Kentucky Geological Survey

CHARLES J. NORWOOD, Director.

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A Geological Reconnoissance

OF

The Tradewater River Region,

WITH

SPECIAL REFERENCE TO THE COAL BEDS

Embracing parts of Union, Webster, Hopkins, Crittenden, Caldwell and Christian Counties.

By L. C. GLENN.

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INDEX.

PLATE.

Group of Vertical Sections showing correlations of Coal beds.

LETTER OF TRANSMITTAL.

His Excellency, AUGUSTUS E. WILSON,

Governor of Kentucky.

Sir: I have the honor to transmit for publication a report by L. C. Glenn, of a geological reconnoissance of of the region drained by the Tradewater river, with special reference to the coals and faults of that area, which includes parts of Union, Webster, Hopkins, Christian, Crittenden, and Caldwell counties. The field work for the report was done in 1909, and the report has been ready for the printer since the spring of 1910.

Very respectfully,

CHARLES J. NORWOOD,

August 1, 1910. *Director, State Geological Survey.*

THE COALS OF THE TRADEWATER RIVER REGION.

By L. C. Glenn.

The following report embodies the general results of a reconnoissance in the Tradewater River region made for the Kentucky Geological Survey during the summer of 1909. Three months were spent in the field and the area examined, while mainly confined to the drainage basin of the Tradewater River, included some small contiguous areas in addition and may be more definitely defined as follows: On the southwest and south the area examined is limited by the edge of the Mississippian limestones in Crittenden, Caldwell and Christian counties, on the east by the Louisville and Nashville railroad from Crofton northward to Sebree; from Sebree the bounding line runs west to Tilden and thence down Highland creek to the Ohio river and down the Ohio to the mouth of Tradewater. The area thus defined includes some 1200 square miles, or is somewhat over a fourth of the total area of the Western Coalfield.

The area is notable as including the Caseyville-Dekoven region in which Dr. Owen determined his type section for the entire Western Coalfield, and where very much of the early mining activity of the Field was centered. It is notable today as being the part of the Western field where there is the greatest activity in mining. The region examined includes the entire area of Union county and practically the entire area of Webster, Hopkins and Christian counties that is now actively producing coal for the general market.

Not all parts of the area as above defined were examined with the same amount of detail. Attention was directed mainly to those parts of the area that seemed to be of the greatest commercial importance either present or prospective. When it became evident that a part of the region did not have coals likely to be of commercial importance under present conditions, further detailed reconnaissance was not attempted. In this way the work would not be considered so much a study of the general geological distribution of the various members of the Pennsylvanian system as a study of the distribution of the several economically important coal bearing members of that system.

The immediate object of the work was thus primarily commercial,—to gain such knowledge of the distribution of the coal and its structure as would enable the Survey to give intelligent and reliable assistance to those interested in its further development. A further object of the work was to lay the basis for more detailed studies that will ultimately lead to the preparation of a detailed geological map of the region and a report that will embody full details as to both the commercial and the geological features of the area.

Previous Geological work in the region. Practically the only detailed geological work of a general character that has been done in the region was done by Dr. Owen and his assistants in 1854-57, the results of which are embodied in the four reports of the First Geological Survey of Kentucky. In volume 1, of the Shaler Survey is a report by Prof. C. J. Norwood of a section made across the southern end of the region along what is today the Illinois Central railroad that gives some data along that line between Nortonville and Dawson Springs. Various volumes of Prof. Norwood's Mine Inspector's Reports, especially those for 1893, and 1901–2, give keys and logs of bore holes or shafts, and contain critical discussions of Owen's type section and of the attempts made by Cox and by Worthen to rectify it, and thus add to our knowledge of the region. Dr. Owen labored at a time when there were few facilities in the region for geological work. The

country was sparsely settled and was largely uncleared. Roads were few, there was very little mining development and no detailed maps. Under these circumstances one can but marvel at the general accuracy of his work. It is all the more remarkable when one realizes after personal examination that in much of the region surface exposures are rare and detailed stratigraphic tracing by such means is in many cases exceedingly difficult and slow and in others is impossible.

Owen's type section is fully elaborated in his third report though it had been outlined with considerable detail in his first and second reports. In these earlier reports a few points are worthy of brief note. In his first report he applies the term Caseyville to the conglomerate underlying the coal measures and states that his Anvil-rock sandstone is named from a mass detached from that bed that may still be seen standing today above the track of the Illinois Central railroad where it rounds the point of the bluff two miles west of Dekoven.

In his second report he makes some long distance correlations of one of his sandstones with the Mahoning sandstone of Pennsylvania and of one of his coals with the Pittsburg coal. His assistant Lyon makes some stratigraphic correlations of the coals at or near the base of the coal measures. These correlations will be discussed on a later page after reference to Owen's section has been given.

In the third report is given a detailed section of nearly 1500 feet extending from the basal conglomerate up to the top of the coal measures. In this section the coals are designated by numbers, beginning with coal number one at the base and ending with coal number 18 at the top. The section is given in a block diagram form that is difficult to give accurately in descriptive terms, but is approximately as follows, beginning at the top.

Owen's Section.

	STRATA.	Ft.	In.
1.	Soft sandstone	25	..
2.	Shale	25	..
3.	Thin coal, No. 18	0	8
4.	Sandstone above and shale below	50	..
5.	Carthage limestone	8	..
6.	Shale	2	..
7.	Thin coal, No. 17	0	8
8.	Soft shale	8	4
9.	Sandstone	2	6
10.	Soft shaly rocks and bands of sandstone	24	10
11.	Thin coal, No. 16	0	8
12.	Fire clay	3	3
13.	Soft and hard sandy limestone	2	..
14.	Hard shaly sandstone	10	5
15.	Soft slaty sandstone	19	4
16.	Argillaceous shale	34	2
17.	Brown shales	11	10
18.	Hard limestone	0	9
19.	Soft shale	1	..
20.	Coal, No. 15	2	6
21.	Fire clay	4	6
22.	White limestone	2	..
23.	Brown shales	5	10
24.	Limestone	3	11
25.	White sandy shale	9	4
26.	White sandstone	50	8
27.	Brown shale	38	..
28.	Hard black shale	1	1
29.	Coal No. 14	1	..
30.	Fire clay	1	..
31.	Hard limestone	7	..
32.	Hard stone	1	1
33.	Brown shale	23	6
34.	Dark brown shale	4	..
35.	Black shale	5	..
36.	Soft gray limestone	1	6
37.	Hard limestone	3	..
38.	Blue and light shales	4	6
39.	White limestone	11	9
40.	Bluish shale	16	2
41.	Thin coal, No. 13	..	4
42.	Fire clay and red oxide of iron	7	..
43.	Shaly sandstone	10	..
44.	Hard gray sandstone	18	6
45.	Soft gray sandstone	14	7
46.	Bluish shale	19	5
47.	Micaceous shale	7	..
48.	Hard gray sandstone, Anvil Rock	12	..
49.	Coarse sandstone	8	8
50.	Hard sandstone	3	..
51.	Thin coal, No. 12	0	3
52.	(Shale)	12	8
53.	Hard limestone, bituminous shale, bluish limestone and clay	8	1
54.	Coal with clay parting, No. 11	5	..

		Ft.	In.
55.	Fire clay and pyritiferous sandstone	5	6
56.	Thin bedded sandstones with harder bands intercalated	40	4
57.	Coal, 2 to 3 feet, No. 10	3	..
58.	Fire clay and shales	7	8
59.	Sandstone	10	..
60.	Shales and thin sandstone	5	..
61.	Sandstone	5	..
62.	Indurated argillaceous shale with clay ironstone basis	36	4
63.	Avicula shale	3	..
64.	Main Mulford coal, No. 9	5	..
65.	Fire clay	2	..
66.	Shale	4	..
67.	Sandstone	25	..
68.	Shale, coal, and shale with argillaceous iron ore	8	..
69.	White and pink sandstone	10	..
70.	Well or water coal, No. 8	2	6
71.	Sandstone with a little shale at base	43	..
72.	Coal and ferruginous limestone, No. 7	2	..
73.	Impure limestone, and ferruginous shales	42	..
74.	Shale	24	..
75.	Thin bedded sandstone with shale partings	18	..
76.	Three foot or "Little coal", No. 6, with thin shale over it	3	..
77.	Fire clay	3	..
78.	Soft sandstone	30	..
79.	Micaceous sandstone	25	..
80.	Shale with carbonate of iron	7	..
81.	Coal No. 5	4	..
82.	Fire clay	3	..
83.	Dark argillaceous shale	20	..
84.	Shale with segregations of ironstone	42	..
85.	Massive Curlew sandstone	25	3
86.	Shale	5	..
87.	Curlew coal with two shale partings, No. 4	4	..
88.	Shale	15	..
89.	Curlew limestone	4	..
90.	Shale, with a coal	62	..
91.	Sandstone	10	..
92.	Shale with thin coal	15	..
93.	Sandstone	10	..
94.	Shale	12	..
95.	Coal	1	3
96.	Shale with ironstone	3	6
97.	Band of sandstone	2	..
98.	Shale with carbonate of iron	10	..
99.	Ice-house coal, No. 3	2	6
100.	(Shale or fire clay)	1	3
101.	Soft brown sandstone	10	4
102.	Massive ferruginous and carbonaceous sandstone of the Finnie bluff	40	..
103.	Shale and thin bedded sandstone	21	..
104.	Thin coal, No. 2	..	..
105.	Shale	15	..
106.	Sandstone	10	..
107.	Shale	6	6
108.	Thin bedded sandstone with shale partings, "Grey metal"	50	..
109.	Bell coal, No. 1 B	4	..

Owen was uncertain about both the distance from the Bell coal down to the top of the conglomerate and whether there is another coal No. 1 A. in that space and so ends his section with the Bell coal. The space down to the conglomerate is regarded by him as probably 50 to 75 feet, making about 1400 feet of coal measures above the conglomerate.

In the second report Dr. Owen correlates the Curlew sandstone with the Mahoning and uses it to divide the Western Kentucky coal measures into an upper and a lower part. In the third report he elaborates this somewhat by making the Anvil-rock sandstone separate the upper coal measures from the middle, and the Curlew or Mahoning, sandstone separate the middle from the lower. In the second report he regards his number 9 coal as the equivalent of the Pittsburg coal, but in the fourth report he regards his number 11 coal as the equivalent of the Pittsburg coal. In the third report he correlates his number 4 coal with the Pomeroy coal of Ohio. In the second report he had already pronounced it the equivalent of the upper Freeport coal of Pennsylvania. Finally in the fourth report he correlates his Western Kentucky coals with the coals of England.

In the second report Lyon, the topographical assistant, places the Bell coal above and the Battery Rock coal below the Cook coal, and regards the Battery Rock coal as an intra-conglomerate coal.

Lesquereux studied the paleobotany of the region and in the third report believes that the Bell, the Cook, the Casey and the Battery Rock coals are identical and that number 8 coal is equivalent to the Pittsburg coal, but in the fourth report he thinks the Battery Rock coal is beneath the conglomerate and that number 11 and 12 are together the equivalent of the Pittsburg coal.

The long distance correlations not only with England but with Pennsylvania and Ohio may be dismissed as founded on entirely inconclusive evidence. None of these correlations are used in Western Kentucky today except the term Mahoning which, unfortunately, is still applied in some places to one or other of the sandstones

of the region. The correlations of the Bell with various other coals are discussed in some detail on page 20.

Dr. Owen's generalized section given on a preceding page has been used until the present day with only slight modification as a standard section for not only Western Kentucky but for Indiana and Illinois as well. The section is not without its defects as will be pointed out later, but they are mostly of a minor character and when one considers the time and lack of facilities for such work it is only to marvel that his work was so good.

Two critics of his section deserve a few words especially because with better opportunities to construct an accurate section both blundered hopelessly. They are E. T. Cox, State geologist of Indiana, and Prof. A. H Worthen, State geologist of Illinois.

In 1871 Cox attempted* to rectify the many errors he conceived to exist in the Western Kentucky section as given by Owen in pp. 18-24 of his Third Kentucky Report. He gave a section of the Kentucky coals corrected from observations made by him in the same Union county localities that furnished the data Owen used in constructing his type section. His chief assumption is that the upper part of Owen's Kentucky section from the sandstone under his No. 18 coal down to the Anvil-rock sandstone is merely a repetition of the section from the Anvil-rock down to coal No. 7, and the section from the Anvil-rock sandstone down to the so-called Mahoning or Curlew sandstone as a repetition of a part of the section from the Curlew sandstone down to the Caseyville conglomerate. He regards the Carthage limestone as equivalent to the limestone over No. 11 coal, the Curlew sandstone as the equivalent of the Anvil-rock sandstone; Owen's No. 4 and his No. 11 coals as the same and his No. 3 as equivalent to his No. 1 B, or Bell coal.

It is difficult to see how Cox could ever have gone into Union county and reached so erroneous a conclusion, as such repetition and such equivalency of strata are not

*American Assoc. Adv. Sci., Proc. for 1871, pp. 236-252, and Sec. Indiana Rept. pp. 164-173, 1871.

supported by any evidence to be found in the field. The rectification is entirely misleading, and does not deserve further consideration, unless it be to give Cox credit for expressing skepticism as to the equivalency of any sandstone in Western Kentucky or Indiana with the Mahoning sandstone of Pennsylvania.

Prof. A. H. Worthen, State geologist of Illinois, also attempted to correlate the Western Kentucky coals with those of his own State, but with no more success than Cox had done.

He constructed a general section for Illinois and on comparing it with the Kentucky section of Owen concluded "that there are no beds in Illinois that can be referred to those in that section intervening between the Mahoning and Anvil-rock sandstones, and no sandstone associated with our upper coals that can properly be considered as the equivalent of the upper sandstone of their section, unless it is that over our coal No. 6. Hence we are inclined to believe that two different outcrops of the same bed of sandstone in Kentucky have been mistaken for distinct beds, occupying different stratigraphical positions, and by adopting this supposition they have increased the thickness of the measure 300 feet more than they really attain, and nearly double the number of their workable coals. That this is the true explanation of the want of parallelism between our section and theirs, seems highly probable from the general correspondence of the strata for 300 feet below these sandstones, as illustrated by the subjoined parallel section of the strata as taken from the Kentucky section.

Anvil-rock sandstone.	Mahoning sandstone.
Coal 3 feet.	Coal 4 feet.
Shale 10 feet.	
Coal 10 feet.	
Shale 40 feet.	Shale 95 feet.
Coal 5 feet.	
Shale 60 feet.	
Coal 5 feet.	Coal 3 feet.
Shale 20 feet.	——25 feet.
Coal 6 inches.	Thin coal & limestone.
Shale 70 feet.	Shale 130 feet.
Coal 2½ feet.	Coal 2½ feet.
Shale 110 feet.	Shale 100 feet.
Coal 3 feet.	Coal 1 foot 8 inches.

The lower portions of these two sections correspond almost exactly the one to the other, while in the upper part, the only variation consists in the intercalation of three beds of coal in the first hundred feet below the Anvil-rock, while there is but one in the same space below the Mahoning. But anyone accustomed to working in the Coal Measures will see at a glance the probable synchronism of the strata in these two sections, for sections could scarcely be made through equivalent beds at points 20 miles apart, anywhere in the measure, that would not show quite as marked a variation in the thickness and lithological characters of the strata, as are presented in those just given. Now, if we take from the Kentucky section this upper sandstone and the beds intervening between it and the Mahoning, we have a general correspondence between the sections in Illinois and Kentucky, perhaps as decided as could be expected to occur in remote portions of the same coal field; the most important difference being the aggregate thickness of the strata, a variation for which we have already suggested an explanation."

Owen's so-called Mahoning sandstone mentioned in the section given by Worthen above is the Curlew sandstone a short distance over No. 4 coal. The section from it up to the Anvil-rock sandstone is not a repetition of the section beneath it as supposed by Worthen, but is a continuation of it, and Worthen's rectification of the Kentucky section is as erroneous as the one attempted by Cox. Each supposed a repetition of certain parts of the Kentucky section, doubtless by faulting. Prof. Norwood concluded in 1893* or earlier that such repetitions did not occur and the field studies of the past season confirm the correctness of his conclusions.†

As has already been remarked, the difficulties in con-

*Norwood, C. J. Rept. of Inspector of Mines of Ky. for 1893, pp. 90-97.

