White, I. C.

Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio and West Virginia

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UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

STRATIGRAPHY

OF THE

BITUMINOUS COAL FIELD

OF

PENNSYLVANIA, OHIO AND WEST VIRGINIA

BY

ISRAEL C. WHITE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1891

CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
APPALACHIAN DIVISION,
Morgantown, W. Va., July 15, 1890.

SIR: I have the honor to transmit herewith the results of my study of the stratigraphy of the bituminous coal rocks in the northern half of the Appalachian field.

As stated in the body of this report, it can not be expected that this first attempt to correlate the different beds of coal, limestone, and sandstone over such a wide area will be free from error, but it represents my best efforts to harmonize the strata of the several regions. No one knows better than I that many of the identifications suggested are largely preliminary, and I not only expect but request the friendly criticism of my brother geologists, knowing that all will be pleased when the correct order of these interesting deposits shall be finally determined.

Many questions of great geological interest have not been discussed in this report, for the reason that I thought it best to postpone their treatment until some one should have done for the southern half of the Appalachian coal field what I have attempted for the northern half, since the field is a unit from Pennsylvania to Alabama, and in the discussion should be treated as such.

It is hardly necessary to say that the accompanying map is not presented with any claim for accuracy as to details, but only to show in a rough way the general distribution of the different members, and with the hope that it may prove of some service in the preparation of a correct map of these several series when the Survey shall have extended its topographic work over the entire region.

Very respectfully, your obedient servant,

I. C. WHITE.

Hon. J. W. POWELL,
Director U. S. Geological Survey, Washington, D. C.

STRATIGRAPHY OF THE BITUMINOUS COAL FIELD IN PENNSYLVANIA, OHIO, AND WEST VIRGINIA.

By I. C. White.

CHAPTER I.

AREA, STRUCTURE, AND CLASSIFICATION.

The Appalachian Basin contains the largest continuous coal field of any Carboniferous area. Beginning near the northern line of Pennsylvania, latitude 42°, longitude 77°, it extends southwestward through West Virginia, southeastern Ohio, eastern Kentucky, and central Tennessee, ending in western Alabama, latitude 33°, longitude 88°, 900 miles from its northern terminus.

The shape of the field has been compared to that of a rude canoe, the pointed ends being in Pennsylvania and Alabama, respectively, while the broadest portion lies in southern West Virginia and Ohio.

As is well known, the general structure of the field is that of a great trough or basin, the line of greatest depth leaving Pennsylvania near its southwest corner, and passing down through West Virginia rudely parallel to the Ohio River, to enter Kentucky 10 miles above the mouth of the Big Sandy River. This general trough or geo-syncline is itself traversed, especially in its northeastern portion, by a series of flexures, which, although so gentle along the region west of the center of the field as to be recognizable with difficulty, yet eastward thereof they increase in amplitude until the great folds of the Alleghany Mountains become a part of the system.

The map sections shown on Pls. X and XI, crossing the Appalachian field nearly normal to the strike, will give the reader a good idea of the structure of the northern half of this field at the localities indicated on the map (Pl. I), and they also show how the folds which are so prominent at the northeast gradually die out toward the southwest, so that in the region of the Great Kanawha River they almost disappear. This flattening out of the flexures in southern West Virginia has been ascribed by Professors Fontaine and Stevenson to the development of the great system of faults along the southeastern margin of the coal field in the edge of Virginia, which relieved the tension on the rocks over

the adjoining portion of the Appalachian field and thus prevented their folding as in Pennsylvania and northern West Virginia. These anticlinal and synclinal folds so well developed at the north are nearly parallel to the Alleghany Mountains, but as they begin to die away in central West Virginia a large anticline (the Volcano) runs nearly north and south diagonally across the general strike of the beds.

There are probably other folds in the southwestern part of West Virginia, which, like the Volcano anticline, run contrary to the usual direction, but they have not been traced out with sufficient care to warrant description.

The distribution of the different geological groups on the accompanying map will serve to show the general position and direction of the principal anticlines, but the topographic base of the map is so inaccurate that it was thought best not to attempt to put in the anticlinal lines of the region described till the Survey should have completed the regular topographical map.

In this connection it should be stated that this map is not presented with any claims for accuracy in detail, but simply to show the general distribution of the Carboniferous system.

The portion of the Appalachian region herein described includes only the bituminous coal fields of Pennsylvania, Ohio, and West Virginia.

The Pennsylvania and Virginia geologists, led by the two illustrious Rogers brothers, long ago discovered that the main coal-bearing portion of the Carboniferous system could be naturally subdivided into five series. This generalization was founded upon a careful study of the rocks over a wide area, and the subsequent work of other geologists has fully established its general truthfulness to nature as well as its great usefulness in stratigraphic geology.

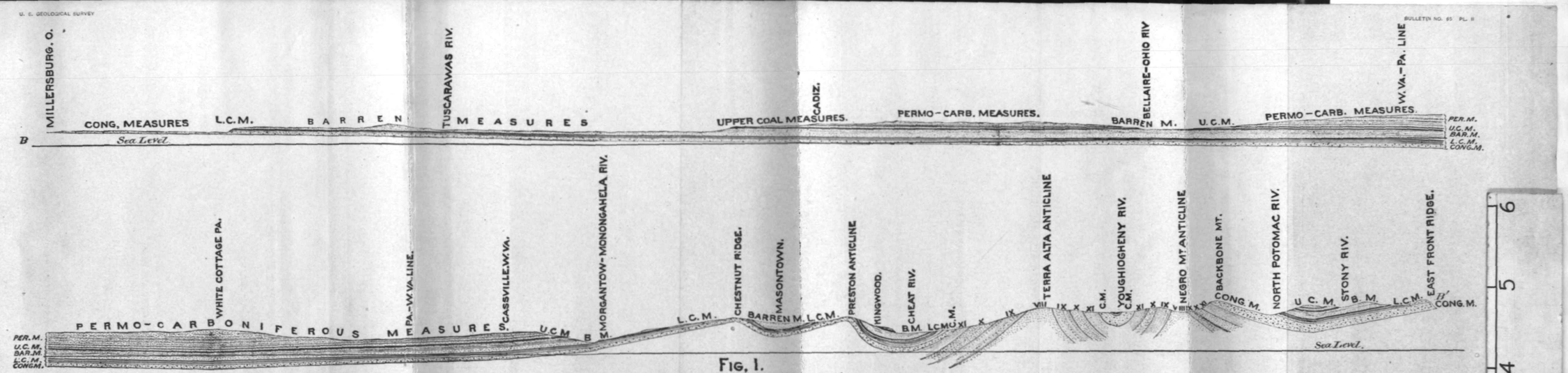
The more detailed and minute studies of recent years, rendered possible by vast mining developments, have only modified the Rogers classification, and hence it has become so thoroughly ingrafted into geological nomenclature and so familiar to the minds of practical coal operators that it would be very unwise to make any radical changes in it. It is true that in minor details the original nomenclature for some of these series was misleading, but this does not materially affect the grand truths expressed in the general framework of the classification, and hence it has been deemed best to modify and supplement this time-honored work, rather than to destroy it and cast it away, as has recently been suggested by some geologists.

The classification adopted in this report attempts to preserve whatever of the old nomenclature has been found useful and helpful to geologists, while at the same time such new features are introduced as seem necessary from our wider and more intimate knowledge of these rocks.

The entire Carboniferous system of the Appalachian region subdivides naturally into three grand divisions founded upon conditions of accu-

LE 5 MILES = 1 INCH.
5000 FT " " "

ROM RAVENNA, OHIO, TO THE ALLEGHANY



FIG, 1.
HORIZONTAL SCALE 5 MILES = 1 INCH.
VERTICAL " 5000 FT = " "

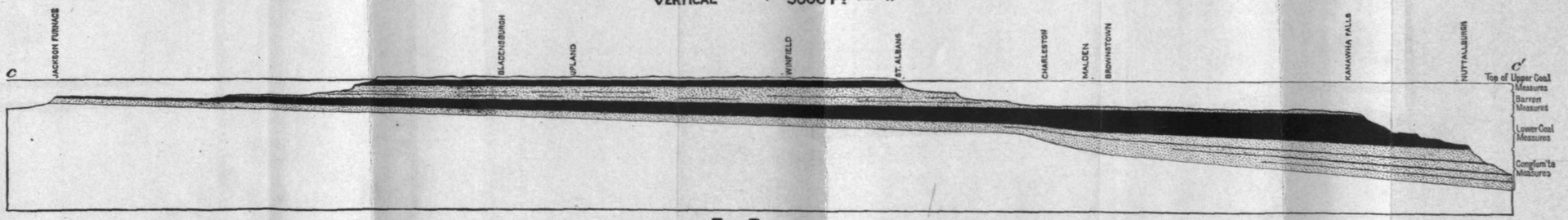
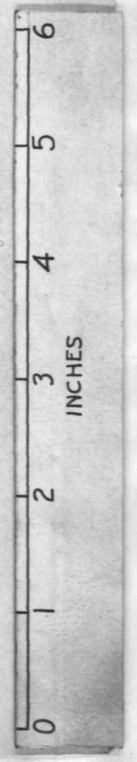
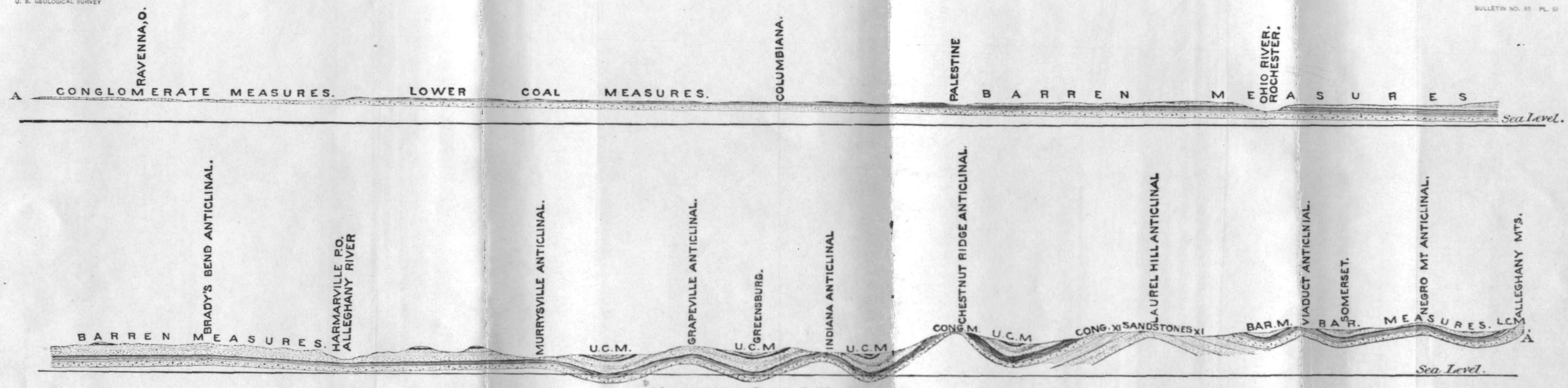


FIG. 2.
HORIZONTAL SCALE 36000 FT = 1 INCH.
VERTICAL " 3600 " = " "



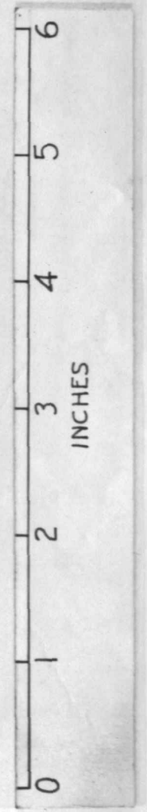
SECTIONS ACROSS THE APPALACHIAN COAL FIELDS.

FIG. 1. Section across the Appalachian coal fields from Millersburg, Ohio, to the eastern edge of the Alleghany Mountains.
FIG. 2. Generalized section across the Appalachian coal fields, drawn to show the thickening of the several coal groups between Jackson County, Ohio, and Fayette County, West Virginia.



HORIZONTAL SCALE 5 MILES = 1 INCH.
VERTICAL „ 5000 FT „ „ „

SECTION ACROSS THE APPALACHIAN COAL FIELDS, FROM RAVENNA, OHIO, TO THE ALLEGHANY MOUNTAINS.



mulation, and these in turn split up into eight minor series, as exhibited in the following scheme:

	Divisions.	Series.	
Carboniferous System	Upper: fresh and brackish water deposits.	Permo-Carboniferous, No. XVI, Dunkard Creek Series.	
		Upper Coal Measures, No. XV, Monongahela River Series.	
	Middle: shore deposits, with incursions of the sea.	Barren Measures, No. XIV, Elk River Series.	Upper half. / Lower half.
		Lower Coal Measures, No. XIII, Allegheny River Series.	
		Pottsville Conglomerate Measures, "Great," "Seral," No. XII, Conglomerate, etc.	
	Lower: marine deposits.	Mauch Chunk Red Shale, Umbral Red Shale. Mountain Limestone, Umbral Limestone, Greenbrier, etc.	No. XI.
		Pocono Sandstone, Vespertine, No. X, "Big Injun" oil sand, etc.	

As will be seen from the foregoing diagram, the line between the Middle and Upper Carboniferous deposits passes directly through the center of the Elk River series. This is due to the fact that marine conditions ceased, never to return, with the deposition of the Crinoidal limestone and its associated beds, midway in the Barren Measures, thus separating them into two divisions which are of almost equal thickness, the lower one abounding in marine life, while the upper has nothing but fresh or brackish water forms. The change in this respect is great enough to warrant the separation of the Barrens into two series, but as the lithological differences at the line of separation are very meager, it is deemed best to keep these rocks a unit as in the Rogers nomenclature.

This report deals only with the Middle and Upper Carboniferous of the above table, and the five series into which they are subdivided will now be described in detail, beginning with the highest.

The discussion of many interesting questions connected with Carboniferous geology is necessarily postponed until the rest or southern half of the Appalachian coal field has been carefully studied as a whole.

CHAPTER II.

THE PERMO-CARBONIFEROUS OR DUNKARD CREEK SERIES.

THICKNESS, CHARACTER, AND EXTENT.

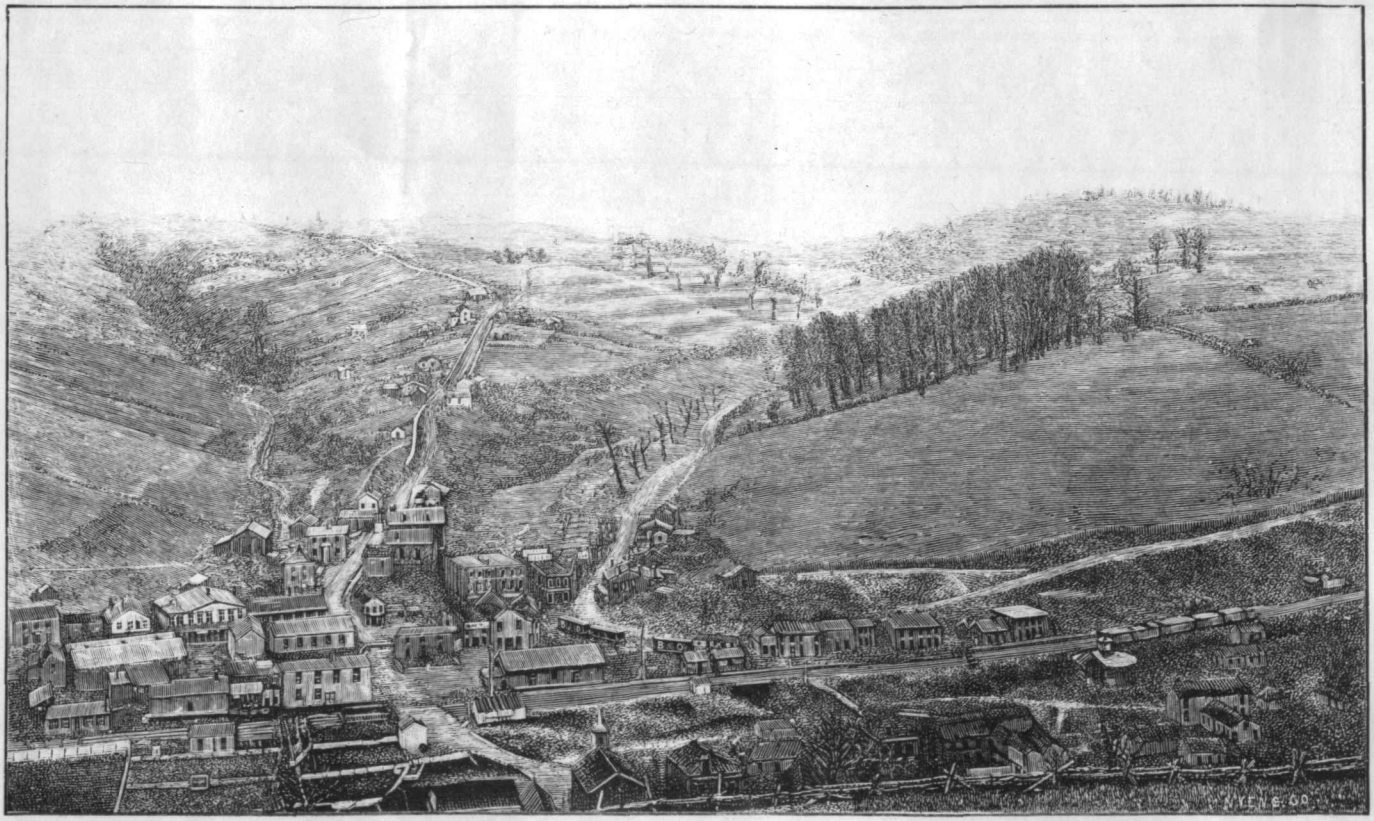
The rocks of this series (Upper Barren Measures, No. XVI) begin with the roof shales of the Waynesburg coal and extend upward to the topmost beds of the Appalachian region.

How many feet of deposits erosion has removed above the highest remaining beds we can only conjecture. However, if the soft and easily yielding character of the rocks which have escaped disintegration can be taken as a criterion for those that have wasted away, the thickness of the latter must be reckoned by the thousand and probably by the 10,000 feet.

Several independent measurements from the highest accessible summits foot up a little more than 1,150 feet for the thickness of the series and it is certain that no other localities could exceed this by more than 100 feet.

The uppermost beds are found at the headwaters of Dunkard Creek, a large stream which heads near the West Virginia-Pennsylvania line, on the eastern slope of the watershed separating the Ohio and Monongahela River drainage system, and flowing eastward puts into the Monongahela two miles above Greensboro, Greene County, Pennsylvania, and four miles north from the West Virginia line. This stream flows over Permo-Carboniferous rocks from its source to the point at which it leaves the West Virginia line at Mount Morris, Pennsylvania, a distance of more than thirty miles, furnishing very fine exposures of these rocks along its banks and bluffs; hence the geographical name (Dunkard Creek) which I have given the series.

These deposits occupy a rather limited area in the Appalachian field, being found in only two counties (Greene and Washington) of Pennsylvania, with the exception of small isolated patches in Fayette, Westmoreland, and Allegheny. In Ohio there is a larger area of them bordering the Ohio River through the counties of Belmont, Monroe, Washington, Athens, Meigs, and Gallia. But it is in West Virginia that we find the principal belt of these beds, for there they cover a wide



PERMO-CARBONIFEROUS, CAMERON, WEST VIRGINIA.

region bordering the Ohio River between the Pennsylvania line at the north and the Great Kanawha River on the south, as the accompanying map shows.

The character of the rocks varies greatly in different portions of this area. At the northeastern end of the field, in Washington County, Pennsylvania, limestones seem to predominate in thickness over the gray shales, sandstones, and thin coal beds with which they are there interstratified. But southwestward the limestones and coals gradually disappear, so that in Jackson County, West Virginia, no regular coal beds are found, and only one limestone (the Nineveh) remains. The limestones continue in considerable number in Greene, Ohio, Marshall, and Monongalia Counties, and the northern part of Wetzel County, but southward from this line they rapidly disappear, with the single exception noted. The coal beds all die out with the disappearance of the limestones, except one (the Washington), which seems to extend beyond the Little Kanawha River before it passes out of the series.

As the limestones and thin coal beds gradually fade out to the southwest, red shale, a variety of rock almost unknown in Washington County, Pennsylvania, gradually comes into the section in thin beds at first, but finally extends throughout the whole series, and forms nearly one-half its thickness, thus making a broad band of red soil from the Pennsylvania line southwestward to the Great Kanawha River.

This increase in red shale beds is accompanied by an increase in the number and massiveness of the sandstone rocks, so that the topography gradually becomes greatly different from that found in Washington County, Pennsylvania. There the surface is gently rolling, the valleys broad, and the hills rounded, with no deep gorges or precipitous slopes, the abundance of limestone rendering the soil so highly fertile that the region has long been famed as one of the finest grazing and agricultural districts in the Union. But toward the southwest, while the soil remains very fertile, owing to a large quantity of marly material in the red shales, yet the thickening up of the sandstone beds makes the valleys narrow and the lower portion of the hills often precipitous, the arable land being confined largely to the ridges, so that the soil is better adapted to grazing than tillage. In many cases the massive sandstones crop out along the ridges which they have protected from erosion, forming narrow "hogbacks," from which the surface falls away rapidly on each side. Another peculiarity of these beds is that the sand rocks contain no pebbles except near the base of the series, since above the Waynesburg sandstone no pebbles larger than coarse sand grains have ever been seen by the writer in all of the 1,000 feet of deposits, except at a single locality on the Parkersburg and Staunton turnpike, along the dividing ridge between Ritchie and Gilmer Counties, West Virginia, where locally the Marietta Sandstones, 140 feet above the Washington coal, thicken up into a very coarse conglomerate, filled with quartz pebbles.

The character of the rocks which compose these measures in the several regions of their area will be seen from the sections which follow.

Section on Dunkard Creek, Greene County, Pennsylvania.—Fig. 1 shows the succession found along Dunkard Creek, from the head of its Pennsylvania fork in Gilmore Township, Greene County, eastward to where the stream veers northward back into Pennsylvania at Mount Morris.

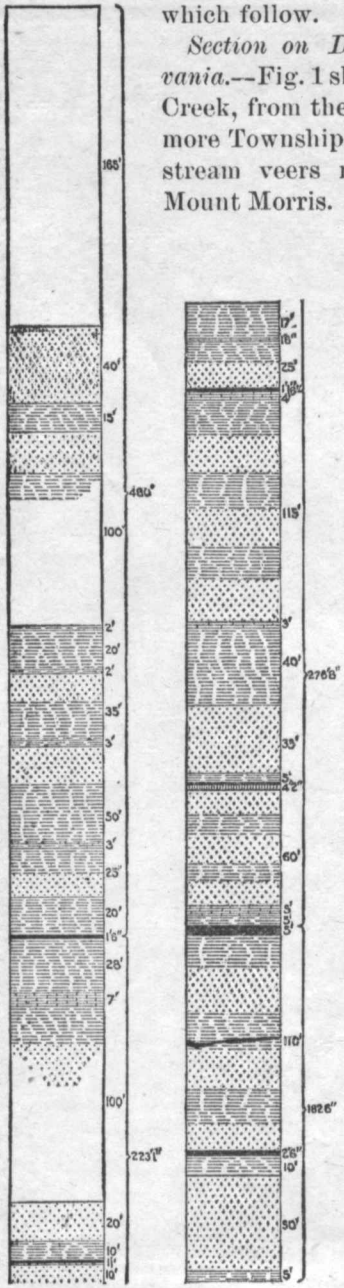


FIG. 1.—Section on Dunkard Creek, Pa.

Dunkard Creek, Greene County, Pennsylvania.

[See map, L l to L k.]

		Ft.	in.	Ft.	in.
1.	Concealed from top of Shough's knob	165			
2.	Sandstone, massive, Gilmore	40			
3.	Shales, with limestone at base	15			
4.	Sandstone and shales and concealed	100			
5.	Shale, red	2			
6.	Shales, gray	20		480	
7.	Shale, marly	2			
8.	Sandstone and shale	35			
9.	Shale, red	3			
10.	Sandstone and shale	50			
11.	Red shale	3			
12.	Shales and sandstone, Nineveh	25			
13.	Shales	20			
14.	Coal, Nineveh	1	6		
15.	Shales	28			
16.	Limestone (No. X), Nineveh	7			
17.	Shales, sandstone and concealed	100			
18.	Sandstone, massive, Fish Creek	20			
19.	Shales with fossil plants	10			
20.	Coal, Dunkard. Coal 0′ 5″ / Slate 0′ 1″ / Coal 0′ 6″	1		223	
21.	Limestone	1			
22.	Sandstone	10			
23.	Shales	17			
24.	Limestone, Jollytown	1	6		
25.	Shales and sandstone	25			
26.	Coal, Jollytown	1	1		
27.	Calcareous shale, fossiliferous, fish teeth	0	6		
28.	Limestone, Upper Washington	4			
29.	Shales and sandstone	115			
30.	Limestone, Middle Washington	3			
31.	Shales	40			
32.	Sandstone	35			
33.	Shale	5		276	8
34.	Coal, Washington "A." Coal, impure 1′ 2″ / Fire clay 2′ 6″ / Coal 0′ 6″	4	2		
35.	Shales and sandstones	60			
36.	Limestone, Lower Washington	5			
37.	Shales	5			
38.	Coal, Washington, slaty	5			
39.	Shales and sandstones, including a coal bed near center	110			
40.	Coal, Waynesburg, "A"	2	6	182	6
41.	Shales	10			
42.	Sandstone, Waynesburg	50			
43.	Shales, with fossil plants (Cassville)	5			
44.	Waynesburg coal.				
	Total			1,162	3

Section on Colvin's Run, Greene County, Pennsylvania.—The lower half of this Dunkard Creek series is very finely exposed in a continuous section on Colvin's Run, a tributary of Dunkard which empties into it near Mount Morris, Greene County, Pennsylvania, and in descending this stream the following intervals, as shown in Fig. 2, were carefully measured:

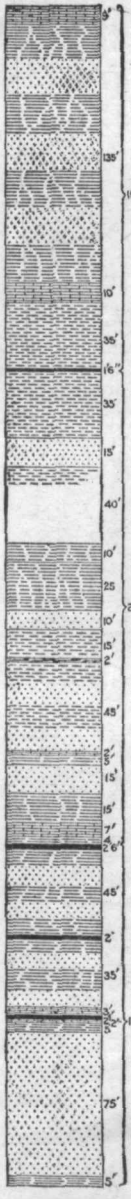


FIG. 2.—Section on Colvin's Run, Pa.

Colvin's Run, Greene County, Pennsylvania.

[See map, L l.]

		Ft.	in.	Ft.	in.
1.	Limestone, Nineveh	9			
2.	Shales and sandstone	135			
3.	Limestone, Jollytown	10		190	6
4.	Sandy shales	35			
5.	Coal, Jollytown	1	6		
6.	Shales, sandy	35			
7.	Sandstone, massive	15			
8.	Sandy shales and concealed	40			
9.	Red shales	10			
10.	Shales	25			
11.	Sandstone	10			
12.	Shales	15			
13.	Coaly shales, Washington, "A"	2		245	
14.	Sandy shales and sandstone	45			
15.	Limestone, gray	2			
16.	Shales	5			
17.	Sandstone, massive	15			
18.	Shales	15			
19.	Limestone, Washington Lower	7			
20.	Shale, dark	4			
21.	Coal, Washington	2	6		
22.	Shales and sandstone	45			
23.	Coal, Waynesburg, "B"	2			
24.	Shales and sandstone	35			
25.	Limestone, Colvin's Run	3			
26.	Shales	1		177	6
27.	Coal, Waynesburg, "A"	2			
28.	Limestone	2			
29.	Shales	5			
30.	Sandstone, Waynesburg	75			
31.	Shales, with fossil plants (Cassville)	5			
32.	Coal, Waynesburg.				
	Total			613	

Section in Aleppo Township, Greene County, Pennsylvania.—Wheeling Creek rises on the western slope of the Monongahela-Ohio divide, and flowing westward enters the Ohio River at Wheeling. It furnishes excellent exposures of the Dunkard beds from the summit of the series to the base. The following intervals (Fig. 3) were measured along the Dunkard Fork of the creek between its source in Aleppo Township, Greene County, Pennsylvania, and the mouth of Crab Apple Creek, near the West Virginia line:

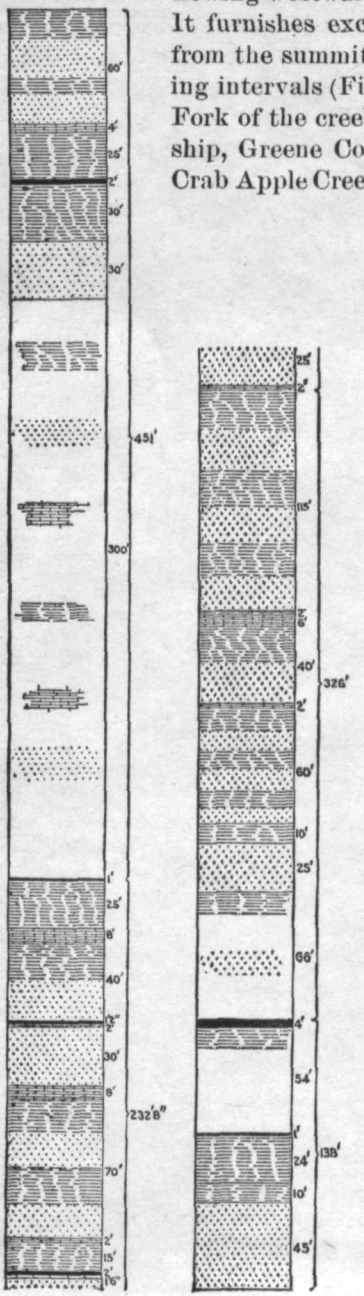


FIG. 3.—Section in Greene County, Pa.

