railroad, exposures are generally poor and not sufficiently connected to reveal the structure with certainty. The observed dips, however, are all southeastward, but vary greatly in amount. According to the writer's interpretation the folds, which are upright on the Louisville and Nashville section, have been overturned to the northwest in the Bamford-Mossboro section, and perhaps additional folds or faults have been developed. The structure of this river belt is confessedly obscure and not well made out. It is hoped that further investigation will reveal other facts which will throw more light on the structure. It is plain that some such structure as that indicated in the Bamford-Mossboro section exists at the south end of this belt, for without the repetition of beds as shown therein the vertical distance from the conglomerate lying between the Helena and Thompson beds to the Gould bed would be 7,000 feet, whereas in all the other sections this distance is less than 4,000 feet. The belt just described is mapped by Squire and designated by him the "interior fault vertical measures." As shown above, however, the rocks are not vertical, except probably from the vicinity of the Louisville and Nashville Railroad northward, and no positive evidence of the existence of a fault was discovered, although such a supposition is entirely reasonable. At Sydenton the structure is synclinal, what is probably the same bed of coal with opposite dips being mined on both sides of the syncline. The abandoned mine at Sydenton followed

the bed down the southeasterly dip, and an older abandoned mine just west of the railroad bridge over Cahaba River followed the dip to the northwest. According to report the bed has never been followed across the syncline between these mines, so it is not certain whether they are connected or separated by a fault along the syncline. The converging strike of the beds south of the railroad indicates that the syncline runs to a point like the end of a canoe about a mile southwest of Sydenton, in the southeast corner of sec. 8, T. 20 S., R. 3 W. The coal bed mined at Sydenton probably outcrops around the point of the syncline, but it is not possible to trace it, although associated sandstones have been followed almost around the point.

A broad, shallow syncline, the axis of which lies along the course of Little Valley Mountain, extends from New Hope to that part of Shades Mountain which follows a north-south course south of Oxmoor. Along the east side of this syncline are Jones and Dolly ridges, which are made by the sandstones of Flat Ridge and Shades Mountain, respectively. Dolly Ridge is an anticline, the sandstone rising from the syncline to the west at a low angle and then plunging abruptly downward to the east at a high angle. This anticline is continued to the southwest through Refuge and across Patton Creek, gradually flattening out and probably disappearing not far south of that creek. Just to the east of Dolly Ridge is another sharp, narrow ridge made by the sandstone of Flat and Jones ridges as it dips to the east at an angle of about 50°.

To the northeast of New Hope, in secs. 12 and 14, T. 18 S., R. 2 W., there is a noticeable flattening of the rocks, which shows in the section north of the pumping station (Pl. V, p. 80). This flattening is also shown by the expansion of the outcrop of the sandstone of Chestnut Ridge, in the above-described section. Another flattening, likewise shown by the expansion of the outcrop of the same sandstone, occurs between the pumping station and the Caldwell ford, including sec. 34, T. 18 S., R. 2 W. In the SE. ¼ sec. 34 a low northwest dip is believed to exist.

GENERAL CORRELATION OF COALS.

Before proceeding with the description of individual coal beds it is necessary to discuss the general correlation and identification of the several beds in the different parts of the field. This discussion begins with the lower beds of the field, because there is no doubt concerning the tracing and identification of these beds from one end of the area to the other. The certainty with respect to these lower beds is due to the presence at the base of the measures of three quartzitic sandstones generally known as the "Millstone grit." These sandstones are hard and resistant, and on account of their attitude make conspicuous and continuous ridges. The uppermost sandstone of these three makes

Chestnut Ridge; the one next below makes the ridge which in the southern part of the area is known as Pine Mountain, in the middle part as Flat Ridge, and in the northern part as Grassy Ridge; the lowest makes the ridge known in the southern part as Shades Mountain and in the north as Blackjack Ridge. By the aid of these sandstones it is possible to identify their associated coals with certainty. Thus the Brock bed, the type locality of which is Brock Gap, lies less than 100 feet below the sandstone of Shades Mountain and Blackjack Ridge. The type locality of the Gould bed, or Gould group of beds, is the old Gould mine in the vicinity of the present Star Cahaba mine No. 1, about 1 mile west of Sydenton, in the NW. ¼ sec. 8, T. 20 S., R. 3 W. This group, therefore, lies between the sandstone of Pine Mountain and Grassy Ridge and that of Chestnut Ridge, and it can be identified everywhere with certainty. Attention may be called to the fact that Squire's map of the Cahaba field shows the outcrop of the Gould coal to the west of Grassy Ridge. Squire, however, applied the name Grassy Ridge to the north end of Chestnut Ridge instead of to the north end of Flat Ridge, so that there is no real disagreement in the identification of the coals.

The Nunnally group of coal beds, the type locality of which is the Nunnally place, on the Louisville and Nashville Railroad, about three-fourths of a mile northwest of Sydenton, lies next east of Chestnut Ridge and can be traced with scarcely a break from one end of the area to the other. In the northern part of the field this group can be identified from its outcrop along the west flank of the prominent ridge known as Owens Mountain.

Next above the Nunnally group lies the Harkness bed, the type locality of which is the old Harkness place, on the Louisville and Nashville Railroad, one-half mile northwest of Sydenton, in the southwest corner of sec. 4, T. 20 S., R. 3 W. The identification of this bed north of the type locality is less certain than that of the Gould and Nunnally coals, partly because it has no key rock that can be traced throughout the field and partly because it is involved in the fault along Hogpen Branch. The coal bed apparently can be identified with some degree of certainty as far north as Acton Creek. Its outcrop may continue northward, parallel to the Nunnally bed, to a point about 1 mile northeast of the pumping station, where it is probably cut out by the above-mentioned fault. In the northern part of the area a thick bed outcropping along the east side of Owens Mountain has been identified as the Harkness, and this identification appears to be correct. This bed has been traced southward to a point (No. 52 [a]) in the southeast corner of sec. 32, T. 17 S., R. 1 W. Two or three miles south of this point the outcrop probably runs into the fault. East of the fault between the pumping station and Hogpen Branch

[a] Numbers refer to corresponding numbers on Pl. V.

the outcrop of the Harkness bed is believed to be repeated by the upthrow of the fault, the identification of the bed depending on both stratigraphic and paleobotanic evidence. Plants collected from a bed outcropping on the Birmingham-Leeds road (No. 54), near the center of sec. 34, T. 17 S., R. 1 W., are regarded by David White as probably associated with the Harkness coal. The outcrop of this bed can be traced, as shown on the map, by openings at points Nos. 55 and 56, by a natural exposure in the road at point No. 57, in the northwest corner of sec. 18, T. 18 S., R. 1 W., and by the relation of the outcrop to continuously traceable sandstones that are also shown on the map.

The stratigraphic evidences for the identification here made are as follows: First, the bed regarded as Harkness is the first known bed above the Nunnally group which can be certainly identified in the section north of the pumping station (Pl. VI, p. 86); second, the supposed Harkness bed in this section is 1,800 feet below a coal bed which lies about 100 feet above a good conglomerate. The significance of this circumstance will appear from the following discussion. In the Black Creek section (see Pl. VI) the interval between the Mammoth and Harkness beds is 1,500 feet, in the Trussville section it is 1,600 feet, in the Central of Georgia Railway section 1,600 feet, and in the Southern Railway section 1,800 feet. On Snake Branch, 1½ miles south of the Southern Railway, the interval is 1,800 to 1,900 feet. There is no doubt as to the identity of the two beds in the last-named locality. Furthermore, about 150 feet beneath the Mammoth bed is a conglomerate which shows in the Trussville and Central of Georgia Railway sections and also appears from Snake Branch southward to Hogpen Branch, where both the Mammoth bed and the underlying conglomerate are cut out by the fault already described. The conglomerate increases in thickness toward the south and becomes more conspicuous near the fault. Now, in the Little Cahaba basin, about 4 miles southwest of the point on Hogpen Branch where the Mammoth coal and the conglomerate run into the fault, there is, as shown in the section north of the pumping station (Pl. VI), a conglomerate underlying a coal 1,800 feet below which, as stated above, lies the supposed Harkness bed. These circumstances point not only to the fact that the supposed Harkness bed in this section is really such, but also to the conclusion that the coal and conglomerate near the top of the section are the Mammoth coal and its conglomerate.

The Wadsworth bed, the next of any importance above the Harkness, presents no particular difficulties of correlation if the identification of the Harkness as stated above is correct, for a bed in corresponding position to the Wadsworth has been observed generally north of the Louisville and Nashville Railroad. The type locality of the Wadsworth is at Tacoa station, where it was mined years ago by Frank Wadsworth. South of Tacoa station the outcrop appears to

run in a nearly straight southwesterly course as mapped. To the north and west the outcrop is repeated as a result of the structure, so that the old mines on both sides of the river in the vicinity of Sydenton are, with almost no doubt, in this bed.