†Note.—The blunder made by Mr. Cox first appeared in his Indiana report for 1869, and the first correction of it was made by the writer of this note in 1875, in his report on the "Geology of the Region Adjacent to the Louisville, Paducah & Southwestern Railroad" (now Illinois Central Railroad), in Vol. I., Reports of the Kentucky Geological Survey, N. S. Shaler, Director, printed in 1876. Further, in the present writer's "Keys to the Coal Field's," given in the report of the State Inspector of Mines (Ky.) for 1892, and reprinted in the report of the same office for 1893, the errors commited by Mr. Worthen, together with those made by Mr. Cox in his report for 1870 and in the paper read before the American Association for the Advancement of Science, were fully discussed and demonstrated. Attention was also called to the matter in the writer's chapter on "Kentucky's Mineral Wealth" published in the report of the State Inspector of Mines (Ky.) for 1895.—C. J. N.

structing a continuous section of any length from surface outcrops are so great that except in a very few exceptionally favorable localities such an undertaking is futile. The streams are generally bordered by flats that are not infrequently several miles wide and the uplands between adjacent streams are mantled by a blanket of loess that in the western part of the area is twenty to forty or more feet in thickness and generally entirely conceals the country rock except along steep slopes where gullies, deep road cuttings, or occasional small stream channels may give good surface sections for short distances. In some cases it was possible to connect such surface sections so as to make satisfactory correlations. In others it is believed that satisfactory tracing may be made by very detailed work. Toward the east and southeast the mantling of loess became thinner, lost much of its loess-like character, and became a yellowish surface loam. It still, however, effectually concealed much of the surface and rendered the work difficult.

Many drill holes have been put down by operating coal companies or prospectors and a few deep wells have been sunk for oil or gas. Whenever possible logs of these holes and of the numerous mining shafts in the region have been obtained. In most cases such records are reliable within the ordinary limitations of such work and when properly interpreted have been of great assistance. In a few cases records given probably in perfectly good faith were obviously misleading, as for instance the record of the deep well at Uniontown.

In only one case was there a refusal on the part of a coal company to give logs of bore holes or other information, and in only one other case was information given in scanty measure. In all other cases every facility was given to gain such information as was desired from their records and to make any desired examination in their mines. Underground examination in some cases, however, could not be made because of the closing down of some of the mines as a result of the great depression in the coal trade.

In most cases free permission to publish logs and

other records was given, but in some few cases business considerations made it inadvisable to publish certain records just at present and though used in drawing general conclusions from, they are withheld from publication. To acknowledge the writer's indebtedness for information and many other courtesies would be to name nearly every coal company in the region and numerous private individuals besides, and would make a list far too long for insertion here. Two companies, however, deserve especial mention, not because they gave information more freely than many another company but because of the magnitude of their operations my indebtedness to them has been especially great. They are the St. Bernard Mining Co., of Earlington, and the West Kentucky Coal Co., of Sturgis. Mr. A. R. Long of De-Koven rendered valuable assistance by personally guiding the writer to the numerous points in that region made classic by Owen's studies.

GENERAL SECTIONS.

Surface tracings and bore hole and shaft records only demonstrate for the Tradewater area what is generally found true of coal measure rocks—that details of sections may vary much in short distances and that sections of the same beds as seen in the weathered surface outcrop and nearby core drill records may differ materially in the color of the shale or other material and in the presence or absence of limestone layers, such layers frequently not showing at all in surface outcrops. With this variation in detail, however, there is usually an equally well marked uniformity in the general character and often in the interval between certain members of the series that make them traceable over large areas and render correlation in such cases a relatively easy matter.

In the Tradewater region it has been possible to trace and identify over considerable areas many individual beds in the part of the section below the Anvil-rock sandstone but above this sandstone the various members

of the section lose much of their individuality and many of them are traceable with much less certainty.

The first detailed section made by the writer was in the Caseyville-DeKoven region where Dr. Owen's general section was made. It is as follows:

		Ft.	In.
1.	Sandstone, coarse, gritty, ribbed with thin ironstone layers, the Anvil-rock sandstone of Owen	36	..
2.	Shale, often rather a fire clay, up to	3	..
3.	COAL, at places up to 7 ft., about DeKoven probably often about or not over	1	..
4.	Shale, varies 0 ft.-10 ft., about DeKoven probably not over	4	..
5.	Limestone, thin around DeKoven, 0 to	4	..
6.	Black shale, about DeKoven	3	6
7.	COAL, NO. 11, average about	5	..
8.	Concealed shale interval, about	5	..
9.	Shaly fine grained sandstone	5	..
10.	Gray sandy shale with macerated plant leaves in first few feet over the coal	16	..
11.	COAL, NO. 10	2	10
12.	Fire clay, sandy	2	..
13.	Shale, lower part with ironstone nodules, upper part very sandy	56	..
14.	Black shale roof of No. 9	2	..
15.	COAL, NO. 9	5	..
16.	Fire clay	1	..
17.	Shale	6	..
18.	Thin, hard, flaggy sandstone	8	..
19.	Concealed about	60	..
20.	Coarse sandstone	12	..
21.	Concealed, about	50	..
22.	Massive cross bedded sandstone	16	..
23.	Concealed shaly interval	10	..
24.	Sandy shale	6	..
25.	Concealed shaly interval	12	..
26.	Sandstone and sandy shale	10	..
27.	Concealed shaly interval	8	..
28.	Roof over No. 6 of thin, micaceous, sandy laminae separated by shaly layers, with several thin laminae of coal	6	..
29.	COAL, NO. 6 of Owen	3	8
30.	Gray shale	23	..
31.	Black shale grading up in 1½ ft. to 2 ft. into blue black and then to lighter color, together	5	..
32.	COAL, OWEN'S NO. 5, or the "four-foot" vein, about	4	..
33.	Fire clay	1	6
34.	Sandy gray shale grading upward into a siliceous, gannister-like clay	8	..
35.	Concealed about	50	..
36.	Sandstone, medium grain, gently cross bedded, weathers into pockety recesses, forming a so-called bee-rock, Owen's Curlew sandstone, 15 ft. to 35 ft., say	25	..
37.	Concealed shale interval about	10	..
38.	COAL, with light colored clay and thin blue-black shale, seen only in surface creep. Owen's No. 4. Said by him to have two shale partings, and, including partings, to be	4	..

		Ft.	In.
39.	Shale with abundant ironstone nodules	20	..
40.	Concealed, shale interval, has a thin coal according to Owen, about	4	..
41.	Shale with limestone nodules abundant	20	..
42.	Thin shaly sandstone	8	..
43.	Concealed, probably shale	10	..
44.	Sandstone, hard, in layers 4 in. to 12 in. thick	8	..
45.	Shale interval, partly concealed, probably with a thin coal, about	35	..
46.	Sandstone, massive, weathers into large blocks	12	..
47.	COAL, hard, bright, clean	1	1
48.	Fire clay	1	3
49.	Dark blue shales	21	..
50.	Thin sandstone	3	6
51.	Thin, sandy, gray to drab shale with ironstone nodules	14	..
52.	COAL, "ICE-HOUSE" OR NO. 3 COAL. Opening now fallen in, said to be	2	6
53.	Shale, sandy at top	22	..
54.	Thin sandstone	8	..
55.	Concealed, probably shale, about	3	..
56.	Light gray shale	3	..
57.	Concealed, probably shale	8	..
58.	Sandstone, lower part with irregular shaly lenses, coal streaks, and shale breccia or conglomerate; upper part gently cross bedded, of alternating white and purplish laminae, medium grained; Finnie sandstone, 0 ft. to 50 ft., say	40	..
59.	Slate colored shale	16	..
60.	COAL NO. 2 of Owen	..	10
61.	Gannister	1	..
62.	Shales and thin shaly sandstone grading into shale, upper part poorly exposed	20	..
63.	Hard sandstone, moderately coarse, 10 ft. to Elsewhere as at Mulfordtown this sandstone may vary from 4 ft. to 16 ft. in a few rods, the thickening being due to cutting out the the underlying shales	20	..
64.	Fine dark shale	..	..
65.	COAL, pockety and very variable 0 in. to	14	..
66.	Conglomerate, rounded or subangular clay ironstone and shale pebbles, up to 3 in. diameter; rarely, rounded quartz pebbles up to 1 in diameter	..	10
67.	Shales, light, sandy	1	6
68.	COAL; Bell, Cook, Caseyville, or Battery Rock coal. Coal 1 B. of Owen 2 ft. to	20	..
69.	Light gray, crumbly, sandy shale with thin shaly sandstone layers	3	..
70.	Dark shale with clay ironstone nodules, part near the top being bluish-black and very thin, about	15	..
71.	Gray micareous silty shale with thin ironstone layers	25	..
72.	COAL 13 in. with 1 in. of thin rotten carbonaceous shale or coal rash at bottom, seen in the edge of Caseyville on the hill road south to the Tradewater river; in Caseyville at this horizon are found 6 ft. of thin carbonaceous shale. It is coal 1 A of Owen	3	..
73.	Light clay with 2 in. or 3 in. of gannister on top	1	2
74.	Concealed about	3	..
75.	Hard gray sandstone in 6 in.-10 in. layers	4	..
76.	Resting on the massive Caseyville conglomerate are thin shales interbedded with sandstone layers each a few inches thick	4	..
		5	..

The foregoing section is a composite one made up entirely from surface tracings and is reproduced in graphic form on the sheet of columnar sections. The lower part was obtained at various points in and around Caseyville, the middle portion in the region between Caseyville and DeKoven and the upper part at DeKoven or a mile west at Curlew. Frequently where several measurements were obtained of the thickness of the same bed they, as would be expected, were found to vary, sometimes considerably. The Finnie sandstone that makes a prominent 40 or 45 foot cliff along the road north of Mulfordtown is less than 15 feet thick a few hundred yards to the east and is scarcely recognizable in the road from Caseyville to Sturgis. In such cases the endeavor has been to give the average thickness where well developed.

The Anvil-rock sandstone caps the ridge north of DeKoven and all connection with the higher part of the section is lost in crossing the broad flats north of there. To connect the section above the Anvil-rock with that below it, it is necessary to take parts of some core drill records of the holes located in the northern edge of the Pond Fork flats some three miles north of Clay. The record above the mouth of these drill holes is continued by surface sections in the hills to the northeast of these drill holes, which are Nos. 20 and 21 of the West Kentucky Coal Co.

		Ft.	In.
1.	Coarse sandstone	12	..
2.	Coal and carbonaceous shale say	0	3
3.	Shale	20	..
4.	Sandstone	8	..
5.	Concealed	50	..
6.	Sandstone ..	10	..
7.	Concealed	18	..
8.	Shale	12	..
9.	Thin bedded sandstone	10	..
10.	Shale	2	..
11.	Coal	1	10
12.	Shale	20	..
13.	Massive sandstone, Dixon sandstone	35	..

		Ft.	In.
14.	Coal, at times a trace, say	0	2
15.	Shale	16	..
16.	Thin bedded sandstone	6	..
17.	Shale	18	..
18.	Thin coal	0	8
19.	Fine greenish shale, poor soil	50	..
20.	Soft thin bedded sandstone	10	..
21.	Concealed	6	..
22.	Fine shale, dark gray	22	..
23.	Concealed, shale interval	10	..
24.	Fine shale, dark gray	12	..
25.	Sandy shale	6	..
26.	Shale	20	..
27.	Coal, about	1	..
28.	Shale	8	..
29.	Concealed	15	..
30.	Fine dark shale	20	..
31.	Concealed, partly alluvial filling and partly dip calculation in offsetting down the dip from the well mouth to the surface hillside section to the northeast, about	120	..
32.	Sandstone, end of core record	20	..
33.	Shale	31	..
34.	Black slate	3	..
35.	Coal	0	4
36.	Fire clay	8	9
37.	Shale	57	..
38.	Bony coal	0	3
39.	Fire clay	5	..
40.	Shale	31	..
41.	Limestone	8	6
42.	Shale	10	3
43.	Coal	0	4
44.	Fire clay	5	8
45.	Shale	25	..
46.	Coal	1	..
47.	Shale	67	..
48.	Black slate	8	..
49.	Shale	108	..
50.	Coal	0	6
51.	Fire clay	1	6
52.	Sandstone	12	..
53.	Shale	20	..
54.	Sandstone	7	6
55.	Shale	2	6
56.	Limestone	5	6
57.	Shale	19	6
58.	Limestone	1	6
59.	Red shale	8	6
60.	Limestone	4	6
61.	Shale	9	6
62.	Sandstone	12	..
63.	Shale	102	6
64.	Coal	0	11
65.	Fire clay	1	7
66.	Shale and sandstone	31	..
67.	Baker coal, not far above Anvil-rock horizon	6	..

This section is reproduced in graphic form on the sheet of columnar sections in two parts, the first being the surface portion and the second the log of bore 20.

The highest rocks in the section above are found in the eastern edge of Union county, some two or three miles southeast of Boxville. It is possible that detailed work may reveal other rocks still higher in the series, but so far these are the highest known and they give to the Western Kentucky coal measures a thickness of 2065 feet above the top of the Caseyville conglomerate.

Surface exposures for about 150 feet below number 9 coal and again for about 100 feet below number 5 coal are almost always poor, so that the section just given contains blank intervals there. These might be partially filled out by composite surface sections taken from other points but it is probably better to give as a section the core drill record of the West Kentucky Coal Company of Sturgis to bridge these gaps in the foregoing surface section. This drill record extends from coal No. 9 down to coal No. 1B, or the Bell coal.

The bore is their number fifteen and is located a mile northeast of Grangertown. It is especially interesting in showing the existence of twenty or more coal seams below No. 9 coal at that point. The interval between No. 9 coal and the Bell coal is less than in the Caseyville region.

Condensed Log of Diamond Drill Hole No. 15 of the West Kentucky Coal Co.:

Elevation: Top, 381.1 feet above tide. Bottom, 373.48 feet below tide. Depth, 764.58 feet.

West Kentucky Coal Co's. D. D. Hole No. 15.	Ft.	In.
1. Surface alluvium	22	6
2. Soft coal blossom, edge of No. 9	0	6
3. Light fire clay	3	0
4. Soft sandstone	11	0
5. Black sandy shale	4	0
6. Black clay shale	23	3
7. Coal, with 1½ in. parting, No. 8b	3	1
8. Dark fire clay	2	9

Drill Hole—Continued.	Ft.	In.	
9. Dark shale with shaly sandstone partings	39	0	
10. Black shale	1	6	
11. Coal, No. 8a	0	3	
12. Light fire clay	6	3	
13. Sandy shale	4	0	
14. Light sandstone	10	0	
15. Clay shale	21	9	
16. Coal No. 6, (now locally called No. 7)	3	0	
17. Sandy fire clay	0	3	
18. Light sandstone	8	0	
19. Dark shale	43	0	
20. Black shale	2	0	
21. Coal No. 5, (now locally called No. 6)	4	3	
22. Light and dark sandy shale and fire clay, mixed	7	0	
23. Light sandstone	11	0	381.33
24. Dark shale, upper 16 in. sandy	22	0	
25. Black shale	3	6	
26. Coal	1	2	258
27. Dark fire clay	1	6	
28. Dark shales and thin sandstone	12	0	
29. Gray limestone	2	0	
30. Black shale	1	0	
31. Hard limestone	0	6	275
32. Coal	0	9	
33. Dark sandy shales and thin sandstone	26	3	302
34. Black shale	2	6	
35. Coal	1	0	
36. Dark sandy clay and gray fire clay	3	6	309
37. Gray limestone	2	0	
38. Dark fire clay	3	0	314
39. Gray and bluish sandy shale with 1 in. of sandstone	25	0	339
40. Gray limestone	1	6	
41. Fire clay	6	6	
42. Bluish fire clay	21	0	
43. Dark fire clay with coal seams	1	0	
44. Bluish fire clay	1	0	
45. Dark sandy shale	8	3	
46. Coal	0	6	
47. Dark sandy fire clay and shales	14	3	368
48. Coal	0	6	
49. Sandy shale, bluish and dark	10	6	
50. Coal	0	3	404
51. Dark sandy fire clay	2	9	
52. Sandy shales	32	0	
53. Dark limestone	3	0	
54. Oil bearing sandstone	11	6	
55. Coal	0	9	454
56. Light fire clay	4	9	
57. Bastard limestone	1	6	
58. Dark sandy shale	10	0	
59. Coal	1	0	
60. Dark sandy shale	49	0	
61. Dark clay shale	11	0	
62. Light sandstone with dark sandy partings	2	6	373.75

	Drill Hole—Continued.	Ft	In.
63.	Coal	1	9
64.	Dark sandy fire clay	2	3
65.	Light sandy shale	4	6
66.	Coal	1	9
67.	Brownish sandy fire clay and sandy shale	12	9
68.	Coal	0	3
69.	Bluish sandy shale	2	9
70.	Coal	0	6
71.	Light fire clay	2	6
72.	Bluish and dark shale, mostly argillaceous	30	0
73.	Light sandstone	26	0
74.	Dark sandy shale	7	0
75.	Dark fossiliferous limestone	2	0
76.	Dark clay shale with light sandy partings	10	0
77.	Light sandstone with bluish sandy partings	53	0
78.	Dark clay shale	7	3
79.	Coal	0	6
80.	Dark clay shale and fire clay	5	3
81.	Coal	0	6
82.	Light sandy fire clay	2	6
83.	Sandy shale and shaly thin sandstone	47	0
84.	Coal. Bell coal	4	1
85.	Sandy fire clay	0	9
	This section is given on the sheet of columnar sections.		