Aleppo Township, Greene County, Pennsylvania.

[See map, L.]

		Ft.	in.	Ft.	in.
1.	Shales and sandstones	60			
2.	Limestone, Windy Gap	4			
3.	Shale	25			
4.	Coal and bituminous shale, Windy Gap	2		451	
5.	Shale	30			
6.	Sandstone, Gilmore	30			
7.	Concealed (shales, sandstones, and limestones)	300			
8.	Coal, Nineveh	1			
9.	Shales	25			
10.	Limestone, Nineveh	8			
11.	Shales and sandstone	40			
12.	Coal	1	2		
13.	Limestone	2			
14.	Sandstone	30			
15.	Limestone	8		232	8
16.	Shales and sandstone	70			
17.	Limestone	2			
18.	Shale	15			
19.	Coal, Dunkard	2			
20.	Limestone	1	6		
21.	Shaly sandstone	25			
22.	Limestone, Jollytown	2			
23.	Shales and sandstone	115			
24.	Dark, calcareous shale	2			
25.	Limestone	6			
26.	Shales and sandstone	40			
27.	Limestone	2			
28.	Shales and sandstone	60		326	
29.	Shales	10			
30.	Sandstone	25			
31.	Shales, sandstones, and concealed	66			
32.	Coal, Washington	4			
33.	Shales and concealed	54			
34.	Coal, Waynesburg, "B"	1			
35.	Shales	24		138	
36.	Coal, Waynesburg, "A"	0			
37.	Shales	10			
38.	Sandstone, Waynesburg	45			
39.	Coal, Waynesburg.				
	Total			1,147	8

Section at Board Tree Tunnel, Marshall County, West Virginia.—At Board Tree Tunnel, on the Baltimore and Ohio Railroad, and close to the line between Wetzel and Marshall Counties, some very high land occurs, while an oil well boring in the valley of Fish Creek near by carries the rock measurement down to the base of the Dunkard Creek beds. In descending from Rice's Knob past the western portal of Board Tree Tunnel to the Nuce farm oil boring on Fish Creek, and connecting with the record of the latter, the following succession (Fig. 4) is revealed:

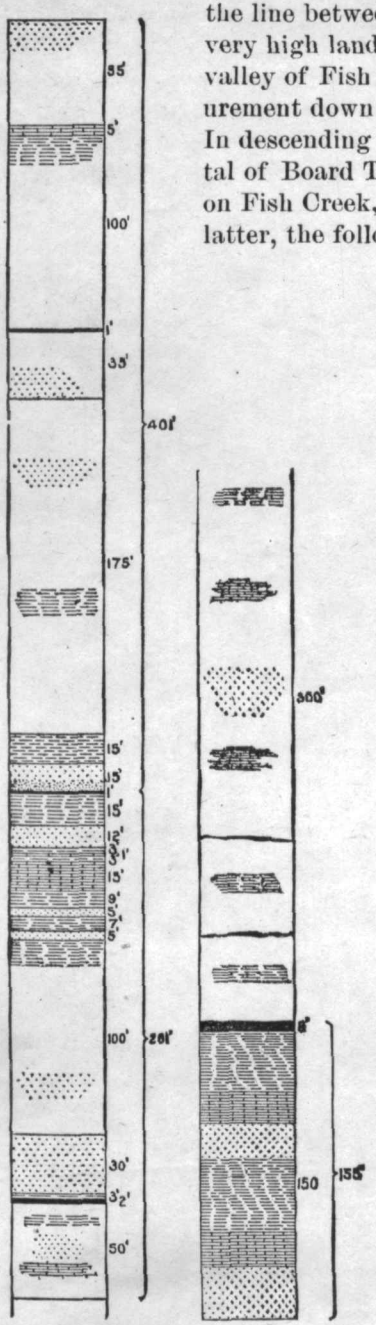


FIG. 4.—Section at Board Tree Tunnel, Marshall County, W. Va.

Board Tree. Marshall County, West Virginia.

[See map, L j.]

		Ft.	Ft.
1.	Sandstone, gray, and concealed	55	
2.	Gray limestone, Windy Gap	5	
3.	Red shales and concealed	100	
4.	Coaly slate	1	
5.	Concealed to base of a massive sandstone	35	401
6.	Concealed, sandstone and red shale to Board Tree Tunnel	175	
7.	Sandy shales	15	
8.	Sandstone, Nineveh	15	
9.	Coal, Nineveh	1	
10.	Gray shales	15	
11.	Sandstone, massive	12	
12.	Shales	3	
13.	Limestone, Nineveh: Limestone 1′; Black slate 3′; Limestone and limy beds 15′	19	
14.	Variegated shales	9	
15.	Sandstone	5	
16.	Shales, limy	7	261
17.	Sandstone, to level of track at west portal	5	
18.	Concealed shales and sandstone	100	
19.	Massive sandstone, Fish Creek	30	
20.	Shales	3	
21.	Coal, Dunkard, to level of bore hole	2	
22.	Interval, shales, sandstones, and limestones, with two thin coal beds	50	
23.	Shales, sandstones, and red beds		300
24.	Coal, Washington	5	155
25.	Shales, limestones, and sandstone	150	
26.	Coal, Waynesburg.		
	Total		1,117

There is some uncertainty about the horizon of the Pittsburgh coal in the oil boring, since two large beds are reported, one at 700 feet and the other at 800. The latter is the thicker bed, and as the depth from it to the third oil sand (2,100 feet) agrees with the

same interval 15 miles to the northeast, I have regarded the lower bed as the Pittsburgh in constructing the above section. If, however, the coal 100 feet higher should prove to be the Pittsburgh, then the 5-foot coal 150 feet above the bottom of the section would probably be the Waynesburg bed, and the Dunkard Creek series should be cut off just above it, and thus shortened by 155 feet at this locality.

In the vicinity of Bellton, Marshall County, West Virginia, 4 miles west from Board Tree Tunnel, the exposures are very fine and the surface outcrops can there also be combined with the record of an oil boring, which thus gives another measurement of the entire series.

Section at Bellton, Marshall County, West Virginia.—In descending from the highest summits near Bellton, the following succession (Fig. 5) is obtained when combined with an oil-boring record which was published by the writer in the Annals of the Lyceum of Natural History, New York, July, 1874:

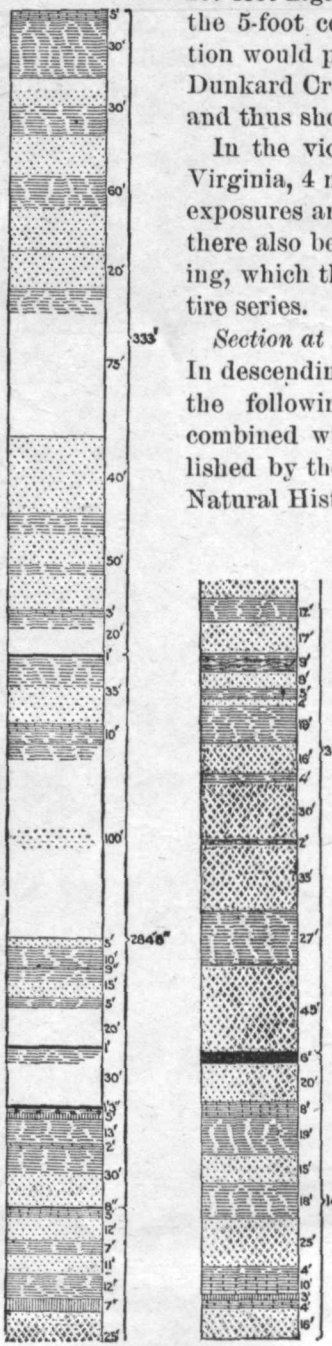


FIG. 5.—Section at Bellton, W. Va.

Bellton, Marshall County, West Virginia.

[See map, L j.]

	Ft.		Ft.	in.
1. Limestone, Windy Gap	5			
2. Shales	30			
3. Coal, Windy Gap, blossom	0			
4. Concealed and sandstone and shales	30			
5. Shales and sandstone	60			
6. Sandstone, massive, gray	20		333	
7. Red shales and concealed	75			
8. Sandstone, massive	40			
9. Red shales and sandstone	50			
10. Limestone	3			
11. Shales and concealed	20			
12. Coal, Nineveh	1			
13. Shales and sandstone	35			
14. Limestone and shales, Nineveh	10			
15. Shales, sandstone and concealed	100			
16. Sandstone	5			
17. Shales	10			
18. Limestone	0	6		
19. Coal	0	3		
20. Shales and sandstone	15			
21. Red shales	5		284	8
22. Concealed	20			
23. Coal	1			
24. Shales and concealed	30			
25. Coal, Dunkard—Black slate 4″ / Coal 11″	1	3		
26. Limy shales and fire clay	5			
27. Shales	13			
28. Limestone, gray, Jollytown	2			
29. Shales and sandstones	30			
30. Coal, Jollytown	0	8		
31. Limestone, gray, Upper Washington (continued from oil-well record)	5			
32. Sandstone	12			
33. Shale	7			
34. Sandstone	11			
35. Shale	12			
36. Fire clay	7			
37. Sandstone	25			
38. Shale	12			
39. Sandstone	17			

	Ft.	in.	Ft.	in.
40. Coaly shales	9			
41. Sandstone	9			
42. Shale	5			
43. Sandstone	4			
44. Shale	19			
45. Sandstone	16			
46. Shale	4		313	
47. Sandstone	30			
48. Shale	2			
49. Sandstone	35			
50. Shale	27			
51. Sandstone	45			
52. Coal, Washington	6		148	
53. Sandstone	20			
54. Limestone	8			
55. Shale	19			
56. Sandstone	15			
57. Shale	18			
58. Sandstone	25		148	
59. Shale	4			
60. Limestone	10			
61. Fire clay	3			
62. Limestone	4			
63. Sandstone	16			
64. Place for Waynesburg coal.				
Total			1,078	8

This boring did not reach the Pittsburgh coal, and hence the identification of the 6-foot coal bed, 142 feet above the base of the section, is made on the same basis as that of the 5-foot bed 150 feet above the bottom of Section 4, since the two coals are evidently identical. The thin coals in the upper half of the series have been named the Bellton group from this locality.

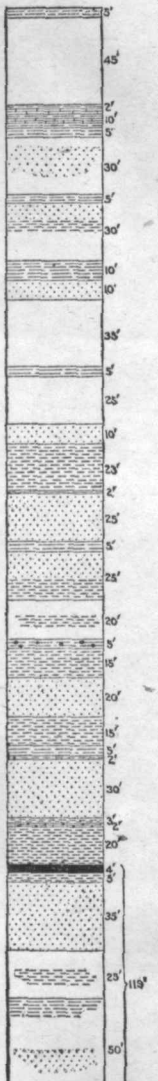


FIG. 6.—Section at New Martinsville, W. Va.

Section at New Martinsville, West Virginia.—In passing southwestward from this area of maximum development of the Permo-Carboniferous rocks a considerable change takes place in the character of the beds. The Bellton coal group practically disappears, and also many of the limestones, so that in the vicinity of New Martinsville, Wetzel County, West Virginia, the lower half of the series presents the structure shown in Fig. 6:

New Martinsville, Wetzel County, West Virginia.

[See map, M i.]	Ft.	Ft.
1. Red shale		5
2. Concealed		45
3. Red shale		2
4. Limestone, Nineveh, in several layers separated by shale		10
5. Red marly shale		5
6. Concealed and sandstone		30
7. Red shale		5
8. Sandstone, sandy shales, and concealed		30
9. Red shale		10
10. Sandstone, massive		10
11. Concealed		35
12. Red shale		5
13. Concealed		25
14. Sandstone, brown massive		10
15. Sandy shales		23
16. Red shale		2
17. Sandstone		25
18. Red shale		5
19. Sandstone and sandy shales		25
20. Concealed and sandy shales		20
21. Red marly shales, with limestone nodules		5
22. Sandy shale, gray		15
23. Sandstone, massive		20
24. Sandy shales		15
25. Red shale with limestone nodules		5
26. Shale, gray, sandy		2
27. Sandstone, massive		30
28. Sandy shales		3
29. Limestone, impure		2
30. Sandy shales		20
31. Coal, Washington	4	
32. Sandy shales	5	
33. Sandstone, massive	35	119
34. Concealed and sandy shales	25	
35. Shales, sandstones, and concealed	50	
36. Waynesburg coal.		
Total		563

No. 4 appears to represent the Nineveh limestone, though its interval above the base of the series is less here than usual.

Not a single one of the Belliton coals was observed in this section, though some of them may have been present and concealed.

Section at Baresville, Ohio.—In the vicinity of Baresville, Monroe County, Ohio, a long section was made by the late Prof. E. B. Andrews. It is referred to in vol. II, Ohio Geology, page 587, and published on Map XIII, section No. II. The locality is only 1½ miles above New Martinsville, West Virginia, and the succession reads as follows (Fig. 7):

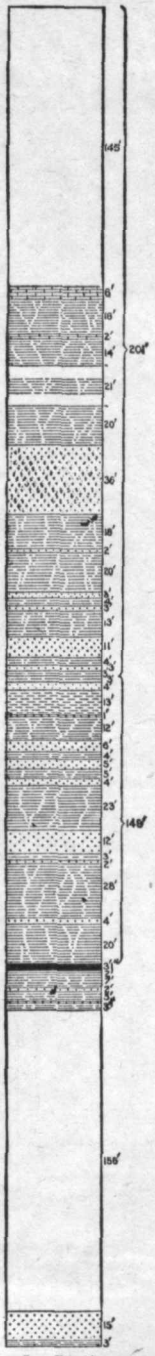


FIG. 7.—Section at Baresville, Ohio.

Baresville, Monroe County, Ohio.

[See map, M i.]

		Ft.	in.	n
1.	Coal, blossom			
2.	Concealed			145
3.	Limestone, Nineveh	6		
4.	Shale	18		
5.	Limestone, sandy	2		
6.	Red shale	14		
7.	Shale, mostly	21		
8.	Shale	20		
9.	Sandstone, laminated	36		
10.	Red shale	18		
11.	Sandstone	2		
12.	Red shale	20		201
13.	Sandstone	3		
14.	Shale	4		
15.	Sandstone	3		
16.	Red shale	13		
17.	Sandstone	11		
18.	Shale	4		
19.	Sandstone	3		
20.	Shale	3		
21.	Coal, blossom, Jollytown			
22.	Shale	3		
23.	Sandstone	4		
24.	Sandy shale	13		
25.	Sandstone	1		
26.	Shale	12		
27.	Sandstone	6		
28.	Shale	4		
29.	Sandstone	5		
30.	Shale	5		149
31.	Sandstone	4		
32.	Shale	23		
33.	Sandstone	12		
34.	Shale	3		
35.	Sandstone	2		
36.	Shale	28		
37.	Sandstone	4		
38.	Shale	20		
39.	Coal, Washington "A". Coal....0′ 9″ / Clay....0′ 4″ / Coal....2′ 0″			3 1
40.	Clay			2
41.	Shale			7
42.	Sandstone			2
43.	Shale			5
44.	Sandstone			1
45.	Shale			3
46.	Concealed			156
47.	Sandstone, Waynesburg			15
48.	Shale			3
49.	Coal, Waynesburg.			
	Total			692 1

The coal blossom at the summit of Section 7 appears to come at a horizon above any of the Bellton beds, and hence is a new and probably extremely local element in the series.

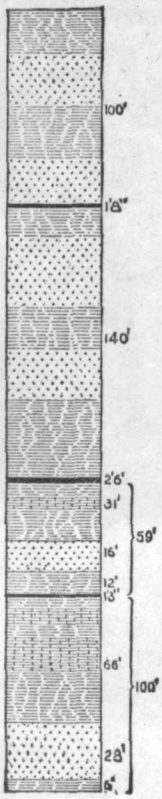


Fig. 8.—Section in Washington County, Ohio.

Section in Liberty Township, Washington County, Ohio.—The following (Fig. 8) succession of the beds in the lower portion of this series is reported by Mr. F. W. Minshall from a hill near the Epler oil-boring in Liberty Township, Washington County, Ohio:

Liberty Township, Washington County, Ohio.

[See map, M g.]	Ft.	Ft.	in.
1. Shales and sandstones		100	
2. Coal, Jollytown		1	8
3. Shales and sandstone		140	
4. Coal, Washington "A"		2	6
5. Shales and limestone	31		
6. Sandstone	16	59	
7. Shales	12		
8. Coal, Washington		1	3
9. Limestone and shales	66		
10. Sandstone, pebbly, Waynesburg	28	100	
11. Shales	6		
12. Waynesburg coal.			
Total		404	5

These identifications are made on the supposition that the Macksburg coal of the Ohio geologists is the equivalent of the Waynesburg bed.

Section at Washington, Pennsylvania.—In Washington County, Pennsylvania, the Dunkard series, as already stated, contains much more limestone than elsewhere, and the intervals between the several members are somewhat less than in Greene County. The following section (Fig. 9) from Geological Survey, Pennsylvania, Report K, page 248, exhibits the structure of the lower portion of these beds at Washington, Pennsylvania:

Washington, Pennsylvania.

[See map, J l.]

	Ft.	in.	Ft.	in.
1. Limestone, Jollytown			10	
2. Shale			5	
3. Coal, Jollytown			1	
4. Sandstone	10			
5. Dark shale	8			
6. Limestone, Upper Washington	30			
7. Concealed	50		190	
8. Coal, blossom	0			
9. Concealed	80			
10. Limestone, Lower Washington	12			
11. Coal, Washington	7			
12. Clay	4			
13. Sandstone	9			
14. Concealed	10			
15. Limestone	2		117	6
16. Shales, limestone, and concealed	65			
17. Black slate	1	6		
18. Limestone	4			
19. Blue shale	15			
20. Waynesburg coal.				
Total			323	6

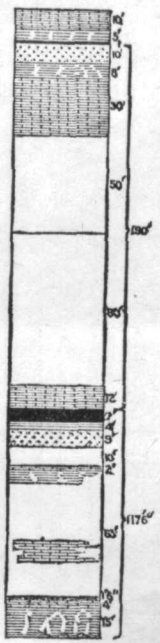


Fig. 9.—Section at Washington, Pa.

Section near Taylorstown, Pennsylvania.—Another section, from the same volume page 259, exhibits the succession in the lower half of this series in Buffalo Township, Washington County, Pennsylvania, as shown in Fig. 10.

In both these sections (9 and 10) the writer has changed the identifications of some of the beds (notably that of the Jollytown coal) from that made in the original sections by Stevenson, but in every such case the change is clearly warranted, since the coal in question was placed too near the Washington coal by Stevenson.

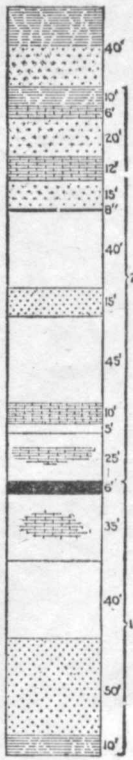


FIG. 10.—Section near Taylorstown, Pa.

Near Taylorstown, Washington County, Pennsylvania.

[See map, J k.]

	Ft.	in.	Ft.	in.
1. Limestone, in fragments			0	
2. Shales and sandstone			40	
3. Coal, blossom, Jollytown	0			
4. Shale	10			
5. Limestone	6			
6. Concealed	20			
7. Limestone	12			
8. Sandstone	15			
9. Coal	0	8		
10. Concealed	40			
11. Limestone	15		203	8
12. Concealed	45			
13. Limestone	10			
14. Concealed	5			
15. Coal	0			
16. Concealed, with much limestone	25			
17. Coal, Washington	6			
18. Concealed, with a limestone	35			
19. Coal, blossom, Waynesburg "B"	0			
20. Concealed	40			
21. Coal, blossom, Waynesburg "A"	0		141	
22. Waynesburg sandstone	50			
23. Shales	10			
24. Coal, Waynesburg			0	
Total			384	8

The very highest beds of the Dunkard Creek series known to the writer occur in Shough's Knob, at the head of Dunkard Creek, Gilmore Township, Greene County, Pennsylvania, but these are concealed by a thick covering of soil, and hence could not be seen in detail. The highest rock of the series which has been traced over any considerable area is the Windy Gap Limestone.

CHARACTERISTIC HORIZONS.

THE WINDY GAP LIMESTONE.

This has been named from its occurrence near Windy Gap, a "divide" separating the Laurel Run branch of Fish Creek from the waters of Wheeling Creek, in Springhill Township, Greene County, Pennsylvania.

The stratum is usually of a bluish gray color, quite pure, and has a thickness of about five feet. It contains minute fresh water fossils, and occasionally small crystals of blende.

The only land geologically and topographically high enough to catch this stratum is that which clusters about the southwestern corner of Pennsylvania, in Greene County, and the adjoining regions of Marshall, Wetzel, and Monongalia, in West Virginia. Only one point (Hunsucker's Knob) in the last county is high enough to catch this limestone, since its outcrop ranges between 1,500 and 1,600 feet above the sea. The sections (Figs. 3 and 4) at Board Tree and Bellton, in Marshall County, as well as the one (Fig. 2) in Aleppo Township, Greene County, show this stratum near their summits, but its horizon is concealed in Shough's Knob of the Dunkard Creek section (Fig. 1).

This is the same stratum as that numbered Limestone XIV by Prof. John J. Stevenson in his Report K, Second Geological Survey of Pennsylvania.

THE WINDY GAP COAL.

At an interval of 25 to 30 feet below the limestone just described there occurs a small coal bed just under the summit of the "divide" at Windy Gap, Greene County, Pennsylvania, and it has been designated from that locality. No opening into it has ever been made, and hence it is known only as a blossom which exposes one to two feet of coal and black slate, the latter filled with the fossil Cypris, or a closely allied form.

The same bed was also seen in Aleppo Township, and in the summit of the hills at Bellton. It is the highest known coal of the series, and comes about 1,050 feet above the Waynesburg bed.

THE GILMORE SANDSTONE.

Crowning the upper portion of the Permo-Carboniferous beds over a considerable area around the heads of Dunkard, Wheeling, and Fish Creeks, there occurs a very massive sandstone having a thickness of 25 to 40 feet. It was named the Gilmore sandstone by Professor Stevenson, from its occurrence in the township of that name in southwestern Greene County. This stratum is usually a coarse and very massive sandstone, excellent for building purposes, and often forming long lines of cliffs on the summits of the high ridges. These cliffs are always traversed with fissures, and they furnish a convenient retreat for foxes when chased by hounds, so that the stratum in question is often locally known as the "Fox rocks," and again it is named from the farms where the cliffs occur, as "Pethtle" rocks, "Efaw" rocks, etc. This stratum has been the main agency in preserving all of the very high beds of the Permo-Carboniferous from erosion.

The interval below the Gilmore sandstone for 200 to 250 feet consists of red shales, occasional thin limestones, and gray sandstones, but con-

tains no beds sufficiently characterized to be identifiable over any considerable area.

THE NINEVEH SANDSTONE.

At 225 to 250 feet below the Gilmore sandstone, we come to another great sandstone deposit which, from its good development near the village of Nineveh, Greene County, Pennsylvania, has been designated from that locality. Like the Gilmore sandstone above, it is usually an excellent building stone, and has long been used for that purpose on the Baltimore and Ohio Railroad, near Littleton, Wetzel County, West Virginia, where it crops out in a great cliff along the hills 150 to 200 feet above creek level.

This same stratum may also be seen in the hills two miles above Jollytown, Greene County, where it has long been quarried on the land of Thomas White for building purposes. It is of a yellowish gray cast, rather coarse-grained, but soft, and splits readily into rectangular blocks.

THE BELLTON COAL GROUP.

At 275 to 300 feet under the Gilmore sandstone we find the uppermost of a series of thin coals which, from their fine exposure at the village of Bellton, Marshall County, West Virginia, have been termed the Bellton group. These coals, few of which are rarely more than one foot thick, occur within a rock interval of 200 to 300 feet, and when all are present, as in the Bellton section (Fig. 5), there are five distinct beds, though not all of them are persistent over any considerable area. The three beds given in the Dunkard Creek section (Fig. 1), viz, the Nineveh, Dunkard, and Jollytown coals, are the most important members of the group. Interstratified with these coals are shales, sandstones, and two important limestones.

THE NINEVEH COAL.

This is the uppermost member of the Bellton group, and was named from the village of Nineveh, Greene County, Pennsylvania, by Professor Stevenson.

The coal rarely exceeds one foot in thickness, yet it is generally quite pure, and is frequently used for smithing purposes.

In the hills at Bellton it crops out 290 feet above Fish Creek, and the same coal is seen in the railroad cut at the western portal of Board Tree Tunnel, 75 feet above track level.

On the head waters of Dunkard Creek it is known as the John Taylor coal, and although only one foot thick is highly valued as a smithing fuel.

THE NINEVEH LIMESTONE.

Below the Nineveh coal at an interval of 25 to 30 feet there comes a limestone which has a very extended distribution. It was called Limestone No. X by Professor Stevenson in his Report K, Greene and Wash-

ington Counties, but it is here designated from the same village in Greene County which has given name to the coal and sandstone already described.

This limestone usually consists of several layers separated by shales the whole of which sometimes foots up nearly 20 feet, as in the section at Board Tree Tunnel (Fig. 4), but its usual thickness is seldom more than 10 feet. Frequently a stratum of bituminous shale is found interstratified with the layers of limestone. Some of the latter are quite pure, and furnish excellent lime. It has a very wide distribution, as may be seen from its presence in each of the first seven sections already given. The same stratum extends clear through to Jackson County, West Virginia, and nearly to the Big Kanawha River, where it occurs high up on the summits of the hills and is hence termed the "Ridge" limestone, by the farmers.

There is a fine exposure of this rock at Limestone Hill Post-office, on the Parkersburg and Charleston turnpike, near the corners of Wirt, Wood, and Jackson Counties, West Virginia. It is there nearly 30 feet thick, in several layers, and contains many minute fossils, all apparently of fresh-water types.

THE HOSTETTER COAL.

Occasionally a bed of coal occurs at 75 to 100 feet below the Nineveh limestone. It has been stripped out of the run on the old Hostetter farm near Burton, Wetzel County, West Virginia, where it is 12 to 15 inches thick and rather pure. It also appears to be present in some localities near the head of Dunkard Creek, and in a local section near Bellton it was seen 15 inches thick at 130 feet below the Nineveh coal.

THE FISH CREEK SANDSTONE.

At 135 to 150 feet below the Nineveh coal, there often occurs a very massive sandstone. It makes the great cliffs along the waters of Fish Creek in Springhill Township, Greene County, Pennsylvania, and was designated from this stream by Stevenson in his Report K.

The rock in question is frequently quite massive, and it makes an excellent building stone. It is very conspicuous in the region of Deep Valley, Pennsylvania, where it forms long lines of vertical cliffs 25 to 30 feet high. It may also be seen in cliffs along the Baltimore and Ohio Railroad, above Littleton, in Wetzel County, where it is quarried for building purposes.

THE DUNKARD COAL.

Below the Fish Creek sandstone, at an interval of 1 to 20 feet, another coal bed is often found, which, from its occurrence along the bed of Dunkard Creek for a considerable distance, was named the Dunkard coal by Professor Stevenson. It is seldom more than 12 to 15 inches thick, but is almost invariably double, having a thin layer of slate near its

center. At Deep Valley, Pennsylvania, however, this parting thickens up to five feet or more and thus separates the coal into two well-defined beds, each of which is 8 to 10 inches thick. In the roof shales of this coal at Mr. Lee Garrison's, in Gilmore Township, Greene County, Pennsylvania, finely preserved fossil plants abound, principally of the genera Neuropteris and Odontopteris.

This bed is frequently stripped along the streams for local use in Greene, Monongalia, Wetzel, and Marshall Counties.

THE JOLLYTOWN LIMESTONE.

Below the Dunkard coal, at an interval of 25 to 30 feet, there occurs a bed of limestone which is rather persistent. It is well exposed in the vicinity of Jollytown, Greene County, Pennsylvania, and has been designated from that locality. As may be seen from its presence in Sections 1 to 5 and also in 9, this limestone has a wide distribution, though at the head of Dunkard (Fig. 1), and on Fish Creek (Fig. 5), the stratum is only 1 to 2 feet thick. In Washington County, Pennsylvania, however, it thickens up to 10 feet or more and is usually a rather pure limestone.

THE JOLLYTOWN COAL.

This is the lowest member of the Bellton coal group, and underlies the Jollytown limestone by an interval of 25 to 30 feet. The coal was named by Professor Stevenson from a village in Greene County, Pennsylvania.

This is the only coal of the Bellton group that ever attains dimensions of 2 to 3 feet, and can therefore be mined by drifting, since in the vicinity of Wise, Monongalia County, West Virginia, and below this along the South Fork of Dunkard Creek, it is nearly 3 feet thick, and is mined to a considerable extent for local use. The coal is not very pure, but in the absence of any other beds it finds a ready market. In the Bellton section (Fig. 5) this coal has been identified with the lowest bed exposed there. This is only a few inches thick and quite slaty, so that it is possible the Jollytown bed is the one next above, and which in that section has been referred to the Dunkard coal.