In the 1,000 to 1,500 feet between the Wadsworth bed and the conglomerate near the top of the measures there are many thin coal beds, and any correlation of individual beds throughout the length of the field would be at best very doubtful. Squire has mapped and shown in various sections ten to fifteen coal beds in this interval, including in ascending order the Schute, Atkins, Coke, Buck, Black Shale, Little Pittsburg, Thompson, and other thin beds. In only one section, that of the Acton basin at Bains Bridge (Pl. VI), did the writer see so many coal beds in this interval. In that section there are at least thirteen beds, many of them being indicated by thin streaks of smut. It is probable that a large number of these are thin and close together. As many or more beds may be present in this interval all along the field, but not exposed, for exposures are generally poor between the horizon of the Black Shale and Buck coal beds and the Wadsworth bed. It is entirely possible that thin coal beds in this interval are present in some sections and absent in others, and that some of these may locally reach a considerable thickness. Many of the correlation lines drawn on Pl. VI are meant to indicate that the coal beds connected lie at about the same horizon, but not that they are necessarily identical.

At this point the question of the correlation of the Mammoth with the Helena bed naturally comes up. The reasons for regarding the coal above the conglomerate in the Little Cahaba basin as the Mammoth bed are fully set forth on page 84. It is also clear and recognized by all workers in this field that the conglomerate and the coal above it are the same as the conglomerate and Helena coal in the Eureka, Helena, and Acton basins. It follows, therefore, that the Mammoth and Helena beds are the same. This conclusion is strengthened by the fact that, so far as the writer has discovered, there is no other conglomerate above the "Millstone grit" in this part of the Cahaba field. It is probable that the conglomerate was all deposited at the same time and formed a continuous bed ranging gradually from thick and coarse at the south to thin and fine at the north. It should be noted in this connection that the interval between the Harkness and Helena beds in the Acton basin and along the Louisville and Nashville Railroad (see sections 9 and 10, Pl. VI) is about 2,400 feet. This is an objection to the correlation of the Mammoth and Helena beds, but is not fatal to it, for, as has been noted, there is a gradual increase of this interval from north to south down to Hogpen Branch, and a further increase from the Little Cahaba basin to the Acton basin is in accord with the general thickening of the coal-bearing rocks toward the southwest.

Squire, in his report on the Cahaba field, regarded the Buck and Black Shale beds of the Louisville and Nashville Railroad section near Helena as the equivalents of the Mammoth bed. He expressed the belief that the two branches of the Mammoth which are separated by 10 feet of shale in the Southern Railway section become more and more widely separated to the south, until they are 100 feet apart, and form the Buck and Black Shale beds at Helena. In conversation with the writer, however, Mr. Squire said he had no positive evidence for such an opinion. Possibly he reported it as a matter of common belief. In the writer's judgment there is no stratigraphic evidence for such a conclusion.

DETAILED DESCRIPTION OF THE COAL BEDS.

In this description only those coal beds will be included that, so far as known, are in some part of the area under discussion 2 feet or more in thickness. In descending order the beds are, according to the writer's identification, the Mammoth-Helena, Thompson-Double, Little Pittsburg, Black Shale, Buck, Wadsworth, Harkness, Nunnally (locally three beds), and Gould. It is, of course, possible that there are other undiscovered beds that are 2 feet thick and that some of the thin beds may locally exceed that thickness. For instance, Squire gives the Atkins (Adkins) bed as 4½ feet thick in the columnar section of the Henryellen basin. The writer, however, found no such bed in that basin and he has the statement of a person thoroughly familiar with that part of the field by extensive prospecting that there are only two beds in the basin—the Harkness and the Mammoth—that are thick enough to mine. With this statement the writer fully agrees. The following description takes up each bed as it occurs in the Henryellen, Little Cahaba, Acton, Helena, and Eureka basins, except the Nunnally and Gould beds, which are continuous throughout the field and for which this method of treatment is not suitable.

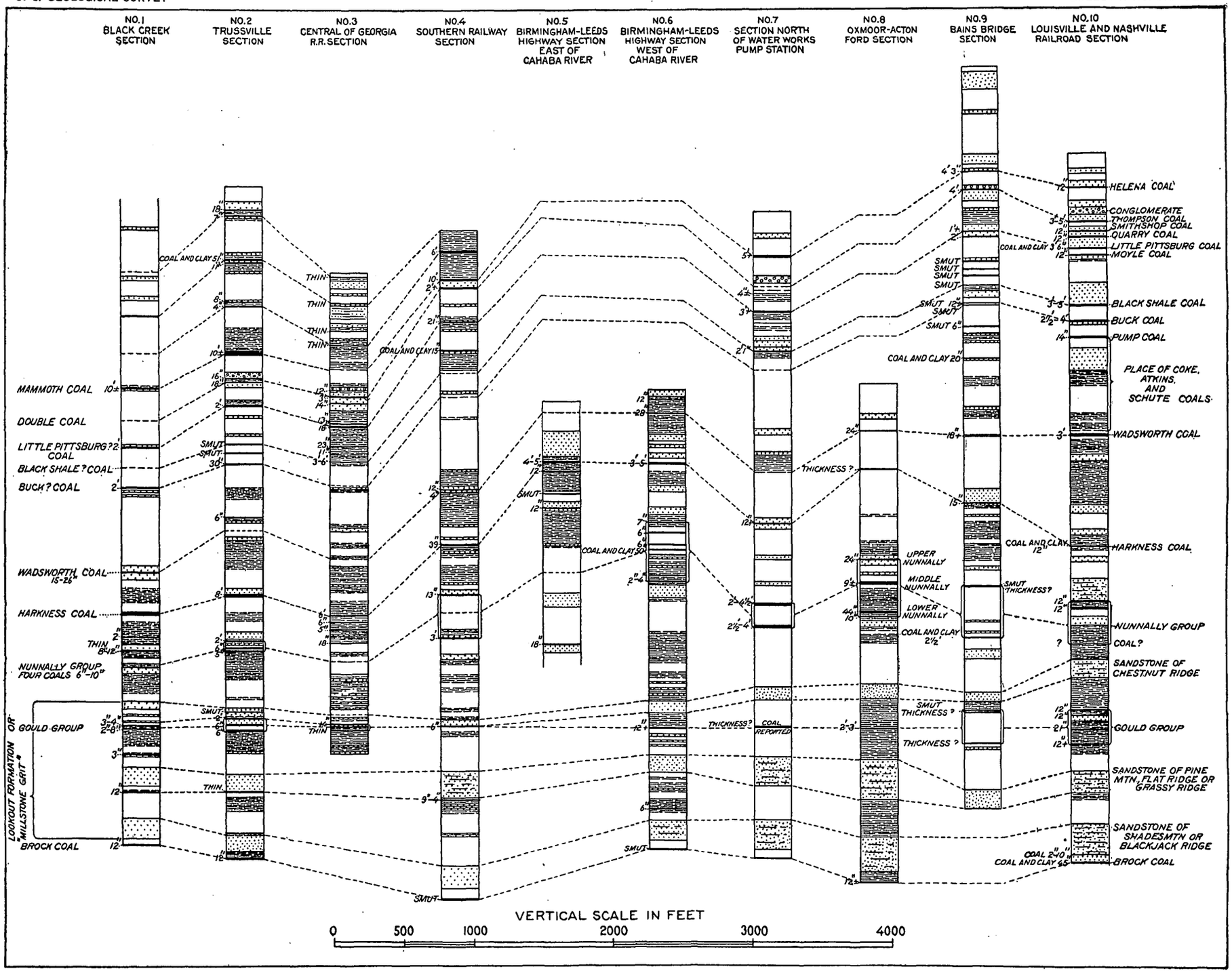
COALS ABOVE THE MAMMOTH-HELENA BED.

There are a number of thin beds above the horizon of the Mammoth-Helena, but only at one point has coal of workable thickness been observed. This is about 1 mile southwest of Henryellen, where a bed about 200 feet above the Mammoth shows the following section:

Section of coal bed 1 mile southwest of Henryellen (No. 1 [a]).

Shale.	Ft.	in.
Coal	1	4
Clay		2
Coal		6
Clay	1	9
Coal	2	4
	6	1

[a] Numbers in parentheses correspond to numbers on the map (Pl. V) showing locations at which observations on the coal beds were made.



SECTIONS IN NORTHERN PART OF CAHABA COAL FIELD.

Showing position and correlation of coal beds.

This bed appears to be in the position of the Yeshic bed of the southern part of the Cahaba field. What is apparently the same bed shows in the Trussville section (Pl. VI) in the road just east of Black Creek, but it is too thin to be of value. Other and higher beds also show in the same section, but they are worthless.

MAMMOTH-HELENA BED.