Another section of much interest is given in the log of the well at Bakersville, 8 miles northeast of Morganfield. It extends from above No. 12 coal to below No. 5 coal of Owen, now generally known in the region as No. 6.

Record of Cyclone Drill Hole Sunk at Bakersville, Ky., in 1907.

	Strata.	Ft.	In.
1.	Clay	12	..
2.	Wash	61	..
3.	Shale	4	..
4.	Sandstone	66	..
5.	Coal	0	8
6.	Clay	3	..
7.	Limestone	7	..
8.	Shale	1	8

	Strata.	Ft.	In.
9.	Coal	0	6
10.	Clay	1	..
11.	Limestone	5	..
12.	Slate	0	4
13.	Coal (No. 11)	5	..
14.	Fire clay	2	10
15.	Sand rock	37	..
17.	Shale	81	..
18.	Black slate	4	..
19.	Coal (No. 9)	6	1
20.	Fire clay	3	..
21.	Shale	52	11
22.	Coal (No. 8b)	2	..
23.	Shale	9	..
24.	———	24	..
25.	Coal (No. 8 a)	1	..
26.	Shale	6	..
27.	Sand shale	77	..
28.	Black shale (No. 6 interval)	66	..
29.	Blue slate	5	..
30.	Coal No. 5	4	6
31.	Shale	22	6
32.	Sandstone	31	..

This log is reproduced on the sheet of columnar sections.

With these sections before us it will be possible to comment on Owen's section and point out the few errors made by him in the part of his section below the Anvil-rock sandstone. Too little is as yet known about correlation in the upper part of the section to make a discussion of it profitable, and such discussion would have very little value for economic purposes, especially in the absence of any coal of known workable thickness above what may be called coal 14 as developed at Nebo.

It is clear from exposures in Caseyville that a few feet above the top of the Caseyville conglomerate and some 40 or 50 or more feet below the Bell coal there is a horizon occupied in the Caseyville region by a foot or more of coal in some places or by several feet of carbonaceous shale at other places. This would correspond to Owen's doubtful 1 A coal. Below it there is exposed at the quarry near the West Kentucky Coal Co.'s Ohio

river tipple a thin inter-conglomerate coal in a shale interval below the 50 or 75-foot bed of sandstone that forms the top of the conglomerate.

The Bell coal is the same as the Cook, the Casey and the Battery Rock coals as Lesquereux originally concluded. Owen confuses the names of two hills in the DeKoven region and has consequently caused confusion as to the prescence of certain coals in these hills. He seems generally to have regarded Curlew and Indian as synonyms applied to one hill near DeKoven but his various statements as to the coals that occur in that hill are inconsistent with each other and are not in actual fact applicable to any one hill there. Indian hill is some three fourths of a mile or more southwest of the DeKoven depot and is bordered on the south by the Ohio river flood plain. It must be the type locality for his Curlew limestone and sandstone and his No. 4 coal, but it is not the same as Curlew hill which lies northwest of the DeKoven depot and north of the Illinois Central railroad, and is a spur or part of the range of hills that extends from Anvil-rock eastward through DeKoven. The Curlew limestone and sandstone are not found in the real Curlew hill.

But one criticism so far seems warranted concerning the part of Owen's section above the Anvil-rock sandstone. He makes the distance from No. 11 coal up to the Carthage limestone too great, if the limestone visible at low water on the Ohio river a mile below Uniontown is the Carthage as seems likely. Instead of being 450 feet, it is only about 200 feet. It seems possible, however, that Owen may have correlated a higher limestone with the Carthage. At the time of the writer's visit to Uniontown the river was too high to allow the limestone to be examined or a collection of fossils to be made, so that the correlation can not yet be considered settled.

These various criticisms of Dr. Owen's work are few and unimportant either singly or collectively and leave the general accuracy of his section unimpaired.

The lower half of the general section given above at such length is more typical of the northwestern or Union

county portion of the Tradewater area than of the southeastern part of it. As one goes southeast from the Ohio river, changes occur in the thickness and character of various members of the section. There is, however, a decrease in the general surface relief in that direction in the area containing the measures from No. 11 coal down to the conglomerate and exposures are so much less satisfactory that the construction of a general section especially applicable to the southeastern part of the field is not yet practicable. Drill records there usually go down only to number 11 or number 9 coal and do not give the section below the latter coal except in the log of a deep well at Earlington. In this log the section which begins a short distance below number 9 coal has changed considerably and contains only thin coals, the higher ones of which may probably be correlated with coals 8b, 8a, 6 and 5 respectively, and possibly the limestone is at the Curlew limestone horizon, though this last can only be a suggestion at present.

This log was published in the Report of the Inspector of Mines for 1893 on page 102 and is reproduced here on the sheet of sections.

MEMBERS OF THE GENERAL SECTION.

The horizon of coal 1A just a few feet above the top of the Caseyville conglomerate is recognizable in natural exposure at several points about Caseyville and on the south side of the Tradewater river at least as far as Smallwood ford near Sullivan. There are usually a few inches of coal but in some places there is only black shale and the transition from one to the other may occur in a few hundred yards. In a gully by the side of the road going south over the hill from Caseyville to the Tradewater the 13 inches of coal exposed represents the maximum thickness seen. It is overlaid by a light fire clay and has an inch of thin rotten carbonaceous shale under it and under this are several inches of gannister. In Caseyville there are at this horizon 6 feet of thin fissile shale

the upper part brownish black, but grading down to black shale at the base but without coal.

The interval of about 40 feet up to the Bell coal about Caseyville decreases up the Tradewater to about 20 feet. It consists of soft shales.

The Bell or 1B coal is well developed in the lower Tradewater region. It has been mined in Mulfordtown and at several points in Caseyville. These openings are now fallen in, but a mile south of Caseyville on the Tradewater the West Kentucky Coal Company has recently re-opened one of the slopes of the old Caseyville mines. The coal is solid and averages 36 inches in thickness with usually an inch or two of thin carbonaceous shale or rash under it. It dips N. 25° or 30° E. about 6 feet in a hundred. Some three-fourths of a mile south of there, the same company cleared out the old Smith slope on the south side of the river and did considerable diamond drilling around it. The slope is driven in about 340 feet and the coal varies from 33 to 39 inches and the drill cores show a considerable area of 39-inch coal. The amount and direction of dip are about the same as at the Casey slope as given above. In bore number 9 a half mile south of Grangertown the West Kentucky company found the Bell coal 36 inches thick; while in their bore 15 a mile northwest of Grangertown it was 4 ft. 1 in. In the old Bell-Union slope No. 1 the thickness is reported to be 4 ft. 4 in.; in slope 3 as 3 ft. 4 in. A short distance east of there in the old Minor shaft it was said to be 4 ft. 6 in.; a mile south in the Fred Barnaby mine it is reported to average 4 feet. The several openings on Heath mountain were fallen in and could not be measured. Two miles southwest of Sullivan the Snead mines showed 36 inches in one opening and 38 in another.

Southeast of the Snead mine none of the several coals seen on the southern side of the Tradewater could be definitely correlated with the Bell coal, though detailed work may enable it to be traced some distance farther up the river.

It is not yet possible to correlate definitely any of

the coals about Dawson Springs, or east of there at Hamby's, Terry's, Wiggins', Empire or Mannington with the Bell coal or to fix their relationship to it. Until further evidence can be obtained by more detailed field study it seems best to hold the matter of the correlation of these coals in abeyance and to describe them by their local names. This description will be found on pages 58–62.

The Bell coal evidently has a thickness of three to four feet or slightly more over a very considerable area in the lower Tradewater region and although it is now neglected for other coals of greater thickness its very superior quality when compared with other coals of the Western Kentucky field make it certain that it must some day become an important source of high grade fuel. The coal is very pure and very low in sulphur and phosphorous for a west Kentucky coal so that it is probable that a good metallurgical coke can be made from it by appropriate treatment. Its calorific value is also high as compared with No. 9 and No. 11.

Over the Bell coal about Caseyville there are 10 to 20 feet of a grayish sandy shale called by Owen "gun metal" shale. To the southeast this thins and disappears and at one of the Snead openings above mentioned the coal is directly overlaid by 12 feet of sandstone.

Along the road east from Caseyville there is an almost continuous surface exposure for about 200 feet above the Bell coal. In this distance there are several coals each a few inches thick only and without distinctive characteristics. Some of these coals are absent in nearby exposures of the same interval. It is difficult to correlate any one of the sandstones in that road section with the Finnie sandstone that becomes so prominent a mile to the north of there on the road to DeKoven. It seems likely that it is represented in the road section by shale. About 140 or 150 feet above the Bell coal this road section contains some thin hard sandstones whose surface is covered with curved fucoidal markings that are very similar to the cauda-galli markings in the Devonian. These fucoid markings are found at one or

two other places, as notably at Kirkwood Springs, and they all probably belong to the same horizon.

It seems impossible to identify any one of the several thin coals as Owen's 1C. Such identification, however, even if made would be of no practical importance as none of them are of workable thickness.

Owen's coal 2 shows in a 10-inch seam some 16 feet below the Finnie sandstone in the first bluff on the road north of Mulfordtown, but it is absent in exposures along a branch a few hundred yards to the east, and on this same branch the Finnie sandstone is represented by 10 or 15 feet of inconspicuous sandstone instead of by the 40 or 50-foot cliff of the Finnie bluff. As seen in this bluff it is a medium, not a coarse, grained sandstone with gently inclined cross-bedding. Its base is shaly and is apt to contain lenticles of coal each several inches thick and a few feet long. In places the base is marked by a foot or more of conglomerate, the pebbles being of shale and one to three inches in diameter.

Coal 3, the Ice-house coal, is definitely known only at an opening now partly closed, in the woods two hundred yards north of where the Caseyville-DeKoven road crosses the branch 3-4 of a mile south of the DeKoven depot. It is not of commercial thickness.

The Curlew limestone is exposed at a number of places on the south side of Indian hill, some 3-4 of a mile southwest of DeKoven depot. It is a blue argillaceous crinoidal limestone with a little chert. No sign was seen of the thin coal said to underlie it. It seems possible that this limestone is at the horizon of the cherty limestone found in the eastern edge of Crittenden county two miles northeast of Shady Grove at J. M. Simpson's where it is 5 feet or more in thickness, is very cherty and overlies a 24 inch bed of coal beneath which at an interval of 3½ feet is another foot of cherty limestone. Over the main limestone there are 10 feet of sandy shale and over it 35 feet of soft micaceous cross-bedded sandstone that may represent the Curlew sandstone. Above this there are some 12 or 15 feet of light colored shale with a thin coal bloom and over this shale a good development of a hard dense fossiliferous shert, unlike the lower chert which is porous and cellular. Farther east and southeast chert is known to occur at a good number of places, usually close above or below a sandstone. These cherts are believed to occur at one or the other of these two known chert horizons. Chert is not elsewhere definitely known in the section except in the extreme southeast in the Mannington region and that may be at this same horizon also.

Aside from serving as an excellent key rock in tracing the general stratigraphy, in places where tracing is difficult, this chert serves as an economic guide as well since it is some distance below number 5 coal, the lowest coal now generally worked on a commercial scale. The chert outcrops at a number of points northwest, north and east of Dalton, for example, and again south of Beulah. It is also known at Montezuma Ford, Tweddleville, and in a fault crossing the road a mile slightly north of west from Kirkwood Springs. Southeast of Beulah it seems either to thin out and disappear in a few miles or to have been faulted so that it does not occur in surface exposure.

This chert is generally fossiliferous and it is hoped that a thorough collecting and study of the fauna may give additional confirmation to the correlations that are here made on stratigraphic grounds alone.

In Indian hill there was in Owen's time an opening on his number 4 coal lying between the Curlew limestone and sandstone, but this has disappeared today and the only evidence of coal there is a little coal smut and some thin blue-black shale seen at a number of places in more or less disturbed condition close beneath loose blocks of Curlew sandstone that are slowly slipping and working their way down hill.

The Curlew sandstone forms the brow of Indian hill and is there overlaid only by some 10 to 20 feet of loess. It forms a cliff 15 to 35 feet high, the higher part being in two benches usually. It is medium grained, generally of light color, but with some parts stained reddish or purplish by iron. Thin ironstone crusts occur through

it and stand out in relief as it weathers away, the softer areas weathering so rapidly as to form recesses or pockets or at its base cave-like shelters some 5 to 10 feet deep. The mass shows gently curving lines of cross-bedding inclined at low angles, indicating that the currents that laid it were feeble. It is probably represented by the prominent sandstone associated with the chert beds already described and traceable southeastward from its type locality in Indian hill at least to the region between Charleston and Beulah.

From the top of the Curlew sandstone the interval up to number 5 coal is almost entirely concealed in the DeKoven region. From the character of the topography the entire interval must be largely shale as are the few feet visible just beneath number 5 coal where it outcrops at the depot at DeKoven.

The coal now generally known as number 6 throughout the Tradewater region is the same as Owen's number 5 of his 4-foot coal and will be called here by Owen's original name. This coal was long mined at DeKoven but the drift has recently fallen in. On the natural outcrop there it is underlaid by 1½ feet of apparently a good quality of fire clay and has over it a prominently developed black shale. This shale looks very much like the shale over number 9 coal but has in it no rounded siderite or pyrite concertions such as characterize the roof of number 9 coal, and other differences occur which will be noted below.

Three miles west of Sturgis this coal is mined by the Crittenden Coal and Coke Co. There it has an average thickness of 3 ft. 10 in. and is without partings. Immediately over the coal there is generally an impure ferruginous limestone some 4 or 5 inches thick. When fresh this is dark blue and solid but on exposure it turns to a rusty brown and soon crumbles to pieces setting free a goodly number and variety of often well preserved marine fossils. This fossiliferous limestone was found in every mine opened on number 5 coal. Above it there are 8 inches of thin black shale, then 12 inches of lumpy,

dark gray shale and then 12 inches of thin black shale again at the above mine.

These black shales generally weather into thin small fragments and not into large sheets as do those over number 9 coal.

This coal has been mined on a commercial scale at Sullivan and southeast of there has been opened at a number of country banks as far as Belleville near Providence.

About DeKoven and from Sullivan to Belleville number 5 coal crops out near the base of a somewhat irregular and broken but very prominent line of hills some 150 to 180 feet high. These hills are really an escarpment facing to the southwest and formed by a very resistant sandstone usually 15 or 20 feet thick that crops on the brow of the escarpment and dips gently to the northeast with the general surface slope in that direction.

This escarpment is a prominent feature of the topography seen well developed near Hopewell church, at Belleville, and at Yarbro, but a mile southeast of the latter place it suddenly dies away just after reaching Clear creek.

After a gap of two miles the prominent scarp reappears at Stony Point in line with the scarp previously traced and may be followed southeastward along Frazier's ridge to about a mile northwest of Beulah where it again disappears. Both the gap in the line and the final disappearance are caused by block faults. In the case of the gap south of Providence the intervening block is down faulted so that number 9 coal crops at Stony Ridge church in line with the scarp over number 5 coal and this scarp is displaced three miles southwestward and is found well developed at New Hope church. The faulting that ends the escarpment near Beulah is more complex and will be discussed on a later page. Although not opened, number 5 coal must be near the surface at Yarbro and at the base of the Stony Point and Frazier ridges, as well as at the base of the ridge southeast of New Hope church. In each of these four places number 6 coal, which is but a short distance below the sand-

stone that forms the brow of the escarpment is seen outcropping in natural exposure. A half mile southeast of Hopewell church, at the nearest place where both are exposed the interval is about 90 feet from 6 down to 5.

On the very bank of the Tradewater river two miles northwest of Kirkwood Springs a country bank was formerly worked by Mr. W. W. Wilson with one and a half feet of thin black shale and 3 inches of ferruginous limestone over a coal reported to be 3 ft. 10 in. thick. The calcareous layer readily disintegrates and contains marine fossils like those elsewhere associated with number 5 coal. The exposure is on the side of a down-thrown fault block and is very limited in extent. When visited the opening had fallen in. A few marine fossils were found on the dump pile. About 15 feet above the coal there is a 15-foot cliff of sandstone such as is found in some places associated with number 5 coal. It would seem most probable that this Wilson opening is on number 5 coal and if so it is the fartherest point up Tradewater at which it has been identified with any approach to certainty.

From the Wilson opening eastward for several miles the region is broken by a number of faults. At Mr. J. P. Lutz's a small block of number 9 coal is down faulted and near and east of Heburn school there are one or more blocks, also down-thrown, with number 9 and number 11 coals. These will be further described in later pages under the heading of faults.