Along Dunkard Creek the Jollytown coal is nearly always present, and seldom less than 1 to 2 feet thick. It becomes a very important key rock over a wide region, since there are seldom any other coals below it for an interval of 250 feet. It extends almost without a break across Greene, Monongalia, Marion, and Harrison Counties, but appears to thin away in Doddridge.

Throughout Monongalia, Greene, and Marshall Counties, the interval between this bed and the Washington coal below is about 275 feet, but westward, in Washington County, Ohio (Section 8), the interval thins away to 200 feet, and practically the same measurement is found in Washington County, Pennsylvania (Sections 9 and 10).

THE UPPER WASHINGTON LIMESTONE.

Three limestones were named from Washington, Pennsylvania, by Professor Stevenson—an Upper, Middle, and Lower one—and two of these are shown in the section (Fig. 9) from the typical locality.

The Upper Limestone is a very important bed in Washington County, since it has a thickness of 20 to 30 feet, and is generally very pure. It is usually of a dark blue color, and is much used for macadamizing roads and burning for agricultural and other purposes. This rock appears to be identical with the limestone seen in the bed of Dunkard Creek near the mouth of Negro Run, above Jollytown, Greene County, Pennsylvania, where it carries a bituminous shale on its top, filled with fish remains and other minute fossils, and underlies the Jollytown coal.

In the bed of Fish Creek at Bellton, Marshall County, West Virginia, we find a limestone with a fish bed on its top, which appears to be identical with the Upper Washington deposit.

THE MIDDLE WASHINGTON LIMESTONE.

About midway in the interval between the Upper Washington limestone and the Washington coal there is frequently found another limestone bed. It is very persistent in Washington County, Pennsylvania, and is often 15 to 20 feet thick and of a buffish color.

On Dunkard Creek it appears to be represented by a stratum seen just above the road at Kent's Mills, where it is only three feet thick. This limestone, like all of those in the Dunkard series, contains minute, undetermined fossils, and the bituminous shales accompanying them hold plenty of fish scales, teeth, etc., as well as fragments of plants.

WASHINGTON "A" COAL.

At 70 to 80 feet above the Washington coal, there occurs a bed of impure coal and coaly shale which is often present in the section along Dunkard Creek. Sometimes the entire bed is four to five feet thick, but little of it is ever merchantable coal, being seldom more than a bituminous slate. It is well exposed in the hills about Blacksville, and Brownsville, in Monongalia County, and there contains many bivalve crustaceans.

Bituminous shale is often found at this horizon in Washington and Greene Counties, Pennsylvania, and in Washington County, Ohio (Fig. 8), a coal bed 2½ feet thick seems to occur at the same place in the series.

THE MARIETTA SANDSTONES.

The Washington "A" coal is often absent, and the portion of the series for 100 to 125 feet above the Washington coal is then frequently occupied by two or three beds of massive sandstone. These crop out in the hills below Marietta, Ohio, where they have long been extensively quarried for grindstones and building stone, and they have been

designated from that locality. There are often three of them, each 25 to 40 feet in thickness, and separated by thin shales, so that in such cases they might be called the Upper, Middle, and Lower Marietta sandstones. Sometimes, however, as near Rock Lick, Marshall County, West Virginia, the shales thin out and let all of the sandstones coalesce into one mass more than 100 feet thick.

These beds form the great cliffs at Raven Rock, Pleasants County, West Virginia. The upper one is extensively quarried at the Jackson quarry in Parkersburg, West Virginia, and it with its associated rocks forms long lines of cliffs up the Little Kanawha River, where they have been extensively quarried in the vicinity of Elizabeth and other points.

It is one of these beds that makes the big cliffs on the hill above the famous McGugan gas well in Washington County, Pennsylvania. These rocks are sometimes gray, but more frequently of a yellowish or buffish cast, and moderately coarse in grain. They also occur in Ritchie, Wirt, Jackson, and Putnam Counties, West Virginia, where they cap the narrow ridges in long lines of cliffs.

In Greene and Washington Counties, Pennsylvania, and Monongalia County, West Virginia, this interval of 100 feet above the Washington coal is generally occupied by shales, limestones, and thin, sandy beds, massive sandstones being exceptional.

THE BLACKSVILLE LIMESTONE.

In some portions of Washington, Greene, and Monongalia Counties, a limestone occurs with considerable persistency at 30 to 50 feet above the Washington coal. This was numbered Limestone III by Professor Stevenson in his Greene and Washington report, but as it comes to the surface near the bed of Dunkard Creek, in the village of Blacksville, Monongalia County, West Virginia, it has been given a geographical name from that locality. The rock is generally gray, quite pure, and only three to five feet thick. It is seen in Section 2 at 46 feet above the Washington coal. It soon disappears southward from the Pennsylvania line.

THE LOWER WASHINGTON LIMESTONE.

At Washington, Pennsylvania, a limestone of unusual thickness (20 feet) forms the roof of the Washington coal, and it was designated, from that locality, the Lower Washington limestone by Stevenson. It has a wide distribution in Greene, Washington, Ohio, Belmont, Marshall, and Monongalia Counties, but disappears southward from these. It often attains a thickness of 20 to 30 feet in Washington County, but is always interstratified with much shale, and outside of Washington County is seldom more than 5 to 10 feet thick. Frequently some of the layers contain so much carbonate of iron as to prove a fair ore. These iron-bearing layers are often interstratified with bituminous shales, and in such cases the iron layers are covered with fossil plants. It is on

these thin, shaly layers of carbonate of iron in the roof of the Washington coal at Brown's Bridge, Dunkard Creek, on the West Virginia–Pennsylvania line, that the Permian plant, *Callipteris conferta*, occurs as described in Report PP, Second Geological Survey, Pennsylvania, page 54.

THE WASHINGTON COAL.

This bed, which is the only one in the Dunkard series that is workable over a wide area, was first described by the writer, and named the Brownsville coal from its occurrence at the village of that name in Monongalia County, West Virginia. Subsequently, however, the same coal was found in greater development at Washington, Pennsylvania, and it was designated from that locality by Professor Stevenson.

It is always a multiple bed, being separated into two or three layers by divisions of slate. Occasionally these divisions are numerous and the entire thickness of the bed is 8 to 10 feet, but in all cases the only pure or merchantable coal is the bottom portion, which seldom exceeds two and a half to three feet. The upper part of the bed is nearly always very impure, since it contains so much ash and slate as to constitute it a mere bed of richly bituminous shale.

This coal is much more persistent than any other coal of the Permo-Carboniferous series, since it occurs everywhere in the northern area of these rocks, and does not disappear to the southwest except beyond the Little Kanawha River, in West Virginia, while in Ohio it seems to be persistent even to the southwestern margin of these deposits. In Washington and Meigs Counties, Ohio, it is frequently referred to by Professor Andrews as the Hobson coal.

Section at Farmington, Marion County, West Virginia.—The following section of this coal, taken near Farmington, Marion County, West Virginia, well illustrates the structure of the bed when it is thick:

	Ft.	in.	Ft.	in.	Ft.	in.
1. Coal	0	6				
2. Shale	0	3				
3. Coal and shale	0	8				
4. Coal	1	0				
5. Shale	0	4				
6. Coal	0	5	6	1		
7. Shale	0	3				
8. Coal	1	0				
9. Shale	0	4			10	9
10. Coal	1	1				
11. Shale	0	3				
12. Coal, fair	2	0				
13. Slate	0	2	4	8		
14. Coal, good	2	6				

Here the upper or roof portion of the coal, although 6 feet thick, is entirely worthless, and the only really good coal in the bed is the 2½ feet at the bottom.

Through Washington County, Pennsylvania, this coal has a thickness of 5 to 6 feet, but very little of it is merchantable.

It is frequently exposed along the Ohio River hills between Wheeling and Parkersburg, being at low water in the latter town.

Before disappearing to the southwest it dwindles down in thickness very much, since at Harrisville, Ritchie County, it is only 2 feet thick, and at the Grahamite mines, near Hughes River in the same county, only 1½ feet.

It is mined for local supply in the vicinity of Smithville, Ritchie County, where it is only 15 inches thick and 150 feet above the level of Hughes River.

Section on Willey Fork, Wetzel County, West Virginia.—At the mouth of the Willey Fork of Fishing Creek, Wetzel County, West Virginia, this coal is brought a few feet above water level by a low, anticlinal roll, and there it exhibits the following structure:

	Ft.	in.	
1. Dark shales			
2. Coal	0	5	Ft. in. 8 2
3. Coaly shale	1	6	
4. Shale, gray, sandy	2	0	
5. Coal	0	3	
6. Gray shales	2	0	
7. Coal, slaty	2	0	

Section near Brown's Mills, Monongalia County, West Virginia.—Near Brown's Mills, Monongalia County, where this coal was first described, it has the following structure:

	Ft.	in.	
1. Bituminous shale	2	0	Ft. 8
2. Coal, impure	1	9	
3. Shale	0	4	
4. Coal, slaty	1	4	
5. Shale	0	3	
6. Coal, good	2	4	

At this locality the Lower Washington limestone forms the roof above the bituminous shale No. 1, and it also contains much iron.

Occasionally a thin coal is found resting immediately on top of the Lower Washington limestone, and that condition of affairs exists at Brown's Mills, where a bed of coal and black slate, in all 2 feet thick, occurs 10 feet above the top of the Washington coal. The bed is not persistent enough to merit a separate name, however.

THE WASHINGTON SANDSTONE.

Very frequently no fire clay is present under the Washington coal, and the latter rests directly upon a flaggy sandstone, often finely laminated, brown, micaceous, and containing vegetable fragments in great quantity. This stratum, which was called the Washington sand-

stone by Professor Stevenson, occurs over a wide area in Monongalia, Greene, and Washington Counties, but is not persistent very far south of the Pennsylvania line.

THE LITTLE WASHINGTON COAL.

Just under the Washington sandstone, and 10 to 20 feet below the Washington coal, there sometimes occurs a thin bed of coal, seldom attaining a foot in thickness. It is more persistent in Washington County, Pennsylvania, than elsewhere, and hence was designated as above by Stevenson. It is seldom seen south from the Pennsylvania line, and in Greene County even is represented only by a thin bed of bituminous slate.

THE WAYNESBURG "B" COAL.

Below the last little coal bed there usually occur shales, thin sandstones, and occasionally a limestone, down to about 45 feet below the Washington coal, where another small bed is found quite persistent in Monongalia, Greene, and Washington Counties. It is seldom more than a foot thick, but sometimes attains to two. It has never been seen south of Monongalia County, and is of little economic importance.

THE COLVIN'S RUN LIMESTONE.

Below the last coal come 30 to 35 feet of shale and thin sandstones, and then we get a limestone that was numbered Limestone I(a) by Professor Stevenson, but I have given it the above geographical designation from its occurrence at the locality of Section 2, where it is 3 feet thick and quite pure. It is often of a buffish cast, however, and contains too much iron to slake well on burning. In Washington County, Pennsylvania, this stratum thickens up to 8 and 10 feet, but it is seldom seen south of the Pennsylvania line.

THE WAYNESBURG "A" COAL.

This occurs just under the last mentioned limestone and like it is confined to the northern end of the Permo-Carboniferous area. It sometimes attains a thickness of 3 and 4 feet, but is generally slaty and worthless, so that it has seldom been mined. It occurs quite generally across Monongalia, Marion, and Harrison Counties, and is possibly present in Ritchie County near Harrisonville, but beyond that it has not been identified. Its horizon is usually 60 to 80 feet above the Waynesburg coal proper.

THE MOUNT MORRIS LIMESTONE.

Separated from the coal last described by only 2 to 5 feet of clayey shales there sometimes occurs a limestone which, although noted, was not named by Stevenson in his Report K. It is well exposed on the north bank of Dunkard Creek at Mount Morris, Greene County, Pennsylvania, and has been designated from that locality. The stratum

is often only 1 to 2 feet thick, and seldom more than 5 feet except in Washington County, Pennsylvania, where it is occasionally thicker.

This limestone is not persistent, and is seldom found south of the Pennsylvania line, being frequently absent even in Greene and Washington Counties.

THE WAYNESBURG SANDSTONE.

Just under the horizon of the Mount Morris limestone, and separated from it by 2 to 5 feet of shales and clay, there comes a very important sandstone. This was long ago termed the Waynesburg sandstone, from its fine development near the town of that name in Greene County, Pennsylvania. It is one of the most persistent members of the Permo-Carboniferous series, since its eastern outcrop can be followed in an almost constant line of cliffs from Greene County, Pennsylvania, clear across West Virginia to the Big Kanawha River at Winfield.

This stratum is the only one in the series that is generally conglomeratic or contains quartz pebbles larger than coarse sand grains. On account of this peculiarity the rock in question becomes a very important guide to the geologist in the interior of West Virginia, where so many of the Dunkard Creek coals and limestones have disappeared, for it retains its pebbly character over a very wide area. When at its greatest development the thickness of this stratum approaches 75 and even 100 feet. It is usually a grayish white rock, with a yellowish cast on freshly broken surfaces, and its weathered bowlders are usually covered with ridges and streaks of harder iron-bearing sand. The rock splits readily and frequently furnishes excellent building stone, the piers of the Baltimore and Ohio Railroad bridges across the Monongahela River near Fairmont having been constructed of it.

Along the western border of the outcrop of this rock it dwindles down and changes its character entirely, being frequently represented in Washington County, Pennsylvania; Marshall and Ohio Counties, West Virginia; Belmont and Monroe Counties, of Ohio, by sandy shales and flaggy sandstones, and occasionally even a stratum of limestone may be found at this horizon.

In passing down the Ohio River below Marshall County the horizon of this sandstone passes below water level, but when it reappears near Saint Mary's, in Pleasants County, the rock has regained its massiveness, and is a coarse pebbly sandstone 50 feet thick, and from this point on down the Ohio River, whenever above the level of the same, it is always a massive sandstone. From Blennerhasset Island, below Parkersburg, this rock is almost constantly visible either in the bed or bluffs of the Ohio on down to 25 miles below the mouth of the Great Kanawha. It is the emergence of this stratum from the bed of the stream which makes Letart Falls in the Ohio River. It is this rock which forms the great cliffs in the top of the hills at Red Rock, in Put-

nam County, on the Great Kanawha, and the same may be seen as a bed of pebbly sandstone at many points in Ritchie, one at the famous Grahamite mine being especially noteworthy, for it is the great sandrock through which the celebrated fissure extends at the base of the hills, and it is there 75 feet thick.

Through Ritchie, Gilmer, and Calhoun Counties a bed of brecciated limestone occurs at the base of this stratum and incorporated with it, which is quite persistent and seems to replace the usual underlying Waynesburg coal, which is there absent.

THE CASSVILLE PLANT SHALE.

The Waynesburg sandstone often rests directly on the underlying Waynesburg coal, but more frequently a bed of dark gray shale, 5 to 15 feet thick, intervenes. This shale is always prolific in fossil plants and is especially so in the vicinity of Cassville, Monongalia County, West Virginia. It is from this locality and horizon that so many of the fossil plants were obtained which are described in the Second Geological Survey, Pennsylvania, Report PP, by Fontaine and White, and it is from the same shale that so many plants of Permian and even Triassic types have been procured, Tæniopteris, Saportæa, Baiera, and Pachypteris being among the number. No systematic search has ever been made at any other locality, and hence it is entirely probable that the list of fossil plants could be largely increased were this bed thoroughly explored in other regions. Other promising localities of the Cassville shale which have been slightly explored are Carmichael's, Greene County, Pennsylvania; Georgetown, Monongalia County; and West Union, Doddridge County. In connection with these roof shales, and sometimes interstratified with the top members of the underlying coal, there occur at Cassville numerous remains of insects, the principal ones being fossil cockroaches, of which Gerablattina seems to be the principal genus.

THE AGE OF THE DUNKARD CREEK BEDS.

The fauna of these rocks has never been systematically studied and its relationships determined. What desultory work has been done in this line goes to show that the animal forms consist principally of minute shells of crustaceans, fish remains, and insects, many of which are probably undescribed. No Brachiopods have ever been seen in these rocks, and hence one important line of evidence which might help to determine their relative age is wanting. Some geologists have been inclined to regard them as belonging in the Carboniferous proper because of the absence of the Permian reptilian fauna, and other types common elsewhere, but as the deposits are mainly of fresh water origin, the absence of such types is to be expected. Hence until the minute fauna occurring in these limestones and black slates shall have been carefully studied, the geologist must rely on the evidence of fossil plants.

These have been studied by Prof. Wm. M. Fontaine and the writer, the results being published in Report PP, Second Geological Survey, Pennsylvania. The conclusions there given show that the flora is closely and unmistakably allied to the Permian of Europe, since it contains so many types that are peculiar to those rocks or even related to Mesozoic forms. The facts and conclusions set forth are sufficient to convince Prof. Archibald Geikie that these rocks are of the same age as the reptiliferous beds at Autun.

The conclusion that these rocks are of Permian age has not been accepted by all American geologists, though none have given any reasons for discrediting the evidence of the fossil plants on which it is based, and until it is contradicted by the animal remains or otherwise shown to be erroneous, no other hypothesis is tenable in view of the evidence at hand. The list of plants from which the Permian age of these Dunkard beds is inferred, together with the general discussion of the same, is given in Chapter III, pages 105, 120, Report PP, Second Geological Survey, Pennsylvania.

The recent discovery of an undoubted Permian invertebrate fauna in Texas by Prof. C. A. White and Mr. Cummins (American Naturalist, February, 1889), confirms the conclusions of Profs. Cope and Marcou with reference to the existence of a great Permian series of rocks in this country, and hence there is no longer any reason for doubting that America contains deposits which are equivalent in part at least to the Permian of Europe. The Texas deposits, as described by Prof. White in the article referred to, are so exactly similar lithologically to these uppermost beds of the Appalachian region, that the description of the one might well answer for that of the other, and there can be very little doubt that the two series are equivalent. Singularly enough the beds have practically the same thickness, 1,000 feet in Texas, and 1,100 in West Virginia and southwest Pennsylvania.

CHAPTER III.

THE UPPER COAL MEASURES, OR MONONGAHELA RIVER SERIES.

THICKNESS, CHARACTER, AND EXTENT.

This series of rocks begins at base with the Pittsburgh coal and extends up to the Cassville shale. The thickness varies between 200 feet along the northwestern outcrop in Ohio and 380 feet in the Monongahela River region, but in the center of the Appalachian trough a boring at Browntown, Harrison County, West Virginia, carefully measured with steel line, reveals a thickness of 413 feet from the top of the Waynesburg coal to the bottom of the Pittsburgh bed.

Within the interval there belong six distinct coal beds, though only four of these are workable over any considerable area. These coals have their greatest development along the waters of the Monongahela River, and hence the series was long ago named after that river by Prof. H. D. Rogers.

The character of the rocks interstratified with the coal beds changes greatly in passing from the Monongahela River southward to the Great Kanawha. At the northern end of the basin in Marion, Monongalia, Greene, Washington, Fayette, and Westmoreland Counties, limestone forms about one-half of the rock material, and the same is true on the western side in Brooke, Ohio, Marshall, and Belmont Counties. Red shale is unknown in the series at the north, but in passing southward from Harrison and Lewis Counties the limestones practically disappear, and with them all of the coals except the Pittsburgh. With their disappearance red shales come in and apparently replace the limestones, so that on the Great Kanawha nearly one-fourth of the rock material in this series is red shale, while the thickness is reduced to 270 feet. Along with this change in the character of the rocks there occurs a great change in the topography made by these beds, for at the north, where limestone is abundant, sandstones are few and shaly, so that a gentle, rolling topography results, with a very rich soil and one of the finest grazing and farming regions in the country, while to the southwest, after the limestones have disappeared the sandstones thicken up and become more massive, thus giving rugged and precipitous slopes with narrow valleys.

The character of the Upper Coal Measure rocks in the several portions of the area they occupy is shown by the several sections which follow.

Section in Fayette and Westmoreland Counties, Pennsylvania.—Prof. Stevenson, who has done so much to elaborate the detailed structure of this series, gives the following (Fig. 11), in Second Geological Survey, Pennsylvania, Report KK, page 31, as the general section of these beds in Fayette and Westmoreland Counties:

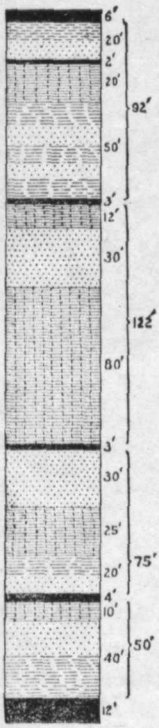


FIG. 11.—Section in Fayette and Westmoreland Counties, Pa.

Fayette and Westmoreland Counties, Pennsylvania.

[See map, K n.]

	Ft.	Ft.
1. Coal, Waynesburg		6
2. Sandy shales or sandstone	20	
3. Coal, Little Waynesburg	2	92
4. Limestone, Waynesburg	20	
5. Shale and shaly sandstone	50	
6. Coal, Uniontown		3
7. Limestone, Uniontown	12	
8. Sandstone	30	122
9. Limestone, "Great"	80	
10. Coal, Sewickley		3
11 Sandstone	30	
12. Limestone, Sewickley	25	75
13. Shale or shaly sandstone	20	
14. Coal, Redstone		4
15. Limestone, Redstone	10	
16. Sandstone or shale	40	50
17. Coal, Pittsburgh		12
Total		367

Section at Brownsville, Pennsylvania.—At Brownsville, Fayette County, Pennsylvania, Prof. Stevenson finds the following structure, (Fig. 12), for this series, as given in KK, page 233:

Brownsville, Fayette County, Pennsylvania.

[See map, K m.]

	Ft. in.	Ft. in.
1. Coal, Waynesburg, blossom		
2. Shales, sandy	45	
3. Coal, Little Waynesburg, blossom	0	104
4. Limestone, Waynesburg	4	
5. Shales and shaly sandstone	55	
6. Coal, Uniontown, blossom		
7. Limestone, coarse, yellow	1	
8. Clay	3	
9. Shale and sandstone	16	
10. Limestone	2	
11. Concealed	17	121
12. Sandstone	3	
13. Limestone with shales	42	
14. Concealed	16	
15. Limestone	6	
16. Concealed	7	
17. Clay shale	8	
18. Sewickley coal horizon		
19. Sandy shale and flaggy sandstone	30	
20. Limestone	30	95
21. Shale	35	
22. Coal, Redstone		0 6
23. Shale, sandy		25
24. Coal, Pittsburgh (Coal 0′ 8″ / Clay 0′ 10″ / Coal 7′ 6″)		9
Total		354 6

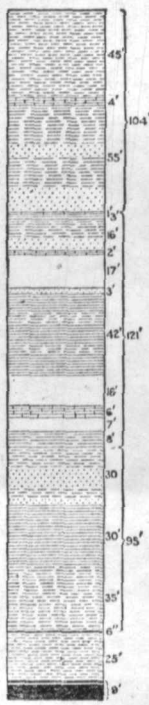
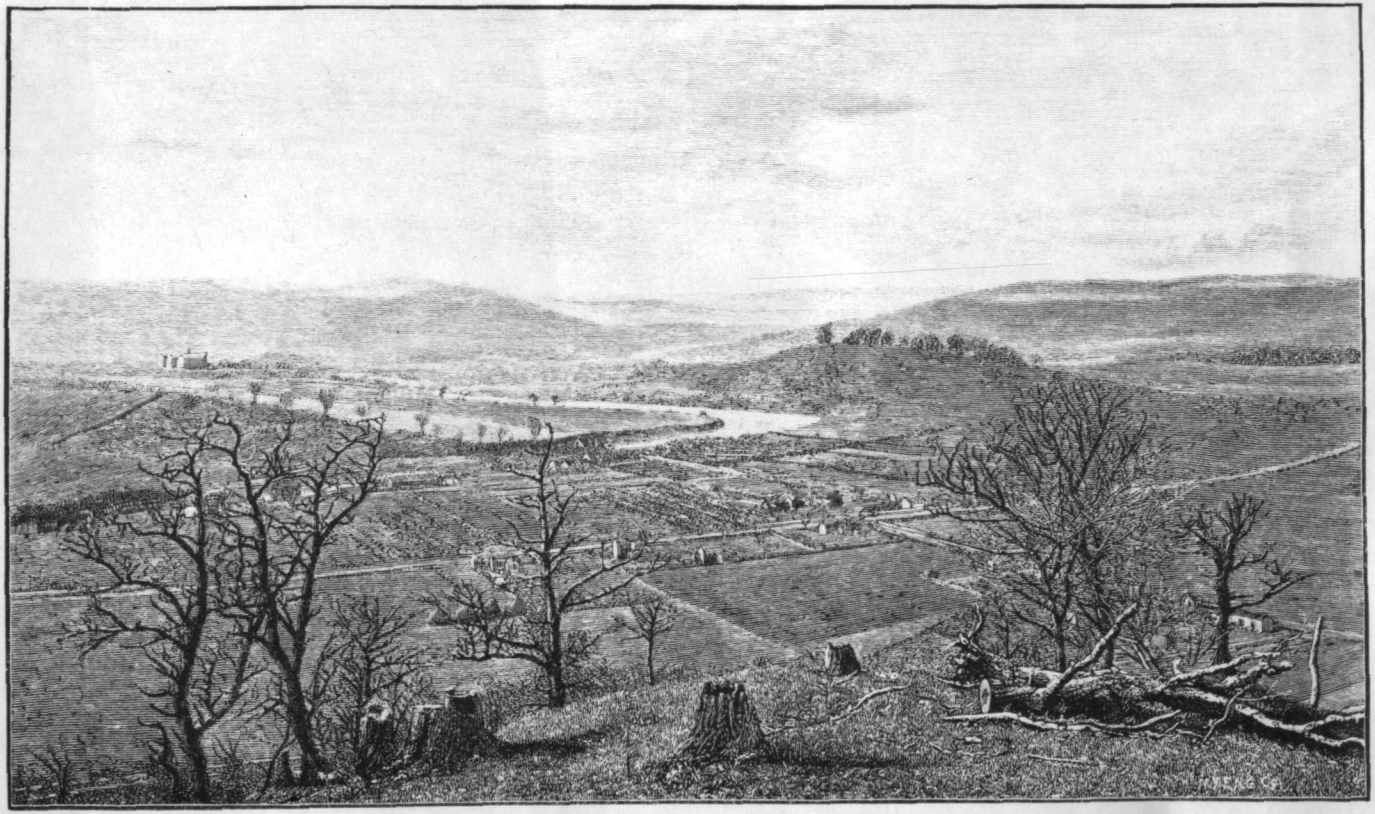


FIG. 12.—Section at Brownsville, Pa.



UPPER COAL MEASURES CAPPED WITH PERMO-CARBONIFEROUS BEDS, WHEELING, WEST VIRGINIA.

Section at West Brownsville, Pennsylvania.—On the opposite side of the Monongahela River, in descending from Kreb's Knob to West Brownsville, in Washington County, the writer measured the several members of this series with the following results (Fig. 13):

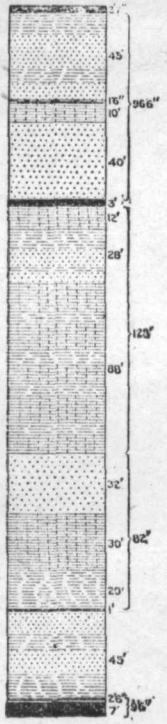


FIG. 13.—Section at West Brownsville, Pa.

West Brownsville, Washington County, Pennsylvania.

[See map, K m.]

		Ft. in.	Ft. in.
1. Coal, Waynesburg	Coal 0′ 10″; Clay 0′ 3″; Coal 2′ 6″		3 7
2. Shales and sandstone		45	
3. Bituminous shale, Little Waynesburg Coal		1 6	
4. Limestone, Waynesburg		10	96 6
5. Sandstone, shaly		40	
6. Coal, Uniontown			3
7. Limestone, Uniontown		12	
8. Shale and sandstone		28	128
9. Limestone, with thin shales		88	
10. Coal, Sewickley, blossom			
11. Sandstone, shaly		32	
12. Limestone		30	82
13. Shales		20	
14. Coal, Redstone			1
15. Sandstone and shales			45
16. Coal, Pittsburgh, roof	Coal 0′ 3″; Clay 0′ 3″; Coal 1′ 0″; Clay 1′ 0″	2 6	9 6
17. Coal, Pittsburgh, main bench		7 0	
Total			368 7

Section at Rice's Landing, Pennsylvania.—In the steep hillside, one mile below Rice's Landing, Greene County, Pennsylvania, the series exhibits the following structure (Fig. 14):

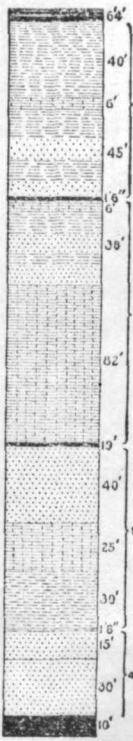


FIG. 14.—Section at Rice's Landing, Pa.

Rice's Landing, Greene County, Pennsylvania.

[See map, K m.]