As stated on page 85, the Mammoth bed of the Henryellen basin is regarded as identical with the Helena of the Little Cahaba, Acton, Helena, and Eureka basins, and the two names are used accordingly.

Henryellen basin.—The Mammoth is the thickest bed in the northern part of the Cahaba field, if not in the whole field. On Black Creek it has the following section:

Section of Mammoth bed on Black Creek.

Shale.	Ft.	in.
Coal and bone	1	10
Coal	3	8
Clay and "rash"		2½
Coal	5	
	10	8½

Farther south the parting near the middle thickens and where the bed has been exposed near the junction of the siding to Henryellen No. 6 mine and the main line of the Southern Railway it has the following section:

Section of Mammoth bed near junction of Southern Railway and siding to Henryellen No. 6 mine (No. 3).

Shale.	Ft.	in.
Coal	5	
Clay		1
Coal		4
Clay		3
Coal	1	
	6	8
Shale	10	
Coal		1
Clay		2
Coal		2
Clay		6
Coal		7
Clay	1	4
Coal	1	8
	4	6

The two benches shown in this section, according to the report of a prospector, persist southwestward to the fault on Hogpen Branch. The same person reports the upper bench to be more or less bony and others in a position to know report the same thing. As the writer had no chance to examine a fresh face of the bed he is unable to make any definite statement on this point.

The average of six measurements of this bed, at points from Black Creek to Henryellen No. 6 mine, is 7 feet 6 inches of coal in the two benches. This is exclusive of partings that could be detected under the conditions of exposure. It is probable that the bed contains 7 feet of minable coal throughout the area underlain by it. The analysis (A) of a sample from this bed collected near Henryellen is given on page 114.

Little Cahaba basin.—A single measurement of the Helena bed at location No. 4, in the Little Cahaba basin, gave a thickness of more than 5 feet gross, without any details as to partings, etc. It is reported to be 11 feet thick at this opening. If that report is true, the thickness is very likely local and due to squeezing, as the rocks are closely folded. The bed may contain 4 feet of minable coal in this basin.

Acton basin.—In the Acton basin the opportunity for examining the Helena coal is very much better than elsewhere in the field, inasmuch as mines are being opened on it at the present time. At one mine the section is as follows:

Section of Helena bed 1¼ miles east of Bains Bridge (No. 5).

	Ft.	in.
Sand and clay	10	
Clay		4
Coal		3
Clay		2
Coal	4	2
Clay		5
Coal	1	9
Clay		1
Coal		3
Total coal bed	7	5

At mine No. 2, three-fourths of a mile southeast of Bains Bridge, the bed has the foilowing sections:

Sections of Helena bed at mine No. 2, three-fourths of a mile southeast of Bains Bridge (No. 6).

A, AT MAIN ENTRY.

	Ft.	in.
Sandstone	15	
Coal	1	
Clay	2	
Coal	1	3
Total coal bed	4	3

B, 100 FEET DOWN THE SLOPE FROM THE MAIN ENTRY.

	Ft.	in.
Coal		3
Clay		2
Coal	1	10
Clay		7
Coal	1	9
	4	7

The inference from the preceding three sections is that in this basin the bed is irregular in thickness and character. The average thickness of coal in the three measurements is 50 inches, and 4 feet may be taken as the probable average thickness of this bed in the Acton basin. The composition of the Helena coal in this basin is shown in analysis B (p. 114).

Helena basin.—No measurements were obtained in the Helena basin. Squire, however, gives three measurements in the NE. ¼ sec. 10 and SW. ¼ sec. 2, T. 20 S., R. 3 W.[a] Below are two of these sections:

Section of Helena bed in the SW. ¼ sec. 2, T. 20 S., R. 3 W.

	Ft.	in.
Sandstone.		
Coal	5	11
Slate		6
Coal	2	
Slate.		
	8	5

Section of Helena bed in the NE. ¼ sec. 10, T. 20 S., R. 3 W.

	Ft.	in.
Sandstone.		
Coal	2	6
Slate		3
Coal	1	6
Slate		8
Coal	2	
Slate.		
	6	11

Squire reports the bed at Helena, in the south end of the basin, only 6 inches thick, as exposed in a drift 100 feet in length. It appears, therefore, that this bed is subject to great variations. If this last-mentioned thickness is taken with the other three given by Squire, the average for this basin is 5 feet 6 inches of coal. Five feet would be a conservative estimate.

Eureka basin.—The Helena bed in the Eureka basin is not now open to inspection, except possibly at one point near the highway half a mile southeast of Falliston, where there is a small mine at which the bed is stated to be 5 feet thick. The bed was worked in the north end of this basin years ago, and Squire reports it 4 feet thick, with 2 or 3 inches of bony coal near the middle.[b] No data as to the thickness or character of the bed in the southern part of the basin are at hand. Squire, however, gives a section 4 feet thick with partings as measured in the Dry Creek basin,[c] which lies next south of the Eureka basin. It appears safe to assume, therefore, that the Helena bed will average 3½ feet of workable coal throughout the Eureka basin.

[a] Rept. on Cahaba coal field, 1890, pp. 57, 58. [b] Op. cit., p. 69. [c] Op. cit., p. 77.

THOMPSON OR CONGLOMERATE BED.

Henryellen basin.—In the Henryellen basin the Double bed or its upper bench is supposed to be the equivalent of the Thompson or Conglomerate bed in the southern basins. The lower bench of the Double may be the equivalent of one of the thin beds close below the Thompson bed in the Helena section. At only one point in the basin does this bed appear to be of minable thickness. This is on the Southern Railway, near the junction of the siding to Henryellen No. 6 mine (No. 7). The bed appears to be thick at this place, but was not well enough exposed to be measured.

Little Cahaba basin.—Nothing was learned of the Thompson bed in this basin unless a thin bed apparently 4 inches thick, 50 feet below the conglomerate, is its representative.

Acton basin.—The Thompson is a minable bed in this basin, though the thickness and character do not appear to offer much encouragement to mining at the present time.

Section of Thompson bed 1¼ miles east of Bains Bridge (No. 8).

	Feet.
Conglomerate	5
Sandstone	10
Shale	8
Coal	3
Shale.	

Section of Thompson bed at mine No. 1, two-thirds of a mile southeast of Bains Bridge (No. 9).

	Ft.	in.
Conglomerate	5	
Shale		6
Coal		4
Clay		2
Coal		2
Clay		2
Coal		2
Clay		1
Coal		2
Clay	1	11
Coal, variable	1	6
Total coal bed	4	8

Fifty feet farther down the slope in mine No. 1 the bench of coal above the 12 inches of clay is as follows:

Section of upper part of Thompson bed at mine No. 1.

	Ft.	in.
Coal		1
Clay		½
Coal		1
Clay		1
Coal		1
Clay		1
Coal		2
Clay		½
Coal		1
Clay		½
Coal		1
Clay		1
Coal		1
Clay		¼
Coal		1
Clay		1
Coal		2
	1	4¾

This intimate mixture of coal and dirt in the upper bench makes it worthless without washing. The measurements given above do not afford a reliable basis for judging the thickness and character of the bed in the whole basin. These measurements indicate an average thickness of 2 feet 6 inches of coal, and that is assumed as the thickness of minable coal. The composition of coal from this bed is shown in the table of analyses (p. 114).

Helena and Eureka basins.—The Thompson bed was not seen in the Helena basin. It has been opened on the Louisville and Nashville Railroad, but the openings are now closed. Squire[a] reports that the bed ranges in thickness from 2½ to 12 feet, with an average of 3 to 5 feet of good coal. He also reports that the bed has a bad roof and in places has many layers of smut, which impair its quality. For these reasons attempts to mine the bed have always been unsuccessful. At the north end of the Eureka basin (No. 10) the coal is reported 5 feet thick. At the Coalmont mine, in the southern part of the basin, the bed has the following section:

Section of Thompson bed at Coalmont mine.

	Ft.	in.
Sandstone.		
Coal	2	
Shale		2
Coal	2	10
Sandstone.		
	5	

[a] Op. cit., p. 55.

It seems safe to assume from these reports and measurements that the bed contains 4 feet of minable coal throughout the basins. (See table of analyses (p. 114) for composition of beds at Coalmont.)

LITTLE PITTSBURG BED.

The Little Pittsburg is the next bed below the Thompson or Double that shows any prospect of being workable. The type locality of this bed is at Helena, where it has been opened and worked to some extent near the Louisville and Nashville Railroad. At this point it is 400 feet below the Helena bed.

Henryellen basin.—In the Henryellen basin a bed from 300 to 400 feet below the Mammoth is regarded as the Little Pittsburg. At a prospect on Black Creek (No. 11) 2 feet of solid coal is exposed below shale. The bed may be a little thicker, as the bottom was concealed. Just north of the Trussville road, west of Black Creek, the following section was measured:

Section of Little Pittsburg bed near Trussville road (No. 12).