The interval from number 5 coal at DeKoven up to number 6 is a practically continuous exposure of 28 or 30 feet of shale. Toward the southeast this interval increases. In the West Kentucky Coal Co.'s bore 15, one mile northwest of Grangertown, the interval is 53 feet and is partly sandstone. Just north of Sullivan it is 40 feet and all shale. Southeast of Hopewell church, as previously stated, it is 90 feet and partly sandstone. If correlations are correct it is 50 feet in the deep well at Earlington.

Number 7 coal as now generally called, but as called by Owen and throughout this report number 6, or the

three-foot coal, was formerly mined by the Ohio Valley Coal and Mining Co. at the depot at DeKoven. Near the mouth of the main entry there the coal is 44 inches thick, the upper part having many thin mother-of-coal or mineral charcoal partings. Over it is an inch of thin carbonaceous shale and over this 4 or 5 feet of thinly laminated and gently cross-bedded soft, gray, micaceous shaly sandstone containing many macerated leaf fragments. Over this are four alternations each of coal, pure or bony, and gray shale in layers of from a half to two inches each, above which there is gray shale. Beneath the coal there is a sandy, gray clay containing some carbonaceous matter. At no other place in the field is this coal known to be near so thick and clean and at no other place has it been regularly mined, although in several places openings have been made on it. In bore 15 of the West Kentucky Co. near Grangertown it is 3 feet thick and underlaid by sandy clay. It shows in the road a half mile north of Sullivan as a 2-foot bloom. Southeast of Hopewell church it shows in good roadside exposure as 7 inches of coal overlaid by 20 inches of thin rotten carbonaceous shale, under it are 2½ feet of sandy gray clay. This crop is just beneath the brow of the steep scarp described at some length in discussing coal 5. Two miles west of Providence openings have been made in it at several places just north of Grove church. At none of these places could it be measured. Part of the black shale roof over it there is hard and massive and part is thin and rotten and crumbles easily. It has also been opened in several places about a fourth to a half mile northeast of Yarbro and shows a thin coal very variably broken by partings and vertical slips of clay and sandstone. It is overlaid there by several feet of thin black shale. It is again exposed in the road on both the north and south sides of the hill a fourth of a mile east of New Hope church and again on the hill-side just below the road a mile southeast of there in the down faulted block previously mentioned.

It shows at Stony Point in the road just west of the cliff forming the "point" and again at several places in

and out of the roads on the brow of Frazier's ridge. It is probably the 30-inch coal with one inch parting in the deep well at Earlington.

In bore 15 of the West Kentucky Coal Company coal 8a is 42 feet above coal 6. The upper half of the interval is largely occupied by the sandstone that in surface exposure usually forms a low cliff 10 to 15 feet high that caps the escarpment over number 5 and 6 coals. This sandstone is seen well exposed on top of the hill just northeast of the DeKoven depot and occupies a similarly prominent topographic position on the scarp southeastward to Stony Point and Frazier's Ridge as has been described in some detail when describing number 5 coal. In the region about Green Grove church the prominent sandstone between coals 5 and 8a is nearer the lower coal, and frequently has lepidodendron and other plant impressions. The interval up to coal 8a is fairly well exposed in the road toward Ruff. It is a light colored shale with thin layers of very fine hard siliceous sandstone at intervals through it.

Coal number 8a is nowhere of commercial importance and is seen in surface outcrop in only a few places. Near Providence it is exposed a half mile west of Ruff on the road to Green Grove church. The section there as naturally exposed is as follows:

	Half-Mile West of Ruff.	Ft.	In.
1.	Dark brown carbonaceous shale, rotten, papery	4	..
2.	Coal, dirty in lower part	2	..
3.	Fire clay	0	1
4.	Dark brown-black carbonaceous shale	0	8
5.	Fire clay floor	..	..

In bore 15 it is only 3 in. thick with 18 in. of black slate over it and dark clay shale over that . In the Earlington deep well it is probably the 12-inch coal near the top of the section.

At Grangertown there is a coal exposed for some distance along the river bluff that is probably to be referred to 8a. The section there in descending order is as follows:

	At Grangertown.	Ft.	In.
1.	Sandy shale, weathered	3	..
2.	Shale, at top leaden gray, grading down to dark gray, with small limonite or hematite clay-ironstone nodules that contain marine fossils	10	..
3.	Black shale	0	4
5.	Coal	0	4
6.	Fire clay	2	6
7.	Lumpy, micaceous soft white gannister	3	..
8.	Ledgy, gently cross-bedded sandstone	7	..
9.	Very sandy shale, thin	6	..
10.	Dark shale	12	..

If the above thin coal be correctly referred to 8a, the most western exposure of 8b known to the writer is in the L. & N. railroad cut at Ruff station just west of Providence. The most important feature there is the black shale that overlies the thin coal and this shale is equally or even more prominent at all other places where there are exposures at this horizon.

In this cut beneath a lighter colored shale the following section occurs:

	At Ruff Station.	Ft.	In.
1.	Thin black shale	..	12
2.	Massive, slabby black shale	..	16
3.	Thin black shale	..	7
4.	Coal, bright and clean	..	6
5.	Thin soft carbonaceous shale	..	2
6.	Sandy gray fire clay	3	..
7.	Hard, white, flinty, rather nodular sandstone	2	..

The massive black shale in the above section contains large strap-shaped leaf impressions, while the thin black shale contains some poorly preserved marcasitic invertebrate fossils. The interval there up to coal 9

is between 50 and 60 feet, that down to coal 8a is between 35 and 40 feet. West of there no exposures of 8b are known but borings show it to be 42 feet below number 9 at DeKoven and at Sturgis.

Two miles south of Providence an exposure of coal 8b in a field shows in descending order;

Two Miles South of Providence.	Ft.	In.
1. Black shale	1	6
2. Gray shale	0	8
3. Thin black shale	0	3
4. Coal	0	6½
5. Dark gray shale	0	2
6. Coal	0	4
7. Dark fire clay	5	0
8. Gannister	7	0

The next exposure of what is regarded to be this same coal is found near Beulah church. Close beneath coal number 9 which is exposed at several places, there is a massive cliff-making sandstone some 40 to 60 feet thick and either immediately beneath it or with a few feet of shale intervening there is a coal that is here correlated with 8b. About 500 yards northwest of Beulah church a small stream has made an amphitheater-like recess in the cliff face of the sandstone which there rests directly on 10 inches of coal, beneath which are 2 inches of very hard clay, and then 33 inches more of coal are exposed without reaching the base. In a few yards the sandstone cuts deeply into the coal and may cut it out entirely. A mile south of the church on the slope of the hill overlooking Lick Creek valley the same coal has been opened in a field. Below 40 feet of soft coarse sandstone there is a concealed interval of 8 feet, then 4 feet of micaceous sandy gray hale, 12 inches of coal, 1 inch of carbonaceous rash, 21 inches of coal and beneath that there is a sandy, micaceous, gray shale floor. At another poorly exposed opening near by the sandstone rests directly on the coal.

It will be seen that there is no heavy black shale here over this coal such as is usually found over 8b. It is the first coal, however, beneath number 9 and while it is possible that 8b is absent and that this represents a lower coal, yet there is no positive evidence for such a view other than the dissimilarity of the sections and it is as different from 8a as it is from 8b.

On the Richland road two miles east of Beulah and just east of Silent Run a coal is exposed by the roadside that is probably 8b, and several other exposures of a similar thin coal just beneath a sandstone in the region southeast of Beulah and on the head of Richland creek may also be coal 8b. Exposures, however, are poor in that region and there is known to be some faulting there so that definite correlations are not yet possible.

In the Crabtree-St. Charles region what is regarded as 8b is exposed in a number of places at what appears to be an interval varying from 40 to 70 or occasionally perhaps over a hundred feet below number 9. At these exposures there is little or no coal but the horizon is prominently marked by a black shale that is sometimes 4 or 5 feet thick and usually splits out in sheets several feet across. It may be seen along a stream some three-fourths of a mile northwest of Crabtree and a few hundred yards south of the road to Charleston. It is well exposed a mile southwest of Crabtree on the main road to Dawson Springs and again about a mile northwest of this latter exposure along a poor country road also leading to Dawson Springs. About a mile southwest of St. Charles what is taken to be the same massive black shale has been prospected along a gully in the woods just east of the Buttermilk road about half way up the hill just south of the railroad. An almost east and west fault occurs just south of the exposure.

Coal number 9 is the most reliable in occurrence and the most uniform in thickness and character of any coal occurring in the field. Of all of the coals that occur widely in this field and are now mined it is the most excellent in quality. It is one of the most widespread in its occurrence of all of the coals in the United States, being

found in Kentucky, Indiana and Illinois over an area, as Ashley has recently pointed out,* of 25,000 square miles, while the Pittsburg coal, also noted for its persistency, covers an area of only some 6000 square miles. In quality it is surpassed only by the Baker coal mined by the West Kentucky Coal Co. a description of which will be given on a later page, and by the Bell coal which is not now mined.

Throughout the area examined, number 9 coal is overlaid by several feet of black shale with concretions of pyrite or more frequently siderite that usually project somewhat down into the top of the coal. These concretions are sometimes rounded but they are more frequently lenticular, especially when large, and range in size up to several feet in diameter. In mining they may either come down or remain attached to the roof. The black shale in which they are imbedded contains fossils in many places. These may be pyrite or more frequently marcasite or merely impressions of the form. They consist of marine invertebrates and impressions of the plates, teeth and spines of fish. At the Barnsley mine of the St. Bernard Coal Co. there are between the coal and black shale 6 or 8 inches of drab shale that is full of crinoid stems.

The coal itself is free from partings and "troubles" and its thickness over much of the area varies but slightly from 4 ft. 10 in. This means that rolls are absent from both roof and floor and that during its deposition conditions were very uniform over wide areas. It is more extensively mined than any other coal in the area examined.

The position of its outcrop line throughout much of the distance across the southwestern border of the basin is very well known. Beginning at the northwest, it rises above the Ohio flood-plain level between the Anvil-rock and the mine at Curlew, Ky. About DeKoven numerous old openings along the lower slope of the hills show its horizon and it is extensively worked by the Ohio Valley Coal and Mining Co. It is mined by drift and

*Ashley. G. H., Thirty-third Ann. Rept. Indiana Dept. of Geol. p. 93, 1909.

shaft at Sturgis and crops have been opened by drifts in numerous places along the southern slopes of broken hills between there and Providence, and at a number of places just back from the outcrop it has been opened by shaft or reached by bore holes. Throughout this distance from Curlew to Providence there is little complication caused by faulting. Faults are known to occur in this interval but they are generally of such slight throw that they are of no practical consequence except near Clay where there is reported one of about 50 feet throw that has hindered development along its line.

From just south of Providence southeastward to Ilsley, St. Charles and Nortonville the outcrop of number 9 is complicated by extensive block faulting. Some of these fault lines have been located during this reconnaissance and closely detailed work will doubtless reveal others but surface exposures are generally so poor in that region that others are doubtless completely hidden and can be revealed only by extensive drilling or underground development. The known outcrops will be given here and the faulting will be discussed on a later page. It crops in Providence and the hills a mile or a mile and a half south of there. From there southwestward its normal strike crosses the extensive low lands along Clear Creek and its tributaries and outcrops do not again appear along this line until the Silent Run region is reached some 7 miles away, where a number of openings are found in the hills around Silent Run church and southward to Beulah church.

Five miles south of Providence, however, number 9 coal crops and is mined at country banks near Stony Point church. This crop is in a down-faulted block whose edges are largely concealed by the alluvial filling of the Clear Creek flats.

A half mile south of Heburn School and again a half mile northeast of Kirkwood Springs number 9 coal is opened at country banks in down-faulted blocks whose outlines are not fully known but which are each believed to be of small area.

This coal underlies the hills between Silent Run and

Richland creek north of the Beulah-Richland road. It crops some 20 to 40 feet above the level of the flats in several places and its position is indicated in others by the outcrop of number 11 coal which is there about 80 or 90 feet above number 9.

In the hills just north of Richland it is just about or a short distance beneath drainage level as number 11 is opened at several places 60 to 80 feet above the flood plain. It underlies Fort Ridge cropping near the base of its southern slope at R. D. Smith's bank and at other points eastward to the Hecla mine at Earlington and east of there passes out of the area under consideration.

The crop line of number 9 thus runs southeastward from Curlew to Silent Run and thence eastward to Earlington. As the dip is northeastward in toward the center of the basin, the coal rises into the air to the southwest and south of the line just traced. Some small outlying areas due to down-faulted blocks have already been mentioned and south of the Silent Run-Earlington crop there is an extensive and valuable area of number 9 coal in the region extending east from Crabtree to Nortonville and north to Barnsley. The existence of this area is due to down-faulting in its western and middle portions and either to a slight down throw in its eastern part between Barnsley and Morton's Gap or to a flattening and reversal of the general northward dip there for some distance.

This area is not one down-thrown block but is divided by faults into several blocks each of which is displaced with reference to adjacent blocks. Some of these blocks are sufficiently large to contain valuable areas of coal, some of which have been mined for years. In other places attempts at mining have failed because of the faults. Good exposures are rare and the difficulties of reconnaisance were increased by the absence of a topographic map.

The most westerly occurrence known in this area is found a mile and a fourth southeast of Charleston. A very poor exposure in the road from there to Ilsley may be the crop of number 9 coal, since number 11 is well

exposed a short distance to the southeast at the old Blackwell openings and of course number 9 underlies it though there below drainage level. The size and shape of this area are not yet known. Southeastward this coal is known again in an isolated area a mile to a mile and a half west of Crabtree. At Crabtree there is a considerable area that is being mined. The Carbondale area just east of there is mined out, and the company has opened new mines a mile and a half northeast of there at New Carbondale. At St. Charles a considerable area has been worked out and a new mine has been opened on the head of Fox Run two miles to the northeast. Eastward and northeastward from Fox Run number 9 coal underlies the higher hills and ridges to Oak Hill, Morton's Gap and Barnsley. Between St. Charles and Daniel Boone number 9 occurs but is much faulted. At Daniel Boone there is an area of number 11 now being mined by a slope but no attempt has been made to open number 9 there.

From there east to Nortonville there is some faulting but how much is not yet known. In a few places number 9 occurs but it is probably not in blocks of sufficient size to work.

At Nortonville number 9 coal occurs in two blocks each of which has been faulted down sufficiently to carry number 11 coal beneath the surface. This latter coal is worked by shaft in one block and by slope in the other, but number 9 is not opened. North of these down-thrown blocks at Oak Hill a mile and a half north of Nortonville, number 9 crops some distance above drainage level and lies almost horizontal for some distance northward.

West of St. Charles the southern limit of number 9 coal lies north of the Illinois Central railway and mostly north of the highway to Dawson Springs as well, except probably for a small area very near St. Charles where the fault that delimits it on the south lies a short distance south of the railroad. East of St. Charles the southern limit of number 9 coal generally lies a short distance south of the railroad and may extend continuously thus eastward to Nortonville or beyond, although but little

is yet known of it in part of the distance from Daniel Boone to Nortonville beyond the fact that it is broken by faulting so that it is doubtful if there is much if any mineable coal south of the railway except at Daniel Boone, and the exact limits there are not yet known except that a fault about 1200 feet south of the Daniel Boone mine cuts off the coal to the south of it.

The general topography as well as the faulting of this Crabtree-Nortonville-Barnsley area is complex and the actual area of number 9 coal can only be determined by much detailed work and can only be represented adequately on a topographic map.

Coal number 10 at DeKoven is about 55 feet above number 9, the intervening section being nearly all shale. The upper half of the interval there becomes a sandy shale and near the top of it there are some thin shaly sandstones. This coal varies at DeKoven and Curlew from 30 to 36 inches but averages 34 inches. These are the only placees where it is known to be of workable thickness. In some places it is only a few inches thick and at other places it is absent altogether. It is known at DeKoven as the Briar Hill coal. At the F. G. Banks mine it is 34 inches thick with a roof of sandy shale full of macerated plant remains. It is underlaid by a sandy, micaceous under-clay.

Coal number 11 is, next to number 9, the most widely mined and most valuable coal in the area. Its average quality is not quite so good as number 9 and it is less reliable in its occurrence, being absent in some places, as will be noted below, and in others varying in thickness from rolls and horsebacks and being subject to clay slips and "troubles." It is nevertheless mined on an extensive scale side by side with number 9 and is shipped to the same markets in direct competition with the latter.

It shows its least average thickness and is of poorest quality in the DeKoven region. At Curlew it is poorly exposed at several places and shows about two feet or slightly more of cannel, part of which is bony. Under this are 2 to 6 inches of clay and beneath it are some 3 or 4 inches of bituminous coal. In all other parts

of the field it is a bituminous coal averaging 5 to 7 feet in thickness and is generally divided into a top, a middle, and a bottom bench. The top bench is the best quality and is known as the Shop coal. It varies from 10 to 19 inches in thickness. The parting beneath it is usually a sulphur band though occasionally it is a clay and is always very thin, varying from a knife blade up to a half inch. It is occasionally absent thus uniting the top and middle benches. The middle or main bench varies from 26 to 36 inches and the bottom from 10 to 32 inches. Between these is a hard clay parting known as the blue band. This averages two inches in thickness and is invariably present. The bottom coal is generally of poorer and more variable quality than the main coal and in one or two places has such high ash and sulphur that at least the lower part of it is not removed.