		Ft. in.	Ft. in.
1. Waynesburg coal	Coal 1′ 0″; Clay 0′ 5″; Coal 1′ 3″; Clay 1′ 2″; Coal 2′ 6″		6 4
2. Shales		40	
3. Limestone, Waynesburg		6	91
4. Shales and sandstone		45	
5. Coal, Uniontown			1 6
6. Limestone, Uniontown		6	
7. Shales and sandstone		38	126
8. Limestone, "Great"		82	
9. Coal, Sewickley			1 9
10. Sandstone		40	
11. Limestone		25	95
12. Sandy shale		30	
13. Slate, bituminous (Redstone coal)			1 6
14. Sandstone, Pittsburgh, flaggy		15	
15. Sandstone, Pittsburgh, massive		30	45
16. Coal, Pittsburgh	Roof: Coaly shale 1′ 0″; Coal 1′ 2″; Clay 0′ 10″; Main bench 7′ 0″		10
Total			378 1

Section on Robinson's Run, West Virginia.—The Upper Coal Measure beds attain a very fine development in Monongalia County, West Virginia, just south from the Greene County line, and there, on Robinson's Run, 2 miles west from the Monongahela River, the following succession (Fig. 15) is exposed:

Robinson's Run, Monongalia County, West Virginia.

[See map, L m.]

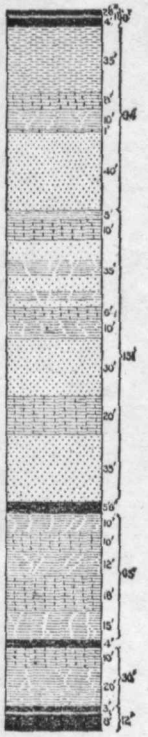


Fig. 15.—Section on Robinson's Run, W. Va.

		Ft. in.	Ft. in.
1. Coal, Waynesburg	Coal...2′ 6″ / Shale...1′ 6″ / Coal...4′ 0″		8
2. Sandy shales with iron ore below middle		35	
3. Limestone, Waynesburg		8	
4. Shales		10	94
5. Limestone		1	
6. Sandstone, flaggy		40	
7. Black slate (Uniontown coal)		5	
8. Limestone, Uniontown		10	
9. Sandstone and shales		35	
10. Limestone		6	
11. Shales		10	151
12. Sandstone, flaggy		30	
13. Limestone, cement beds		20	
14. Sandstone, Sewickley		35	
15. Coal, Sewickley			5 6
16. Shales		10	
17. Limestone		10	
18. Shales		12	65
19. Limestone		18	
20. Shales		15	
21. Coal, Redstone			4
22. Limestone, Redstone		10	30
23. Shales and slates		20	
24. Coal, Pittsburgh	Roof coals...3′ / Clay.....1′ / Coal.....8′		12
Total			369 6

Here, as will be seen from the above section, the Redstone coal, which belongs between the Pittsburgh and Sewickley beds, has thickened up into merchantable condition. This coal contains a little more sulphur than either the Pittsburgh below or the Sewickley above, but it makes a very fair fuel for domestic and steam-producing purposes. It is softer than either of the other two and would coke well.

The Redstone, Pittsburgh, and Sewickley beds of this section foot up a total thickness of 21½ feet, including partings, and about 17 feet of this is merchantable coal.

Section on Scott's Run, West Virginia.—A short distance south from Robinson's Run, we get another fine exposure of the Upper Coal Measure beds along the waters of Scott's Run, between Cassville and the mouth of the stream, as follows (Fig. 16):

Scott's Run, Monongalia County, West Virginia.

[See map, M m.]

		Ft.	in.	Ft.	in.
1. Coal, Waynesburg	Coal 2′ 0″; Shale, fossiliferous 1′ 0″; Coal 1′ 4″; Shale, gray 1′ 6″; Coal 5′ 0″			10	10
2. Black slate		1			
3. Sandy shales, with *iron ore*		25			
4. Limestone, Waynesburg		8		99	
5. Sandy shales, with limestone layers		30			
6. Sandstone, massive		20			
7. Limestone and shales		15			
8. Black slate, representing Uniontown coal				2	
9. Limestones, interstratified with thin shales, cement beds near base		105		145	
10. Sandstone, Sewickley		40			
11. Coal, Sewickley				5	
12. Shales		5			
13. Sandstone		10			
14. Limestone		5			
15. Shales, greenish gray		8		65	
16. Concealed		15			
17. Limestone, steel gray		7			
18. Concealed		15			
19. Coal, Redstone				4	
20. Limestone, Redstone		18			
21. Shale and fire clay		5		28	
22. Slate, black		5			
23. Coal, Pittsburgh, roof	Coal 0′ 3″; Shale 2′ 0″; Coal 1′ 0″; Clay 1′ 0″	4	3		
24. Coal, Pittsburgh, main bench	Coal 3′ 6″; Slate 0′ ½″; Coal 0′ 8″; Slate 0′ 1″; Coal 1′ 6″; Slate 0′ ½″; Coal 0′ 6″; Slate 0′ ½″; Coal 3′ 3″	9	7½	13	10½
Total				372	8½

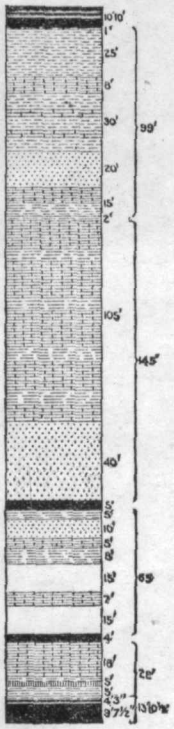


FIG. 16.—Section on Scott's Run, W. Va.

The same Redstone coal makes its appearance in this section; in fact it underlies all of the region intervening between Scott's and Robinson's Runs, thinning out southward as well as northward. It underlies an area of probably 5,000 acres where it is of workable thickness. In the oil-well borings on Doll's Run, and as far west as Mannington and Fairview, this bed is still present, though apparently not of workable thickness.

Section on Buffalo Creek, West Virginia.—Along Buffalo Creek, in the vicinity of Fairmont, Marion County, West Virginia, the Upper Coal Measures exhibit the following succession (Fig. 17):

Buffalo Creek, Marion County, West Virginia.

[See map, M 1.]

		Ft.	in.	Ft.	in.
1. Coal, Waynesburg	Coal...0′ 6″ Shale..0′ 1″ Coal..1′ 0″ Shale..1′ 4″ Coal...3′ 0″			5	11
2. Shales		20			
3. Sandstone, massive		30			
4. Shale		3			
5. Limestone, Waynesburg		1	6		
6. Shales		18			
7. Limestone		1	6	101	
8. Shales		12			
9. Sandstone		10			
10. Shales		5			
11. Coal, Uniontown				2	6
12. Fire clay		4			
13. Sandstone		1			
14. Shales and black slate		5			
15. Limestone		3			
16. Fire clay		5			
17. Shales with limestone		5			
18. Sandstone		2		149	
19. Blue shale		8			
20. Limestone		1			
21. Shales and concealed		25			
22. Limestone interstratified with thin shales		85			
23. Shales		5			
24. Coal, Sewickley	Coal.....5′ 0″ Clay.....0′ 4″ Coal.....0′ 4″ Slate, dark..0′ 3″ Coal.....0′ 5″			6	4
25. Shales		3	6		
26. Limestone, buff		4			
27. Sandstone, gray, massive		18			
28. Limestone, gray		5			
29. Concealed and shales		15		100	6
30. Impure clay		5			
31. Limestone and shales		20			
32. Sandstone, Pittsburgh		25			
33. Shales		5			
34. Coal, Pittsburgh	Coal, bony..0′ 10″ Bone.....0′ 1½″ Coal.....2′ 3″ Slate.....0′ ½″ Coal.....0′ 5″ Slate.....0′ ¼″ Coal.....3′ 5½″			7	1½
Total				372	4½

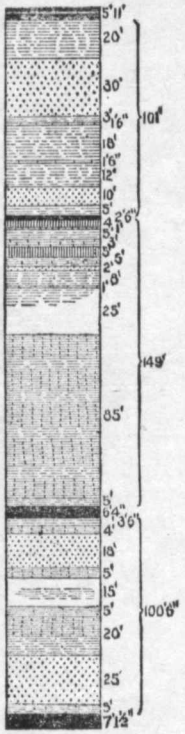


FIG. 17.—Section on Buffalo Creek, W. Va.

The portion of this section from the Sewickley coal down to the base of the series was measured at the Montana mines, 2½ miles below the mouth of Buffalo Creek.

The Redstone coal is entirely absent here, its horizon being occupied by the 5 feet of impure fire clay, 50 feet above the Pittsburgh bed.

Section at Clarksburg, West Virginia.—In passing from Marion County southward towards Clarksburg, in Harrison County, a great change takes place in the character of the sediments of the Upper Coal Meas-

ures. The limestones, so prominent in Greene, Monongalia, and Marion, dwindle down to insignificant proportions, as shown by the following section (Fig. 18), made at Clarksburg by Mr. Jno. L. Johnston, civil engineer:

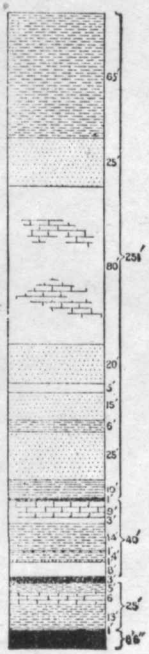


FIG. 18.—Section at Clarksburg, W. Va.

Clarksburg, Harrison County, West Virginia.

[See map, O k.]

		Ft.	in.	Ft.	in.
1.	Waynesburg coal, absent or not seen			0	
2.	Concealed and yellow sandy shales	65			
3.	Sandstone	25			
4.	Concealed, with some limestone	80			
5.	Sandstone	20			
6.	Concealed	5		251	
7.	Sandstone	15			
8.	Sandy shales	6			
9.	Sandstone, Sewickley	25			
10.	Shales	10			
11.	Coal, Sewickley			1	
12.	Limestone { Shaly 1′ 6″ / Good 7′ 6″ }	9			
13.	Concealed	3			
14.	Shales, sandy	14			
15.	Shale, with iron nodules	1		40	
16.	Shales, sandy	4			
17.	Sandstone	1			
18.	Concealed	8			
19.	Coal, Redstone, slaty			3	
20.	Shale, dark, bituminous	5			
21.	Limestone, Redstone	6			
22.	Shale, greenish	13		25	
23.	Slate, bituminous	1			
24.	Coal, Pittsburgh { Coal 3 5″ / Bone 0′ 1″ / Coal 5′ 0″ }			8	6
	Total			328	6

Section at Chapline Hill, Wheeling, West Virginia.—Between the Monongahela and Ohio Rivers a considerable change takes place in the character of the Upper Coal Measure beds, and also in the thickness of the several members, as will be seen by the following section (Fig. 19) from Chapline Hill, Wheeling, West Virginia:

Chapline Hill, Wheeling, West Virginia.

[See map, K j.]

		Ft.	in.	Ft.	in.
1.	Coal, Waynesburg			2	
2.	Concealed	5			
3.	Flaggy sandstone, filled with plant fragments	4			
4.	Concealed	4			
5.	Limestone, shales and concealed	60		158	
6.	Sandstone, massive, gray	5			
7.	Limestone and concealed	20			
8.	Green shale	5			
9.	Limestone, interstratified with shales	55			
10.	Coal, Sewickley { Coal / Sandy shales with plants / Coal }	1 0 / 12 0 / 0 8		13	8
11.	Shales	8			
12.	Sandstone, rather massive, micaceous, current-bedded	20		29	
13.	Limestone, impure, flaggy, filled with fossil ferns	1			
14.	Coal, Redstone			0	10
15.	Limestone, mostly buffish and impure			55	
16.	Pittsburgh coal { Coal, roof 2′ / Shale 2′ / Coal, main bench 5′ }			9	
	Total			267	6

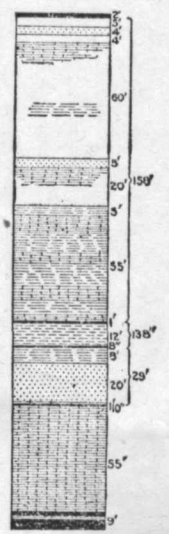


FIG. 19.—Section at Chapline Hill, Wheeling, W. Va.

Here the Waynesburg coal has dwindled to an unimportant bed, and the Sewickley has split into two portions separated by 12 feet of shales, while the whole column has lost more than 100 feet of thickness compared with the Monongahela River region.

Section near Bellaire, Ohio.—At Bellaire, Ohio, 4 miles below Wheeling, the following carefully leveled section (Fig. 20) was made by Prof. C. N. Brown, of the present Ohio Geological Survey. It exhibits some interesting changes as compared with the Wheeling section:

Near Bellaire, Belmont County, Ohio.

[See map, K i.]

		Ft.	in.	Ft.	in.
1. Coal, Waynesburg				2	
2. Shale, sandy		6			
3. Shale		12			
4. Limestone		3		40	
5. Concealed		5			
6. Coal, blossom, Little Waynesburg					
	7. Concealed	14			
	8. Coal, blossom, Uniontown			1	
	9. Shale	4			
	10. Sandstone	6			
	11. Shale, argillaceous	20			
	12. Concealed	32			
	13. Shale	2		127	6
	14. Sandstone	3			
	15. Shale	3			
	16. Concealed	33			
	17. Calcareous shale, with thin limestones	24	6		
	18. Coal, Sewickley: Coal 4′ 0″; Shales, sandy 13′ 10″; Coal 0′ 8″; Shale, argillaceous 6′ 0″; Coal 3′ 0″			27	6
	19. Shale, argillaceous	2			
	20. Limestone, thin clay in center	8			
	21. Limestone, magnesian, cement rock	5		38	
	22. Clay	1			
	23. Limestone	11			
	24. Concealed	11			
	25. Coal, Redstone, blossom			2	
	26. Concealed	17		18	
	27. Shale	1			
	28. Coal, Pittsburgh			7	
	Total			263	

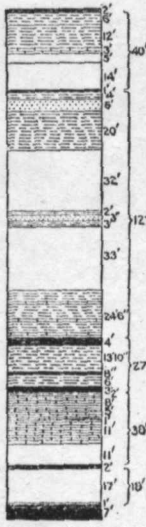
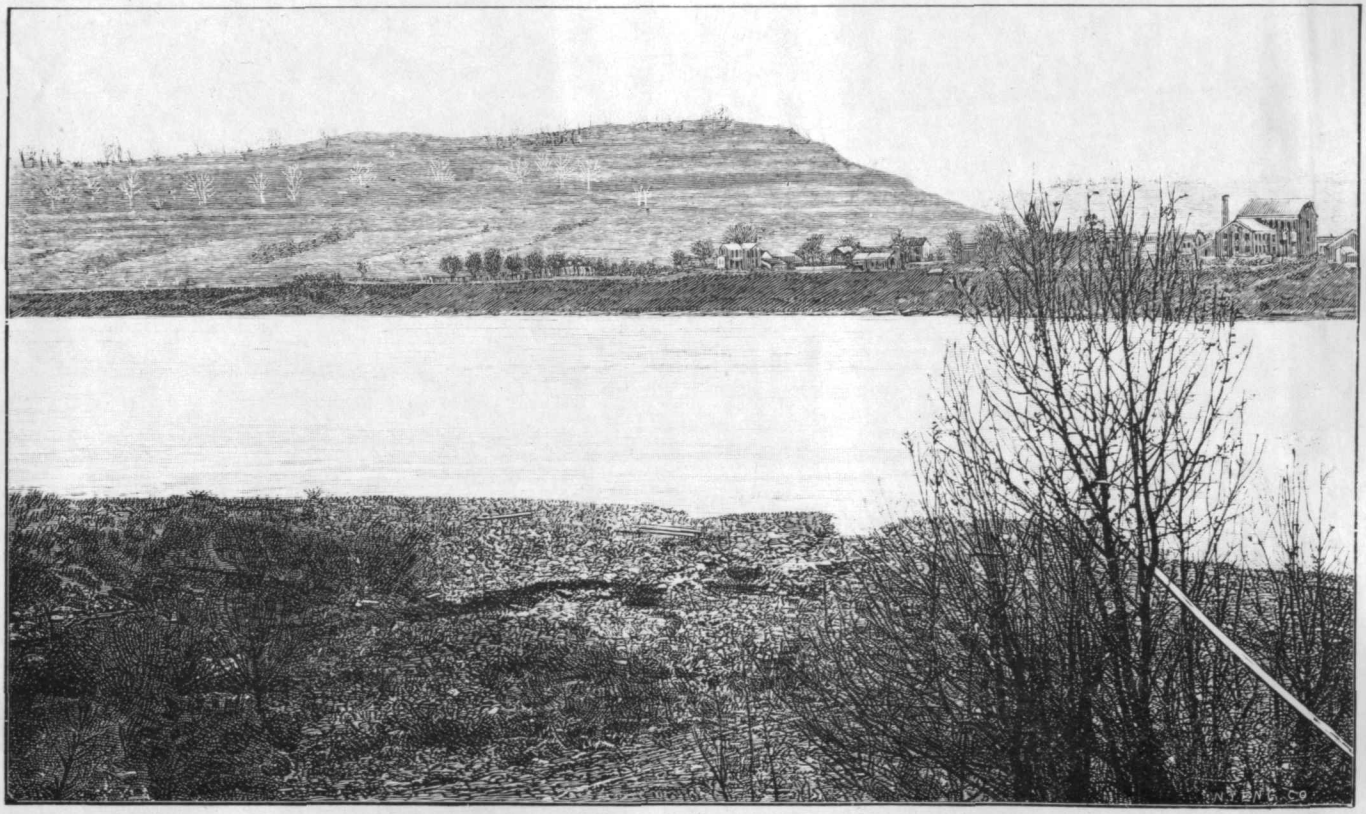


FIG. 20.—Section near Bellaire, Ohio.

The interval between the two members of the Sewickley coal has here increased to 20 feet, and the upper one seems to keep permanently above the lower one from here southwestward through Ohio, becoming the Cumberland and Meigs Creek bed of the Ohio geologists.

Both the Little Waynesburg and Uniontown coals are represented in this section, but neither one was observed at Wheeling.

It is worthy of note that there is a difference of only 4 feet in the total thickness of the Upper Coal Measures as given by Prof. Brown's section at Bellaire and mine at Wheeling, four miles above.



UPPER COAL MEASURES AND PERMO-CARBONIFEROUS, POWHATAN, OHIO.

Section at Moundsville, West Virginia.—Near the mouth of Grave Creek, one mile below Moundsville, West Virginia, and 7 miles below Bellaire, these measures exhibit the following succession by combining the surface exposures with the record of an oil boring (Fig. 21):

Moundsville, Marshall County, West Virginia.

[See map, K i.]

		Ft.	in.	Ft.	in.
1. Coal, Waynesburg	Coal, impure	0′	6″		
	Shale	1′	0″		
	Coal	1′	6″		
				3	
2. Shale, soft, gray		5			
3. Sandstone, massive, gray, micaceous		20			
4. Concealed, with limestone layers at base 2 feet thick		20			
5. Flaggy sandstone and sandy shales		20			
6. Concealed		10			
7. Limestone		1			
8. Concealed		14			
9. Limestone, gray		22		223	
10. Concealed to mouth of oil and gas well at 30 feet above low-water mark in Ohio River		28			
11. Conductor hole of oil-well record		18			
12. Limestone, light gray		40			
13. Slate		15			
14. Black rock, shales		10			
15. Coal, Redstone				1	6
16. Fire clay		7			
17. Hard slate		4		41	
18. Gray limestone		20			
19. Bastard limestone		10			
20. Coal, Pittsburgh				6	
Total				274	6

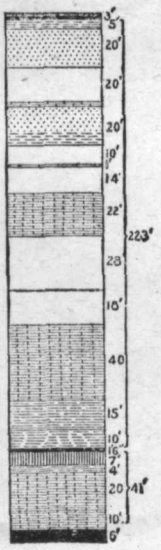


FIG. 21.—Section at Moundsville, W. Va.

Section on Pipe Creek, Ohio.—Pipe Creek puts into the Ohio River 3 miles below the mouth of Grave Creek, and there, on the Belmont County side of the river, the Pittsburgh coal is at low-water level. The following structure (Fig. 22) is found in the steep hills which border the mouth of Pipe Creek:

Pipe Creek, Belmont County, Ohio.

[See map, K i.]

		Feet.	Feet.
1. Coal, Waynesburg, slaty at top			4
2. Concealed, limestone and shales			55
3. Bituminous slate, Uniontown coal			1
4. Limestone, Uniontown		10	110
5. Concealed, with much limestone		100	
6. Coal, Sewickley	Coal, and coaly shale	2′ 0″	24
	Sandstone	12′ 0″	
	Coal	0′ 4″	
	Shale	1′ 0″	
	Coal	0′ 4″	
	Shale, sandy	5′ 0″	
	Coal, slaty	1′ 8″	
	Shale	0′ 4″	
	Coal	1′ 0″	
	Black slate	0′ 4″	
7. Limestone, Sewickley, and shales			22
8. Bituminous shale, (Redstone coal)			1
9. Limestone, (Redstone) and concealed			25
10. Coal, Pittsburgh			6
Total			248

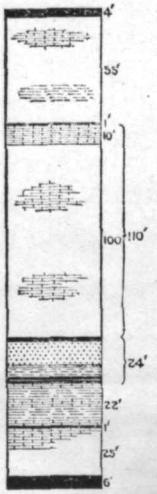


FIG. 22.—Section in Belmont County, Ohio.

Below this last locality no measurement of the Upper Coal Measure series is possible for a long distance, because most of the members are below water level. They are all brought to the surface, however, by the Volcano anticline, which crosses the Ohio River from Pleasants County, West Virginia, into Washington County, Ohio.

Section in Washington County, Ohio.—Mr. F. W. Minshall, of Marietta, Ohio, has made a very careful study of these measures in Washington County, Ohio, and has prepared the following section (Fig. 23) as representing their usual structure there:

Washington County, Ohio.

[See map, M g.]	Ft. in.	Ft. in.
1. Coal, Waynesburg (Macksburg)		4
2. Shale	14	
3. Sandstone	11	
4. Shale	18	
5. Limestone	6	96
6. Shaly sandstone	18	
7. Limestone and shale	29	
8. Coal, Sewickley (Meigs Creek)		2 6
9. Shales and limestone	25	
10. Shales	40	88
11. Sandstone	19	
12. Shales	4	
13. Coal, Pittsburgh, thin		
Total		190 6

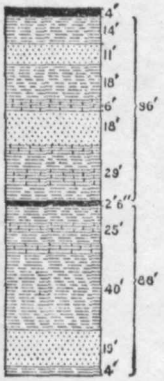


FIG. 23.—Section in Washington County, Ohio.

The thickness here given is 50 to 60 feet less for the entire series than that usually found in any other portion of the Appalachian field.

Section at Burning Springs, West Virginia.—In the vicinity of Burning Springs, Wirt County, West Virginia, these rocks are brought above the surface by the same anticline, and there Mr. Minshall reports the following structure (Fig. 24):

Burning Springs, Wirt County, West Virginia.

[See map, P g.]	Ft. in.
1. Coal, Waynesburg	1 8
2. Concealed and shales	207
3. Sandstone, Pittsburgh	30
4. Shales	10
5. Coal, Pittsburgh	1 8
Total	250 4

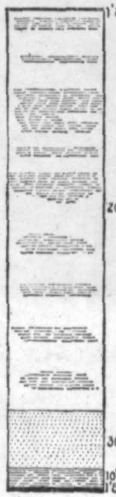


FIG. 24.—Section at Burning Springs W. Va.

Both here and all along the Volcano anticline the Pittsburgh coal is very poorly developed, as shown in this and the previous section, and it is frequently absent entirely.

Section on Leading Creek, West Virginia.—Near Leading Creek post-office, at the eastern edge of Gilmer County, West Virginia, this series shows thus (Fig. 25):

FIG. 25.—Section on Leading Creek, W. Va.

Leading Creek, Gilmer County, West Virginia.

[See map, P j.]

		Feet.
1.	Waynesburg coal horizon (absent)	0
2.	Shales	10
3.	Limestone, brecciated	3
4.	Shales and concealed	35
5.	Sandstone, yellow, massive, soft, pebbly	40
6.	Shales	10
7.	Limestone, impure	2
8.	Shales	40
9.	Sandstone, massive	40
10.	Shales	55
11.	Coal, Pittsburgh: Coaly shales 2′ 0″; Clay 0′ 10″; Bony coal 0′ 6″; Coal 2′ 4″; Bony slate 0′ 4″; Coal 2′ 0″	8
	Total	243

Section at Antiquity, Ohio.—Along the Ohio River, below where the Volcano arch crosses, the Upper Coal Measures again plunge under water level, and do not emerge again till we come to the vicinity of Antiquity, Meigs County, Ohio, 100 miles below. A shaft to the Pittsburgh bed (130 feet under river level), taken in connection with the surface exposures there, reveals the following succession (Fig. 26):

FIG. 26.—Section at Antiquity, Ohio.

Antiquity, Meigs County, Ohio.

[See map, P e.]

		Ft.	in.
1.	Waynesburg coal (absent)	0	
2.	Shales and sandstones	172	
3.	Sandstone, massive, Pittsburgh	70	
4.	Shales, with fossil plants	10	
5.	Coal, Pittsburgh: Coal 2′ 6″; Slate 0′ 2″; Coal 3′ 0″	5	8
	Total	257	8

Section at Hartford City, West Virginia.—Six miles below the shaft at Antiquity, and in the vicinity of Hartford City, the Pittsburgh coal

comes above water level. In the steep bluffs above Hartford the following succession (Fig. 27) was observed:

FIG. 27.—Section at Hartford City, W. Va.

Hartford City, Mason County, West Virginia.

[See map, P d.]

	Ft.	in.
1. Waynesburg coal (absent)	0	
2. Red shale	10	
3. Shale, gray	5	
4. Sandstone	6	
5. Shales, brown, sandy	10	
6. Shales, red	2	
7. Concealed	14	
8. Red shale, with limestone nodules	10	
9. Sandstone	20	
10. Shales, variegated with limestone nodules near base	28	
11. Concealed	20	
12. Red shale	5	
13. Concealed	20	
14. Shale, red	15	
15. Sandstone, massive, Pittsburgh	70	
16. Shales, gray, fossil plants	15	
17. Coal, Pittsburgh	5	6
Total	255	6

Section at Arbuckle, West Virginia.—In the vicinity of Arbuckle, Mason County, West Virginia, on the Great Kanawha River, and 18 miles above its mouth, the Waynesburg coal makes its appearance in the section. Here the following structure (Fig. 28) was obtained for the series, by combining the surface exposures with the record of a boring made by Mr. Craig:

Arbuckle, Mason County, West Virginia.

[See map, Q e.]

	Ft.
1. Waynesburg coal: Coal, slaty 0′ 10″; Coal, sulphurous 0′ 8″; Shale, dark 0′ 5″; Coal, good 0′ 8″; Coal, slaty 0′ 5″	3
2. Shales, sandstone, and concealed	150
3. Sandstone, blue	4
4. Shales, red	2
5. Sandstone, blue, hard	14
6. Variegated shales	8
7. Coal, Sewickley	1
8. Sandstone	6
9. Shales, red	4
10. Shales, variegated	48
11. Fire clay, impure (Redstone coal)	2
12. Sandstone, coarse, white, Pittsburgh	29
13. Fire clay and shale with a little slaty coal at bottom, Pittsburgh	10
Total	281

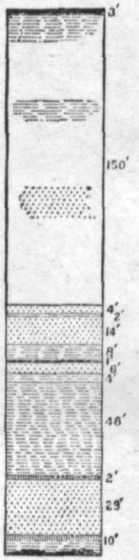


FIG. 28.—Section at Arbuckle, W. Va.

Here there is practically no merchantable coal in the whole series, since the Waynesburg bed, although 3 feet thick, is poor and slaty.

The locality is near the center of the deepest portion of the Appalachian trough, and the horizon of the Pittsburgh coal is 90 feet under the Kanawha. A hole was drilled as a test for this coal, but the result proved only a trace of it present.

Section at mouth of Big Hurricane Creek, Putnam County, West Virginia.—Southward up the Kanawha River from Arbuckle, the locality of Section 28, the rocks rise and the entire series comes above water level at the mouth of Big Hurricane Creek, in Putnam County. Here, 32 miles from the mouth of the Big Kanawha, the following succession may be seen (Fig. 29):

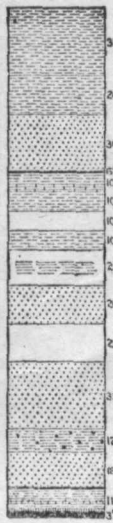


FIG. 29.—Section at mouth of Big Hurricane Creek, W.Va.

Mouth of Big Hurricane Creek, Putnam County, West Virginia.

[See map, R d.]