	Ft.	in.
Shale.		
Coal	1	5
Fire clay		3
Coal		5
Fire clay		8
Shale.		
	2	9

On the Southern Railway, at the east end of the bridge over Cahaba River (No. 13), the bed is 21 inches thick and consists of solid coal, under 20 feet of thick-bedded sandstone. Still farther south, on Snake Branch (No. 14), the bed shows 2 feet 4 inches of solid coal under 20 feet of sandstone. Nothing is known of the coal bed southwest of the last-described point. The bed will probably not average 2 feet of coal in this basin.

Little Cahaba basin.—What appears to be the Little Pittsburg bed shows a good thickness at some points on Coal Bed Branch, on the west side of the Little Cahaba basin. At other points the bed is thin, indicating considerable irregularity in thickness. Below are are a number of measurements, the first being near the mouth of Coal Bed Branch.

Section of Little Pittsburg coal near mouth of Coal Bed Branch (No. 14a).

	Inches.
Coal	5–12
Clay	3
Coal	5
	13–20

On the highway a short distance farther north the following section is exposed:

Section of Little Pittsburg coal near Coal Bed Branch (No. 15).

	Ft.	in.
Sandstone	10	
Shale	15	
Coal	1	
Shale	10	
Coal		6
Shale	6	
Coal		3
Clay		3
Coal		2
Clay		3
Coal and clay		2–4
Coal		4
Clay		2
Coal		2
Clay		8
Coal		4
Shale.		
	45	6

The worthless character of the bed is evident. It may be that the upper thin coals represent some of the beds above the Little Pittsburg. Farther north, however, the bed is better, as shown by the following section:

Section of Little Pittsburg bed on the east side of Little Cahaba basin (No. 16).

	Ft.	in.
Sandstone	4	
Coal	3	
Clay		2
Coal		1
Clay		2
Coal		5
Clay	1	
Total coal bed	3	10

On the west side of the basin (No. 17) the bed is at least 3 feet 9 inches thick, but the bottom was concealed and the full thickness could not be determined. Six feet of coal is reported at this point. At another point near by 5 feet of coal is reported. From the above data it seems possible that the Little Pittsburg bed does not average more than 2 feet of coal throughout the area included within its outcrop in this basin.

Acton, Helena, and Eureka basins.—It is a question whether the Little Pittsburg is to be considered a minable bed in these basins. At a single point in the road east of Bains Bridge, a bed of solid coal

2 feet thick, which appears to be in the position of the Little Pittsburg bed, is exposed under a heavy sandstone. At the type locality on Buck Creek, just west of Helena, the following section was obtained from a weathered face near the outcrop:

Section of Little Pittsburg bed near Helena (No. 18).

	Ft.	in.
Shale.		
Coal		10
Clay		1
Coal		2½
Clay		1
Coal		1½
Coal and clay		8
Clay		2
Coal and clay		2
Shale		7
Coal and clay		7
Shale.		
	3	6

An effort was made by Mr. Squire to mine the bed at this point, but it was unsuccessful. If the above section fairly represents the character of the bed, its worthlessness is evident. Squire[a] reports the following section at a test pit near the type locality:

Section of Little Pittsburg coal in sec. 16, T. 20 S., R. 3 W.

	Ft.	in.
Sandstone.		
Coal	1	6
Slate		8
Coal	1	2
Clay.		
	3	4

This indicates a better condition of the bed, but probably it is so variable as to be worthless for mining on a commercial scale.

BLACK SHALE AND BUCK BEDS.

The type locality of the Black Shale and Buck beds is near Helena, where they have been opened and worked to some extent. The attempt to identify them north of the type locality is very unsatisfactory, on account of scarcity of exposures and the number of thin beds occurring between the Little Pittsburg and the Wadsworth coals.

Henryellen basin.—A bed exposed on the Central of Georgia Railway three-fourths of a mile northwest of Henryellen, and having the following section, may be the Black Shale bed.

[a] Op. cit., p. 54.

Section of Black Shale bed (?) on Central of Georgia Railway, three-fourths of a mile northwest of Henryellen (No. 19).

	Ft.	in.
Shale.		
Coal		6
Clay		7
Coal		1
Clay		1
Coal	1	2
Clay		6
Coal		5
Clay.		
	3	4

This bed may be represented by smut on the Trussville road, as shown on section 2, Pl. VI, p. 86. A prospect pit on Black Creek, not seen by the writer, but apparently between what is identified as the Buck bed and the Little Pittsburg bed, may also be on the Black Shale. There are other prospect pits on Snake Branch at about the horizon of this bed, but they were closed and the coal could not be seen.

A coal bed 2 feet thick, exposed by a prospect on Black Creek one-fourth of a mile east of the Central of Georgia Railway (No. 20), is regarded as the possible representative of the Buck bed. What is possibly the same bed shows the following section on the Trussville road, about half a mile west of Black Creek:

Section of Buck bed (?) on Trussville road (No. 21).

	Ft.	in.
Shale.		
Coal		4
Clay		4½
Coal		8
Clay		1
Coal, dirty	1	
Clay.		
	2	5½

The sections given above are the best that were seen in this basin between the Little Pittsburg and the Harkness beds. None show more than 2 feet of coal, and these beds are not minable with profit under present conditions. They may be minable in places at some future day and it does not seem that they should be ignored in estimating the amount of available coal in the basin. It is therefore assumed that the Black Shale and Buck beds will together furnish minable coal in the Henryellen basin equivalent to a bed 2 feet thick, over the area of the Buck bed.

Little Cahaba basin.—Neither the Buck nor the Black Shale bed is known to be of value in the Little Cahaba basin. A bed 21 inches thick in the road on the west side of the basin (No. 22) may be the

Black Shale. Other points at which apparently the same coal was seen are indicated on the map.

Acton basin.—There are many thin beds below the Little Pittsburg in this basin, some of which undoubtedly represent the Black Shale and Buck beds. So far as observed none of these beds have sufficient thickness to be of value.

Helena and Eureka basins.—At the type locality west of Helena (No. 23) the Black Shale bed is reported by Squire to be all coal and 3½ feet thick. One-half mile south of the Louisville and Nashville Railroad the following section of the bed was measured:

Section of Black Shale coal bed one-half mile south of Louisville and Nashville Railroad (No. 24).

	Ft.	in.
Sandstone	5	
Shale	1	
Clay	2	
Coal	4	3
Floor not exposed.		
Total coal bed	4	3

One-half mile farther south a thickness of 4 to 5 feet is reported. No other measurements of this bed were obtained north of Mossboro, where in a railroad cut (No. 25) a bed which may be the Black Shale is exposed, with a thickness of 3 feet 2 inches. The average of all measurements obtained is 3 feet. It is therefore assumed that the Black Shale bed contains 2½ feet of minable coal in the Helena and Eureka basins.

The Buck bed at the mine of the Pratt Cahaba Coal Company, near Falliston (No. 26), is solid coal and ranges from 2 feet 5 inches to 3 feet in thickness. At Mossboro (No. 27) what appears to be the Buck bed has a thickness of only 15 inches. These measurements indicate an average thickness of 26 inches, and 2 feet is therefore assumed as the thickness of minable coal in the Helena and Eureka basins.

COKE BED.

The Coke is a good bed in the southern part of the Cahaba field, but if it is present in the northern part it can not be identified except possibly near Mossboro, on the south boundary of the area under discussion. At this point (No. 28) there is an abandoned mine, apparently in the Coke bed, which shows a thickness of 2 feet 4 inches of coal. No account is taken of this bed in computing the tonnage of the field, as nothing further is known of its extent.

WADSWORTH BED.

So far as known the Wadsworth is the next bed of minable proportions below the Buck bed in this area, except possibly the Coke bed at Mossboro as just described.

Henryellen basin.—In the Henryellen basin the Wadsworth bed does not appear to be thick enough to be mined to any extent except near the south end of the basin on Cahaba River. Near Parsons station, on the Seaboard Air Line Railway, at the north end of the basin, the following section was measured:

Section of Wadsworth bed near Parsons station (No. 29).

	Ft.	in.
Shale		3
"Rash"		1
Coal		5
Parting		⅛
Coal		5
Parting		¼
Coal		9
Parting		¼
Coal		5
Clay.		
Total coal bed	2	1⅝

At location No. 30, a short distance south of No. 29, the coal is only 15½ inches thick immediately under 60 feet of sandstone. These sections do not indicate a workable bed in this part of the basin, nor is it known to be of workable thickness between this locality and the Birmingham-Leeds road. On the west side of Cahaba River, one-half mile above the highway bridge (No. 31), the bed contains approximately 5½ feet of pure coal. On Kanetuck Branch (No. 32), one-half mile south of No. 31, the bed is 2 feet 4 inches thick, all coal. If the conception of the structure in this locality is correct, there is only a small area of workable coal here, inasmuch as the bed would be faulted out one-half mile east of the outcrop. If, however, the thickness existing at locations Nos. 31 and 32 persists for a considerable distance to the north, as may be the case, the Wadsworth bed would contain workable coal worth considering in estimating the general tonnage of the field. Since these points are not certainly determined, the Wadsworth bed is not taken into account in the Henryellen basin.