The coal is overlaid by a few inches to a foot or more of soft shaly clay—usually called gob—or by a combination of gob and black slate, the latter being next to the coal, and the gob and slate together generally averaging 18 to 32 inches in thickness. In a few places, however, the black shale may become 2 or 3 feet thick and resembles very much the black shale over number 9, even to the extent of containing similar fish spines and dermal tubercles or ossicles. Moreover, when the black shale is so thick the overlying limestone that is usually present and serves as one of the usual ear-marks of number 11 coal may be absent, thus increasing the chance of confusing it with number 9. The black shale over number 11 rarely contains large lenticular concretions usually known as niggerheads, and the blue-band clay parting is never absent in number 11 coal and never present in number 9. Furthermore, where the black shale is thickest there is usually a prominent development of the coarse, massive, cliff-marking Anvil-rock sandstone a very short distance above the number 11 coal, while there is no correspondingly prominent sandstone above number 9 coal in the same region. The black shale over number 11 coal, along with the Anvil-rock sandstone, are usually well developed near Daniel Boone, and from

Fox Run northeastward to Morton's Gap and Barnsley.

In the usual section there is a limestone above the few inches of gob or gob and black shale that overlies number 11 coal. This limestone is usually compact and fine grained and weathers to a light gray color. It usually contains some fossils, among which fusulina is characteristic and so far has not been found by the writer in any other limestone in Kentucky, although in Iowa and Missouri it ranges through a considerable interval. Its value as a horizon marker, however, is greatly diminished by the fact that number 11 coal carries its own characteristic ear-marks in its sulphur and blue bands.

This limestone is usually 5 to 8 feet thick and makes an excellent roof. Occasionally there may be areas a few yards in extent where it thins down to a few inches and then gives trouble by coming down.

Under number 11 there are several feet of fire clay that is firm enough if a mine is kept dry but where water is allowed to stand on it for some time may soften and creep so as to allow pillars to sink down into it and thus close entries or other openings.

The interval from number 9 up to number 11 is greater in the northwestern part of the area examined than in the central and southeastern. It is 119-125 feet in the Uniontown and Morganfield region and in the DeKoven region it is 95-115 feet. Elsewhere in the region the interval is usually only 80 to 90 feet. As the dip to the northeast or north is rarely as much as 6 or 8 feet per hundred and usually not over half that amount, the outcrop of number 11 coal lies just northeast or north of the outcrop of number 9 and were it not for topographic variations would be parallel to it.

At Spring Grove 6 miles southwest of Morganfield a coal outcrops—and was formerly worked—that is said to be number 11. It was nowhere accessible for observation but the identification is probably correct for a mile east of there number 11 coal is worked by a 60-foot shaft and dips between the two places are apparently very slight.

It is exposed close beneath the Anvil-rock sandstone

in a number of old openings about the Curlew mine. At DeKoven it crops close beneath the top of the hill a few hundred yards above the outcrop of number 9. and a small area of it on top of the hill near the Ohio Valley Company's breaker has been worked out by them. Southeast of there its outcrop is concealed by the loess on the uplands and by the alluvial filling in the valleys until near Wheatcroft, where it outcrops in a number of places and is being actively mined by the West Kentucky Coal Company.

It was formerly mined by a drift at Toga, and after an interval of two miles or more about Clay where it is wanting as will be described more fully later, it reappears in the hills some three miles northwest of Providence and has numerous openings from there through Providence and a mile to the southeast before it disappears beneath the Clear Creek flats. It reappears at Nick Parish's probably because of elevation from faulting west of there. Two miles northeast of Rocky Point it is exposed and was once opened just on the southern edge of the Clear Creek flats in the southern edge of a downthrown fault block.

It catches under the very tops of the hills just east of Silent Run church and extends south to near Fiddlebow School. It crops in the upper part of the hills just east of Silent Run, and just north of Richland and in Fort Ridge. It crops low in the hills around Earlington and is extensively mined there by the St. Bernard Coal Company. On the north side of Clear Creek it is slightly above flood plain level from the mouth of Greasy Creek where it is opened in two places, eastward practically to the head of the creek just north of Earlington.

In describing the occurrence of number 9 detailed mention was made of the extensive outlying area on the southern edge of the field in the Crabtree-St. Charles-Nortonville region. In part of this area the hills rise high enough to include number 11 coal in areas large enough to be workable, while in other parts downthrown blocks have carried number 11 coal beneath present drainage level and preserved it from erosion.

A mile and a half east of Charleston number 11 coal is exposed at the old Blackwell mine and may be seen at several other nearby places south and southwest of there. It may extend some distance east of the Blackwell mine though its exact eastern limit is not known. To the north it is soon delimited by a fault with strikes slightly north of east. Northwest of Crabtree it catches beneath the uplands and extends eastward toward New Carbondale though its eastern limit has not been determined. At Fox Run it has been opened above number 9 coal and is known from numerous openings to underlie a considerable area of the high ridge north, northeast and east of there. Its northern limit is determined by a fault that runs N. 75-80 E. and passes somewhat less than a mile north of New Carbondale.

Number 11 coal again occurs in one or more downthrown blocks that lie south of a fault that passes through St. Charles and has a strike of N. 80 E. and may be traced a mile or more eastward and may extend beneath the flats on to Nortonville and beyond. It is exposed in one of these blocks about a mile west of St. Charles at the old Woodruff place on the road to Dawson Springs. Just west of the Woodruff exposure it is cut off by a north-south fault. Between St. Charles and Daniel Boone it is again exposed at several places a short distance south of the railroad. At Daniel Boone it is worked by a slight slope and a half mile northeast of there is exposed near the railroad. Farther east toward Nortonville it occurs, at least in places, south of the railroad but it is probably badly broken up by faults, as is indicated by drill records. A nearly east-west fault or series of closely parallel faults runs just south of St. Charles, Daniel Boone and Nortonville, and makes the extreme southern limit of number 11 coal.

At Nortonville number 11 is mined in a downthrown block, whose southern limit is 800 to 1000 feet south of the I. C. R. R. and whose northern one is some 1000 feet north of it. Both fault lines run approximately N. 80 E. North of this block is another that is terminated on the north by another east-west fault at Oak Hill. The

Nortonville Coal Co. mines the southern block by shaft and the northern one by slope. North of Oak Hill number 9 coal occurs some 90 feet or more above drainage level. For further discussion of this faulting see page 72.

Just north of Barnsley it crops in the Madisonville road and underlies the range of hills that extends northeast from there some four miles to the lowlands along Flat creek. The last opening on the northeast is Doc. Littlepage's and is only 12 feet above the flats.

Absence of number 11 Coal. Extensive borings as well as shaft records show that in the vicinity of Clay number 11 coal is absent. It is mined northwest of there at Wheatcroft and has been mined at Toga, at both of which places it is of normal character and quality. At the Baker shaft, however, it is absent and in the old Blackwell shaft in Clay it was also absent, but following the outcrop line southeastward to the present Blackwell mines three miles southeast of Toga number 11 is found again, although it is very thin, is not worked and the opportunity to study it was poor.

The absence of number 11 coal here may be due either to non-deposition or to erosion shortly after its formation while Carboniferous deposits were still being formed. If its absence is due to non-deposition it would mean that the continuity of the coal basin in which it was formed was broken here either by a land area that rose above the coal swamp level or by an open water area. If the former were the case it is probable that the coal near the edge of the basin would show signs of thinning, or of increasing impurities or other variations due to close proximity to the edge of a basin. If the latter were the case the margin of the coal swamp next the open water would probably thin as the beach line was neared and would certainly show a mingling with sand or clay from wave or tidal action. So far as is known there is no change in the character of number 11 as it approaches the area in which it is absent.

It is believed that its absence is much more probably due to its having been cut out shortly after deposition. In this same area there is a massive sandstone to be seen

at Fairmont, for instance, resting on the 30 or 40 feet of shale that overlies number 9 coal while a short distance away at the Johnson opening this sandstone has cut down through the shales until it almost rests on the coal. It is possible that there was an old Carboniferous river channel there soon after number 9 was formed and that it either persisted or again extended along there shortly after number 11 was formed. Surface exposures are poor because of the soil covering, and the dip to the north-northeast is strong enough to carry its horizon in a short distance beneath the limits of any bore holes yet put down there.

Again, in the region about midway between Providence and Nebo and also in the region between Nebo and Clear Creek flats, drill records indicate the local absence of number 11 coal, although other nearby records indicate its presence and outcrops so far as they have been traced show it to be of normal character, so that it is somewhat doubtful at present as to how much of this seeming irregularity may be due to defects in the churn drill records—which are unsatisfactory at best—and how much may be due to actual irregularities in the coal. In strong contrast to the various irregularities that have been noted in number 11 coal are the persistent occurrences of the thin sulphur band in the upper part of the coal and the universal presence of the blue band in the lower half wherever the coal is found.

Number 12 coal lies close above the limestone that overlies number 11 coal. The limestone separating these two coals and the gob and shale that usually accompany it vary considerably in thickness so that the interval between coals 11 and 12 may be no more than 2 or 3 feet or may be as much as 20 to 27 feet. The average interval is 6 to 12 feet, but variations in interval may be rapid and irregular. Number 12 coal itself is generally very unreliable in thickness and is not worked at present anywhere within the Tradewater basin. Shafts and drill holes go through it without paying much attention to it so that opportunities for determining its quality or character were not good. It may be only a few inches

thick at one place while nearby it is 4 to 7 feet thick. The average thickness, so far as any average can be given for so variable a coal, may be taken as 2 to 5 feet. It may be solid or may have a clay parting in the middle of the lower half. There are usually from a trace to a few inches of thin carbonaceous shale at its base and over it are generally one to three feet of fire clay. This fire clay may be overlaid by shale but in a few places there are one or two feet of thin shaly limestone over it as may be well seen in surface exposure one and a half miles southwest of Beulah. In other cases, the overlying clay may contain one or several stringers of bright clean coal each an inch or two in thickness. Frequently the coal is bony and unfit for use. In places, especially near Providence, it is more promising in thickness and quality and might possibly be mined were it not for the presence of the much more reliable number 11 coal only a few feet beneath it.

At Baker shaft about half way between Wheatcroft and Clay number 9 coal was formerly mined at a depth of 215 feet. It was only 4 feet 4 inches thick and is said to have contained some gas. After working for some time it was decided to investigate the quality of what was supposed to be number 11 coal which though 6½ feet thick had been passed in sinking the shaft without receiving much attention. The quality was found to be excellent and this with the nearness to the surface and greater thickness caused it to be developed and number 9 to be abandoned.

It was soon found that the coal section was very peculiar for number 11 in that it was underlaid by thin flaky carbonaceous shale, showed no sulphur or blue band, was overlaid by fire clay, and instead of having the limestone over it, had it beneath it. These and other peculiarties will be seen more readily from the following log of the shaft which though given from memory is believed to contain no material errors.

Log of Baker Shaft.

	STRATA.	Ft.	In.
1.	Soil	12	..
2.	Tough clay, hard pan	4	..
3.	Quicksand and blue muck	6	..
4.	Yellow clay	6	..
5.	Sandy shaly rock	2	..
6.	Coal	1	2
7.	Fire clay	4	..
8.	Gray sandy shale	47	..
9.	Fire clay	1	6
10.	Coal	6	6
11.	Thin flaky carbonaceous shale	3	..
12.	Fire clay	7	..
13.	Limestone boulders in fire clay grading into limestone below	15	..
14.	Limestone	12	..
15.	Gray sandy shale with streaks of hard sandstone in lower part	51	..
16.	Gray shale	30	..
17.	Black slate	3	..
18.	Coal, typical number 9	4	4
19.	Very hard fire clay	1	..

Some 400 yards northeast of the Baker shaft diamond drill hole number 2 of the West Kentucky Coal Co. gave the following record:

Hole N. E. of Baker Shaft.

	STRATA.	Ft.	In.
1.	Surface	21	..
2.	Gray shale	45	..
3.	Gray slate	27	..
4.	Coal	1	..
5.	Gray shale	38	..
6.	Coal (number 12?)	7	..
7.	Fire clay	3	..
8.	Variegated shale	3	..
9.	Flint rock (limestone)	18	..
10.	Gray shale	18	..
11.	Sandstone	37	..
12.	Dark slate	36	..
13.	Coal, (number 9)	4	..
14.	Fire clay	2	..

An inspection of these and other logs and an examination of the coal itself in the Baker mine at once convinced

the writer that number 11 coal is absent there and that the 6½ foot coal is either number 12 or some higher coal not far above the horizon of number 12. The writer thinks that it is probably not the same as number 12, for its thickness, excellent quality and uniformity in both these respects over an area of at least several square miles to the north of the Baker shaft as is shown by the core records of the West Kentucky Coal Company, make it unlike number 12 as it is ordinarily developed. As an alternative and non-committal name the writer would propose the term Baker coal to designate it.

This coal is bright and clean and has the lowest average sulphur content of any coal now mined in the Tradewater basin. The sulphur in the cores of this coal from 21 bore holes near Baker shaft average 1.28% as against an average of 2.5-3.5% for the sulphur in number 9 coal.

The Bell coal alone probably averages lower in sulphur than the Baker, while the Bell and the Baker both have somewhat lower ash than the other coals of the region.

The roof consists of 8 to 18 inches of gray clay often slickensided, above which are one to three inches of coal and carbonaceous shale and over it 12 to 18 inches of gray shale with flattened carbonized tree trunks or erect rounded casts of trees with carbonized outer shells some ¾ of an inch thick. This assemblage forms a very weak roof that requires 12 to 14 inches of the top coal to be left to support it and render mining safe.

This area of proven coal is being developed by the West Kentucky Coal Co. by sinking one of the largest shafts in the region, about a mile north of Baker. The deepest bore holes sunk to this coal are numbers 20 and 21 on the flats at the foot of the hills two miles southeast of Hearin. The depth of the coal in bore 20 is 663 feet. In bore 21 it is 657 feet. The log of bore 21 forms a part of the long general section given in the early pages of this report and extends from the Baker coal up to the sandstone that ends the core record; this sandstone itself being taken from the log of bore 20.

Outside of the Baker region number 12 coal—should

it be the Baker coal—is not known to possess such thickness and quality and at no other place in the Tradewater region has it been developed commercially.

It will be noted that the Baker coal, with its unusually good quality, occurs in the region where number 11 is absent and the coincidence suggests some possible causal connection.

From the brief descriptions given to the writer of the section found at Smith's Mills and Corydon it is possible that the same unusual conditions prevail there that are found in the Baker region.

Over the undoubted number 12 coal some well and shaft logs show a few feet of limestone. This limestone is well exposed a mile southeast of Heburn School in the road leading to Charleston. It is two or three feet thick and rather shaly.

In its type locality two miles west of DeKoven the Anvil-rock sandstone is a massive, medium coarse grained somewhat ferruginous sandstone. It often forms low cliffs and occasionally blocks such as the Anvil-rock become detached. When traced to the southeast it is in places very soft and ferruginous and may not show well in exposures except along road cuttings. In the Nortonville region it becomes pebbly in places and is then apt to be highly ferruginous and much disintegrated. This phase is well shown just east of the cannery at Nortonville. These pebbles mark a more distinct change in sedimentation than occurs at any other point in the entire coal measure section in the region.

It will be seen from an inspection of the log of bore 21 that there is no coal more than one foot thick in the next 600 feet above number 12 coal, but that this long interval there consists largely of soft shales with some thin limestones, while sandstones are almost entirely absent. It will also be noted that occasional red or varigated shales occur in this part of the section associated with the limestones. These shales and limestones offer less resistance to erosion than any other part of the entire Tradewater coal measure section, and along the entire extent of their outcrop in the area under consideration, erosion has developed a broad lowland that forms one of the conspicuous features of the topography. It extends southeastward from the Ohio flood plain just north of the Anvil-rock in almost a direct line to Madisonville. It passes just north of Sturgis and Clay, and just south of Lisman and Nebo. This lowland is from one to four miles or more in width and, although it is itself continuous, is not occupied by any one stream but is drained by numerous streams that either enter and flow along it for some distance as do Cypress creek and Pond fork before turning southward to leave it, or that head in the upland north of it and flow directly across it and out through the hills on the south as do Lynn's, Rose, Pond and Greasy creeks.

The alluvial filling in some parts of this lowland is 100 to 150 feet thick and in all parts is thick enough to effectually conceal all surface exposures, so that at no place in the area under consideration do these red shales show at the surface. The writer has, however, examined them as removed from the West Kentucky Coal Company's new shaft north of Baker. They are typical red or purplish red mottled shales.