				Ft.	in.
1. Waynesburg coal (absent)				0	
2. Shales, red and sandy				35	
3. Sandy shales				20	
4. Sandstone, massive				30	
5. Coal, Uniontown				0	6
6. Red shales, with limestone				10	
7. Shales, sandy				10	
8. Concealed				10	
9. Shales, sandy				10	
10. Concealed and red shales				20	
11. Sandstone, massive				20	
12. Concealed				20	
13. Sandstone, massive				35	
14. Shale, with iron ore				12	
15. Sandstone				18	
16. Coal, Pittsburgh, roof	Coal	0′	10″		
	Shales	5′	0″		
	Slate, black	1′	0″	11′	9″
	Sandstone	1′	8″		
	Slate, black	2′	0″		
	Fire clay	1′	3″		
				15	8
17. Coal, Pittsburgh, main bench	Coal	3′	3″		
	Slate	0′	2″	3′	11″
	Coal	0′	6″		
Total				266	2

The Pittsburgh coal is patchy all through this region, being workable on some farms and absent on others.

Section opposite Winfield, West Virginia.—As showing the unreliable character of the coals in this series along this portion of the Kanawha, the section (Fig. 30) of the rocks opposite Winfield, Putnam County, 5 miles above Big Hurricane, is given:

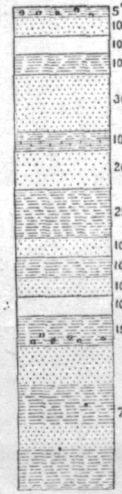


FIG. 30.—Section opposite Winfield, W. Va.

Opposite Winfield, Putnam County, West Virginia.

[See map, S c.]

	Ft.
1. Waynesburg coal (absent)	0
2. Shales, red, with limestone nodules	5
3. Sandstone, shaly	10
4. Concealed	10
5. Red shale	10
6. Sandstone, flaggy	30
7. Red shales, with limestone	10
8. Sandstone, shaly	20
9. Red shale	25
10. Sandstone, shaly	10
11. Red shales	10
12. Sandstone, flaggy	10
13. Concealed	10
14. Red shale, with limestone nodules near base	15
15. Sandstones, red, and gray shales	75
16. Fire clay, place for Pittsburgh coal	0
Total	250

This section was measured in the steep hill at Red House Station, on the Kanawha and Ohio Railroad, and, as may be seen, the series does not there contain any coal whatever.

Section near Raymond City, West Virginia.—Further up the Kanawha the Pittsburgh coal again comes in, and the following structure (Fig. 31) is found in the vicinity of Raymond City, 6 miles above Winfield:

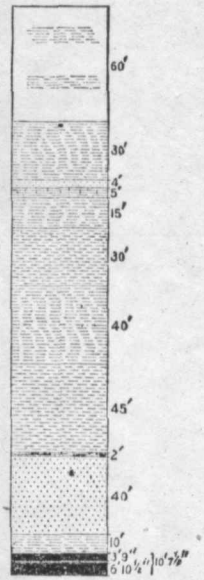


FIG. 31.—Section near Raymond City, W. Va.

Near Raymond City, Putnam County, West Virginia.

[See map, S e.]

				Ft.	in.
1.	Waynesburg coal (absent)			0	
2.	Concealed, with red shale			60	
3.	Red shale			30	
4.	Sandstone, gray, micaceous			4	
5.	Limestone, in red shale			5	
6.	Red shale			15	
7.	Sandy shale, gray			30	
8.	Shale, red			40	
9.	Sandy shales, yellowish gray			45	
10.	Black shale, Redstone coal			2	
11.	Sandstone, Pittsburgh			40	
12.	Shales			10	
13.	Coal, Pittsburgh, roof	Coal	0′ 4″		
		Shale	0′ 4″		
		Coal	0′ 6″	3′ 9″	
		Shale	0′ 1″		
		Coal, slaty	1′ 0″		
		Fine clay	1′ 6″		
				10	7½
14.	Coal, Pittsburgh, main bench	Coal, good	6′ 0″		
		Slate	0′ ½″	6′ 10½″	
		Coal, slaty	0′ 10″		
	Total			291	7½

Section in vicinity of Western Port, Maryland.—In the Cumberland or Georges Creek basin, the Upper Coal Measures exhibit the following structure (Fig. 32), as observed in the vicinity of Western Port, Maryland:

Vicinity of Western Port, Allegheny County, Maryland.

[See map, N p.]

				Ft.	in.
1.	Waynesburg coal (not seen)			0	
2.	Concealed and shales			130	
3.	Coal, Sewickley			5	
4.	Shales and concealed			115	
5.	Coal, Pittsburgh, roof	Coal	0′ 8″		
		Shale	4′ 0″	6′ 8″	
		Coal	1′ 0″		
		Shale	1′ 0″		
				20	3¼
6.	Coal, Pittsburgh, main bench	Coal	10′ 0″		
		Slate	0′ 2″		
		Coal	0′ 9″		
		Slate	0′ ¼″	13′ 7¼″	
		Coal	2′ 0″		
		Black slate	0′ 6″		
		Soft coaly shale	0′ 2″		
	Total			270	3¼

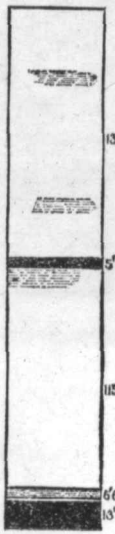


FIG. 32.—Section near Western Port, Md.

From the foregoing sections it will be perceived that the beds in the Upper Coal Measures which have received distinct names are in descending order as follows:

Waynesburg coal.
Browntown sandstone.
Little Waynesburg coal.
Waynesburg limestone.
Uniontown sandstone.
Uniontown coal.
Uniontown limestone.
Great limestone.
Sewickley sandstone.
Sewickley coal.
Sewickley limestone.
Redstone coal.
Redstone limestone.
Pittsburgh sandstone.
Pittsburgh coal.

These several beds we shall now notice more in detail.

CHARACTERISTIC HORIZONS.

THE WAYNESBURG COAL.

This, the highest member of the series, is generally quite persistent around the northern end of the coal field, but followed southward through West Virginia it soon becomes patchy and interrupted, so that beyond the line of Marion County the coal is only occasionally present along the eastern and central portions of the Upper Coal Measure belt, its horizon being frequently occupied, as at Harrisville, Ritchie County, by a brecciated limestone.

On the Great Kanawha this coal occurs near the center of the Appalachian trough over a small area in the vicinity of Arbuckle, and its structure there is given in Section 28.

Along the western side of the field, down the Ohio River and across southern Ohio, this coal is fairly persistent. It dips under the Ohio River at New Martinsville, but rises to daylight again near St. Mary's, where it is only 1 to 3 feet thick, and quite sulphurous.

In the Macksburg oil region it is the principal bed, according to the Ohio geologists, and has a thickness of 4 feet.

This coal is almost universally double, being separated into two layers by a division of shale and slate. This is so common at the northern end of the field that it is known there as the "horse-back" vein. In Monongalia and Greene Counties the bed is often 8 to 10 feet thick and separated into three layers, the upper division of slate being very fossiliferous, and often, as at Cassville, West Virginia, containing many insect remains, together with fossil plants.

The coal from this bed is usually rather hard, and comes out in large blocks; but it frequently contains injurious quantities of sulphur. This renders it unfit for smithing, as well as for the manufacture of coke and gas, but it is generally a useful fuel for steam and domestic purposes.

IRON ORE.

The shales which underlie the Waynesburg coal sometimes contain a considerable quantity of iron nodules, and they were once mined in

Morgan Township, Greene County, Pennsylvania, and used in manufacturing iron. The same ore occurs near Bethel Church, Cass District, Monongalia County, at 15 to 20 feet below the coal.

THE BROWNTOWN SANDSTONE.

In many portions of Marion and Harrison Counties, West Virginia, the interval beginning 5 to 10 feet below the Waynesburg coal is occupied by a hard, gray, massive sandstone, 20 to 35 feet thick. It is finely exposed along the bed and bluffs of Ten Mile Creek, at and below Browntown, Harrison County, West Virginia, and has been designated from that locality. The deep, rocky cuts along the Baltimore and Ohio Railroad, beginning 1 mile east of Mannington, Marion County, and extending to the mouth of Mod's Run, are all in this sandstone. It is sometimes called the "Gilboy" sandstone, from a rocky cut of that name near Mannington. This is nearly always a water-bearing stratum, and the oil wells of Marion County have to be cased below this rock in order to shut off the fresh water.

THE LITTLE WAYNESBURG COAL.

At many localities around the northern end of the Upper Coal Measure area a thin streak of coal or bituminous slate occurs at 25 to 40 feet below the Waynesburg coal, and it was termed the Little Waynesburg coal by Prof. Stevenson. It seldom exceeds 1 foot in thickness, and is of no economic importance. It is usually separated from the main coal above by shales and sandy beds, and should probably be regarded as an offshoot from the Waynesburg coal proper. It is seldom seen south from the Pennsylvania line, though it occurs along the Ohio River at several places.

THE WAYNESBURG LIMESTONE.

Directly under the last described stratum there occurs a limestone of very wide distribution. Its place is generally about 40 feet below the Waynesburg coal, though sometimes it is less, and occasionally a few feet more. It is usually of a dark gray color, and several of the layers make excellent lime for agricultural and building purposes. The thickness in Pennsylvania and northern West Virginia is seldom less than 8 feet, and frequently double that, but southwestward, toward the Great Kanawha region, the limestone disappears entirely.

THE UNIONTOWN SANDSTONE.

At 60 to 75 feet below the top of the series there frequently occurs a massive, gray sandstone whose horizon comes immediately above the Uniontown coal; and hence, although the stratum in question is not prominent at Uniontown, it has been designated from its relations to the underlying coal.

The rock has occasionally been mistaken for the Waynesburg sandstone, which belongs nearly 100 feet above. It is well exposed at Bob-

town, Greene County, Pennsylvania, where it crowns the summit of the hill overlooking Dunkard Creek as a bold cliff.

In the Georges Creek coal field a massive sandstone occurs 250 feet above the Pittsburgh coal, and it was once referred by the writer to the Uniontown horizon under the name of "Westernport sandstone," but subsequent study seems to place it in the horizon of the Waynesburg sandstone.

THE UNIONTOWN COAL.

This bed underlies the Waynesburg coal by an interval of 80 to 100 feet, and is of economic importance only in Fayette and Washington Counties, Pennsylvania. It was named by Rogers from Uniontown, Fayette County, where it is well exposed. The thickness seldom exceeds 3 feet, even in the region of its best development, and the coal has never been used except for domestic purposes, since it is usually neglected for the great Pittsburgh bed below. It often contains a clay or slate parting near the center, 4 to 6 inches thick, and is rather too rich in ash for a first-class fuel.

Southward from Fayette County, through Greene, Monongalia, Marion, and Harrison, this coal thins away to a bed of black slate mixed with slaty coal that is often rich in fish remains and bivalve crustaceans, which may be found in abundance near Davistown, Greene County, Pennsylvania.

Along the Ohio River at Wheeling, Bellaire, Clarington, and other points, this bed is sometimes represented by a thin streak of black slate or coal. In the Salisbury basin of Pennsylvania it is recognized by Messrs. Platt, and is there over 3 feet thick, with slate near center.

THE UNIONTOWN LIMESTONE.

To the division of the "Great" Limestone which immediately underlies the last described coal bed, Dr. Stevenson gave the name Uniontown, since it seems to be fairly well separated from the great mass of limy deposits below. This division is usually 10 to 15 feet thick, though occasionally it surpasses these figures. The rock is frequently impure and of a buffish color, being magnesian, and occasionally a good cement rock, as at Uniontown, Pennsylvania. This is the only member of the "Great" Limestone which appears to be persistent from the Pennsylvania line southward across West Virginia to the Big Kanawha River, since an impure limestone only 2 to 5 feet thick occurs at this horizon in the vicinity of Raymond City and other points in that region.

In the Salisbury basin this limestone occurs only 160 feet above the Pittsburgh coal, and is 10 to 12 feet thick, according to Platt.

THE "GREAT" LIMESTONE.

This name, given by Rogers, is generally applied to all of the great mass of lime deposits which intervene between the Uniontown and Sewickley coals, though, as already stated, the name Uniontown is now given to the uppermost division of the same.

At many localities in Greene, Washington, Fayette, and Monongalia Counties there are nearly 160 feet of limestones and limy shales at this horizon, and the same beds hold their place, though with diminished thickness, across to the Ohio River at Wheeling. Westward and southward, however, from Ohio and Marion Counties, these limestones disappear very rapidly, so that at Clarksburg on the one hand, and westward through Ohio on the other, they have practically disappeared, and in their stead we find shales, gray at first, but gradually getting reddish toward the Little Kanawha River and the western margin of their outcrop in Ohio. On the Big Kanawha much red shale occurs at this horizon. These limestones are of different qualities, some of the layers being quite pure and forming good fluxes for iron, while others are magnesian and make excellent hydraulic cements.

The only fossils ever seen in any of these limestone beds are fish remains and minute ostracoids.

THE SEWICKLEY SANDSTONE.

At many localities where the "Great" Limestone is well developed there are no other beds except limestones and shales in all of the interval between the Uniontown and Sewickley coals, but in other regions a sandstone frequently makes its appearance just above the Sewickley coal. This has been called the Sewickley sandstone, and while it is often flaggy, yet again it becomes massive, and even pebbly, varying in thickness from 20 to 60 feet. Its massive character is well shown along the Monongahela River between Morgantown and Fairmont, in the vicinity of the Big Falls.

THE SEWICKLEY COAL.

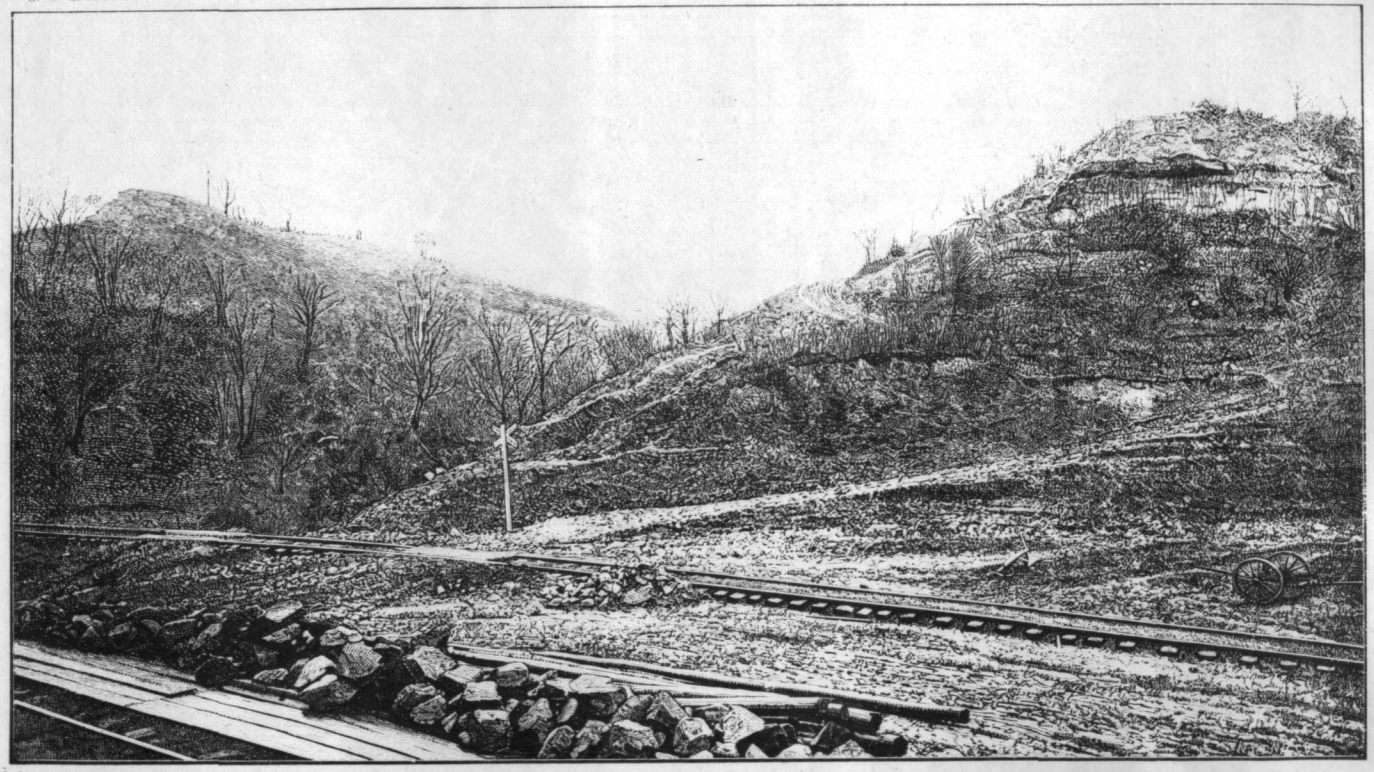
Directly under the Sewickley sandstone, or in its absence the "Great" Limestone, there comes the Sewickley coal, a bed which is widely persistent, though the area where it is valuable is not so large.

The bed attains its maximum thickness and importance along the Monongahela River in Greene, Monongalia, and Marion Counties, being there 5 to 6 feet thick, with only one slate parting of 2 to 3 inches near the center. The coal is generally high in both ash and sulphur, but is open-burning and makes a rather fair domestic fuel.

The following represents the general structure of this bed along the Monongahela River in Marion and Monongalia Counties:

	Ft.	in.	
Coal	2	8	5′ 6″
Slate	0	2	
Coal	2	8	

Followed down the Monongahela River, the bed retains about the same structure as far as the mouth of Whitely Creek, Greene County, Pennsylvania, when the slate partings thicken up, and new ones come in and dissipate the coal in several thin layers through 25 feet of rock



UPPER COAL MEASURES AT POINT PLEASANT, WEST VIRGINIA, SHOWING RUGGED CHARACTER OF THE T[illegible]GRAPHY.

material, and from thence on down that river it is of no importance. But followed in the other direction, up the Monongahela, this bed holds a thickness of 5 to 6 feet through Marion County until the Harrison County line is approached, when it again splits up into three or four divisions separated by several feet of shales and slates, and when Clarksburg is reached there remains only 1 foot of coal at this horizon (Section 18), which soon disappears entirely toward the southwest.

From the Monongahela region this coal dips down westward under the great mantle of Permo-Carboniferous beds, and when it reappears on the Ohio River, in the vicinity of Wheeling (Section 19), Bellaire (Section 20), and Pipe Creek (Section 22), we find it split up again into three or four layers, and the separating slates several feet thick, thus giving the whole bed a thickness of 20 to 30 feet, with the main coal layer at the top.

This uppermost division of the Sewickley is separated from the Pittsburgh below by an interval of 80 to 100 feet, and attains considerable importance in the counties of Belmont, Harrison, Guernsey, Monroe, Morgan, Muskingum, Noble, etc., and has there been mined under a variety of names, among which are "Upper Barnesville," "Upper Bellaire," "Cumberland," "Meigs Creek," and several others. Prof. Orton, while intimating its identity with the Sewickley of Pennsylvania (Vol. V, page 1059, Ohio Geology), prefers to call it by the name of Meigs Creek, from a stream in Morgan County along which it is well developed.

Throughout much of this Ohio region the coal is 3 to 4½ feet thick, and nearly always has a clay or bony streak near its center. It also frequently has a rider coal in the roof, and the entire bed is rather rich in ash and sulphur, according to Orton.

In Fayette County, Pennsylvania, the Sewickley coal has a thickness of 4 to 5 feet through several townships, according to Stevenson, but northward through Westmoreland it thins down and is unimportant. It is scarcely known in the Ligonier basin, but in that of Salisbury is 2 feet thick and 90 feet above the Pittsburgh.

In the Georges Creek basin of Maryland and West Virginia the bed is 5 to 7 feet thick, 90 to 115 feet above the Pittsburgh, and an excellent coal for steam purposes.

The oil-borings across Monongalia and Marion Counties reveal this coal present in good thickness 10 to 15 miles west from the Monongahela River, and 100 to 110 feet above the Pittsburgh coal. The oil drillers usually call it the "Mapletown" coal, from a locality in Greene County where it is mined.

THE SEWICKLEY LIMESTONE.

The interval between the Sewickley coal and the one next below is often occupied largely by limestone, especially in Greene, Fayette, Washington, Monongalia, and Marion Counties, and to the one which

comes next below the coal Messrs. Platt have given the name Sewickley. It has also been termed the Fishpot Limestone by Stevenson, from a small stream in Washington County. I have deemed it preferable to apply the name Sewickley to the whole limestone group which lies between the Sewickley and Redstone coal beds. This interval is 40 to 60 feet thick and sometimes contains two beds of sandstone intercalated with the limestones. Along the Monongahela River in Greene, Monongalia, and Marion Counties, these limestones are well developed, and many of the layers furnish excellent lime for mortar and agricultural uses, while near the base of the group occur some excellent limestone flags at Laurel Point, Monongalia County.

The only fossils ever noted in these beds are minute fresh-water types.

These limestones disappear southward from Harrison County, West Virginia, there being only 9 feet of them in the Clarksburg section, and none on the Little and Big Kanawha Rivers. The same thing takes place in Ohio, westward from Washington County, the interval being occupied by shales and sandstones.

In Pennsylvania this Sewickley limestone holds a prominent place eastward from Washington and Greene, through Fayette, Westmoreland, and Somerset Counties.

THE REDSTONE COAL.

In Fayette County, Pennsylvania, a small coal was found cropping out along Redstone Creek, at an interval of 40 to 45 feet above the Pittsburgh, and this was named from that stream by the geologists of the First Pennsylvania Geological Survey.

Monongalia is the only county in West Virginia where this bed is workable, it being there, on Scott's and Robinson's Runs, 4 to 5 feet thick and of fair quality, though having rather too much sulphur and ash for manufacturing purposes. It is also workable in several townships of Fayette and Westmoreland, being 3 to 4 feet thick. In the Salisbury basin of Somerset County, Messrs. Platt identify the Redstone coal as a slaty bed, 4 feet thick, at 45 feet above the Pittsburgh. It has not been reliably reported from the Georges Creek field unless it be represented by one of the rider layers in the roof of the Pittsburgh bed.

In the vicinity of Wheeling, Bellaire, and other points on the Ohio River, this bed is only a few inches thick, never becoming workable anywhere in Ohio.

Through central West Virginia, beyond the Little Kanawha, its presence is unknown except by a bed of black slate which is occasionally seen at this horizon.

THE REDSTONE LIMESTONE.

At many localities along the Monongahela River in Harrison, Marion, Monongalia, Greene, Washington, Fayette, and Westmoreland Counties, there occurs a bed of limestone often 10 to 20 feet thick, and im-

mediately underlying the Redstone coal. From this latter fact it was termed the Redstone limestone by Messrs. Platt, who find the same bed in Somerset County, 40 to 45 feet above the Pittsburgh coal. It often contains several layers, which make fairly good lime for many purposes, and is occasionally used for flux in iron furnaces.

This limestone is also in great force in the vicinity of Wheeling, Bellaire, and vicinity, where it occupies nearly the entire interval between the Redstone and Pittsburgh coals, and is extensively quarried as a flux for the furnaces there.

It, like all the other limestones, disappears southwestward through West Virginia, and is not known beyond the Little Kanawha River.

THE PITTSBURGH SANDSTONE.

Very frequently, and especially when the Redstone limestone is well developed, there is nothing but shales intervening between it and the Pittsburgh coal, but when the limestone is absent, or but poorly represented, there is often present a coarse, massive sandstone immediately above the Pittsburgh coal, and to this Mr. H. D. Rogers long ago gave the name of Pittsburgh sandstone. It varies in thickness from 25 up to 70 feet, and is usually coarse, friable, and often pebbly. Good building stone has never been obtained from it, since it yields so readily to atmospheric agencies.

This rock is especially massive in the vicinity of Hartford City, Pomeroy, and other contiguous regions, and the same may be said of the eastern line of its outcrop from Pennsylvania clear across West Virginia to the Kentucky border.

In the Georges Creek, Salisbury, and Ligonier basins, however, this rock makes but little show in the topography, its place being occupied by soft shales.

THE PITTSBURGH COAL.

The last and lowest member of the Upper Coal Measures is the celebrated Pittsburgh bed, the most important mineral deposit of the Appalachian field.

It was formerly thought that this coal bed was entirely persistent; that wherever its horizon was to be found, there the coal might be expected with absolute certainty. This generalization, however, was founded on data obtained only from the northern half of its area. In Pennsylvania, for instance, no area has yet been discovered where, at the proper geological horizon for this bed, it does not exist. Even in central Greene, at a depth of 1,500 feet below the Permo-Carboniferous summits, the drill of the petroleum seeker invariably finds this coal bed, while the isolated peak of Round Top, in the Broad Top coal basin of Bedford County, 50 miles distant from any other outcrop of the coal, likewise contains it. But when we pass southwestward across the West Virginia and Ohio coal field, Pennsylvania conditions of course continue

for many miles, but ultimately there comes a change, and when we look for the Pittsburgh bed it is gone, or so reduced in thickness that the geologist can only recognize it by its associated rocks. The region of country covered by this barren area is quite extensive, and seems to be rudely coincident with the line of the Volcano or Burning Springs anticlinal of West Virginia.

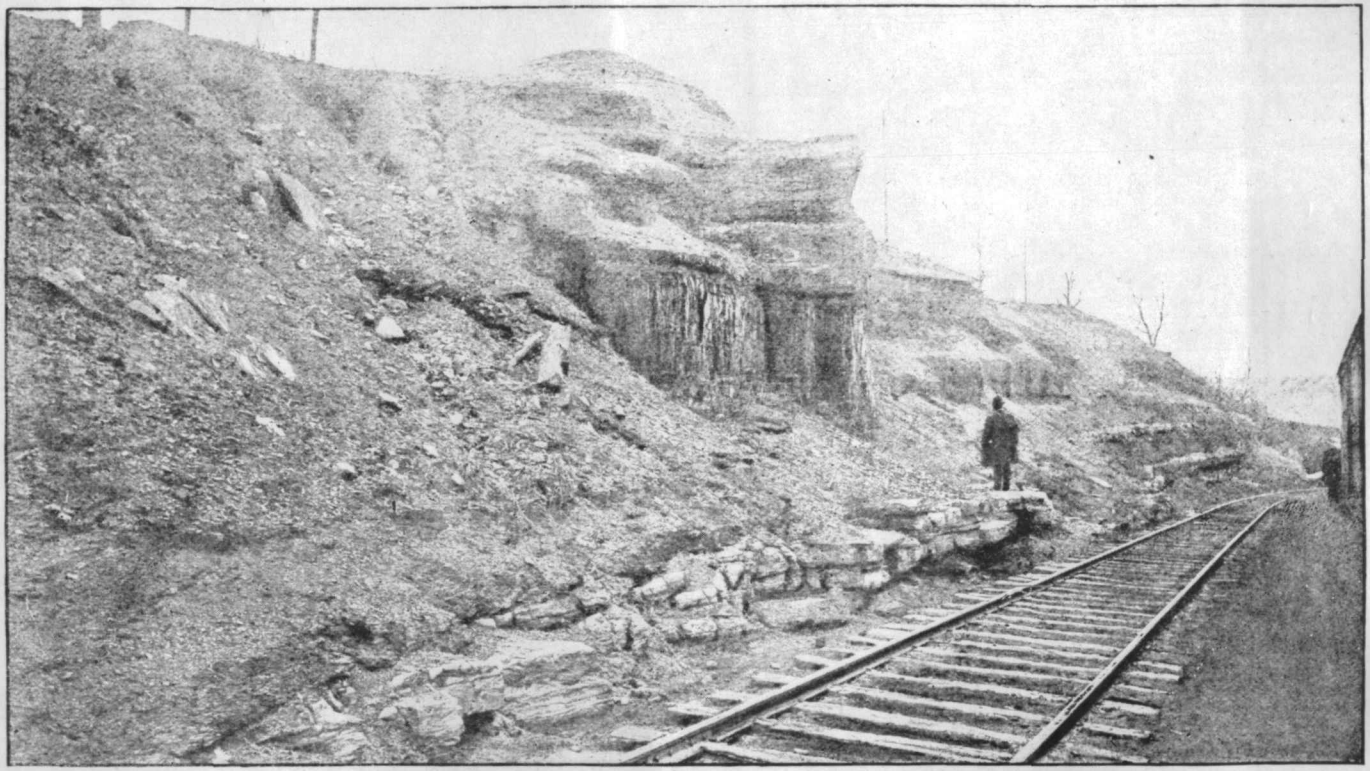
The following counties in that State have the coal but poorly developed or wanting at the horizon where it belongs: Calhoun, Roane, Wirt, Ritchie, Pleasants, and Wood. This belt projected northward through Ohio takes in the counties of Washington, Noble, and Morgan, in all of which the coal is thin or wanting altogether. Thus it happens that over a belt of country 30 to 50 miles wide, and running nearly north and south across the Appalachian coal field, the spread of this bed, so even and persistent at the north, is here irregular, interrupted, and wanting. West from this belt the coal comes in again and is fairly regular in parts of Kanawha, Putnam, and Mason Counties, east from the Big Kanawha; but west from that stream the bed is thin, patchy, and of little importance through Cabell and Wayne, till it disappears from the center of the great Appalachian trough in the hilltops overlooking the Big Sandy River.

In Ohio, also, a considerable area of this coal comes in west from the barren belt, and extends through Meigs and Athens Counties with fairly good thickness, but westward from them, in Gallia, the coal is again thin and uncertain.

The foregoing sections, Nos. 11 to 32 inclusive, show in a general way the detailed structure of the Pittsburgh coal, so that only a few others need be given in this connection to exhibit its structure in every important region of its widely extended area.