Little Cahaba basin.—As set forth in the discussion of the general correlation of coals (pp. 82–86), there is difficulty in the identification of the lower coals in this basin on account of the fault which is supposed to exist along its west side. According to the interpretation of

the writer, the bed now mined for coal for use at the waterworks pumping station is the Wadsworth. It is supposed, also, that the same bed was worked at the old mine near the station (No. 33), in which the fault was encountered that led to the abandonment of the mine and the removal to the present location.

The character of the bed at the mine now in operation, 1 mile southeast of the pumping station, is shown by the section below:

Section of Wadsworth bed at pumping station mine (No. 34).

	Ft.	in.
Shale	8	
Coal	2	8
Shale		3
Coal	1	4½
Clay		7
Coal		5
Clay		5½
Coal, variable		6½
Shale.		
Total coal bed	6	3½

The bed at this point is about 250 feet below the conspicuous heavy white sandstone which makes the ridge east and northeast of the pumping station. (Pl. VI, p. 86.) As shown on the map, the bed is slightly displaced by the fault in the locality of the old mine (No. 33). Northeast of this region the identity of the bed is more or less uncertain and nothing is known of its thickness and character. A small showing of coal in a ravine east of the fault, about 1 mile northeast of the pumping station (No. 35) is supposed to be in this bed, and a thin coal bed outcropping in vertical shale toward the north end of the basin, about one-half mile south of the Birmingham-Leeds road (No. 36), is possibly the Wadsworth.

In view of the very meager data concerning the Wadsworth bed in this basin it seems hazardous to venture an estimate of the amount of coal that it carries. The sections obtained in the south end of the Henryellen basin at locations Nos. 31 and 32 afford some basis for judging of its condition in the north end of the Little Cahaba basin. All the facts being taken into account, the bed may reasonably be assumed to contain on the average 2 feet of workable coal.

Acton, Helena, and Eureka basins.—The Wadsworth is known to be of workable thickness along most of its outcrop in the Acton, Helena, and Eureka basins and may be assumed to be workable throughout the area of these basins. On Acton Creek, at the north end of the Acton basin (No. 37) an exposure of what may be the Wadsworth shows 18 inches of coal, and probably the entire bed is at least 2 feet thick. Near Cahaba River, on the east side, one-half mile south of Bains Bridge (No. 38), is an opening in this bed at which 18 inches of

coal is in sight, the bottom not being exposed. The bed is probably 2 feet or more thick. On Cahaba River, farther south, near Langston ford, this bed shows the following section:

Section of Wadsworth bed one-half mile north of Langston ford (No. 39).

	Ft.	in.
Shale	8	
Coal	3	9+
Clay		4?
Coal		3
Total coal bed	4	4

Near the water's edge on the east side of the river at Langston ford the coal is reported at least 2½ feet thick by Mr. Roy, an old resident of the locality. South of Sydenton is the Star Cahaba No. 2 mine, at which the following section was obtained:

Section of Wadsworth bed at Star Cahaba No. 2 mine, south of Sydenton.

	Ft.	in.
Sandstone.		
Shale	2–5	
Coal	2	1
"Rash"		7½
Clay	1	
Shale.		
Total coal bed	3	8½

The bed is said to average 3 feet in thickness. This agrees approximately with the statement of Mr. Squire, who has had much experience in mine surveys in this locality. He considers the average thickness to be 3 feet 3 inches. On account of the anticlines and synclines the outcrop of the bed is repeated three times along the Louisville and Nashville Railroad. There is an imperfect exposure at Tacoa (No. 40), and the bed was originally worked near this point by Frank Wadsworth, from whom it takes its name.

Little is known of the bed south of Tacoa, but an old mine one-half mile west of Roebuck station (No. 41) and an old pit east of the big bend of the Cahaba one mile northwest of Coalmont (No. 42) appear to be on the Wadsworth. One-half mile northwest of Mossboro (No. 43) the bed shows 5 feet of coal. The average thickness of workable coal in this bed in the Acton, Helena, and Eureka basins may be safely taken as 2½ feet. The bed is said to have an excellent roof wherever it has been mined, and it may be considered one of the most valuable in the southern part of the area discussed in this paper.

HARKNESS BED.

Although the type locality of the Harkness bed is on the Louisville and Nashville Railroad northwest of Sydenton, the coal is too thin

to be of value in this area except in the Henryellen and possibly in the Little Cahaba basin.

Henryellen basin.—At the Margaret mine at Davis, 3 miles northeast of Parsons station and about 1 mile east of the territory represented by the map, the bed presents the following section:

Section of Harkness bed at Margaret mine, 3 miles northeast of Parsons.

	Ft.	in.
Shale.		
Clay	1	
Coal		7½
Clay		4½
Coal		7¼
Clay		9
Coal	2	6
Clay	1	8
Total coal bed	4	10¼

Near Parsons station is a prospect pit (No. 44) at which the coal is reported to be of good thickness. Just south of the Trussville road the following measurement was obtained at an old mine:

Section of Harkness bed near Trussville road, one-half mile east of Cahaba mine (No. 45).

	Ft.	in.
Shale	8	
Clay with streaks of coal	1	
Bone		1
Coal		6
"Rash"		1
Coal		8
Clay	1	5
Bone		1
Coal	1	
Clay		4
Coal		1½
Coal, solid	1	2
Coal, crushed (?)	2	6
Clay.		
Total coal bed	7	11½

The lower 30 inches of coal at this point has a peculiar shattered or hackly appearance, as if it had been crushed. The same feature was noted at a pit on the Southern Railway and at intermediate points. It seems likely that this condition is due to some peculiar original constitution of the bench which has been revealed by weathering, rather than the result of crushing due to folding, inasmuch as none of the other coals of the region exhibit such characteristics nor does the Harkness bed at other localities.

This coal has been thoroughly prospected from the Trussville road to Snake Branch, 1 mile south of the Southern Railway, and for nearly the whole distance it shows a workable thickness. In the NW. ¼ sec. 5, T. 17 S., R. 1 E., it has the following section:

Section of Harkness bed in NW. ¼ sec. 5, T. 17 S., R. 1 E. (No. 46).

	Ft.	in.
Coal, with thin streaks of dirt (?)	1	7
Clay	1	2
Coal, crushed	3	10
	6	7

On the Central of Georgia Railway the bed has an unusual amount of bony coal and exhibits the section given below:

Section of Harkness bed on Central of Georgia Railway (No. 47).

	Ft.	in.
Coal	1	
Coal, bony	1	4
Clay	1	
Coal		8
Coal, bony	1	
Coal	1	2
	6	2

On the Southern Railway the bed is considerably diminished in thickness and much less valuable than farther north. The section at this place is as follows:

Section of Harkness bed on Southern Railway (No. 48).

	Ft.	in.
Shale	3	
Coal		2
Clay	1	
"Rash"		8
Coal		9
Clay and coal		5
Coal, crushed, soft		11
Clay.		
Total coal bed	3	11

The deterioration in the value of the coal bed increases to the southwest, and on Snake Branch 1½ miles southeast of Lovick (No. 49) it is broken by so many partings as to be worthless.

Nothing is known of the coal from Snake Branch to Cahaba River, but near the river the bed is considerably improved, as shown by the following section exposed a short distance above the mouth of Hogpen Branch:

Section of Harkness bed near Cahaba River 1½ miles above mouth of Hogpen Branch (No. 50).

	Ft.	in.
Clay	1	
Coal	1	8
Clay and dirty coal	1	7
Coal		9
Clay		5
Coal		1½
Clay	1	
Total coal bed	4	6½

One-third mile farther south another section was taken, as follows:

Section of Harkness bed on north side of Cahaba River near Birmingham-Leeds road (No. 51).

Sandstone.	Ft.	in.
Clay, coaly		4
Coal	1	6
Clay		4
Coal		2½
Clay		1½
Coal, dirty, and clay		3
Clay		1
Coal		4
Clay		½
Coal		½
Clay		½
Coal		½
Clay		1
Coal		½
Clay		4
Coal		11
Clay		¾
Coal		¾
Clay		4½
Coal		2
Clay	1	
	6	4½

Still farther southwest, in the SE. ¼ sec. 32, T. 17 S., R. 1 W., the following section was obtained:

Section of Harkness coal in the SE. ¼ sec. 32, T. 17 S., R. 1 W. (No. 52).