The thin limestones in this 600 feet are exposed only in rare instances, the most conspicuous one of which is the 6 to 10 feet seen at a number of places in and around Madisonville, and known as the Madisonville limestone. It belongs to the horizon of the group of thin limestones found from 150 to 190 feet above the Baker coal in bore 21. As removed from the new shaft referred to above, these limestones show a scant marine fauna that may show that they occupy about the same horizon as the Carlinville limestone of Illinois.

Coal 14.—Although in the region north of Clay there are no coals of commercial importance in the 600 feet or more above the Baker coal, one or, possibly, two coals occur in the lower part of that interval in the region southeast of Clay. The first of these coals is found in outcrop two miles south of Nebo at Circle City and Coil City and is mined by the Nebo Consolidated Coal and Coking Com-

pany by drift. It is at the horizon of coal 14 and apparently the same coal is again found at Nortonville.

This coal averages about 6 feet in thickness but varies from 3 ft. 6 in. to 6 ft. 8 in. It has no partings of clay or shale and no sulphur band. Sulphur balls with coal bound in with the sulphur occasionally occur but are readily separated from the coal. Two published analyses give the sulphur as 1.94 and 1,97% respectively. The roof is weak shale streaked with clay and needs careful attention to prevent falls. It is underlaid by 18 inches of fire clay.

This coal is 128 feet above number 12 coal according to the log of bore number 3 of the Nebo Consolidated Coal and Coking Co.; and according to their bore number 2 the interval from coal 9 up to coal 12 is also 128 feet. Three-fourths of a mile west of bore 3 these intervals in the shaft of the Rose Creek Coal Company at Coil City as given from memory are 120 feet from coal 9 to coal 12 and 160 feet from coal 12 up to the Nebo coal. If this be the same as the Baker coal, the interval to number 9 at Baker has decreased. If the intervals be the same, its horizon would seem to be in the upper part of the 102-foot shale bed in bore 21 of that region. The log of the Reinecke shaft at Madisonville, 7 miles east of Circle City shows that it is not represented there.

From the foregoing it is evident that this Nebo or number 14 coal is a local lens at a horizon at which coal is not generally found in that region. From its outcrop where mined at Circle City it extends northward at least a mile as is shown by its occurrence in bore 6 of the Nebo Company but the Terhune bore hole about the same distance to the northeast shows no coal more than 3¾ feet thick and it probably passes through the Nebo coal horizon although correlations of the individual beds may not be very satisfactory. In the R. P. Marr bore located 1½ miles northwest of Circle City where the "Y" leaves the main railway line, the Nebo coal is 3 feet thick and is 171 feet above number 12 coal.

The several logs that have been mentioned in describing the Nebo coal will throw enough light on the thickness of the various coals encountered and their stratigraphic relations to warrant their inclusion here.

Core Record of Bore 2, Nebo Consolidated Coal Co.

Situated 6250 feet S. 38½° W. from bore 3.

	STRATA.	Ft.	In.
1.	Surface soil	8	..
2.	Sandstone	26	..
3.	Coal	2	5
4.	Blue band. } No. 12	..	11
5.	Coal	3	4
6.	Fire clay	1	4
7.	Limestone	23	..
8.	Blue shale	13	..
9.	Coal (#11)	2	7
10.	Fire clay	2	5
11.	Sandstone	57	..
12.	Sandy shale	10	..
13.	Blue shale	14	..
14.	Black shale	4	..
15.	Coal (#9)	4	9

Core record of Bore 3, Nebo Consolidated Coal Co.

About 125 yards northeast of mine mouth at Circle City.

	STRATA.	Ft.	In.
1.	Surface soil	4	..
2.	Sandstone	8	..
3.	Blue shale	10	..
4.	Black shale	4	..
5.	Coal (Nebo coal)	6	7
6.	Fire clay	1	5
7.	Blue shale	6	..
8.	Sandstone	18	..
9.	Sandy shale	12	..
10.	Sandstone	75	..
11.	Sandy shale	16	..
12.	Coal	1	11
13	Blue band (shale or clay) } No. 12	0	10
14.	Coal	2	10
15.	Fire clay	0	8
16.	Limestone	24	..
17.	Sandstone	10	..
18.	Blue shale	11	..
19.	Coal	2	3
20.	Fire clay (blue band) } No. 11	0	5½
21.	Coal	2	8
22.	Fire clay	1	6
23.	Sandstone	21	..

Core record of bore 6, Nebo Consolidated Coal Co.

Distant 4135 feet N. 3° E, from bore 3.

	STRATA.	Ft.	In.
1.	Surface material	12	..
2.	Blue shale	4	..
3.	Sandstone	2	..
4.	Coal	1	8
5.	Fire clay	2	4
6.	Blue shale	22	..
7.	Limestone	6	..
8.	Sandy shale	6	..
9.	Coal	0	3
10.	Fire clay	1	9
11.	Sandy shale	4	..
12.	Quartz (sandstone)	8	..
13.	Sandy shale	16	..
14.	Quartz (sandstone)	7	..
15.	Sandy shale	11	..
16.	Black shale	3	..
17.	Coal (Nebo coal)	5	6
19.	Blue shale	6	..
20.	Sandstone	10	..

Terhune Bore.*

	STRATA.	Ft.	In.
1.	Clay	15	..
2.	Shale	53	..
3.	Coal	1	..
4.	Shale	26	..
5.	Limestone and shale	4	..
6.	Coal	1	..
7.	Limestone and shale	6	..
8.	Shale	3	..
9.	Soft gray sandstone	12	..
10.	Shale	65	..
11.	Coal	3	..
12.	Fire clay	4	..
13.	Sandstone	2	..
14.	Shale	15	..
15.	Soft gray sandstone	10	..
16.	Shale	5	..
17.	Hard white sandstone	35	..
18.	Soft calcareous shale with quartz crystals	6	..
19.	Shale	2	..
20.	Soft gray shale	3	..
21.	Hard white limestone	3	..

	TERHUNE BORE—CONTINUED.	Ft.	In.
22.	White shale with lime	5	..
23.	Hard white limestone	4	..
24.	Very hard blue limestone	2	..
25.	Black slate	2	4
26.	Coal	3	9

*U. S. Geol. Surv. Bull. 298 pp. 230–231.

At the "Y" one-half mile west of Nebo. R. P. Marr Bore.

	STRATA.	Ft.	In.
1.	Clay	10	..
2.	Soapstone	15	..
3.	Fire clay	15	..
4.	Black slate	33	..
5.	White sandstone	41	..
6.	Coal (Nebo or No. 14)	3	..
7.	Shale and slate	60	..
8.	Sandstone	83	..
9.	Shale and slate	28	..
10.	Coal (No. 12)	5	..
11.	Fire clay and shale	13	6
12.	Limestone	10	..
13.	Coal (No. 11)	6	6
14.	Fire clay	2	..

Test Hole No. 1, Rose Creek Coal Co.

At 100 feet N. 80° W. from shaft and 10 feet lower.

		Ft.	In.
1.	Surface	12	..
2.	Soapstone and white sandy shale	31	..
3.	Light gray sandstone, very coarse	83	..
4.	Fire clay	4	..
5.	Hard limestone	12	..
6.	Shale	14	..
7.	Coal (No. 12)	6	..
8.	Fire clay	3	..
9.	Limestone	14	..
10.	Slate	6	6
11.	Coal (No. 11)	6	6
12.	Fire clay	2	6
13.	Shale	12	..
14.	Gray sandstone	52	..
15.	Dark gray slate	22	..
16.	Black slate	5	..
17.	Coal (No. 9)	5	6

Log of Reinecke Shaft, Madisonville.

	Strata.	Ft.	In.
1.	Red clay	18	6
2.	Red sandstone, water-bearing	3	..
3.	Blue sandstone	1	6
4.	Blue limestone	4	6
5.	Clay	2	4
6.	Limestone	0	10
7.	Blue fire clay	6	6
8.	Red sandstone	10	..
9.	Red clay	13	..
10.	Limestone, seamy, water-bearing	4	..
11.	Soapstone	18	..
12.	Blue sandstone	98	..
13.	Black soft slate	20	..
14.	Coal (No .13)	2	4
15.	Fire clay	3	..
16.	Red sandstone	6	..
17.	Black slate	26	..
18.	Limestone	1	7
19.	Coal (No. 12)	4	6
20.	Fire clay	0	10
21.	Blue limestone	6	..
22.	Clod	0	6
23.	Black slate	0	10
24.	Coal (No. 11)	6	6
25.	Fire clay	0	11
26.	Limestone	1	..
27.	Red sandstone	60	..
28.	Coal (No. 10)	1	6
29.	Red sandstone	14	..
30.	Black slate	22	..
31.	Coal (No. 9)	5	4

The other occurrence of thick number 14 coal mentioned as lying above number 12 coal is found at Nortonville at the shaft mine of the Nortonville Coal Co., where it is said to average 5 feet in thickness and was formerly mined. It was drifted into on the hillside only a short distance above drainage level and was worked for some time. The quality of the coal was so poor that it was abandoned and a shaft was sunk to number 11 coal 135 feet below the No. 14 or Nortonville coal. The coal now mined at Nortonville is exclusively No. 11.

This Nortonville coal had a very poor roof and the coal itself was rashy and bony. The abandoned workings are now badly fallen in but where accessible in the main entry the coal is badly weathered and disintegrated and is very dirty. Where examined 5 feet of coal were visible and 9 inches or slightly more were under water. The top 12 inches is cleaner and better than the rest. The bone and rash are in very thin streaks scattered irregularly through the other 4 feet visible. Over it were 6 inches of soft clay shale, then 4 inches of coal, then 3 feet of rotten crumbling shale, dark with thin streaks or laminae of coal. Over this there is a massive soft sandstone 60 feet or more in thickness.

Near this shaft and the old drift a bore hole was sunk in a low place at a point about 75 feet northwest of the powder house. Its record is as follows:

	Borehole at Nortonville.	Ft.	In.
1.	Surface clay	17	..
2.	Coal (Nortonville or No. 14)	5	..
3.	Fire clay	2	..
4.	Soapstone	25	..
5.	Sandstone	34	6
6.	Black slate	2	..
7.	Coal	1	6
8.	Fire clay	6	6
9.	Sandstone	21	6
10.	Shale	2	6
11.	Dark soapstone	10	..
12.	Gray slate	12	..
14.	Coal (No. 12)	6	..
15.	Fire clay	2	6
16.	Limestone	5	..
17.	Coal (No. 11)	6	6
18.	Fire clay	2	..
19.	Soapstone	30	..
20.	Shale	31	..
21.	Soapstone	10	..
22.	Black slate	3	..
23.	Coal (No. 9)	4	8

This Nortonville or No. 14 coal is not known in the Tradewater district except there and at Nebo, unless the Baker coal is also the same. It is to be regarded at Nortonville as a local lens of too poor quality to be classed as a commercial coal under any economic conditions that

are likely to exist for years to come. It will be noted that the Nortonville lens is 121½ feet above No, 12 and the Nebo lens in bore 3 is 128 feet 5 inches above the same coal. These two lenses are of the same age and indicate that at the time they were formed the region was characterized by a development of local coal swamps, and if so, restricted areas of thick coals may be found elsewhere at this number 14 horizon. From the areas so far known the chances would be about even for their being of good or of poor quality in this immediate neighborhood.

OTHER HIGH COALS.

With the exception of the Baker and the Nebo and Nortonville there are in the Tradewater area no known coals of commercial importance above No. 12 coal. At a few places, though, country openings have been made in some of the thin higher coals. In some cases these have been abandoned for years and in other cases they were recently fallen in or partly filled with water rendering satisfactory examination difficult or impossible.

Lisman coal.—Near the base of the hill a mile northeast of Lisman there is a coal reported to be 28 inches thick, of good quality and without partings. It was formerly opened on the land of J. M. Cole. It is below the Dixon sandstone but the exact interval can not yet be given nearer than to say it is about 150 to 200 feet.

Geiger's Lake coal.—Southeast of Blackburn which is on the Kentucky side of the Ohio river opposite Shawneetown, Illinois, the Ohio flood plain is bordered by a rolling upland that rises 60 to 100 feet above flood plain level. For several miles in the vicinity of Geiger's Lake about midway up the steep slope that borders the flood plain there is a sandstone that in many places makes a cliff 10 to 20 feet in height. Close beneath this sandstone is a coal that will be called the Geiger's Lake coal. It has been opened at several places overlooking the Ohio

flood plain. At the Runyon opening near the south end of Geiger's Lake the following section was found:

	Runyon Opening.	Ft.	In.
1.	Sandstone	15	..
2.	Slate colored shale	8	..
3.	Bone	0	8
4.	Dark clay shale	0	6
5.	Gray shale with fern impressions	0	5
6.	Coal	0	7
7.	Gray clay	0	2
8.	Bone	0	4
9.	Coal	1	4
8.	Bone	0	4
9.	Coal	1	4
10.	Fire clay	7	0

Other openings were fallen in but were probably of about the same character. The overlying sandstone may be traced eastward to Henshaw where it is conspicuous in the upper half of the hillsides just northwest of town. The coal once opened on the B. F. Gardner place just north of Gum Grove is probably the same coal. It has 130 feet of soft sandstone directly above it, and is reported to have been 3½ feet thick. At C. M. Callender's a half mile southeast of Seven Gums there is a coal with clay partings that was once opened close beneath a sandstone that makes similar low cliffs or bare rounded slopes and the combination suggests a possible correlation with the Geiger's Lake coal. Six feet below the Callender coal there is a thin limestone, and southeast of Callender's on the uplands as far as Dixon and beyond there is a prominent sandstone here called the Dixon sandstone with a thin coal close beneath it and at times some earthy nodular limestone close beneath the coal that suggests a possible correlation with the Callender coal.

Although exposures are poor especially for a part of the distance yet it is believed that by detailed work it will be possible to establish either the identity of, or the stratigraphic relationship between, the Dixon and the Geiger's Lake coal and overlying sandstone. Such

a correlation would give an exceedingly valuable datum plane for the rocks near the upper end of the Pennsylvanian section, which here lie along the axis of the synclinal trough that is bounded on the north by the Gold Hill-Rough Creek anticline.

Polley coal. Some thirty to fifty feet above the Dixon sandstone there is a coal partly opened by I. W. Polley a mile northwest of Shelton, near the Union-Webster line and showing 22 inches at the outcrop. The coal appears to be clean. It has been seen at several other places eastward toward Dixon.

At many other places coals of a few inches thickness show in surface exposure in the upper part of the coal measure section but at no place did they seem to be thick enough to open even as country banks.

COALS OF UNCERTAIN POSITION IN THE LOWER PART OF THE MEASURES.

In the southern part of the Tradewater area there are some coals of commercial importance whose correlation with the coals of the standard section has not yet been made and whose exact position in the section is not determined farther than that they belong in the lower part or near the base of the section. These coals occur in several areas one of which includes Empire and Mannington and the country west of these places for at least four or five miles. Another includes the region from Dawson Springs northward to the vicinity of Pleasant Hill School and Charleston.

Empire Coal.—At Empire a coal has been mined for years that averages about 44 inches in thickness, with individual measurements ranging from 39 to 46 inches. The coal is bright and clean, with no parting and shows but little sulphur. The upper 15 inches is hard and furnishes most of the lump, while the lower part is tender or soft and crushes more readily to nut and slack. The roof is of gray slate and gives no trouble. Beneath the

coal are two or three feet of fire clay. A log of the present shaft given from memory by Mr. Robert Gray is as follows:

		Ft.	In.
1.	Surface	20	..
2.	Slate and sandstone, mixed	10	..
3.	Slate	16	..
4.	Coal	3	8
5.	Fire clay	2 to 3	..
6.	Sandstone	..	..

He also gave the following Log of the old Empire shaft:

		Ft.	In.
1.	Surface	18	..
2.	Coal	2	..
3.	Bastard limestone	10	..
4.	Slate and sandstone, mixed, as above	27	..
5.	Coal	3	8

No examination of the old shaft could be made but the limestone from it is a compact gray limestone containing brachiopods and other fossils. The thin coal of the last section given above was once stripped near the railroad just north of Empire Station. Over it there are some 20 to 25 feet of shale and over that a soft sandstone some 40 or 50 feet thick.

The thickness and character of the coal and the associated shales, limestone and sandstone lead the writer to correlate, at least provisionally, this Empire coal with the coal recently opened at Mannington by the Petersburg and the Terry Coal companies. The thickness averages somewhat greater at Mannington than at Empire, but otherwise the section and association is similar.

At Mannington the Clifton Coal Co. formerly worked

this same coal by a shaft 33½ feet deep to the coal, which there varied from 2½ to 6 feet in thickness and was of poor quality where thickest. It contained so much clay and other impurities that attempts to wash it were unsuccessful and the mine was abandoned. Over it some fifty feet is another coal reported to be about 3 feet thick. This is doubtless the thin coal 37 feet above the coal worked at Empire.