As will be seen from these sections, the coal is nearly always separated into two well defined portions (the roof and the main bench) by a layer of clay, and there are often several divisions of the roof, as also of the main bench. The layers of coal in the roof are usually not more than 1 to 1½ feet thick, and separated by shales of about the same thickness, while the divisions of slate in the main bench are mere knife edges, seldom exceeding an inch in thickness and generally not more than half that amount.

Along the Monongahela River, two of these slates are especially constant, since they come about 2½ to 3 feet above the bottom of the bed and are 4 to 6 inches apart. They are usually known as the "bearing in" slates, and are seldom more than one-half inch thick. Then 1 to 1½ feet below these there is generally another thin parting of slate which runs through the bed with great persistency, dividing the lower portion into two layers known by the miners as the "brick" coal, and "bottom" coal. Of course there are other partings which occasionally make their appearance in the bed at some localities, but they are irregular and not persistent.



THE PITTSBURG COAL OUTCROP NEAR CONNELLSVILLE, PENNSYLVANIA, SHOWING COLUMNAR STRUCTURE OF TYPICAL COKING COAL.

Section at Newburg, West Virginia.—The summits around Newburg, Preston County, West Virginia, catch small areas of this bed in the syncline between the Chestnut Ridge and Laurel Hill anticlinals, and the coal has there the following structure:

	Ft.	in.	Ft.	in.	Ft.
Pittsburgh sandstone					
Slaty coal	0	8			
Shale	0	9	4	3	
Coal	0	10			
Shale and fire clay	2	0			15
Coal	9	0			
Slate	0	3	10	9	
Coal, slaty	1	6			

Section at Copeman's Knob, West Virginia.—In the next trough east of the Laural Hill anticlinal, a small isolated area of the Pittsburgh coal is caught in Copeman's Knob, which overlooks Cheat River at the foot of Briery Mountain, near Albrightsville, Preston County, West Virginia, and there the coal shows this structure:

		Ft.	in.	Ft.	Ft.
Roof.	Shales				
	Coal	2	0		
	Slate	1	6		
	Coal, slaty	2	4		
	Slate	0	2	9	
	Coal	1	6		19
	Clay	1	6		
Main coal, partings not visible				10	

Section 32 gives the structure of this coal still farther eastward in the Georges Creek basin, and it, when compared with the Albright, Newburg, and Fairmont (Sec. 17) structures, shows a gradual eastward thickening of the bed from 7 feet on the Monongahela to 20 at many points in the Georges Creek field.

Section at Fairfax Knob, Tucker County, West Virginia.—Near the southern end of the Georges Creek basin, at the head of the North Potomac River, a small area of the Pittsburgh bed is caught in the summit of Fairfax Knob, 3,250 feet above tide, and 20 miles distant from any other outcrop of the coal. The main portion of the bed is here split into three portions, separated by several feet of shales, from the thickening up of the parting slates, as follows:

		Ft.	in.	Ft.	Ft.
Roof.	Shales				
	Coal	2	0		
	Shale	6	0		8
Coal, "breast".	Coal	8′	2″		
	Slate	0′	2″	9	6
	Coal	1′	2″		
Shales		5′	0″		
Limestone		4′	0″	16	0
Shales		7′	0″		55
Coal, "brick"		4	6		
Fireclay and shales		18	0		
Coal, "bottom," slaty		7	0		

As will be seen from the above, it would appear that the three main divisions of the Pittsburgh bed, viz, "breast," "brick," and "bottom," are here separated by shales, 16 and 18 feet thick respectively, instead of mere partings of a fraction of an inch, as on the Monongahela and elsewhere, thus spreading the 21 feet of coal through an interval of 55 feet. It is also worthy of note that although the partings have here increased so wonderfully, yet the total thickness of coal remains the same as in the central part of the Georges Creek Basin.

In the vicinity of Glenville, on the Little Kanawha River, this coal is 4½ to 5 feet thick, with a bony streak 16 inches below the top of the bed.

The structure on the Big Kanawha is given in Section 31.

Section at Huntington, Cabell County, West Virginia.—In the summits of the hills south of Huntington, Cabell County, West Virginia, this coal displays the following structure:

	Ft.	in.	Ft.	in.
Coal	0	6	4	8
Clay	0	6		
Coal	3	6		
Slaty coal	0	2		

The farthest point to the southwest that this bed has ever been seen is in the summit of a hill overlooking the Big Sandy River, 10 miles above its mouth, where a small patch is caught in the center of the Appalachian trough, which, rising to the southwest, carries the coal above the highest hills on the Kentucky side of the Big Sandy. The coal is here 3 feet 2 inches thick and single bedded, or with only faint partings.

Section at Pomeroy, Meigs County, Ohio.—At Pomeroy, Ohio, the Pittsburgh coal shows thus, according to Prof. E. Lovejoy, Ohio Geological Survey, Vol. VI, page 636:

	In.	Ft.	in.
Coal	8–14	5	10
Horn coal	3		
Coal	42–47		
Clay	4		
Coal	7		

Section on Shade Creek, Ohio.—In the Shade Creek coal field of Meigs and Athens Counties, Ohio, Prof. Lovejoy finds a well developed rider coal 12 to 20 feet above the main bed, and often mined separately from it. The two have the following structure:

	Ft.	in.	Ft.	in.
Coal	0	6	2	8
Slate	0	4		
Coal	1	10		
Shales		12–20		
Coal	0	9	4	3
Slate, streak	0	0		
Coal	2	6		
Slate, streak	0	0		
Coal	1	0		

Section on Federal Creek, Ohio.—In the Federal Creek field of Athens and Morgan Counties, Ohio, the coal shows as follows (Lovejoy), op. cit., p. 648, Heyburn Brothers & Co.'s mine, Berne Township, Athens County:

	Ft.	in.	Ft.
Coal	1	10	
Slate, streak	0	0	
Coal	2	4	
Slate	0	7	
Coal	0	3	10
Clay	1	0	
Coal	1	0	
Slate, streak	0	0	
Coal	3	0	

Section at Berry's mine, Ohio.—Berry's mine, in Homer Township, Morgan County (op. cit. page 650), gives the following:

	Ft.	in.	Ft.	in.
Coal	0	11		
Slate, streak	0	0		
Coal	3	5	5	4
Clay	1	0		
Coal	0	4½		
Slate, streak	0	0		
Coal	0	7½		
Slate, streak	0	0	3	7½
Coal	1	10		
Slate, streak	0	0		
Coal	0	9½		

The clay stratum in these and other mines appears to correspond to the main clay parting which always separates the roof coals of the Pittsburgh bed from the main bench along the Monongahela, and the 12 to 20 feet of shales which separate the two coal beds in the Shade Creek field would appear to belong at the same horizon.

East from the barren area of the Pittsburgh coal of Morgan, Noble, and Washington Counties, Ohio, it comes in again with a fine development in Belmont, Harrison, and Jefferson.

Section in Belmont County, Ohio.—The following section from Ohio Geology, Vol. VI, page 621, exhibits the structure in the southern portion of Belmont County, Washington Township, as given by Prof. Brown:

	Ft.	in.	Ft.	in.
Coal	1	0	1	11
Clay	0	10–12		
Coal	2	9		
Slate	0	0½		
Coal	2	0	6	0
Slate	0	0½		
Coal	1	2		

Section at Bellaire, Belmont County, Ohio.—In Bellaire the following is shown at Heatherington's mine:

	Ft.	in.	Ft.	in.
Coal	1	0		
Black slate	0	4		
Coal	1	0	3	2
Clay	0	10		
Coal	2	6		
Slate	0	0		
Coal	0	5		
Slate	0	0		
Coal	1	9	6	0½
Black slate, pyritous	0	0½		
Coal	1	0		
Hard, slaty coal	0	4		

Section in Jefferson County, Ohio.—In Warren Township, Jefferson County, Ohio, this coal has the following structure (Brown, Ohio Geology, Vol. VI, page 603):

	Ft.	in.	Ft.	in.
Roof coal	2	3		
Clay	0	4	2	7
Coal	2	2		
Clay parting	0	2		
Coal	0	2		
Black slate	0	⅛	4	11
Coal	1	3		
Parting				
Coal	1	2		

Section in Harrison County, Ohio.—In German Township, Harrison County, Ohio, Stevenson reports the Pittsburgh coal as follows (Ohio Geological Survey, Vol. III, p. 212):

	Ft.	in.	Ft.	in.
Roof coal, not exposed	0	0		
Coal	1	9		
Parting	0	0½		
Coal	0	6		
Parting	0	1½	4	9½
Coal	1	2		
Parting	0	0½		
Coal	1	2		

Section at Columbia mine, Westmoreland County, Pennsylvania.—As a typical section of this coal on the Monongahela River with reference to the structure of the main bench and roof, we may take that found at the Columbia mine, near Webster and 36½ miles above Pittsburgh, as given by Mr. J. Sutton Wall (K^4, Pennsylvania Geological Survey, p. 50):

	Ft.	in.	Ft.	in.
Roof coals, in seven divisions	3	9		
Over-clay	0	6	4	3
"Breast" coal	3	8		
Parting	0	0½		
"Bearing in" coal	0	3		
Parting	0	0½	6	6½
"Brick" coal	1	2		
Parting	0	0½		
"Bottom" coal	1	4		

A careful comparison of the structure of this famous bed at a great many points very widely separated exhibits such a striking resemblance to that just given above that we can scarcely attribute it to chance, but must find the explanation in the prevalence of nearly uniform conditions over the immense area covered by the Pittsburgh marsh.

The great excellence of this coal for steam and domestic purposes, and also for the manufacture of gas and coke, combine to render it the most valuable bed of coal in the entire Appalachian field.

Page plate 6 gives a view of this bed at Connellsville, the center of the coke-making industry, and in this the peculiar columnar structure of a typical coking coal is fairly shown.

It was formerly believed that this bed would not make first-class coke over any large area outside of the Connellsville basin, but recent developments along the Monongahela River in Marion and Monongalia Counties, West Virginia, have proved this belief erroneous, since it is there successfully coked on a large scale.

By crushing and washing, where there is too much sulphur present, there is no reason why this bed will not make coke equal to that of the Connellsville, throughout all of the region south and west from the latter.

The roof coals of this bed are never mined; not because they do not furnish good fuel, but because they are always interstratified with shale, which renders the mining difficult. These roof layers often amount to 3 or 4 feet of good coal, and thus this large quantity of fuel is continually wasted, though the time will doubtless come in the distant future when the Pittsburgh bed will be mined over again for the coal now neglected in its roof and bottom.

FOSSILS OF THE UPPER COAL MEASURES.

The flora of the Pittsburgh roof shales as well as of the entire Upper Coal Measures is very meager, and only a few of the very common types, like *Neuropteris hirsuta*, *N. flexuosa*, and *Pecopteris arborescens*, are usually found, while the fauna of the whole group, so far as known at present, seems to be restricted to fresh water types.

CHAPTER IV.

THE BARREN MEASURES, OR ELK RIVER SERIES.

THICKNESS, CHARACTER, AND EXTENT.

Below the Pittsburgh bed we descend into a very natural group of rocks (No. XIV) which was long ago clearly recognized by the Rogers brothers in both Pennsylvania and Virginia. The group as defined by them extended from the base of the Pittsburgh coal down to the top of the Mahoning sandstone, and was called the Lower Barren Measures; but subsequent investigation seems to render it more desirable to extend the group downward so as to include the Mahoning sandstone. This brings the group within the definite limits of two important and very persistent coal beds, the Pittsburgh above and the Upper Freeport below; and hence, for purposes of comparison, study, and all the uses which classification subserves, is more desirable than the old system, since the top of the Mahoning sandstone is too variable a quantity for the limit of any group.

I have already indicated in a previous chapter that a larger view of the Carboniferous Measures, which overlooks details invaluable for classification to the working geologist, would run a line through the middle of the Barren Measures, and call everything above it, to the top of the Dunkard Creek series, Upper Carboniferous; that below it, to the base of the Pottsville conglomerate, Middle Carboniferous, and the rest down to the Catskill, Lower Carboniferous. Such a classification of the Appalachian Carboniferous may be useful for comparison with the Carboniferous system in other regions and countries, but it is too general for the practical geologist, and can never supplant that which has stood the test of long and continuous use. Hence we deem it best to retain the limits of the Barren Measures intact, with the slight modification just suggested, and already long in use by the Second Geological Survey of Pennsylvania.

I have adopted the name Elk River series as a geographical designation for these beds, since they are very finely exposed along that stream between its mouth at Charleston, West Virginia, and Braxton Court-House, or Sutton, nearly 100 miles above.

This series, as thus limited above and below by important coal beds, consists of two very different members; an upper one composed largely of shales, therefore soft, easily eroded, and always making rounded hills and rolling topography; the other, or lower, composed largely of massive sandstones which resist erosion and thus form steep cliffs, deep gorges, rugged topography, and wild scenery generally.

These sand rocks form a coping to the Lower Coal Measure hills, and cap the summits long after the soft beds above have disappeared.

The soil formed by the soft member, while rather thin and not to be compared in fertility to that of the Upper Coal Measures, yet with care and a liberal use of lime yields excellent crops and always makes good grazing lands. But the lower portion, being almost destitute of lime, and containing so much sand, forms a very poor soil, on which only the scantiest crops can be grown.

The upper portion always contains a large percentage of red and marly shales, which make a broad band of red soil from Pennsylvania clear through central West Virginia, to and beyond the Kentucky line on the one hand, and thence circling around through eastern Kentucky and southern Ohio, back to Pennsylvania again on the other. These red clays are the fruitful source of landslides, bad roads, and many other troubles. They cave easily in drill holes, and thus give endless annoyance and expense to oil and gas drillers. Their tendency to slide causes much expense in cleaning out railroad cuttings, so that a proper knowledge of their character by engineers would lead to economy of money in building and maintaining both railroads and wagon roads.

The coal beds of this series are, with one or two exceptions, noted for their variableness and uncertainty. They may be in fair development on one farm, and absent entirely on the adjoining one. They are also usually rich in ash and poor in carbon, and although they are patchy in their distribution, yet the main beds appear to maintain the same horizons in the stratigraphy, and can thus be identified with reasonable certainty over wide areas. The sandstones found within the limits of this group are of more economic importance than the coal beds, since the former nearly always furnish most excellent building stone, while the latter are commercially valuable only over limited areas. Iron ore in valuable quantity exists locally at several horizons in the Barrens, and these will be referred to hereafter in detail.

The limestones of this series, like the coals, are generally thin and impure, so that they are of more importance in determining the stratigraphy than for economic purposes.

The entire thickness of the group varies much in different portions of the Appalachian field, reaching a maximum of 800 feet in the vicinity of Charleston, West Virginia, while along the northwestern outcrop of the beds in Ohio the minimum is not much above 300 feet.

In Pennsylvania and northern West Virginia the average is about 600 feet, but it sometimes runs up to 650 and down to 550.

The following sections, taken in the several portions of the Appalachian field, will serve to illustrate both the changing thickness of the series and the variable nature of the individual beds.

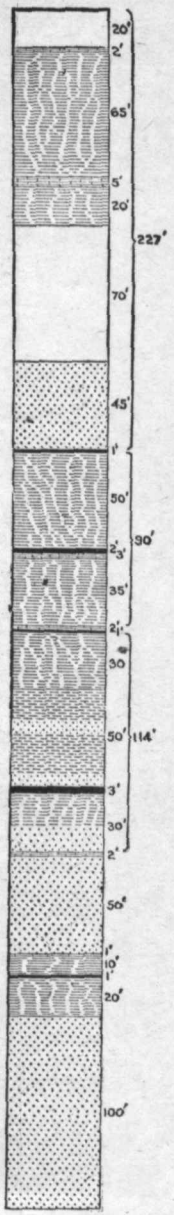


FIG. 33.—Section in the Pittsburgh region.

Section in the Pittsburgh region.—We shall begin the list at Pittsburgh, where the upper half of the Barrens is finely exposed, and the numerous carefully kept records of drill holes have revealed the constitution of the lower half, so that by uniting the two we get the following (Fig. 33):

In Pittsburgh region.

[See map, I m.]

	Ft.	Ft.
1. Pittsburgh coal		
2. Concealed	20	
3. Limestone	2	
4. Shales, variegated	65	
5. Limestone	5	227
6. Red shale	20	
7. Concealed	70	
8. Sandstone, Morgantown	45	
9. Coal, Elk Lick		1
10. Shales, variegated	50	
11. Coal	2	
12. Limestone	3	90
13. Shales, variegated	35	
14. Limestone, crinoidal		2
15. Coal, crinoidal	1	
16. Red and variegated shale	30	
17. Sandy shales and shaly sandstone	50	114
18. Coal, Bakerstown	3	
19. Shales and sandstone	30	
20. Limestone, Upper Cambridge		2
21. Sandstone, massive		50
22. Limestone, Lower Cambridge		1
23. Shales		10
24. Coal, Masontown		1
25. Shales		20
26. Sandstone, Mahoning		100
27. Upper Freeport coal.		
Total		618

Section at Sewickley, Pennsylvania.—At Sewickley, Pennsylvania, a diamond-drill hole was put down by Mr. Cochran Fleming as a test for coal. The cores were carefully preserved, and from them I obtained a very accurate section of the lower portion of the Barrens, which, combined with the good surface exposures around Sewickley, gives the following structure (Fig. 34) for this series in that region:

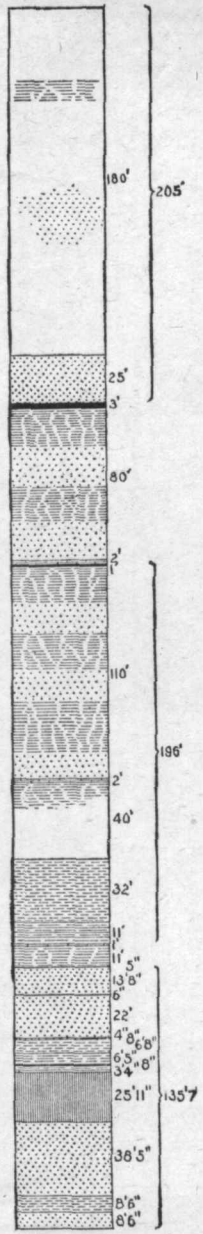


FIG. 34.—Section at Sewickley, Pa.

Sewickley, Allegheny County, Pennsylvania.

[See map, H 1.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Shales, sandstones, and concealed	180		205	
3.	Sandstone, Morgantown, massive	25			
4.	Coal, Elk Lick			3	
5.	Shales and sandstone			80	
6.	Limestone, crinoidal			2	
7.	Coal, crinoidal	1		196	
8.	Red shales and sandy beds	110			
9.	Limestone, gray, Upper Cambridge	2			
10.	Shales and concealed	40			
11.	Sandy shale	32			
12.	Dark slate	11			
13.	Limestone, dark, Lower Cambridge			1	
14.	Dark shales			11	
15.	Coal, Masontown			0	5
16.	Sandstone, micaceous, gray	13	8		
17.	Fire clay, sandy	0	6		
18.	Sandstone, light gray	22	0		
19.	Shale, dark gray	8	4		
20.	Sandstone, gray	0	8		
21.	Shale, sandy	6	8		
22.	Shale, blue	6	5	135	7
23.	Sandstone	0	8		
24.	Slate, gray	3	4		
25.	Fire clay, variegated at base, impure	25	11		
26.	Sandstone, gray, micaceous	38	5		
27.	Shales, sandy, blue	8	6		
28.	Sandstone, light gray	8	6		
29.	Upper Freeport coal.				
	Total			634	

Mahoning sandstone.

The interval No. 2 in this section was estimated, since the Pittsburgh coal is not found in the immediate vicinity of Sewickley, the highest stratum remaining there being the Morgantown sandstone, No. 3.

Section on Dunbar Creek, Pennsylvania.—Eastward from the Pittsburgh region, we have a line of measurements of the Barren series which extend across the Alleghanies. The first one is in the adjoining county of Fayette, at the foot of Chestnut Ridge, made by Prof. Stevenson and published in his Report KK, page 182. It is as follows (Fig. 35):

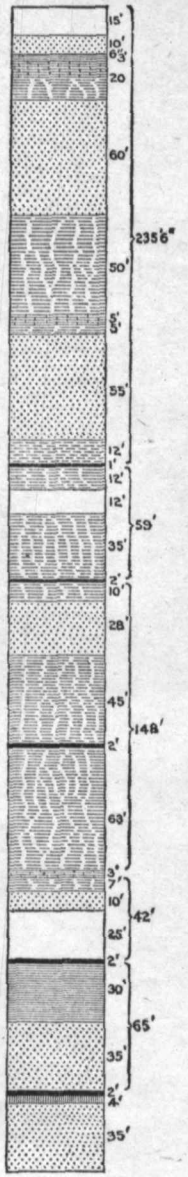


FIG. 35.—Section on Dunbar Creek, Pa.

Dunbar Creek, Fayette County, Pennsylvania.

[See map, K n.]

	Ft.	in.	Ft.	in.
1. Coal, Pittsburgh				
2. Concealed	15			
3. Sandstone	10			
4. Coal, Little Pittsburgh	0	6		
5. Clay	3			
6. Limestone and shale	20			
7. Sandstone, Connellsville	60		235	6
8. Shales	50			
9. Limestone	5			
10. Shale	5			
11. Sandstone, Morgantown	55			
12. Shale, sandy	12			
13. Coal, Elk Lick			1	
14. Shale	12			
15. Concealed	12		59	
16. Shale, variegated	35			
17. Coal, clay, crinoidal			2	
18. Shales, brown	10			
19. Sandstone	28			
20. Shale	45		148	
21. Coal, Bakerstown	2			
22. Shale	63			
23. Limestone, Lower Cambridge			3	
24. Shale	7		42	
25. Sandstone, argillaceous	10			
26. Concealed	25			
27. Coal, Masontown			2	
28. Clay	30		65	
29. Sandstone, Upper Mahoning	35			
30. Coal, Mahoning			2	
31. Fire clay			4	
32. Sandstone, Lower Mahoning			35	
33. Coal, Upper Freeport.				
Total			598	6

The identification of the Lower Cambridge limestone in the above section is open to question, but the probabilities are in favor of the one given.

Section at Ligonier, Pennsylvania.—Eastward from the last locality, and between Chestnut Ridge and Laurel Hill, the following section (Fig. 36) of these beds was measured at Ligonier, Westmoreland County, Pennsylvania, by Prof. Stevenson, as given in Report KKK, page 129:

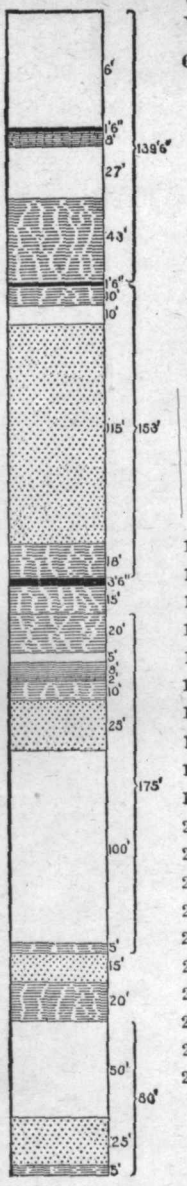


FIG. 36.—Section at Ligonier, Pa.

Ligonier, Westmoreland County, Pennsylvania.

[See map, J p.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Concealed	60			
3.	Coal, Little Pittsburgh	1	6		
4.	Limestone	8		139	6
5.	Concealed	27			
6.	Shale, variegated	43			
7.	Coal, Little Clarksburg			1	6
8.	Shale	10			
9.	Concealed	10			
10.	Sandstone, Morgantown	115		153	
11.	Shale, olive	18			
12.	Coal, Elk Lick			3	6
13.	Shale			15	
14.	Limestone, green, fossiliferous				
15.	Shale	20			
16.	Sandstone	5			
17.	Clay	8			
18.	Limestone, ferruginous	2		175	
19.	Shale	10			
20.	Sandstone	25			
21.	Concealed	100			
22.	Shale	5			
23.	Sandstone, Upper Mahoning			15	
24.	Shale			20	
25.	Coal, blossom, Mahoning				
26.	Concealed	50			
27.	Sandstone, Lower Mahoning	25		80	
28.	Shale	5			
29.	Coal, Upper Freeport.				
	Total			602	6

This and the preceding section, as well as the one which follows, illustrate in a remarkable manner the rapid variation in the individual elements of the Barrens, while the total thickness remains almost exactly the same.

Section near Berlin, Pennsylvania.—Still farther east, in the Berlin basin of Somerset County, Pennsylvania, and on the very summit of the Alleghany Mountains, we find this series with the following structure (Fig. 37) as determined by Messrs. Platt, with some additions and modifications by the writer:

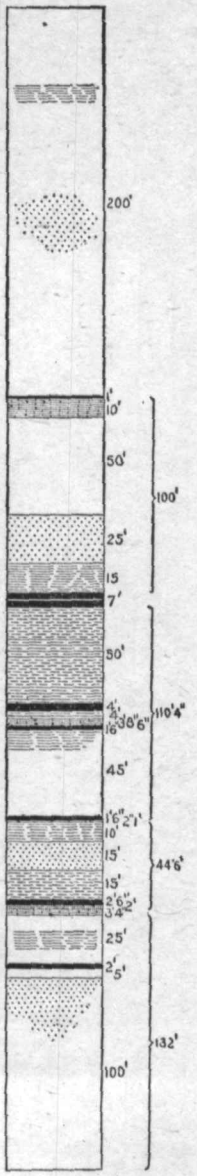


FIG. 37.—Section near Berlin, Pa.

Vicinity of Berlin, Somerset County, Pennsylvania.

[See map, K p.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Interval, shales, sandstones, etc			200	
3.	Coal			1	
4.	Limestone, gray and buff	10			
5.	Concealed	50		100	
6.	Sandstone, massive	25			
7.	Shales, dark	15			
8.	Coal, Platt (crinoidal): Cannel slate 1′; Coal, slaty 2′; Shale 1′; Coal 3′			7	
9.	Sandy shales and black slates	50			
10.	Coal, Price (Bakerstown): Coal 3′ 2″; Slate 0′ 4″; Coal 0′ 6″	4			
11.	Slates, dark	4			
12.	Limestone, dark gray: Limestone 1′ 8″; Slate 0′ 8″; Limestone 1′ 4″	3	8	110	4
13.	Shale	0	6		
14.	Coal	1	6		
15.	Shales, and concealed	45			
16.	Coal, Coleman	1	6		
17.	Slate, dark	0	2		
18.	Limestone, Coleman (Upper Cambridge)			1	
19.	Shales	10			
20.	Sandstone, and concealed	15			
21.	Shales, sandy	15			
22.	Coal, Philson: Coal 1′ 3″; Slate, black 0′ 9″; Coal 0′ 6″	2	6	44	6
23.	Fire clay	2			
24.	Limestone, Philson (Lower Cambridge): Limestone, dark 1′ 0″; Shale, black 0′ 4″; Limestone 2′ 0″			3	4
25.	Concealed, and shales	25			
26.	Coal, Masontown	2		132	
27.	Concealed	5			
28.	Sandstone, Mahoning, and concealed	100			
29.	Coal, Upper Freeport.				
	Total			599	2

Section at Broad Top, Pennsylvania.—As showing the remarkable persistence of this series in its general thickness over the Pennsylvania

field, we give another measurement (Fig. 38) from far east of the Alleghany Mountains, in the center of the Broad Top Basin, Bedford County, Report T², Stevenson, page 60:

FIG. 38.—Section at Broad Top, Pa.

Broad Top, Bedford County, Pennsylvania.

[See map, J t.]

	Ft.
1. Pittsburgh coal	
2. Poorly exposed (shales and sandstones)	425
3. Sandstone, Upper Mahoning	50
4. Coal, Mahoning	5
5. Clay	3
6. Sandstone, Lower Mahoning	40
7. Coal, Upper Freeport.	
Total	523

Section opposite Steubenville, Ohio.—The next line of sections in this series across the Appalachian field will begin at Steubenville, on the Ohio River, and keeping south of the former line, end at Davis, Tucker County, West Virginia. The following succession (Fig. 39) was obtained opposite Steubenville by combining the surface observations with the records of drill holes and shafts:

Opposite Steubenville, Ohio.

[See map, I j.]

	Ft.	Ft.
1. Pittsburgh coal		
2. Shales, sandstone, and concealed	100	200
3. Shales	15	
4. Sandstone, massive, Morgantown	85	
5. Limestone, fossiliferous, crinoidal		10
6. Red shales	40	
7. Concealed, with shales and flaggy sandstone	100	142
8. Coal	1	
9. Shale	1	
10. Limestone, fossiliferous, Lower Cambridge		2
11. Shales, drab	8	
12. Shales, with coal, Masontown	2	
13. Shales, gray	5	145
14. Sandstone, Mahoning, and concealed under river	130	
15. Coal, Upper Freeport.		
Total		499

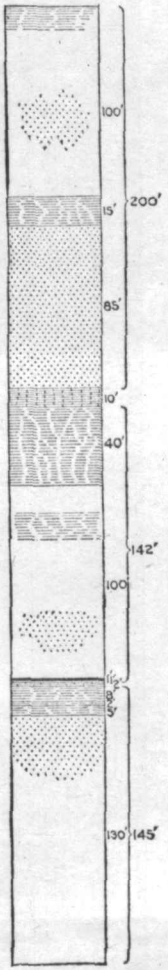


FIG. 39.—Section opposite Steubenville, Ohio.