	Ft.	in.
Sandstone	25	
Clay		7
Coal	1	10
Clay		3
Coal		3½
Clay		7
Coal		3
Shale.		
Total coal bed	3	9½

At this locality the bed is so dirty and contains so little coal that it is practically worthless. Still farther south, near the center of the east line of sec. 12, T. 18 S., R. 2 W. (No. 53), is the outcrop of a coal bed over 2 feet thick which is probably the Harkness.

The average thickness of coal in 16 measured sections of the bed from the Margaret mine to the south end of the Henryellen basin is 3 feet, and it is assumed that the bed contains that amount of minable coal throughout the basin.

Little Cahaba basin.—As shown in the discussion of correlations (pp. 82–86) and on the map (Pl. V, p. 80), the outcrop of the Harkness bed is probably repeated on the east side of the fault extending from Hogpen Branch to the waterworks pumping station. The following section of the supposed Harkness in this basin was measured in a prospect pit on the Birmingham-Leeds road, 1 mile east of the river:

Section of Harkness bed on the Birmingham-Leeds road, 1 mile east of Cahaba River (No. 54).

	Ft.	in.
Shale	10	
Coal	2	8
Clay	1	
Coal		10
Clay.		
Total coal bed	4	6

Near this point fossil plants were collected which David White regards as probably representing the horizon of the Harkness bed.

About half a mile southwest of this prospect pit is another opening in the same bed which shows the following section:

Section of Harkness bed a little south of the Birmingham-Leeds road, 1 mile east of Cahaba River (No. 55).

	Ft.	in.
Shale	10	
Coal	3	4
Clay		1½
Coal		2
Clay		2
Coal	1	1
Shale or clay.		
Total coal bed	4	10½

In the road about half a mile east of the river, near the line between secs. 33 and 34, what was recognized as the Harkness bed is exposed at two points near each other but in opposite sides of a subordinate syncline. At the western exposure the following section was measured:

Section of Harkness bed on Birmingham-Leeds road, one-half mile east of Cahaba River (No. 56).

Shale.	Feet.
Coal	4
Clay	1
Coal	1
	6

The structure at this locality, as well as the similarity of the coal sections, strongly indicates that the coal beds showing at Nos. 54, 55, and 56 are the same bed. The writer has no knowledge of this bed between the Birmingham-Leeds road and the northeast corner of sec. 18, T. 18 S., R. 1 W. (No. 57). At this point there is an exposure indicating over 1 foot of coal. The position of this bed with respect to the strike of the rocks and with relation to the sandstone mapped one-third mile to the east indicates that it is the Harkness coal. On the west side of the fault, half a mile northwest of the pumping station (No. 58), there is an opening showing 3 feet of coal which, on account of its relation to the beds of the Nunnally group along the river to the west, is regarded as Harkness.

From the foregoing sections it appears not improbable that the Harkness bed contains 2½ feet of workable coal in the Little Cahaba basin. No data are at hand regarding the bed south of this basin except near the south margin of the area mapped, where it may be thick enough to mine. About 1 mile south of Bamford (No. 59) a bed in the position of the Harkness shows a thickness of 27 inches, and about half a mile farther south (No. 60) the same bed is 40 inches thick. The bed south of the Little Cahaba basin is not taken into account in estimating the amount of coal in the area under consideration.

NUNNALLY GROUP OF COALS.

It seems best to treat as a group the apparently varying number of coal beds occurring in the zone that includes the Nunnally bed of the type locality on the Louisville and Nashville Railroad, one-half mile northwest of Sydenton; for it would be very difficult and uncertain, if not impossible, to identify any individual bed as the Nunnally throughout the northern part of the field. The group includes the "Five group" of Squire, the type locality of which is apparently near the center of sec. 18, T. 20 S., R. 3 W., where five thin beds are exposed near the road between Genery Gap and Helena. On the Birmingham-Leeds road just west of the Cahaba River bridge no less than six thin beds of this group are exposed. The lowest of these is mapped as the Nunnally of the type locality from the south margin of the field northward to the Birmingham-Leeds road. From that point to the north end of the field the next upper bed has been mapped, but it is by no means certain that the correlation implied in this mapping is correct. The mapping, however, serves to connect the group of coal beds throughout and to show the approximate position and extent of its outcrop.

This group underlies all the basins, and consequently its distribution is treated for the whole field and not by individual basins, as has been done in the case of the higher beds. Except for a small area south of Bamford, the workable coals of this group are roughly limited on the north by the Birmingham-Leeds road and on the south by Patton Creek. Within these limits one or more of the beds are well developed and contain much good coal. In a single locality, about 1 mile south of the Acton ford, there are three workable beds, but at no other place are there known to be more than two workable beds. The three beds at the above-mentioned place are, for convenience, designated the Upper, Middle, and Lower Nunnally.

UPPER NUNNALLY BED.

The only complete exposure of the Upper Nunnally bed is at a prospect pit three-fourths of a mile south of the Acton ford, south of the river and near the bank (No. 61). Here the bed contains 2 feet of coal between layers of sandstone. Though this bed is undoubtedly represented by some of the thin coals north of this point, no bed in a corresponding position thick enough to work has been observed, and hence it is ignored in estimating the resources of the field.

MIDDLE NUNNALLY BED.

The Middle Nunnally is known to be a valuable bed locally, and it may have a greater workable extent than is now recognized.

On the west side of Owens Mountain, on the Trussville road (No. 62), it shows 1 foot 7 inches of coal overlain by 5 inches of dirty coal. About 25 feet below this exposure are three small beds 2 to 6 inches thick. The Middle Nunnally bed was measured on the Southern Railway half a mile east of Lovick, where it exhibits the following section:

Section of Middle Nunnally bed on Southern Railway one-half mile east of Lovick (No. 63).

	Ft.	in.
Shale	1	
Coal		4
Shale and clay	3	
Dirty coal		2
Clay		5
Coal		4
Clay		7
Coal		11
Clay		1½
Coal		6
Clay		4
	7	8½

On the Birmingham-Leeds road a short distance west of Cahaba River this bed shows the following section:

Section of Middle (?) Nunnally coal bed on the Birmingham-Leeds road west of Cahaba River (No. 64).

	Ft.	in.
Coal		9
Clay	2	3
Coal	1	2
	4	2

The general worthlessness of this group of coal beds north of the Birmingham-Leeds road is shown by the sections given above. South of the road the Middle Nunnally bed improves greatly, as shown by the following section obtained in the SW. ¼ sec. 32, T. 17 S., R. 1 W.:

Section of Middle Nunnally bed in the SW. ¼ sec. 32, T. 17 S., R. 1 W. (No. 65).

	Ft.	in.
Sandstone.		
Coal	3	1
Coal, bony	1	
Coal	1	11
Clay.		
	6	

About 2 miles farther southwest on the east bank of the river, in the NE. ¼ sec. 12, T. 18 S., R. 2 W., the section below was measured.

Section of Middle Nunnally bed in the NE. ¼ sec. 12, T. 18 S., R. 2 W. (No. 66).

Sandstone.	Inches.
Coal	3–4
"Rash"	2
Coal	7–9
Clay	7–8
Coal	3
Clay	6–7
Coal	28
	56–61

The bed holds this section for one-fourth mile southwest of the river and then begins to deteriorate. Half a mile southwest of the point at which the preceding section was obtained it has thinned to the following section:

Section of Middle Nunnally bed in the SW. ¼ sec. 12, T. 18 S., R. 2 W. (No. 67).

	Inches.
Coal	14
Clay	1
Coal	6
Clay.	21

The writer has no knowledge of the Middle Nunnally as a workable bed between the locality just described and a point three-fourths of a mile south of the Acton ford. In the latter locality, near the south bank of the river, is a thick bed, which is supposed to be the same as that described above. There are two openings half a mile apart, at which the following sections were obtained:

Section of Middle Nunnally bed one-half mile south of the Acton ford (No. 68).

	Ft.	in.
Shale	6	
Coal	3	8
Parting		3
Coal		10
Parting	1	6
Coal (bottom not seen)	1	
Total coal bed	7	3

Section of Middle Nunnally bed three-fourths of a mile southwest of the Acton ford (No. 69).

Sandstone.	Ft.	in.
Coal	2	9
Parting		3
Coal		11
Shale	1	5
Coal	1	7½
Clay with streaks of coal		5
Coal		3
Clay		2
Coal	1	9
Clay		6
Total coal bed	9	6½

Nothing is known of this bed either north or south of the Acton ford, and it is doubtful whether it preserves the thickness shown above for any great distance. The facts at hand indicate that the Middle Nunnally is subject to extreme variations in character and thickness.

LOWER NUNNALLY BED.

The Lower Nunnally, as identified, shows only a streak in the Birmingham-Leeds road. It increases in thickness farther south, and in the SW. ¼ sec. 32, T. 17 S., R. 1 W., near the west bank of the river, shows the following section:

Section of Lower Nunnally bed in the SW. ¼ sec. 32, T. 17 S., R. 1 W., near the west bank of Cahaba River (No. 70).