Near the Terry mine the Mannington limestone is exposed in the road. It is about 35 feet above the Terry coal, is about 3 feet thick where seen, and is fossiliferous. It is here correlated with the limestone passed through in the old Empire shaft.

Some two miles west of Empire station, what the writer regards as the same limestone is exposed in the road and at several places in the woods nearby. It is in several beds separated by calcareous shale, the total thickness being about 8 feet. A short distance west and about forty feet beneath it, the Empire coal is opened on the Terry Coal Co.'s lands, and a short distance northwest of there it was again seen at the Wiggins and the Porter banks. The frequent mother-of-coal partings, and the bright jet like streaks in the coal as well as the thin rotten sandy shale roof with its macerated leaf fragments remind one very much of the Dawson Springs coal presently to be described. They may prove to be the same.

From these last banks it is not far northwest to openings on the Virgil Hamby place and to others at George Terry's, John Gilliland's and Bert Ashmore's. All of these seem to be on the same coal and it seems to correlate with the Wiggins coal to the southeast. This correlation makes the coal in the Hamby country the same as that at Mannington and Empire and it is believed that detailed work will only confirm this reconnaissance correlation.

The Jesse Robertson Coal.—On the top of the hill three-fourths of a mile south of Hamby Station there is opened by the roadside a coal 47 inches thick overlaid by 3 inches of coal and shale in thin films, and that by dark, leaden gray shale that forms a poor roof. The coal is free from partings, but contains much mother-of-coal and readily breaks into fine pieces. It appears to be a poor coal and the immediate area is small. Its exact position is not yet evident except that it is one of the coals near the lower end of the section and can not be regarded as of any economic importance from all that is known concerning it.

Dawson Springs Coal.—In the vicinity of Dawson Springs and for some distance northward there is a coal of considerable local importance. It is 48 to 52 inches thick, is without parting or visible sulphur and has frequent mother-of-coal films that cause it to break or later to weather into small pieces. Over it there are often one or two inches of thin carbonaceous rash, over which there are 35 or 40 feet or more of gray shale, the lower part of which usually contains many badly broken and apparently macerated fragments of strap-shaped leaves. Over this shale there is about a hundred feet of sandstone that occasionally forms broken cliffs but is more usually soft and inconspicuous. The coal is underlaid by 19 inches of fire clay beneath which there is reported 20 inches of very hard material—probably a siliceous mudstone or gannister. Beneath that a drill hole reports 10 feet of soapstone, then 37 feet of coarse white sandstone, and then shale that was penetrated 8 feet.

The town of Dawson Springs is supplied by mines owned by the Tradewater Coal Co., the Banner Coal Co., and the Hillman Land & Iron Co. North of town the same coal is opened at J. E. Duncan's, Gid Townsend's and J. J. Dockery's. It is very probable that the coal opened at Charleston is also the Dawson Springs coal. Some of those interested locally in the coal believe it to be number 5 coal. Its position can only be determined by detailed stratigraphic work supplemented perhaps by a study of the plants in the roof shale. Unlike number 5 it contains no marine fossils or black shale in its roof. Its stratigraphic relationship to the Pottsville is obscured by a main east-west fault that passes through Dawson Springs and by numerous minor faults in other directions.

Cox Coal.—Between the Townsend and Dockery openings mentioned above there is a higher coal reported to be 4½ feet thick, once opened on the Z. T. Cox land but now closed by fall of roof at the entrance. It would seem to be 100 or 125 feet above the Dawson Springs coal. It is overlaid by 2 feet of gray shale over which are 6 feet of shaly sandstone, while some 20 to 25 feet above the coal there is a coarse highly ferruginous sandstone that is perhaps more properly called an ironstone.

COALS NEAR THE ROUGH CREEK FAULT.

On the northeastern edge of the Tradewater region the rocks are brought up sharply toward the surface by a prominent fault to which the above name has been given. Exposures of the rocks are so poor as to leave uncertain the correlation of several coals that are of local note.

Watkins Coal.—Four miles southeast of Morganfield Mr. T. J. Pearcy works what is known as the Watkins mine. It is about a mile south of the main fault which marks the northern edge of the Chalybeate Ridge but has another fault of considerable throw less than half a mile north of it and may have still another quite near it. At the mine the rocks dip 35° S. 20 W. The coal is free from partings and averages 52 to 55 inches in thickness. It is almost free from sulphur balls, shows slickensiding in some places apparently as if there had been differential movement within the coal parallel to the bedding plane when the rocks were being deformed and a rather persistent line of such movement is found 18 inches above the floor. The coal is very tender and soft and breaks up and slacks easily. Above it there are 12 to 20 inches of black slate and then a blue slate is visible for 40 or 50 feet. The black slate is without either concretions or fossils so far as could be found. The floor is fire clay and some 30 feet below it a thin coal is reported and some 40 feet below that a 15-foot ledge of sandstone occurs close beneath which a coal reported to be 6½ feet thick

was worked some 40 years ago. This last coal is locally believed to be number 7 and the Watkins coal now worked to be number 9. This interpretation may possibly prove correct but the writer would reject it until further proof is forthcoming. If the Watkins coal is number 9 there should be some sign above it of 11 and 12 and the intervening limestone, the roof should have large concretions and marine fossils, and the coal should be much harder. Nowhere else is number 7 coal known of such thickness and of such short interval beneath number 9. To call the coal once mined number 8a would fit the interval and downward succession, but this latter coal is nowhere in the entire region known to be more than a foot or two thick and is everywhere worthless. To call it number 5 only increases the difficulty of too short an interval. It is easily conceivable that local variations in character and thickness of the coal or the rock section, the influence of the steep dip, and the effects of the nearby fault as well as other possible causes might explain any one of the above discrepancies but they do not seem to explain all of them satisfactorily and more information is awaited before attempting to correlate the Watkins coal. It is of interest in connection with the section at the Watkins mine to compare the drill record of the Bakersville bore hole as given on page 18.

Roberson Coal.—Two miles southeast of the Watkins mine Mr. T. L. J. Roberson has a country bank opened on a coal that shows the following section:

Roberson Section.	In.
	24 to 27
1. Coal	.. 1
2. Blue band, (gray shale)	.. 3
3. Block coal	.. 2
4. Blue band	20 to 22
5. Coal	½ to 1
6. Soft clay band	6 to 8
7. Coal	.. 8
8. Fire clay	

Over the coal there are 25 to 30 feet of sandy shale and beneath the fire clay floor there is a light gray brecciated limestone whose thickness could not be ascertained. The dip of the coal is 9 degrees to the west. Six hundred yards northwest of the present mine a coal apparently 250 to 300 feet higher stratigraphically than that now worked was once opened. It is said to have been thick and to have had a number of thick partings. Over it about a hundred feet there are fragments of a light colored fine grained limestone with obscure bird's eye structure but without fossils. The position of this coal is uncertain. It probably belongs in the part of the section below number 6 coal and may possibly be Owen's number 4, or it may not be represented at all in the DeKoven section.

Sparks Coal.—A half mile northwest of Marksville the Sparks mine shows a solid coal that averages 4 ft. 6 in. to 4 ft. 8 in. in thickness, has a black shale roof with an occasional niggerhead and a fire clay floor. The bottom foot of the coal carries some sulphur in knife edge lenticles and when stored it is inclined to slack. The dip at the mouth of the mine is 50°S. 25 W. but in the mine the dip varies considerably, being in one place 9° N. 85 W. This coal is very certainly No. 9.

Marks Coal.—A fourth mile south of Marksville the Marks Coal Co. mine by a 30-foot shaft a coal that measures 4 ft. 6 in. and is solid and bright. It is of average hardness and is clean except for some sulphur in the lower 6 inches. In parts of the mine the roof is a massive sandstone thirty feet thick, but in other places there are two or three feet of shale between the coal and the sandstone. The floor is a fire clay reported to contain masses of very hard rock—probably a gannister. The dip is 7½° S. 25 W. This coal is probablyNo. 12.

Woods Coal.—Three-fourths of a mile east of Marksville attempts have been made to open a coal on the Dave Woods place. On the weathered outcrop the coal appears to be bony and is much slickensided. It dips 7° S. 20 W. and shows the following outcrop section:

	Section at David Woods'.	In.
1.	Dark argillaceous shale	18
2.	Thin blue black shale	26
3.	Coal	1
4.	Gray clay.)	10
5.	Coal	3
6.	Carbonaceous shale	24
7.	Fire clay	

At several points in the next mile east of the Woods opening are other openings now fallen in but probably the same as the Woods coal. They all agree in having black shale roofs and in being close above a massive sandstone, and are the same as the Sparks or No. 9 coal.

STRUCTURE.

The larger part of the area here considered forms a structural basin or trough that lies between the Tradewater river on the southwest and the Rough Creek fault on the northeast. This fault extends from Shawneetown, Ill., in almost a direct line to Sebree, Ky. From Shawneetown it passes through the Bald Hills, Spring Grove, the Chalybeate Ridge, just south of Sulphur Springs, Boxville, Givens, and Tilden and is well seen in Sebree. The axis of the Tradewater trough or basin extends from the Ohio river south 60 to 70 degrees east. The basin is unsymetrical in shape, since the rocks dip into it on its southwestern side at uniformly low angles, while on the northeast side the dip is usually at high angles. On the southwest side dips about Caseyville and DeKoven average 4° to 6° N. 20° E. At Sturgis the dip is slightly less and is N. 15° E. At Wheatcroft it is 2° N. 35° E. At Providence 1½° N. 23° E. Farther to the southeast as at Nortonville and St. Charles the dip changes to the north, but while generally at a low angle varies somewhat in amount and direction because of the extensive block faulting of that region.

It is often difficult to tell how far into the basin these marginal dips continue. In the region from DeKoven to Clay, for instance, broad flats with deep alluvial filling conceal all outcrops for several miles down the dip. From certain bore hole records and some surface exposures in the hills on the north side of these flats it is believed that the dips generally persist across the flats and in some places at least are seen to continue for some distance into the hills on their northeast side before dying out. For some miles in the center of the basin the rocks either lie approximately flat, or the dips are slight, local, and of variable direction. The flat central part of the basin will average four or five miles wide in Union county but broadens to several times this width in Eastern Webster and in Hopkins counties. As the Rough Creek fault is neared dips to the southwest rapidly develop and in some places as on the south side of the Chalybeate Ridge may reach 60° or over. The belt of steep dips along the faulted northeast margin of the basin perhaps nowhere exceeds a mile in width.

The dips on the southwest side of the basin are low enough not to interfere with or complicate the problem of coal mining, but on the northeast side the rocks rise from the basin at such high angles as to make mining more difficult and expensive and the coal is more apt to be sheared and slickensided or otherwise disturbed where the dips are high.

Depth of the basin.—The depth of the flat central part of the basin becomes of much practical importance since it includes an area of several hundred square miles all of which is underlaid by the entire series of commercially valuable coals.

At the foot of the uplands on the north side of the Pond Fork flats northwest of Clay, the Baker coal is 663 feet beneath the level of the flats, and if dip calculations are correct and the somewhat prominent sandstone in the uplands north of there is the same as the Dixon sandstone and the one at Henshaw and west of there overlooking the Ohio flood plain, coal number 12 is 1,000 feet below its top and coal number 9 is 100 feet lower still.

This would place number 9 coal 1050 feet beneath the town level at Henshaw, or 1100 feet below court house level at Dixon.

Disregarding any change because of thickening or thinning it may be said that in the deepest part of the Tradewater basin number 9 coal would seem to be on the average about 1000 to 1100 feet beneath the surface. Although this places it too deep for mining under present conditions, yet the day is probably not very far distant in Western Kentucky when shafts will be sunk to such depths. In Illinois one shaft now slightly exceeds 1000 feet in depth.

STRUCTURE IN UNION COUNTY NORTH OF THE ROUGH CREEK ANTICLINE.

The area examined included also the part of Union county lying north of the Rough Creek anticline. The structure of this part of the county is quite simple. The rocks lie almost flat everywhere that data could be obtained as to their attitude. Very much of this part of Union county is covered with a mantle of loess or loam that entirely conceals the underlying rocks. Exposures at Raleigh Lake and Uniontown and mining shafts and bore holes at Uniontown, Waverly, Morganfield and Bakersville, however, show the general flatness of the structure. It seems that the rocks on this north side of the Rough Creek anticline remain essentially horizontal up practically to the very fault itself. The tilting and disturbance are largely confined to the rocks on the south or overthrust side of the fault.

At Morganfield number 11 coal is mined at a depth of 215 to 225 feet. At Uniontown its depth is 170 feet, at Waverly it is 250 feet. At Morganfield there are reported local dips to the northeast of about 6 or 7 feet per mile. Several bore holes have reached number 9 coal in this northern part of Union county. It is found to lie 119 to 125 feet below number 11 coal. No mines, however, have been opened on it in this part of the coun-

ty. The Bakersville bore hole has gone down to number 6 coal which is there 247 feet below number 9 as may be seen from the log given on page 18. At Uniontown a well was sunk 1077 feet for oil but the reputed log that has been widely circulated is thoroughly unreliable.

ROUGH CREEK FAULT.

The profound structural disturbance to which this name has been given in Kentucky but which is known in Illinois as the Gold Hill axis extends, as has been said, from Shawneetown to Sebree and for many miles farther eastward. Throughout much the greater part of the distance from Shawneetown to Sebree all surface exposures along the fault line are concealed by loess, loam or alluvium.

A mile southeast of Blackburn, at what is known as "The Rocks", ledges of Pottsville that show an aggregate thickness of about 125 feet border the Ohio flood plain. The dip is 25° to 30° mostly about S. 5° E., though in some places it varies to S. 20° W. The rock is a massive coarse sandstone without pebbles but with ironstone streaks.

Some three miles east of there in the "Bald Hills," there are again found sandstones, here interbedded with shale, dipping 40° S. 5° to 25° W. In the Chalybeate Hills south and southeast of Morganfield exposures of the Pottsville are again found for several miles and at one place, at least, the Mississippian limestone beneath it is also exposed. The relationships here strongly suggest that the disturbance originated as an anticline that developed into a reverse fault with overthrust from the south as is shown in figure 1. Dips vary from 12° or 15° to 60° in the general direction of S. 20° to 30° W. though in some places dips are nearly south and in others they are N. 70° W. The main fault plane lies along the northern base of the Chalybeate Hills and there are numerous minor faults farther south but within the main

mass of the hills. At one of these there is a somewhat noted Chalybeate spring which gives its name to the hills.

Farther east the fault becomes more difficult to trace, though it passes through Sulphur Springs and Boxville. It probably runs just north of Givens. It passes through Tilden. The hill top a half mile southeast of there is formed by the Pottsville which there dips about 50° S. and the chert on its north slope indicates that the Mississippian is above drainage level. A mile farther southeast intermingled boulders of Mississippian limestone and Pottsville sandstone outcrop in a complex manner that is probably the result of cross faulting.

Exposures are lacking for some miles farther east but in the hills two miles southwest of Pratt the rocks have been much disturbed and show dips of 30° or more to the south—southeast. The fault passes through Sebree, the rocks on the north side of it lying flat and being unaffected almost up to it, while those on the south side dip southward, some of them at high angles. About 150 feet south of the depot at least 35 feet of Missippian limestone is exposed a few rods west of the railroad. It dips 30° to 40° S. 30° E., and 150 yards farther south sandstones and limestones in the railway cut stand vertically and strike N. E. while 1200 feet farther south the dip has changed to 22° to 30° N. 45° E., and 1600 feet still farther south a massive sandstone is seen at Sebree Springs dipping 3° to 4° N. 20° E. The chalybeate water at Sebree Springs doubtless issues from a subordinate fault plane.

These dips vary much in both amount and direction and show that the Rough Creek fault was not a simple one but was compound and that at least some of the subordinate movement was of the nature of cross faulting. The rapid variablility in both the amount and direction of dip seems to characterize the rocks on the south side of the fault whenever numerous exposures are to be found and show that the faulting was generally complex. It is believed that the fault is due to an overthrust from the south with subordinate parallel and cross

faulting and probably crushing. Either the Pottsville conglomerate is but partly exposed at Sebree or it is thinner and less massive than south of Caseyville.

MINOR FAULTING.

While there are large areas in the region under consideration when there is no faulting of importance, yet there are in it many faults of a few inches or a few feet throw. Such faulting is rarely or never determinable from surface exposure but is seen in many of the mines of the region. In most cases the throw does not equal the thickness of the coal. In one or two cases the throw of a few feet decreased slowly to zero along the course of the fault and beyond that point increased again as a reversed fault. Such faults are usually sharp and neither the rocks or the coal show signs of disturbance till the fault plane itself is reached. This plane may be marked by a thin clay seam or the coal may be clean and show merely slight shearing and slickensiding.