This shows a westward thinning of about 100 feet for the series between Pittsburgh and Steubenville.

Section under Washington, Pennsylvania.—Near Washington, Pennsylvania, many wells drilled for gas and oil have revealed the structure of the Barren Measures, although they lie many hundred feet below the surface.

One of these borings was supervised by Prof. Linton, of Washington and Jefferson College, and from the record thus obtained of the Thayer oil well, as

published in Pennsylvania Geological Report, 1886, page 764, we get the following for the Barrens there (Fig. 40):

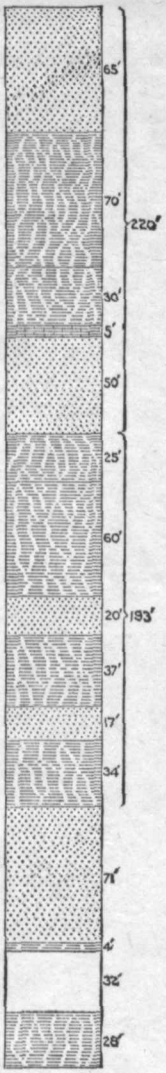


FIG. 40.—Section at Washington, Pa.

Washington, Pennsylvania.

[See map, J k.]

	Ft.	Ft.
1. Coal, Pittsburgh		
2. Sandstone	65	
3. Shale, black and red	70	
4. Shale, red	30	220
5. Limestone	5	
6. Sandstone, Morgantown	50	
7. Shale, black	25	
8. Shale, red and variegated	60	
9. Sandstone, hard	20	
10. Shale, black	37	193
11. Sandstone	17	
12. Shale, red, variegated	34	
13. Sandstone, Upper Mahoning		71
14. Shale, olive green		4
15. Sandstone, Lower Mahoning { gray, fine flaggy 15' / white 17' }		32
16. Shale, dark, to place for Upper Freeport coal		28
Total		548

Nos. 8 and 12 are the beds which "cave" and give the oil drillers so much trouble.

Section near Cannonsburg, Pennsylvania.—In the vicinity of Cannonsburg, a few miles northeast from Washington, the record of a well drilled for gas on the Boyce farm, furnished me by Mr. Wm. S. Stevenson, assistant superintendent of the Philadelphia Natural Gas Company, gives the following (Fig. 41) as the structure of the Barrens there:

Near Cannonsburg, Washington County, Pennsylvania.

[See map, J l.]

	Ft.	Ft.
1. Coal, Pittsburgh		
2. Limestone, blue, hard	20	
3. Slate, white, soft	45	
4. Shale, red	36	
5. Slate, black	9	
6. Shale, red	47	225
7. Sandstone, gray, hard	10	
8. Slate, black	20	
9. Sandstone, gray, hard, Morgantown	38	
10. Shale, red	25	
11. Slate, black	5	
12. Sandstone, gray, hard	20	
13. Slate, white, soft	10	
14. Sandstone, gray, hard	20	
15. Slate, black	15	
16. Sandstone, gray, hard	10	190
17. Slate, black	25	
18. Sandstone, gray, hard	5	
19. Slate, black	10	
20. Sandstone, gray, hard	20	
21. Shells and slate, gray, hard	25	
22. Slate, black, soft		40
23. Slate, with coal, Mahoning		15
24. Shells, gray, hard		2
25. Slate, black, soft		40
26. Sandstone, white, hard, Lower Mahoning		45
27. Coal, Upper Freeport.		
Total		557

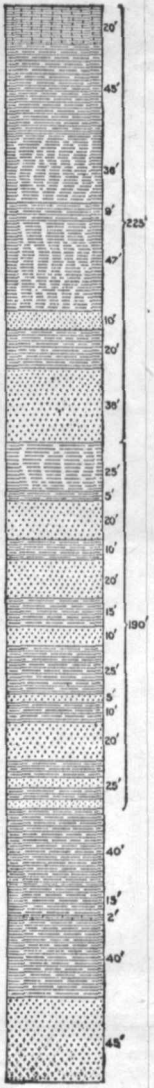


FIG. 41.—Section near Cannonsburg, Pa.

Section at Morgantown, West Virginia.—From Washington across to Morgantown, West Virginia, the Barren Measures, as revealed by borings, hold about the same thickness as in Washington County. In the vicinity of Morgantown the entire column of the Barrens is exposed, and there the following structure is exhibited (Fig. 42):

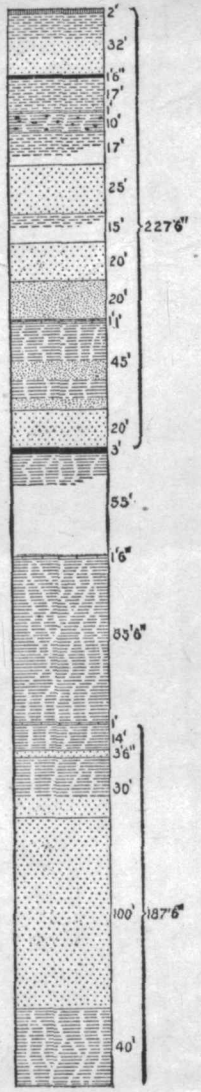


FIG. 42.—Section at Morgantown, W. Va.

Morgantown, Monongalia County, West Virginia.

[See map, M m.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Fire clay	2			
3.	Sandy shales and sandstone	32			
4.	Coal, Little Pittsburgh	1	6		
5.	Sandy shales	17			
6.	Limestone	1			
7.	Yellowish shales with iron ore	10			
8.	Sandy shales, and concealed	17			
9.	Sandstone, rather massive	25		227	
10.	Sandy shales, and concealed	15			
11.	Massive sandstone	20			
12.	Bluish green sandy beds	20			
13.	Black slate, fossiliferous	1			
14.	Limestone, Clarksburg	1			
15.	Shales and sandy beds	45			
16.	Sandstone, Morgantown	20			
17.	Elk Lick coal			3	
18.	Shales, and concealed			55	
19.	Limestone, crinoidal			1	6
20.	Variegated shales			85	6
21.	Limestone, Upper Cambridge			1	
22.	Shales	14			
23.	Sandstone, Upper Mahoning	3	6		
24.	Shales and shaly sandstone	30		187	6
25.	Massive sandstone, Lower Mahoning	100			
26.	Shales	40			
27.	Coal, Upper Freeport.				
	Total			561	

The black fossiliferous slate, No. 13, represents the horizon of the Little Clarksburg coal, and is here filled with *fish teeth and scales.* The Upper Freeport coal is about 100 feet under the river at the Morgantown wharf, but southward it rises very rapidly and comes up to the bed of the river at the mouth of Coburn's Creek, 2 miles above. It is there about 4 feet thick and very pure.

Section near Little Falls, West Virginia.—In the vicinity of Little Falls, Monongalia County, 9 miles above Morgantown, the basal members of the Barrens can be obtained more in detail than in the Morgantown section, and the following (Fig. 43) shows the structure there:

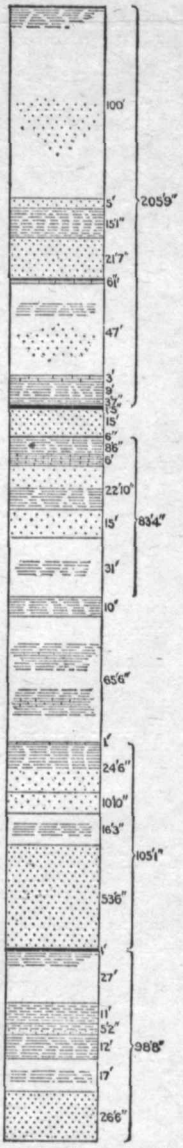


FIG. 43.—Section at Little Falls, W. Va.

Little Falls, Monongalia County, West Virginia.

[See map, M m.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Shales, sandstones, and concealed	100			
3.	Sandstone, in knob	5			
4.	Shales	15	1		
5.	Massive, coarse yellow sandstone	21	7		
6.	Coaly shale, Little Clarksburg	0	6		
7.	Limestone, fossiliferous, Clarksburg	1		205	9
8.	Concealed, shales and sandstone	47			
9.	Limestone, nodular	3			
10.	Gray and yellow shales	9			
11.	Black slate	3	7		
12.	Coal, Elk Lick: Coal (Coal 12″; Slate 1″; Coal 4″) 1′ 5″; Concealed with red shale 15′; Coal, good 0′ 6″			16	11
13.	Shales	8	6		
14.	Limestone, gray and buff in several layers, Elk Lick	6			
15.	Flaggy sandstones and shales	22	10	83	4
16.	Sandstone, massive, pebbly at base for 4 feet	15			
17.	Concealed, probably shales	31			
18.	Fossiliferous shale, crinoidal			10	
19.	Concealed, red shales and impure limestones			65	6
20.	Limestone, light gray, Upper Cambridge			1	
21.	Shales and flaggy sandstones	24	6		
22.	Sandstone, rather massive	10	10		
23.	Concealed, and shales	16	3	105	1
24.	Sandstone, Upper Mahoning, massive	53	6		
25.	Coal, Mahoning			1	
26.	Shales and concealed	27			
27.	Shale, greenish, sandy	11			
28.	Sandy shale and flaggy sandstone	5	2		
29.	Shale, greenish yellow	12		98	8
30.	Concealed, probably shale	17			
31.	Lower Mahoning sandstone	26	6		
32.	Coal, Upper Freeport.				
	Total			587	3

This section illustrates well the variability of the Barren Measures, when compared with the previous one, taken only a few miles distant.

Section at Newburg, West Virginia.—The syncline between the Chestnut Ridge and Laurel Hill anticlines crosses the Baltimore and Ohio Railroad at Newburg, Preston County, West Virginia, about 15 miles east from Little Falls, and there the Barren Measures admit of vertical measurement by combining surface exposures with the record of the Orrel Coal Company's shaft. The result is as follows (Fig. 44):

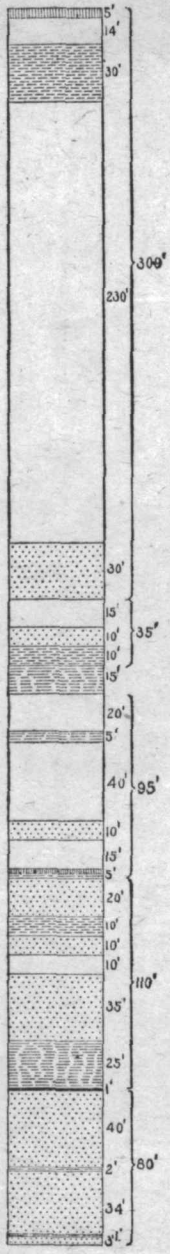


FIG. 44.—Section at Newburg, W. Va.

Newburg, Preston County, West Virginia.

[See map, N m.]

		Ft.	Ft.
	1. Pittsburgh coal		
	2. Fire clay	5	
	3. Concealed	14	
	4. Shales, sandy	30	309
	5. Concealed	230	
	6. Sandstone, pebbly, Morgantown	30	
	7. Concealed	15	
	8. Sandstone, flaggy	10	35
	9. Shales, sandy	10	
	10. Shales, dark, fossiliferous (crinoidal)		15
	11. Concealed	20	
	12. Red, marly shale	5	
	13. Concealed	40	95
	14. Sandstone, yellow	10	
	15. Concealed	15	
	16. Fire clay and shales	5	
Upper Mahoning.	17. Sandstone, massive	20	
	18. Sandy shale	10	
	19. Sandstone, massive	10	110
	20. Concealed	10	
	21. Sandstone	35	
	22. Shales	25	
	23. Coal, Mahoning		1
Lower Mahoning.	24. Sandstone	40	
	25. Shale	2	
	26. Sandstone	34	80
	27. Shale	1	
	28. Sandstone	3	
	29. Coal, Upper Freeport.		
	Total		645

This is in the same geological trough as the section at Ligonier (Fig. 36), and, as will be observed, agrees with it in having an unusually large interval between the Pittsburgh coal and the base of the Morgantown sandstone. It is possible that the Upper Mahoning sandstone should not include Nos. 17–20 at this locality.

Section near Fairfax Knob, West Virginia.—About 50 miles east from Newburg we come to the North Potomac Coal Basin, the southward extension of the Cumberland or Georges Creek field of Maryland, and there, in the vicinity of Fairfax Knob, Tucker County, West Virginia, the Barrens exhibit the following structure (Fig. 45):

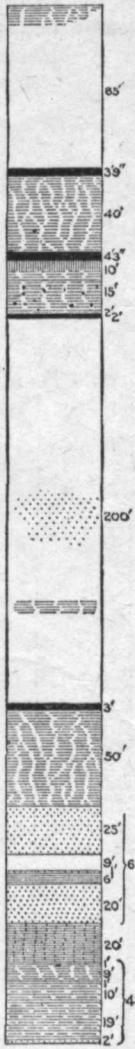


FIG. 45.—Section at Fairfax Knob, W. Va.

Fairfax Knob, Tucker County, West Virginia.

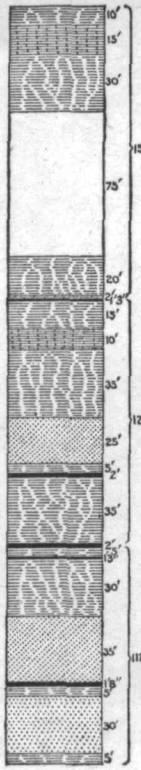
[See map, O o.]

		Ft.	Ft. in.
1.	Pittsburgh coal		
2.	Shales and concealed		85
3.	Coal, Little Pittsburgh: Coal 2′ 9″; Slate 0′ 6″; Coal 0′ 6″		3 9
4.	Shales		40
5.	Coal: Coal, slaty 0′ 10″; Coal 1′ 5″; Slate 1′ 0″; Coal 1′ 0″		4 3
6.	Fire clay and shales		10
7.	Blue shales with iron ore		15
8.	Black slate		2
9.	Coal, Little Clarksburg: Coal 0′ 8″; Slate 0′ 4″; Coal 1′ 0″		2
10.	Concealed, with sandstones and shales		200
11.	Coal, and black slate, Masontown		3
12.	Shales		50
Upper Mahoning. 13.	Sandstone, massive	25	
14.	Concealed	9	
15.	Sandstone, soft	1	61
16.	Clay, yellow	6	
17.	Sandstone	20	
18.	Limestone, Mahoning		20
Lower Mahoning. 19.	Soft shale	1	
20.	Hard shale	9	
21.	Soft shale	1	
22.	Slate, light blue	10	42
23.	Slate, dark	19	
24.	Sandstone	2	
25.	Coal, Upper Freeport.		
	Total		538

The last 100 feet of the section was obtained from the record of a diamond drill hole put down by the West Virginia Central Railroad to test the character of the Upper Freeport coal. The writer saw samples of the Mahoning limestone, taken from the drill hole, and it was a dark gray, rather pure limestone.

No. 5 is a second Little Pittsburgh coal which is occasionally present in the Potomac basin and elsewhere.

Section in Guernsey County, Ohio.—Toward the northwestern side of the Appalachian basin, in Ohio, the Barrens are thinner than elsewhere, as may be seen from the following section (Fig. 46), made by Mr. F. W. Minshall, in Guernsey County, Ohio.



Guernsey County, Ohio.

[See map, K f.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Shales	10			
3.	Limestone	15			
4.	Shales	30		150	
5.	Concealed	75			
6.	Shales	20			
7.	Limestone, crinoidal			2	
8.	Coal, crinoidal	1	3		
9.	Shales	15			
10.	Limestone	10			
11.	Shales	35		128	3
12.	Sandstone, pebbly	25			
13.	Shales	5			
14.	Coal, Bakerstown	2			
15.	Shales	35			
16.	Limestone, Lower Cambridge			2	
17.	Shales	5			
18.	Coal, Masontown	1	3		
19.	Shales	30			
20.	Sandstone, Upper Mahoning	35		112	11
21.	Coal, Mahoning	1	8		
22.	Shales	5			
23.	Sandstone, Lower Mahoning	30			
24.	Shales	5			
25.	Coal, Upper Freeport.				
	Total			395	2

FIG. 46.—Section in Guernsey County, Ohio.

Section at Burning Springs, West Virginia.—At Burning Springs, Wirt County, West Virginia, the Barren Measures have the following structure (Fig. 47), according to Mr. Minshall:

Burning Springs, Wirt County, West Virginia.

[See map, P g.]

		Ft.	in.	Ft.	in.
1.	Pittsburgh coal				
2.	Shales	10			
3.	Limestone	10		200	
4.	Concealed	180			
5.	Limestone, crinoidal			3	
6.	Coal, crinoidal	1	8		
7.	Shales	10			
8.	Limestone	3		294	8
9.	Concealed	200			
10.	Sandstone	40			
11.	Shales	40			
12.	Coal, Upper Freeport.				
	Total			497	8

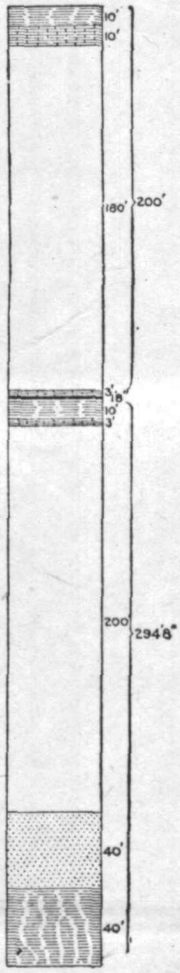


FIG. 47.—Section at Burning Springs, W. Va.

Section near Huntington, West Virginia.—Near the southwestern limit of the district, in the vicinity of Huntington, West Virginia, the Barren Measures have the following structure (Fig. 48) according to the determinations of Mr. A. G. Selby, who made careful measurements of the rocks exposed there, and combined them with the record of a boring for gas:

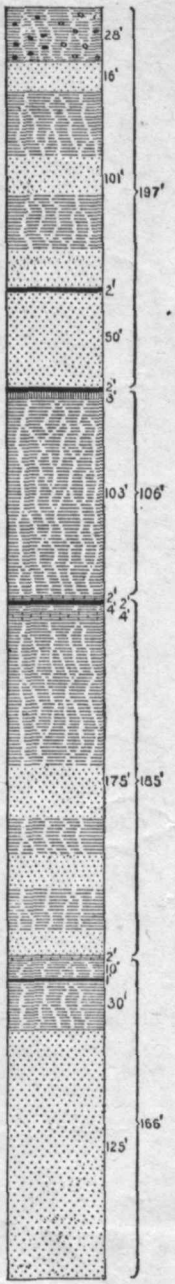


FIG. 48.—Section near Huntington, W. Va.

Vicinity of Huntington, West Virginia, along Ohio River.

[See map, S b.]

	Ft.	Ft.
1. Pittsburgh coal		
2. Red shale, containing limestone nodules	28	
3. Sandstone, shaly	16	
4. Red shales and shaly sandstone	101	197
5. Coal, Little Clarksburg	2	
6. Sandstone, massive, Morgantown	50	
7. Elk Lick coal		2
8. Fire clay	3	106
9. Shales, deep red	103	
10. Limestone, crinoidal		2
11. Coal, crinoidal	2	
12. Red shales	4	185
13. Limestone	4	
14. Shales and sandstones	175	
15. Limestone, Lower Cambridge		2
16. Shales	10	
17. Coal, Masontown	1	166
18. Shales	30	
19. Sandstone, Mahoning	125	
20. Upper Freeport coal.		
Total		660

This is nearly twice the thickness that the Ohio geologists report for the Barrens along the northwestern margin of their outcrop, but all of the measures thicken very rapidly toward the southeast from this portion of Ohio. It is possible, however, that Mr. Selby may have gotten some of the elements of the section too thick, since there is no single point between Huntington and the Big Sandy where a vertical measurement of all the members can be made. The true thickness can not be much under 600 feet at least.

Section near Charleston, West Virginia.—In the vicinity of Charleston, West Virginia, and just north from it, the Barren Measures attain a greater thickness than anywhere else in the Appalachian Basin, so far as known. The following structure (Fig. 49) may be observed along the Great Kanawha River there, and its tributary, Two-mile Creek:

Near Charleston, West Virginia.

[See map, S f.]

		Ft.	Ft.
1.	Pittsburgh coal		
2.	Concealed red shales and sandstone	140	
3.	Sandstone, massive	30	320
4.	Red shales, sandstone and concealed	150	
5.	Coal, Elk Lick		1
6.	Shales	10	
7.	Sandstone	30	70
8.	Shales, marly, with limestone nodules	30	
9.	Limestone, impure (crinoidal horizon)		5
10.	Dark red shales with iron nodules	30	
11.	Shales	25	
12.	Coal, impure, Bakerstown	5	
13.	Fire clay and shales	5	215
14.	Sandstone, massive, pebbly	30	
15.	Shales and sandstone	100	
16.	Shales, with streaks of coal, Masontown	20	
17.	Sandstone, very hard	25	
18.	Coal, Mahoning	4	
19.	Massive sandstone	75	
20.	Shales	10	
21	Coal, Upper Cannelton	2	189
22.	Sandstone, massive	50	
23.	Sandy shales	15	
24.	Coal, Middle Cannelton	1	
25.	Black flint	5	
26.	Shales	2	
27.	Coal, Upper Freeport.		
	Total		800

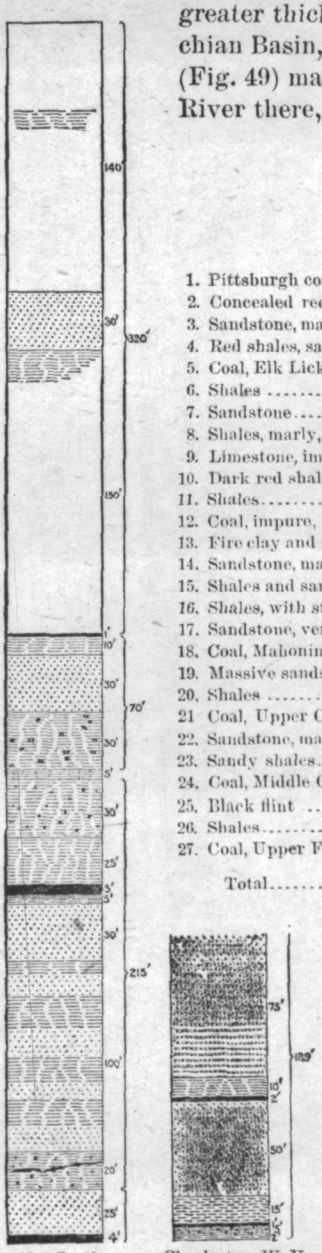


FIG. 49.—Section near Charleston, W. Va.

As may be seen from these sections just given, many of the beds which have received distinct names are not persistent. They occur at some localities but are wanting in others, and hence are so variable that they are never all found in one section.

We shall now take up the more important members of the series and describe them in more detail as exhibited at their type localities and elsewhere.

CHARACTERISTIC HORIZONS.

THE PITTSBURGH COAL ORES.

In Fayette County, Pennsylvania, a group of iron ores come immediately below the Pittsburgh coal, and have been mined for the manufacture of iron for nearly 75 years. They have been very carefully studied by Stevenson, who describes them in his report (KK) of the Pennsylvania Geological Survey. He gives the following as the general section of the ores:

Pittsburgh coal	
Clay	2 to 8 feet.
Blue Lump ore	1 to 0 foot.
Clay	4 inches to 1 foot 6 inches.
Condemned flag ore	1 to 0 foot.
Clay	4 inches to 2 feet 6 inches.
Big Bottom ore	1 foot to 1 foot 8 inches.
Clay	10 inches to 5 feet.
Red flag ore	2 inches to 6 feet.
Clay	1 to 3 feet.
Yellow flag ore	4 inches.

This succession does not, of course, represent the structure of the ore layers at all localities, as the thickness and quality are constantly varying.

The "Blue Lump" and the "Big Bottom" beds are of the most importance, and it is from the former one especially that Mr. F. H. Oliphant manufactured iron so long and successfully at Fairchance. These ores are confined principally to the Blairsville basin, in Fayette County, though they extend into the edge of Monongalia County to the south, and have been recognized on the edge of Greene County to the west.

When these ores are not present their places are often occupied by ferruginous limestones or shales, though occasionally a sandstone stratum comes in close under the coal and cuts out everything else. This interval, immediately below the Pittsburgh, for 30 to 40 feet is more variable than any other portion of the Barrens, and hence it is useless to attempt to classify its rocks.

THE LITTLE PITTSBURGH COAL.

At a varying interval of 25 to 60 feet from the top of the Barrens there often occurs a thin and usually impure coal bed, which has been termed the Little Pittsburgh coal, from the fact that it is so close to the great bed above. The thickness seldom exceeds two feet, and it is often only half that. The best development of this coal which the writer has ever seen occurs in Fairfax Knob, Tucker County, West Virginia, at the locality of Section 45, where the bed is nearly 4 feet thick and is locally known as the "coking vein," from the fact that it has the typical structure of a good coking coal.

Occasionally there appear to be two of these beds, one at 20 to 30 feet below the Pittsburgh and the other at 50 to 75 feet below, but they may probably both be splits from the same bed.

The Little Pittsburgh coal is quite persistent at the northern end of the Appalachian coal basin, but it disappears southwestward across West Virginia and is seldom seen beyond Harrison County. It also fades away southward in Ohio, since it does not appear in any of the Ohio sections, unless it should be the "Jeffers" coal of Prof. Andrews, in Gallia County. That, however, may possibly represent the Pittsburgh bed. In the vicinity of Wellersburg, Somerset County, Pennsylvania, there appear to be two of these Little Pittsburgh beds, and the upper contains 3 to 4 feet of good coal, while the lower is only 18 inches thick.

THE PITTSBURGH LIMESTONES.

There are very frequently two limestones in the shale interval of 50 to 75 feet below the Pittsburgh coal, one of which comes above the Little Pittsburgh coal and the other a few feet below. They are both known under the general name of Pittsburgh limestone; but it would be better to call the first one Upper Pittsburgh and the other one Lower Pittsburgh. The first is seldom more than 3 to 5 feet thick, but the latter is occasionally much thicker, as it is the more persistent of the two, being purer and frequently quarried and burned into lime for agricultural and other purposes.

THE CONNELLSVILLE SANDSTONE.

At a short interval under the Lower Pittsburgh limestone there is often found a massive sandstone which is frequently conglomeritic. This rock rises from the bed of the Youghiogheny River at Connellsville, and was named from that locality by Dr. Stevenson. Being one of the cliff rocks in the Barren Measures, it has played an important part in shaping their topography. It is especially hard and massive in the Cumberland or Georges Creek basin, and the rounded hills which hold the "Big" (Pittsburgh) "vein" rest on a platform of this rock, which, owing to its erosion-resisting power, makes a bold terrace far up the mountain sides after all the soft beds above have disappeared. It is this great bed of pebbly sandstone that caps the summits in the center of the trough south from Elk Garden, after the Pittsburgh coal has disappeared, forming almost level plateaus over thousands of acres where the great Pittsburgh bed is missed by an interval of only 50 to 60 feet.

The same pebbly sandstone marks the summits of the hills at Belington, Barbour County, West Virginia, and forms huge cliffs at many points along the Monongahela River between Fairmont and Morgantown.

At Connellsville the top of this stratum lies about 60 feet under the Pittsburgh coal; but this interval is sometimes as small as 40 feet, and

again increases to 80 or 90. When not pebbly it frequently furnishes excellent building stone. The thickness varies from 25 to 50 feet, but it is often absent as a massive rock, and then its place is filled with sandy shales or flaggy sandstone.

THE LITTLE CLARKSBURG COAL.

By this name has been designated a bed of slaty coal which occasionally makes its appearance close under the Connellsville sandstone, and 100 to 125 feet below the Pittsburgh coal.

At Clarksburg, West Virginia, the coal in question crops out along the bed of Elk Creek for a considerable distance, and is 1½ to 2 feet thick, but poor and slaty. It is called Little Clarksburg to distinguish it from the Pittsburgh coal, which is extensively mined in the vicinity of that town, and is locally known as the Clarksburg bed.

Very frequently this coal is represented by a bed of black slate, which is filled with fish remains, teeth, scales, etc. The deposit in question is rarely more than 1½ to 2 feet thick, and is often absent altogether, so that it is of very little economic importance, though in the Wellersburg region of Somerset County, Pennsylvania, it attains a thickness of nearly 6 feet, and contains some good coal, being known as the "6-foot" bed.

THE CLARKSBURG LIMESTONE.

Directly under the last described coal there often occurs a limestone which is finely exposed in the vicinity of Clarksburg, along the bed of Elk and the West Fork River. The upper portion is there rather slaty, and filled with fossil ostracoids and fish remains. The next layers under this are very compact, and come out in peculiar rhomboidal blocks. This entire limestone series is 20 to 30 feet thick, and some of the layers are quite ferruginous, so much so that they were mined for ore many years ago at an old charcoal furnace on Elk. Some iron ore was also obtained near Clarksburg from the roof shales just above the Little Clarksburg coal, and used in this furnace. The Clarksburg limestone is rather widely distributed in Pennsylvania and northern West Virginia, and is frequently mined, since many of its layers furnish good lime for fertilizing and building purposes.

THE MORGANTOWN SANDSTONE.