	Ft.	in.
Shale	5	
Coal, variable	1	5
Clay	4	
Coal		4
Clay		2½
Total coal bed	5	9

It improves still farther south, and near the river in the SE. ¼ sec. 1, T. 18 S., R. 2 W., has the following section:

Section of Lower Nunnally bed near Cahaba River, in the SE. ¼ sec. 1, T. 18 S., R. 2 W. (No. 71).

	Ft.	in.
Shale	10	
Coal	2	
Clay		3
Coal	1	
Parting		1
Coal	1	
Total coal bed	4	4

Half a mile southwest of the above-described point (No. 72) the bed is 4 feet thick, with a 3-inch parting of clay and "rash" near the middle. Half a mile farther south, near the west side of sec. 12, in the same township and range (No. 73), the bed is 30 inches thick, all coal.

In the northeast corner of sec. 13, T. 18 S., R. 2 W. (No. 74), what is believed to be the Lower Nunnally is again brought to the surface on the east side of the fault. At this point it is 28 inches thick. If the interpretation of the structure and identification of the coals are correct, the Nunnally beds must outcrop east of the fault in the tract between it and the Harkness bed, as mapped. Since nothing is known of the coals except at the point just described

and possibly one or two others in the immediate vicinity, the Nunnally beds are not mapped in this tract.

The outcrop of the Lower Nunnally has been traced carefully by prospectors southward almost continuously to the Acton ford, but the writer has no information as to its condition except at a few points. One-half mile south of the waterworks pumping station the bed is exposed in a pit and has the following section:

Section of Lower Nunnally bed one-half mile south of the pumping station (No. 75).

Shale.	Ft.	in.
Coal	1	8
Clay		10
Coal	1	
	3	6

At a pit about 1 mile south of the pumping station (No.76) the bed is 2 feet thick. About 1 mile northeast of the Acton ford, on the east side of the river, the coal bed has the section given below:

Section of Lower Nunnally bed 1 mile northeast of Acton ford (No. 77).

	Ft.	in.
Coal		1
Clay		2
Coal		1
Clay		2
Coal		1
Clay		3
Coal		4
Clay		1
Coal	2	
	3	3

At this point there is a bed 1 foot thick 15 to 20 feet below the Lower Nunnally, and above it the outcrops of two coal beds show in the road. At the Acton ford the bed has the following section:

Section of Lower Nunnally bed at Acton ford (No. 78).

Shale.	Ft.	in.
Coal		1
Shale		4
Coal		1
Shale, variable		4½
Coal	3	8
Shale.		
	4	6½

One-half mile southwest of the Acton ford there are two other openings, at which the bed exhibits sections practically identical with the preceding. Two miles farther southwest, near Patton Creek, the following section was measured:

Section of Lower Nunnally coal near Patton Creek (No. 79).

	Ft.	in.
Shale.		
Coal		6
Clay		10
Coal		9
Clay, variable		2½
Coal, variable	1	6
	3	9½

The bed is traceable farther southwest and is reported to be 7 feet thick at a point 1½ miles southwest of Patton Creek (No. 80). The bed is not exposed, and the writer has no way of verifying the report, but it is regarded as very doubtful. This bed can be pretty surely traced to an opening near the Louisville and Nashville Railroad, the type locality, at which the following section is disclosed:

Section of Lower Nunnally coal near the Louisville and Nashville Railroad (No. 81).

	Ft.	in.
Coal		6
Clay		2
Coal		6
Shale	25	
Coal	1	
Shale.		
	27	2

Whether the lower bed shown in the preceding section is the original Nunnally the writer could not ascertain with certainty. A still lower bed is reported on the Nunnally place, but no exposure could be seen at the time of the writer's visit, and no information as to its thickness and character could be obtained. As stated on a preceding page, there are five thin beds of this group exposed 2 miles southwest of the Louisville and Nashville Railroad (No. 82), and this has probably given rise to the expression "Five group" used by Squire for the Nunnally group. About 1½ miles south of Bamford (No. 83) one of the beds of the group is reported 24 inches thick, but the report could not be verified. With this possible exception, no bed of value is known in the group south of Patton Creek.

The average thickness of coal in all the good sections of the Lower Nunnally bed from the Birmingham-Leeds road to Patton Creek is 2 feet 8 inches. No effort is made to compute the coal of the other beds separately, because their workable areas appear to be so irregular as to defy reliable calculation. Since they are known to contain some workable coal, however, it is arbitrarily assumed that

the amount of such coal will equal 1 foot added to the thickness of the Lower Nunnally bed throughout the area in which it is regarded as workable, making, for the purpose of computation, an average thickness of 3 feet 8 inches for that bed.

GOULD GROUP OF COAL BEDS.

In the interval between the sandstone of Chestnut Ridge and that of Grassy Ridge lie a number of coal beds which are mostly thin, but which generally contain one bed of workable thickness. One bed of this group was originally mined by William Gould, near the present Star Cahaba No. 1 mine, about 1 mile west of Sydenton. From this circumstance the bed has been named the Gould bed, whence the name Gould group. The number of beds observed in the group at various localities is shown in the columnar sections (Pl. VI, p. 86). Whether it is everywhere the same bed of the group that is workable or whether one is workable here and another there is a question that can not be answered at present, though on the map a single bed is shown to indicate the continuity and general position of the group.

A bed belonging to this group is 14½ inches thick 2 miles north of Parsons station (No. 84), where it is immediately overlain by the sandstone of Chestnut Ridge. In the cut on the Seaboard Air Line Railway at the road crossing 1 mile southwest of Parsons (No. 85) two of the lower beds of the group, each only 6 to 8 inches thick, are exposed. On the Trussville road near the crest of Chestnut Ridge (No. 86) the main bed is solid coal 2 feet thick. No measurements of the bed and only two or three observations were obtained on it between this point and the Ratliffe mine, 2 miles southwest of Lovick, where the section is as follows:

Section of Gould coal at Ratliffe mine, 2 miles southwest of Lovick (No. 87).

	Ft.	in.
Sandstone	15	
Coal		6
Parting		⅕
Coal	1	9
Clay	1	
Total coal bed	2	3⅕

Practically nothing is known of the thickness and character of this coal from the Ratliffe mine southward to Rocky Ridge Church. About 1 mile north of New Hope (No. 88) coal smut was seen that probably is made by this bed, and coal is reported at three other points within a mile farther north. One-half mile south of Rocky Ridge Church is a prospect pit (No. 89), now closed, at which the coal bed is reported 3 feet thick. In the Little Valley syncline, 1½

miles west of Rocky Ridge Church (No. 90), the Gould bed is 18 inches thick. Two miles north of the Louisville and Nashville Railroad (No. 91) is a prospect pit at which 1 foot of coal is visible and 2 feet or more indicated. Just north of the railroad (No. 92) 2 feet is shown in a pit. At location No. 93, just west of No. 92, one of the lower beds of the group has been opened in shale. It shows 18 inches of coal and is possibly 2 feet thick. At the Star Cahaba No. 1 mine, 1 mile south of the railroad, the following section was measured:

Section of Gould bed at Star Cahaba No. 1 mine.

	Ft.	in.
Shale		4
Coal	4	
"Rash"		8
Clay		5
Shale	2	
Total coal bed	5	1

In this mine the bed shows great variations of thickness, as shown below:

Thickness of the Gould bed at Star Cahaba No. 1 mine.

	Inches.
Outside of mine	18
At pit mouth	25
50 feet in slope	23
100 feet in slope	30
200 feet in slope	48

It is said that this is about the range in thickness, though in places the bed reaches 5 feet. The bed appears to be without partings and to have a good roof.

At Bamford is another small mine on this bed. The coal is 20 inches thick at the pit mouth and is said to range from 18 to 36 inches, with an average of 26 inches, all coal. At Bamford a greater number of beds of this group was observed than elsewhere (Pl. V, section Q–R), and there has possibly been a repetition by folding or faulting, which is indicated by the offset in the crest line of Chestnut Ridge.

By taking into consideration all the observations and reports it appears not improbable that the Gould bed will average 2 feet of workable coal from the Trussville road to the south margin of the area discussed in this paper.

AMOUNT OF COAL IN THE AREA.

In the computation of the amount of available coal in this area only the coal is included that occurs in beds containing on the average 2 feet or more of coal exclusive of partings. No bed having a smaller average is regarded as workable. The average thickness of the several minable beds is stated in the preceding descriptions. It is assumed that the averages computed from the measurements made on the outcrop will hold under ground as far as the fault that bounds the field

on the southeast and limits the extension of the coal beds in that direction. A layer of coal of density 1.35, 1 foot thick and an acre in extent, contains in round numbers 1,800 tons. That factor is used in this calculation. Most of this coal lies at a depth not exceeding 4,000 feet. The Gould bed, however, may exceed this depth over small areas in the deepest parts of some of the basins.