MAJOR FAULTING.

No important faults are known in the Tradewater basin west of Clay. At Clay, however, and at numerous places to the south and southeast to Dawson Springs and Nortonville and beyond, faulting is common. In the reconnaissance that has been made it is probable that numerous faults have escaped detection and there was not time to follow out in detail those that have been located. In several cases the fault planes are concealed by extensive alluvial flats and are incapable of exact location, but have been necessarily inferred from the stratigraphic relationships on either side of them.

The faulting is usually clean-cut and sharp with little or no disturbance of the rocks on either side. When there is disturbance it dies away within a few yards. These facts and the poor exposures make the discovery and tracing of faults very difficult.

In most cases the faulting is normal and the fault planes dip at high angles. The general direction of the more prominent faults is N. 75 to 80 E. and where near together they divide the surface into long parallel-sided areas that may be tilted so that one side has risen while the other has been depressed or they may be faulted down on both sides in trough fashion, and in either case minor cross faults may break the faulted area into blocks. In some cases down-faulted blocks are known to exist, although their boundaries are as yet indefinite. In some of these cases the alluvial or other surface covering is so complete that the location of the bounding fault planes can only be made by drilling or other exploratory work.

The effect of these faults on the value of the land for coal mining is a subject about which no general statement can be made farther than the obvious one that where faults occur they usually determine the bounds between productive and non-productive territory. Some blocks or strips are so small or so narrow, or some large blocks are so badly broken by other minor faults within then that it is not possible to mine the coal. On the other hand some of the oldest and best mines in the area are in fault blocks so large and so free from subordinate disturbances within them that they have long been worked as profitable properties.

Surface exposures are rarely ever sufficiently numerous or continuous to determine the presence or absence of faulting and in any given area there should be a thorough prospecting by core drill before investment or development is attempted. This applies to the entire area here considered but applies with special force to the southern and southeastern parts of the area. Mention of a number of the faulted areas has already been made in discussing the outcrops of the various coals.

In the old Blackwell mine in Clay a fault is reported as running N. 75° E. with a down throw of 50 feet on the south side. Two miles southwest of Clay near the Johnson bank there is surface indication of a fault probably of small throw running N. 33° E. South of Providence there is a large downfaulted block extending from Yar-

bro to Montgomery Ford and eastward into the Clear Creek flats two miles northeast of Stony Point. It preserves an area of number 9 coal that would otherwise have long since been eroded. The same can be said of a small downfaulted area northeast of Kirkwood Springs that may or may not be continuous with a similar area south and east of Heburn School. In each of these cases the outlines of the block are not yet fully known. They are, however, each believed to be of small size.

A half mile southeast of Fiddle Bow school a fault shows in the road, running N. 65° E. It probably continues northeastward to Richland creek or beyond and southwestward may form the southern boundary of the Heburn School—Kirkwood faulted areas. South of it for several miles the rocks contain only the lower coals. Just southeast of Charleston there is another fault trending a little north of east and possibly continuous with the fault that crosses the road three-fourths of a mile north of New Carbondale. This or some closely parallel fault marks the northern limits of the Crabtree and New Carbondale coal areas. A mile north of the Fox Run mine there is a fault that delimits that coal area on the north but is not quite in line with the Charleston-New Carbondale fault and probably is not a continuation of it.

The next fault to the south is seen at Old Carbondale. It trends N. 80 E. with down throw to the north and delimits the Crabtree-Carbondale area to the south. The amount of the throw at Old Carbondale has not yet been determined but it cuts off number 9 coal to the south of it and decreases eastward to about 17 feet on the north side of the old St. Charles mine. Farther east it probably soon disappears. About a mile farther south another prominent fault trending also N. 80° E. passes through St. Charles and has downthrow on the south of about 150 feet. It is probably continuous to the east with the fault about 1000 feet south of the shaft mine at Nortonville. Something like another mile south of the St. Charles fault is another parallel one that may be called the Daniel Boone one since it passes about 1200 feet south of Daniel Boone mine. The block between

it and the St. Charles fault is downthrown and both number 9 coal and number 11 coal have thus been preserved in it from erosion and at Daniel Boone number 11 has been mined for some years. South of St. Charles and again east of Daniel Boone this long strip or block is broken by numerous cross faults so that the coal can not be mined there. About 1000 feet north of Nortonville railroad crossing a small fault running N. 80° E. occurs with downthrow of probably 25 to 50 feet to the south. At Oak Hill there is another fault south of the old Oak Hill mine that runs somewhat north of east and has a throw of about 200 feet on the south side.

By tracing the normal outcrop of the number 9 coal around this southern end of the Tradewater area it may be seen that the general effect of this extensive faulting has been to depress certain blocks so as to keep the coal from erosion and has thus preserved for us a larger coal area than we would otherwise have had.

In the Earlington-Madisonville region a few small faults each of only a few inches or a few feet throw are known, but they are so rare and slight as to be of no importance in mining coal. Two miles north of Madisonville a fault with strike N. 60 E. crosses the road and a half mile farther north another may be seen with strike N. 85 W. The block between the two faults has been dropped probably 150 feet.

Alluvium in stream valleys.—Borings and shafts show that the Tradewater region stood, probably in Pleistocene time, considerably higher than it does today. During this stage the Tradewater and its tributaries cut their valleys much deeper than they are today and broadened them until their valley walls had gentle slopes. Since then the country has been depressed and the valleys have been filled half full or more with alluvium. The alluvial filling in the valley of the Tradewater near its mouth is 180 or 200 feet, at Sturgis 170 or 180 feet and even up at Dawson Springs it is more than 86 feet. All of its tributaries on the northeast side have similar deep alluvial filling, and wells go through anywhere from nothing up to 150 feet of it according to their position. Where

a coal dips under present stream level it may be cut out for a half mile or more back from where it would crop were it not for the deep stream filling. This has not always been recognized in the purchase of lands, and areas supposed to contain coal have sometimes been found to have it cut out.

Formations suggested.—It seems possible in the Tradewater region to map the horizon of number 5 coal—now generally called number 6—in the northwestern and central part of the region and probably in the southeastern as well. The formation extending from it down to the Caseyville conglomerate would contain nothing of economic value save the Bell coal near its base, and within its 600 feet of rocks there is no horizon that can be easily recognized and traced in the field.

From the base of number 5 coal to the base of number 9 would be 180 to 240 feet to be mapped as a formation, or the upper boundary might be drawn on top of number 9 coal and include it in the formation.

The next formation might extend from the base or top of number 9 coal either up to the base or top of number 11 coal, or just a little farther to the base of the Anvil rock sandstone. For ease of tracing and economic use perhaps drawing the line at the base of number 11 coal would be desirable, though a more profound change in the stratigraphy occurs at the base of the Anvil rock sandstone. The formation would be 80 to 125 feet thick.

From the Anvil rock sandstone there is a long interval of soft shales with some limestone that very rarely show in natural exposure, but with no horizon traceable in the field for mapping purposes until the Dixon sandstone is reached some 900 or 950 feet above the Anvil rock sandstone.

The Dixon sandstone is believed to be traceable over a large area, marks a prominent change in sedimentation and with the shales and sandstones above it would make another formation of about 200 feet.

Before settling on cartagraphic units it would be well to see what light the coal plants and the marine invertebrates of the cherts, roof shales, and limestones may throw

on the position of floral or faunal breaks in the section. These paleontological data when correlated with the formational units here suggested—which seem to be the only ones capable of being traced in the field—would probably be of material aid in tracing horizons, especially in the southeastern part of the field where faulting has made stratigraphic and structural relations so obscure.

ANALYSES.

No attempts were made to secure samples for analysis but in a number of cases analyses made either for coal companies or their customers were secured, and along with some analyses made by the U. S. Coal Testing Plant at St. Louis are grouped together here for convenient reference.

TABLE OF ANALYSES.

Mine.	Coal	Kind of sample.	Loss of moisture on air drying.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories determined.	Calories calculated from ultimate analysis.	British thermal units determined.	British thermal units calculated from ultimate analysis.	
Smith	1 B	Mine	.....	.....	32.90	57.74	9.36	.94	.010	.....	.....	.....	.....	.....	.....	14,360	.....	Fresh, air dried. Pittsburg Testing Lab.
"	"	.....	.....	.....	33.83	56.77	9.40	1.06	.004	.....	.....	.....	.....	.....	.....	14,173	.....	From pile ruined for coke making. Pbg. Testing Lab.
Sturgis	"	Mine	5.10	7.46	30.69	57.25	4.60	.97	.....	.....	.....	.....	.....	7,494	.....	13,489	.....	U. S. G. S. Bull. 332, p. 160. No. 3678.
"	"	"	5.70	8.09	30.10	56.65	5.16	1.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " " 3679.
"	"	Car	3.20	5.46	30.99	55.63	7.92	1.18	.....	5.07	72.59	1.19	12.05	7,355	.....	13,239	.....	" " " " " " 3680.
"	"	"	.....	5.76	30.36	56.21	7.67	1.28	.....	4.72	76.87	1.26	7.65	Ash 8.14	S 1.36	.....	.....	" " " " " " 434.
"	"	"	.....	5.53	29.68	57.05	7.74	1.10	.....	4.73	77.01	1.26	7.65	Ash 8.19	S 1.16	.....	.....	" " " " " " 443.
"	"	"	.....	4.97	30.87	56.66	7.50	1.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " 161. Coal, test 164.
"	"	"	.....	0.50	.65	87.96	10.89	.93	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " Coke, " "
"	"	"	.....	5.49	30.36	55.49	8.66	1.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " Coal " 165.
Crittenden Coal & Coke Co.	6	Mine	.....	0.47	.50	86.10	12.93	1.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " Coke " "
Barnsley	9	"	.....	.....	35.60	54.52	9.88	3.06	.008	.....	.....	.....	.....	.....	.....	13,269	.....	East side, first level, room 10. Coal 3' 11½".
"	"	"	3.30	6.00	37.45	48.23	8.32	3.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	U. S. G. S. Bull. 261, p. 47. Air dried. No. 1361.
"	"	"	.....	9.10	36.21	46.64	8.05	2.97	.....	.....	.....	.....	.....	.....	.....	.....	.....	" Analysis corrected to sample as received.
"	"	"	2.20	5.91	38.39	46.19	9.51	4.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	
"	"	"	.....	7.98	37.55	45.17	9.30	4.03	.....	.....	.....	.....	.....	6,797	.....	12,235	.....	" Bull. 261, p. 47, No. 1367. Air Dried.
"	"	Car	2.20	5.85	36.90	46.96	10.29	3.60	.....	5.27	66.75	1.43	12.66	6,647	.....	11,965	.....	" Analysis corrected to sample as received.
DeKoven	"	Mine	.....	7.92	36.09	45.93	10.06	3.52	.....	5.39	65.29	1.40	14.34	6,829	6,746	12,292	12,143	" Bull. 261, p. 147. No. 1506. Air dried.
"	"	"	.....	0.89	34.61	51.12	13.38	4.32	.....	.....	.....	.....	.....	6,679	6,598	12,022	11,876	" Analysis corrected to sample as received.
"	"	"	.....	0.92	34.48	52.40	12.20	3.54	.....	.....	.....	.....	.....	.....	.....	12,368	.....	Pittsburg Testing Lab. No. 30108. Evidently dry coal. 4" W. level.
"	"	"	.....	0.89	36.14	51.60	11.37	4.39	.....	.....	.....	.....	.....	.....	.....	12,531	.....	" " " " " " " " 3" E. "
"	"	"	.....	0.90	34.67	51.95	12.48	2.90	.....	.....	.....	.....	.....	.....	.....	12,633	.....	" " " " " " " " 3" W. "
"	"	"	.....	0.87	36.17	52.54	10.42	3.10	.....	.....	.....	.....	.....	.....	.....	12,578	.....	" " " " 30109. " " " 6" E. "
Providence Coal Co. No. 1 Mine	"	"	.....	0.78	36.09	52.94	10.19	1.65	.....	.....	.....	.....	.....	.....	.....	12,929	.....	" " " " " " " " 6" W. "
Sturgis No. 1	"	"	.....	4.04	32.46	56.74	6.76	.807	.....	.....	.....	.....	.....	.....	.....	13,160	.....	" " " " 30111. " " " Lump, top coal.
Earlington	11	"	2.90	1.85	37.10	53.57	7.48	2.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	Anal. by U. S. Navy. Of vol. mat. 1.86% is non-combustible. S. too low.
"	"	"	.....	5.76	39.19	47.74	7.31	3.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	From Wets Ky. Coal Co. Coal 61/.
"	"	"	.....	8.49	38.05	46.36	7.10	3.53	.....	.....	.....	.....	.....	7,063	.....	12,713	.....	U. S. G. S. Bull. 261, p. 46. No. 1365. Air dried.
"	"	"	2.60	5.34	38.61	45.56	10.49	4.31	.....	.....	.....	.....	.....	6,858	.....	12,344	.....	" " " " " " " Analysis corrected to sample as received.
"	"	"	.....	7.80	37.60	44.38	10.22	4.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 1366. Air dried.
"	"	"	2.70	5.36	38.99	46.27	9.38	3.72	.....	5.33	67.64	1.25	12.68	6,966	6,840	12,539	12,312	" Analysis corrected to sample as received.
Eureka	"	Mine	.....	7.91	37.94	45.02	9.13	3.62	.....	5.48	65.81	1.22	14.74	6,778	6,655	12,200	11,979	U. S. G. S. Bull. 261, p. 46. No. 1461. Air dried.
"	"	"	.....	3.27	40.55	50.31	5.87	3.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	" Analysis corrected to sample as received.
"	"	"	.....	3.35	38.83	50.72	7.10	2.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	Smith, Rudy & Co., Philadelphia analysts. 6" W. entry.
"	"	"	.....	3.53	40.63	49.69	6.15	3.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 8" " "
"	"	"	.....	3.50	39.90	49.88	6.72	3.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 10 " "
"	"	"	.....	3.34	41.20	48.80	6.66	3.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 12" " "
"	"	"	.....	3.99	41.44	47.40	7.17	3.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 16" " "
"	"	"	.....	3.18	40.45	46.63	9.74	4.93	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 18" E. "
"	"	"	.....	0.41	45.40	52.12	2.07	3.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " 18" W. "
Uniontown	"	"	.....	4.58	38.92	51.16	3.34	2.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	Regis Chauvenet & Bro. St. Louis. Analysts.
Waverly	"	"	.....	3.73	39.79	46.36	10.12	3.89	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " " "
Webster Co. Coal Co., Providence	"	"	.....	3.30	39.60	41.58	15.52	4.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	Ky. C. Mining Co. Air dried. J. S. McHargue, Analyst.
Wheatcroft No. 4	"	"	.....	2.20	38.05	50.45	9.05	.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	" " " " " " "
" " "	"	"	.....	1.70	35.91	54.11	8.28	3.14	.....	.....	.....	.....	.....	.....	.....	13,840	13,270	Ansil Maffott, Indianapolis, Analyst, S. is too low.
" " "	"	"	2.60	2.06	39.19	51.15	7.60	3.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	From W. Ky. C. Co. Coal 65".
" " "	"	"	.....	4.61	38.17	49.82	7.40	3.33	.....	.....	.....	.....	.....	7,336	.....	13,205	.....	U. S. G. S. Bull. 261, p. 47. Air dried. No. 1382.
" " "	"	"	2.00	2.82	40.53	49.50	7.15	3.28	.....	.....	.....	.....	.....	7,165	.....	12,861	.....	" Analysis corrected to sample as received.
" " "	"	"	.....	4.76	39.72	48.51	7.01	3.21	.....	.....	.....	.....	.....	.....	.....	.....	.....	" Bull. 261, p. 47. No. 1384. Air dried.
" " "	"	Car	2.80	2.54	36.08	46.79	14.59	4.67	.....	4.53	66.50	.....	.....	.....	.....	.....	.....	" Analysis corrected to sample as received.
" " 5 (Baker Shaft)	12	"	.....	5.27	35.07	45.48	14.18	5.54	.....	4.71	64.65	1.28	8.43	6,830	6,677	12,294	12,019	" Bull. 261, p. 47. No. 1539. Air dried.
Nebo, Coil Coal (N. Consol. C. Co.)	14	Mine	4.24	37.22	51.39	7.15	0.90	.....	.....	.....	.....	1.24	10.68	6,639	6,490	11,950	11,682	" Analysis corrected to sample as received.
" " " " " "	"	"	.....	5.24	37.90	50.90	5.96	1.97	.....	.....	.....	.....	.....	.....	.....	14,055	.....	B. t. a. on day basis. R. M. Redding, Chemist, New Orleans Gas Light Co. Lab.
			.....	6.34	41.80	46.86	5.18	1.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	No. 10500. A. M. Peters, Lexington, Ky. Dec. 24, 1902.
																		By R. M. Parkes, Louisville, Ky. Dec. 5, 1905.