Below are given in tabular form the acreage and gross tonnage of the minable beds:

Acreage and tonnage of coal in the northern part of the Cahaba basin.

	Average thickness.	Extent.	Amount.
Mammoth-Helena bed:	*Feet.*	*Acres.*	*Short tons.*
Henryellen basin	7	3,200	40,302,000
Little Cahaba basin	4	100	720,000
Acton basin	4	484	3,524,000
Helena basin	5	234	2,106,000
Eureka basin	3½	2,067	1,302,200
Thompson bed:			
Acton basin	2½	910	4,095,000
Helena basin	4	457	3,290,400
Eureka basin	4	2,404	17,308,800
Little Pittsburg bed:			
Henryellen basin	2	4,068	14,644,800
Little Cahaba basin	2	621	2,235,600
Acton basin	2	1,261	4,539,600
Black Shale and Buck beds (Henryellen basin)	2	5,261	19,139,600
Black Shale bed (Helena and Eureka basins)	2½	3,510	15,895,000
Buck bed (Helena and Eureka basins)	2	4,105	14,778,000
Wadsworth bed:			
Little Cahaba basin	2	3,556	12,801,600
Acton, Helena, and Eureka basins	2½	8,214	36,963,000
Harkness bed:			
Henryellen basin	3	7,698	41,569,200
Little Cahaba basin	2½	4,992	22,464,000
Nunnally bed	3⅔	14,281	95,254,600
Gould bed	2	55,908	201,268,800
Total		123,331	565,920,100

CHARACTER AND COMPOSITION OF COALS.

The coals of the Cahaba field are all bituminous, the average composition being 2½ per cent moisture, 59 per cent fixed carbon, 32 per cent volatile matter, 6 per cent ash, and 1 per cent sulphur. In fixed carbon they are about the same as the coals of the Warrior field, in volatile matter they are higher, and in ash and sulphur they are lower. They are a little higher in calorific power than the Warrior coals and a little lower than the coals of the New River and Kanawha field of West Virginia. They are excellent steam and domestic coals

Some of the earliest coking operations in the State were located along the Louisville and Nashville Railroad, coal from the Helena, Wadsworth, and Gould beds being used to produce coke for the Oxmoor furnace. Coke from the two beds last mentioned is said by Squire to be of excellent quality. On account of the higher proportion of volatile matter in these coals, however, the yield of coke is less than from the Warrior coals, so that coking them is unprofitable, and they are not coked at present.

Below is a table of analyses showing the composition of mine samples from the principal beds of the field. The number of samples collected is small because the opportunities for obtaining fresh samples were few. The analyses were made by F. M. Stanton at the United States Geological Survey fuel-testing plant at St. Louis. The samples were obtained by channeling the bed from top to bottom and rejecting such impurities as are rejected in mining. About 50 pounds of coal was thus cut from a fresh working face and reduced by pulverizing and quartering to a quart sample. This was sealed in a galvanized-iron can, in which it was transmitted to St. Louis. It is believed that by these means analyses were obtained that nearly represent the actual composition of the coal as it is mined. A number of other analyses are published in Squire's report on the Cahaba field.

Analyses of coal samples from the Cahaba coal field, Alabama.

	A.	B.	C.	D.	E.	F.	G.	H.	I.
Laboratory No.	3460.	3771.	3769.	3745.	3744.	3770.	3484.	3499.	3644.
Analysis of sample as received:									
Prox. Moisture	2.51	2.74	3.59	2.75	2.60	3.65	3.39	1.98	2.12
Prox. Volatile matter	33.81	33.34	33.18	32.56	34.21	33.74	30.69	30.66	28.15
Prox. Fixed carbon	56.85	58.22	58.67	58.46	60.01	58.86	57.08	58.95	61.50
Prox. Ash	6.83	5.70	4.56	6.23	3.18	3.75	8.84	8.41	8..23
Ult. Sulphur	.48	.44	1.08	.87	.66	.48	2.34	1.09	1.98
Ult. Hydrogen	.....	5.20	5.13	5.08	5.32	5.48	5.18	4.94	.....
Ult. Carbon	.....	77.96	77.57	76.55	78.62	80.12	73.81	76.03	.....
Ult. Nitrogen	.....	1.52	1.23	1.12	1.32	1.51	1.53	1.68	.....
Ult. Oxygen	.....	9.18	10.43	10.15	10.90	8.66	8.30	7.85	.....
Calorific value determined:									
Calories	.....	7,722	7,805	7,699	8,026	7,976	.....	7,563	.....
British thermal units	.....	13,990	14,049	13,858	14,447	14,537	.....	13,613	.....
Loss of moisture on air drying	1.00	.90	2.00	1.10	1.10	2.40	1.80	.80	.80
Analysis of air-dried sample:									
Prox. Moisture	1.53	1.86	1.62	1.67	1.52	1.28	1.62	1.19	1.33
Prox. Volatile matter	34.15	33.64	33.86	32.92	34.59	34.56	31.25	30.90	28.38
Prox. Fixed carbon	57.42	58.75	59.87	59.11	60.68	60.32	58.13	59.43	62.00
Prox. Ash	6.90	5.75	4.65	6.30	3.21	3.84	9.00	8.48	8.29
Ult. Sulphur	.....	.44	1.10	.88	.67	.49	2.38	1.10	2.00
Ult. Hyrogen	.....	5.15	5.01	5.01	5.26	5.34	5.07	4.89	.....
Ult. Carbon	.....	78.67	79.16	77.40	79.50	82.09	75.17	76.64	.....
Ult. Nitrogen	.....	1.53	1.25	1.13	1.33	1.55	1.56	1.69	.....
Ult. Oxygen	.....	8.46	8.83	9.28	10.03	6.69	6.82	7.20	.....
Calorific value determined:									
Calories	.....	7,791	7,964	7,764	8,115	8,180	.....	7,613	.....
British thermal units	.....	14,117	14,336	14,012	14,607	14,812	.....	13,722	.....

A. Mammoth bed, 2 miles southwest of Henryellen.
B. Helena bed, in Acton basin, north of Helena.
C. Thompson or Conglomerate bed, in Acton basin, north of Helena.
D. Thompson or Conglomerate bed, at Coalmont.
E. Buck bed, at Falliston.
F. Wadsworth bed, near Sydenton.
G. Harkness bed, at Davis.
H. Gould bed, at Lovick.
I. Gould bed, 1 mile west of Sydenton.

MINING CONDITIONS.

As previously stated, it will be comparatively easy to reach by railroad almost all points at which mines might be opened to advantage in this part of the field; the problem of transportation is therefore simple.

Probably most of the mining in the field will be done from the outcrop. For all the minable beds except the Gould a haul of less than 3 miles will be required in mining to the boundary fault on the southeast. It is only in the Gould also that a depth exceeding 4,000 feet may be reached over small areas in the deepest parts of the various basins.

As usual in the coal fields of Alabama, the roof and floor of the coal beds are firm, giving but little trouble in mining. The mines are never dangerously gaseous, nor is water particularly troublesome except in times of unusual rains.

DEVELOPMENTS.

At present only six mines are operating in this field. At two of these the production is small, being hauled away in wagons. The other four ship coal by rail, but are not large producers. One of these, the Henryellen No. 6, owned by the Tennessee Coal, Iron and Railroad Company, is working the Mammoth bed 2 miles southwest of Henryellen; the second, the Star Cahaba No. 1, owned by the Star Cahaba Coal Company, is working the Gould bed 1 mile west of Sydenton; the third, the Coalmont mine, owned by the Gray Eagle Coal Company, is working the Thompson bed at Coalmont; and the fourth, owned by the Pratt Cahaba Coal Company, is working the Buck bed at Falliston. Henry De Bardleben, who has for many years been active in the development of this field, is now opening some new mines in the Helena and Thompson beds in the Acton basin which will probably produce a large amount of coal. Much coal has been mined from the Mammoth bed in the past at Henryellen and farther north, but at present all mines except the Henryellen No. 6 either have been abandoned or shut down. For fifteen years previous to 1890 the Helena bed was worked on a considerable scale in the north end of the Eureka basin by the Eureka Company, which used the coal for coke at the Oxmoor furnace. The Wadsworth bed has been worked by different persons at various times. Years ago the bed was worked by Frank Wadsworth at Tacoa station, and during the war it was mined by Woodson & Gould near the railroad bridge on the east side of Cahaba River. More recently the Wadsworth bed has been mined rather extensively at Sydenton by the South Birmingham Coal and Iron Company. Immediately after the war the Gould bed was worked by William Gould at the type locality 1 mile west of Sydenton. The total amount of coal mined in these operations probably has not been very great. These historical statements for the region west of Helena are made on the authority of Mr. Squire, either in verbal statements or in his report, already cited.