At 25 to 40 feet under the Clarksburg limestone, and separated from it by soft shales, we find one of the great sandstone horizons of the Barren Measures. This rock was named by Dr. Stevenson from its fine exposure at Morgantown, West Virginia, where it has been extensively quarried and used in building the State University and other structures. At this typical locality the top of the stratum lies about 200 feet below the Pittsburgh coal, and the thickness of the sandstone is 25 feet. It is of a yellowish gray cast, of medium grain and hardness, and splits readily into blocks of any desirable size. Scattered

through the rock are stains of peroxide of iron and also a considerable quantity of feldspar grains, which are generally decomposed, thus giving the surface of the stone a mealy look. In some of the crevices and cavities of the sandstone pure kaolin has accumulated from this source. The base of the sandstone is often conglomeritic and sometimes brecciated.

This is a quarry sandstone nearly everywhere that its outcrop extends. All along the Monongahela River it has been quarried and used in building the locks of the Slack Water Company. The stone dam, No. 9, was built of rock from this stratum. It is one of the most persistent members of the Barren Measures, and often makes high cliffs. It caps the hills in the vicinity of Grafton, West Virginia, where it is also quarried, and it makes a line of conspicuous bluffs from there to beyond Newburg, along Three Fork, and far up into Barbour County along the Valley River. Along the North Potomac River, in Mineral, Grant, and Garrett Counties, the same rock is found, and on the Great Kanawha, Guyandotte, Big Sandy, Big and Little Muskingum, and other tributaries of the Ohio, this bed is generally conspicuous. At Huntington, West Virginia, on the banks of the Ohio, it is 50 to 60 feet thick, while on Crooked Run, Monongalia County, near the Pennsylvania line, the stratum is 100 feet thick. It is the first oil rock on Dunkard Creek, and some of the wells produced largely from it. In the deep borings of Washington County, Pennsylvania, where it underlies the surface 500 to 1,000 feet, this stratum is 35 to 50 feet thick, and generally contains salt water.

THE ELK LICK COAL.

Immediately under the Morgantown sandstone, or separated from it by only a few feet of shale, there comes a coal of very wide distribution which occasionally attains workable dimensions.

This name was given the coal in question by the First Geological Survey of Pennsylvania, but the place of the bed in the series remained uncertain till Messrs. Platt, of the Second Survey, recently determined the matter finally by identifying the massive sandstone above it at the typical locality as the Morgantown.

This coal attains a thickness of 4 feet in Somerset County, Pennsylvania, and has there been mined to a considerable extent for local use.

In Westmoreland, Fayette, and Alleghany it seldom exceeds 2 feet, and is generally less, but quite persistent.

In Preston County, West Virginia, north from Cheat River, this bed has been mined to a considerable extent and is known as the "top vein." In the summits near Bruceton it is 4 feet thick and a rather good coal.

At Morgantown it is nearly 4 feet thick, but rather poor and slaty.

South from Monongalia County, it is occasionally seen, but is not so

thick as at the northern end of the field. At Glenville, Gilmer County, it is in the bed of the Little Kanawha River, and 18 to 20 inches thick.

The same coal is also recognizable on the Big Kanawha, but is there quite thin. In the section (48) at Huntington, West Virginia, Mr. Selby finds this coal 2 feet thick but very slaty.

It is not often reported by the Ohio geologists, and hence may frequently be absent from the measures in that State.

THE ELK LICK LIMESTONE.

In sections 37 and 43, a limestone is seen at a short interval below the Elk Lick coal, and from its occurrence at this horizon in Somerset County, Pennsylvania, it has been termed the Elk Lick limestone by Mr. Franklin Platt, of the Second Geological Survey, Pennsylvania. The stratum in question occurs at 200 to 240 feet under the Pittsburgh coal, and is not always present.

As exhibited in Somerset County, Pennsylvania, this limestone is of a light gray color, and often tinged with buff, the same being true of it in Monongalia. Platt reports it as 12 feet thick in Somerset, but in Monongalia it is only about half that, and is not persistent.

THE CRINOIDAL LIMESTONE (GREEN FOSSILIFEROUS LIMESTONE, AMES LIMESTONE).

The next step downward in the rocks takes us to a very important horizon and one which marks a change from fresh or brackish water deposits to marine conditions, for here we get abundant marine fossils for the first time in descending the column of rocks.

The bed in which these fossils occur has received several names. The geologists of the First Geological Survey of Pennsylvania called it the Green Fossiliferous limestone, the Ohio Survey has termed it the Ames limestone, while the Second Geological Survey of Pennsylvania has termed it the Crinoidal limestone. This latter name is so well known now in geological literature that it is probably best to let it stand, though as a synonym and geographical designation the Ames limestone may be retained.

The character of this stratum and its fossils have been admirably worked out by Stevenson, who first showed its importance as a stratigraphical horizon. It comes almost exactly midway in the Barren series, and hence it is a constant datum from which the geologist can measure either upward or downward to identify the rocks.

When once thoroughly known it can not be confused with any other rock in these measures, since it is the highest bed that contains abundant Brachiopods and Lamellibranchs, and its lithology is distinctly different from anything else. Prof. Stevenson thus aptly describes its general features: "Dark bluish or greenish gray, tough, and breaks with a granular surface much resembling that of a coarse sandstone. * * *. In all cases it is fossiliferous and contains immense numbers of crinoidal stems and spines or plates."

Its common fossils are: *Productus Nebrascensis*, *P. Prattenianus*, *P. longispinus*, *P. semi-reticulatus*, *Hemipronites crassus*, *Spirifera camerata*, *S. plano-convexa*, *Athyris subtilita*, *Lophophyllum proliferum*, *Zeacrinus mucrospinus*, together with the undetermined plates and stems of crinoids.

Throughout Pennsylvania this stratum comes about 275 to 300 feet below the Pittsburgh coal, and the same distance above the Upper Freeport, though occasionally this last interval is increased to 350 feet. The rock is rarely more than 2 feet thick, and often not so much, but is wonderfully persistent. Even when not present as limestone its horizon is almost invariably made known by the fossiliferous shales which accompany the bed.

Through Ohio this rock is almost continuously present from the point where it enters the State near Steubenville clear around to where it leaves it at the Kentucky line near Catlettsburg.

Opposite Steubenville the bed is 8 to 10 feet thick, but this is unusual, since it is only 1 to 3 feet at most points in Ohio.

The interval between this rock and the Pittsburgh coal decreases westward to 200 feet on the Ohio River at Wellsburg, and farther west in Ohio the interval still further declines to 140 feet, but where it leaves the State at the southwest it increases again and gets to be 300 feet opposite Huntington, West Virginia.

Through this latter State the limestone holds its place very regularly in the series from the Pennsylvania line southward into Harrison and Lewis Counties, and it is also present on the Volcano uplift at Burning Springs and other points, still holding its characteristic fossils. It disappears, however, in passing from this Little Kanawha region southward to the Big Kanawha, for when we come to this latter stream the fossiliferous limestone is gone, and its horizon replaced near Charleston by a thin, impure limestone which holds only minute fresh water forms. It is highly probable, however, that the crinoidal bed comes in again a few miles north from Charleston, since on the Big Sandy it was followed 20 to 25 miles above the mouth of that stream, and there it still retains its crinoidal phase, though getting very impure where last seen in that valley.

THE CRINOIDAL COAL.

Immediately under the last described limestone we very often find a thin coal bed, which seldom exceeds 18 inches in thickness, and hence is of very little economic importance. In Somerset County, Pennsylvania, Mr. Franklin Platt identified with this coal No. 8 of the Berlin (37) section, a very impure, slaty bed, occurring in several layers in the vicinity of Berlin, where it is altogether 7 feet thick, and locally known as the Platt coal. If this identification be correct, this is the greatest development the coal ever attains.

There is only one other locality besides the Berlin region where this coal has been mined to any considerable extent, and that is at

Burning Springs, Wirt County, West Virginia. Here it was mined and used for fuel in drilling the numerous oil wells once put down there, and it is still taken out on a small scale for domestic purposes, though only 20 inches thick. Some very finely preserved fossil Brachiopods and Lamellibranchs have been obtained from the roof shales of the coal at Burning Springs, since it there comes only 2 to 5 feet below the Crinoidal limestone.

The "Weller" coal, near Wellersburg, Pennsylvania, is probably identical with this bed.

RED SHALE BEDS.

Throughout most of the Pennsylvania and West Virginia region, the Crinoidal limestone is underlaid by very soft, red, and variegated shales, and marly clays. They make a broad red band in the soil wherever they extend, and are a great nuisance along roads and railroads, since when wet they decompose into a greasy mud, which produces many landslides and slips.

It is this stratum which causes so much trouble to the oil and gas drillers of southwestern Pennsylvania and the adjoining regions of West Virginia, since it is so easily reduced to mud, which runs into the hole and fills it up, so that casing must be put through the stratum as soon as the drill has penetrated it. From this tendency to slide out into the drill hole, it is termed by the oil drillers the "caving" rock.

Over a large portion of Ohio and in many regions of West Virginia a hard, bluish gray limestone, not at all or but sparingly fossiliferous, occurs near the center of this shale interval. The bed is 3 to 10 feet thick, and in Ohio is generally called the Ewing limestone. It is shown in the West Virginia sections at Burning Springs (47) and at Huntington (48), and it is recognizable at many other points in the State.

The rest of the Barren Measures from this red shale down to the Mahoning sandstone is extremely variable. Sometimes it is nearly all shales, much of which is red, and "caves" in drilling through it, just like that under the Crinoidal limestone, and again as in the Berlin section (37) it contains 3 or 4 coal beds, and as many limestones. Some of these, however, are rather persistent and will be referred to in detail.

THE BAKERSTOWN COAL.

At some localities in western Pennsylvania a bed of coal is found 75 to 90 feet under the Crinoidal limestone. This bed is mined in the vicinity of Bakerstown, Alleghany County, and it has been designated from that village. As there exhibited, it is not quite 3 feet thick and rather slaty. In the Berlin region a coal called the Price bed seems to come at this horizon. It is about 4 feet thick and furnishes some valuable fuel in Somerset County.

In Section 37 will be found some thin coal beds under the Price coal, which are rarely represented in any other section of the Barrens.

Among these are the Coleman, Philson, and the one a few feet under the Price bed; but they are all local, though occasionally we find traces of some of them in other regions than Somerset County. This whole interval for 100 feet below the Crinoidal limestone is so extremely variable that the classification for one region is of very little use in another. An instance of this is seen at Saltsburg, Pennsylvania, where a great sandstone 100 feet thick comes into the series a few feet under the Crinoidal limestone horizon. This was termed the Saltsburg sandstone by Stevenson, but it is hardly persistent enough to classify as a regular member of the Barrens. In the Charleston, West Virginia, region a massive pebbly sandstone occurs not far from the horizon of the Saltsburg rock, and the one which caps the hills at the mouth of the Big Sandy River may be identical with the same bed.

THE CAMBRIDGE LIMESTONES.

At many localities in Ohio two dark fossiliferous limestones occur only 20 to 30 feet apart, and Prof. Orton, director of the Ohio Geological Survey, has named them respectively the Upper and Lower Cambridge limestones. In Ohio these beds generally occur from 90 to 130 feet under the Crinoidal limestone and are always very fossiliferous.

In many regions of Pennsylvania two dark fossiliferous limestones occur, which correspond to the two in Ohio, only there they are 60 to 70 feet apart, and the upper one 90 to 120 feet under the crinoidal bed, while the lower one is 150 to 190 feet below the same horizon. I have identified the two in Pennsylvania with the two in Ohio, and have also adopted the Ohio names, since the Pennsylvania beds are known under several names in different parts of the field, while the Ohio names are now well established. The upper one is the lighter colored of the two, and while generally fossiliferous, the fossils are not so abundant as in the lower limestone. This upper one was termed the Pine Creek limestone in my Report Q of the Pennsylvania Survey, while in Somerset County it seems to be identical with the Coleman limestone of Platt.

At Morgantown, West Virginia (Section 42), this bed is dark, quite fossiliferous, and lies 85½ feet below the Crinoidal limestone.

The term Black Fossiliferous limestone of the First Pennsylvania Geological Survey Reports was probably applied quite as often to this upper rock as to the lower one, since at times they very closely resemble each other, and contain practically the same fossils.

The interval separating the two limestones is generally shale in Ohio, but in Pennsylvania it is sometimes a massive sandstone, and 60 to 90 feet thick.

The Lower Cambridge limestone is identical with the one termed Brush Creek limestone by the writer in Report Q, Second Geological Survey of Pennsylvania, but the geological horizon of that limestone was there placed lower than it should have been by 50 to 60 feet, since it was considered to belong between the two members of the Mahoning

sandstone, instead of above both members, and hence the term Brush Creek limestone should be dropped from the nomenclature, and Lower Cambridge substituted. This lower limestone is very fossiliferous, often being a mere mass of Brachiopods and Lamellibranchs, of which the most common are *Chonetes mesoloba*, *Athyris subtilita*, *Pruductus Nebracensis* and a large Solenomya, together with *Nautilus occidentalis* and *Orthoceras cribrosum*.

This bed seems to be quite as persistent in Ohio as the Crinoidal limestone, since it is present in almost every section at the proper horizon, from Steubenville clear around to Ironton, near which latter point it is only 75 feet above the base of the Barrens.

In the hills at Catlettsburg, Kentucky, a dark fossiliferous limestone occurs at 160 feet above the Upper Freeport coal, but this is probably the Upper Cambridge, and the same limestone occurs in the summits of the hills opposite Louisa, Kentucky, at 200 feet above the Upper Freeport bed. It is barely possible, however, that this may be the Lower Cambridge limestone, since the Barrens thicken very rapidly southward from their northwestern outcrop. In the Berlin section, (37), the Lower Cambridge limstone appears to be represented by the Philson limestone of Platt. The "calcareo-siliceous rock" of Hildreth, in Ohio, appears to represent the same bed.

THE MASONTOWN COAL.

At an interval of 5 to 20 feet below the Lower Cambridge limestone there occurs a coal bed which has quite a wide distribution. It attains its best development in the region of Masontown, Preston County, West Virginia, and it has been designated from that village. It is there, and at many other points in the Preston basin, mined for domestic purposes, being known as the "4-foot" bed, and is a dry, open-burning coal, highly prized for domestic fuel. It is everywhere preferred to the Upper Freeport, which is accessible in the same region.

This appears to be the same bed which the writer described in Report Q, Second Geological Survey of Pennsylvania, under the name of Brush Creek coal, since a diamond drill hole has recently shown that the Brush Creek bed lies 135 feet above the Upper Freeport coal instead of 75, as formerly supposed, and hence it is deemed best to drop the name Brush Creek altogether for both the coal and the limestone. This Masontown coal is generally the first one above the top of the Mahoning sandstone, and the interval separating it from the latter varies from 5 to 50 feet. Very frequently the coal is only one-half to 1 foot thick, and sometimes it is represented only by black slate.

Near Gallitzin, Pennsylvania, it is seen in a cut on the old Portage Railroad, where it is only one-half foot thick, but it is overlaid by 3 to 4 feet of black slate. The coal is here 140 feet above the Upper

Freeport coal as measured in the McCoy shaft, which starts at the horizon of the Masontown bed.

This coal is reported as present at many localities in Ohio, though there it seldom exceeds 2 feet in thickness. It is probably this bed which has been opened near the summit of the hill opposite Louisa, Kentucky, where it is 2 feet thick and rather slaty.

In the Belington basin, Barbour County, West Virginia, this coal attains a fine development and is often 4 to 5 feet thick with 6 inches of bony coal near the center.

THE IRONDALE LIMESTONE AND ORE.

Directly under the Masontown coal there is occasionally found a bed of buffish gray limestone, which at Irondale, Preston County, West Virginia, and adjoining regions, is accompanied by a bed of iron ore immediately under the limestone.

When the ore is present, however, the coal above is generally absent, as is the case at Irondale and Gladeville, Preston County, where the ore has been used to a considerable extent. It varies in thickness from 1 to 2 feet, and is rather siliceous, there being only about 38 per cent of metallic iron in the ore. It comes 155 feet above the Upper Freeport coal, and hence its horizon is assigned to that of the Masontown coal, since the interval agrees, and then a similar limestone 3 feet thick is seen under the coal at Albright and other localities in Preston County.

THE MAHONING SANDSTONE.

This is the lowest sandstone deposit of the Barren Measures, and although at times consisting of one solid rock, yet it is generally complex. The usual rule is for the mass to divide into two sandstones, an Upper and Lower Mahoning, each 40 to 50 feet thick, with a shale interval between containing a coal bed and limestone or iron ore, but sometimes when the group reaches a great development, as on the Big Kanawha (Section 49), it contains three coal beds, and as many sandstone divisions. This is exceptional, however, the normal structure having only two sandstones with one included coal, the whole series being 100 to 150 feet thick.

The wild scenery and poor soil of the lower portion of the Barrens are largely due to these sandstones. Being frequently quite hard and even pebbly, they cap the hills long after all the other members of the Barrens above have disappeared, and they have thus protected the underlying Lower Coal Measures over wide areas where the latter would otherwise have been carried away by erosion.

In Wyoming County, West Virginia, they cap the summits of Guyandotte Mountain at an elevation of 3,000 feet above the sea. Much of the Lower Coal Measures between that mountain and the Great Kanawha River would have been swept away but for this massive coping.

It is the same friendly cover that has preserved large areas of the

Coal Measures on the summits of the Alleghany Mountains, and in isolated basins like Broad Top. The great tunnels on the Pennsylvania and Baltimore and Ohio Railroads, Gallitzin and Kingwood respectively, pass under domes of this sandstone group. Some portions of this sandstone nearly always furnish good building rock, the Government locks on the Great Kanawha being constructed of it. The same stone is also largely quarried along the Ohio River hills in Beaver County, Pennsylvania.

The Upper Mahoning is generally more massive than the Lower one, and is the conglomeritic member, since it is often a mere mass of quartz pebbles, having once been quarried for mill stones on Cheat River near Morgantown. In the Great Kanawha region this rock is extremely hard and siliceous, and at many points a mere bed of pebbles, some of which are as large as an egg.

THE MAHONING COAL.

This is the coal bed which is so often bound up between the two great divisions of the Mahoning sandstone. It was formerly called the Brush Creek by the writer, but as the place of that coal was misunderstood, it is thought best, as already stated, to drop the name entirely, and replace it with the name Mahoning, since it comes in the middle of the Mahoning sandstone. It is possible that the Gallitzin coal of Platt in Cambria and Blair Counties may belong at this horizon, but owing to the uncertainty connected therewith it has been deemed best not to adopt that name.

This is a very widely distributed coal bed, and frequently attains commercial importance. It is the coal No. 7 of the eastern Ohio series, where it is 3 feet thick and very excellent fuel. It is mined at many localities in Ohio, as well as in Pennsylvania.

On the Great Kanawha River, a few miles above Charleston, this bed swells out to a thickness of 17 feet in the vicinity of Coalburg; but much of this is slate and bone, there being only 5 to 6 feet of good coal in the bed. There is probably a considerable area of this coal of merchantable thickness in the region southwest from the Great Kanawha, since it is several feet thick along the summits of ridges in the Huff Creek Mountains, at the southern line of Logan County, and the same bed is 5 feet thick along the Tug branch of Big Sandy, and in the Peach Orchard region of Kentucky, where it occurs 235 feet above the Peach Orchard bed (Winnifrede). The coal is quite hard, and in many places a "block" coal through this southwestern region. The interval of this bed above the base of the Barren Measures varies from 50 to 175 feet, this latter being the figure at Coalburg and Peach Orchard.

THE MAHONING LIMESTONE.

Occasionally a limestone comes into the series immediately under the Mahoning coal. In Beaver County, Pennsylvania, it is often 5 to 8 feet

thick, and is locally termed the "Summit" limestone. It is not a persistent bed, being much less so than the coal of the same name above, and when present it is often impure and ferruginous. In fact it is occasionally an iron ore, the Johnstown ore of Pennsylvania being identical with this stratum.

THE UPPER AND MIDDLE CANNELTON COALS.

Along the Great Kanawha, where all of the measures have thickened up so abnormally, two other coal beds make their appearance in the Barren series below the Mahoning coal, and they have been termed the Upper and Middle Cannelton, from a locality on the Kanawha where both are exposed. The former has there been mined for a long time in the summit of the hills, where it furnishes 5 feet of excellent "block" coal. It comes 90 feet above the base of the series, but the interval constantly decreases northward, and at Charleston is only 40 to 50 feet. As this interval decreases the coal becomes inferior, until at Charleston it is represented by some coaly streaks only, about the middle of the Lower Mahoning sandstone.

The Middle Cannelton coal never attains commercial value, and is found only in the region of Cannelton and southward. It is slaty, worthless, never more than 3 feet thick, and comes 20 to 25 feet above the base of the Barrens.

The Lower Mahoning sandstone is generally of a bluish gray color, quite homogeneous, and often an excellent building stone. Though occasionally containing pebbles, it is much freer from them than the Upper Mahoning. The thickness varies from 30 to 50 feet, except in the Kanawha region, where it splits up into two or three divisions, and is more than 100 feet thick.

The shales which separate the Upper and Lower Mahoning sandstones are sometimes red, or variegated, as in the Sewickley section (34); and, occasionally, as in the vicinity of Tunnelton, Preston County, West Virginia, good fire clay occurs at the horizon of the Mahoning limestone.

Both members of the Mahoning sandstone are occasionally oil-producing, but more generally the upper one, this being the main oil rock at Bobtown, on Dunkard Creek, Greene County, Pennsylvania, and on Whitely Creek. It is known to the oil producers as the "Dunkard sand," and it is also oil-bearing in the Macksburg and other regions of Ohio.

The shales which usually intervene between the base of the Mahoning sandstone and the Upper Freeport coal often contain fossil Brachiopods and Lamellibranchs, as well as the common coal measure plants. They are quite variable in thickness, the Lower Mahoning sometimes cutting out the shales entirely and resting on the Upper Freeport coal, while again the shales may thicken up to 50 feet.

THE KANAWHA BLACK FLINT.

In the midst of the shales at the base of the Barrens, and apparently at the horizon which usually contains the marine fossils, there occurs along the Great Kanawha River a peculiar deposit, known locally as the "Black Flint." It makes its appearance in the section first at Charleston, and occurs from there southward along the river until the Barrens disappear from the summit of Gauley Mountain, 50 miles distant.

The distribution of the flint appears to be confined to a belt along the river 10 to 12 miles wide, since at 5 to 6 miles back on either side it generally disappears from the section, so as to be no longer recognizable. It is not confined to the Kanawha region however, since the deposit is visible near Clay Court House, on Elk River, and near the California House, on the crest of the Burning Springs anticlinal, where it crosses Hughes River at the corner of Wirt and Ritchie Counties. The rock varies from 5 to 15 feet in thickness, and is usually of a dark or bluish black color, though at the California House it is light colored. Being almost indestructible by atmospheric agencies, it has played a conspicuous part in shaping the topography in the Kanawha region, since it protects the underlying beds from erosion. Through the agency of heat and cold it finally breaks down into oblong and rudely rectangular blocks which everywhere line the beds of streams and cover the surface below the line of outcrop. The Indians manufactured arrow heads and other implements from this material, so that pieces of it have been found as far north as Pennsylvania. It is evidently a marine deposit, since it is distinctly stratified, and specimens of *Discina*, *Spirifera*, and *Productus* are common in the less siliceous layers. The flint is evidently derived from the skeletons of diatoms and protozoa, though no microscopic examination has been made.

CHAPTER V.

THE LOWER COAL MEASURES, OR ALLEGHANY RIVER SERIES.

THICKNESS, CHARACTER, AND EXTENT.

Below the Barren Measures or Elk River series there occurs a group of rocks (No. XIII) which always holds valuable coal beds. From the fact that they are finely exposed along the Alleghany River, they were long ago called the Alleghany River series, and their geological position in the general scale of the Carboniferous gave them the name Lower Coal Measures. The discovery in recent years that the next lower group of beds (the Pottsville Conglomerate) sometimes holds workable coal, has been used as an argument by some geologists for breaking up the old nomenclature and rearranging the Carboniferous into new groups, but this nomenclature is so convenient, and expresses the natural divisions of the rocks so well, that it would be very unwise to make any such changes as have been proposed, since it would be of no particular service and would only bring confusion to the minds of many people interested in Carboniferous geology who are now thoroughly conversant with the old and tried nomenclature of Pennsylvania and Virginia. Hence, while for strictly scientific purposes it may be well to group the Carboniferous rocks on a wider basis as proposed in a former part of this report, yet for every day field work in practical geology, the old nomenclature can not be improved upon.

The Lower Coal Measures, as now limited, begin at the top with the widely distributed and valuable Upper Freeport coal bed (a horizon which is easily recognized anywhere by the field geologist) and extend down through several beds of shale, limestone, coal, and sandstone till a horizon is reached where a marked change in lithology takes place, the sandrocks becoming harder, more massive, and often pebbly, accompanied with a corresponding change in the character of the imbedded fossils.

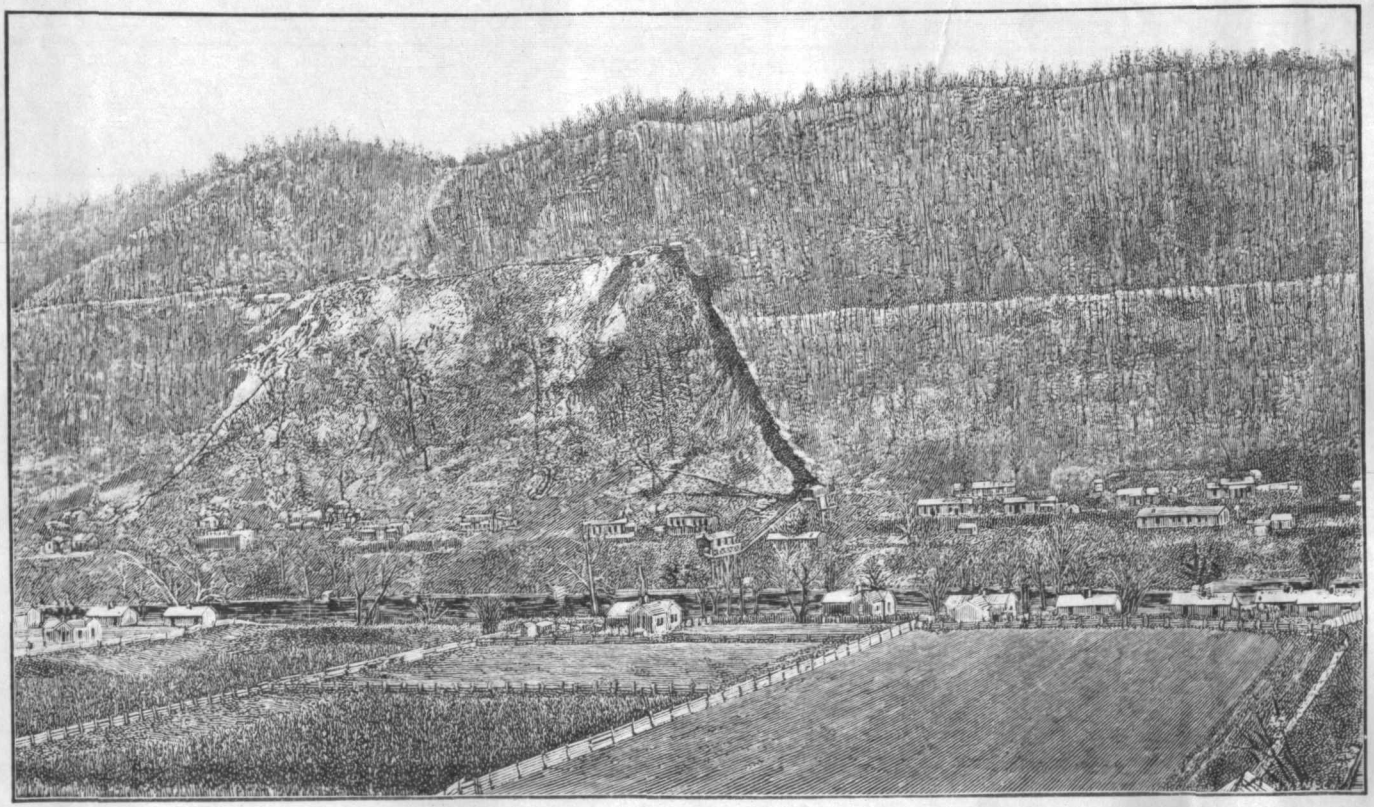
The thickness of this series varies greatly in different portions of the field, being not far from 300 feet in western Pennsylvania, and seldom less than 250 feet anywhere in that State, except in the Broad Top field. But westward through Ohio the thickness of these measures declines until around the northwestern border of the field it is less than 200 feet. Southward from this region of Ohio, where the Lower Coal Measures are thinnest, they thicken up rapidly until on the Great Kanawha River the series is 1,000 feet thick, and the same on the Guyan-

dotte and Tug Rivers. Just where this great thickening up begins in going southwestward from the Pennsylvania line is not exactly known, but there are good reasons for believing that much the greater portion of it takes place beyond the Little Kanawha River.

The topography made by these rocks is generally very much the same, except where the thickness is very great. It is nearly everywhere characterized by a hilly country, terraced with a series of parallel benches which, as Lesley long ago showed, mark the outcrops of the several coal beds, since the soft rocks usually found with every coal are more rapidly eroded than the harder ones above or below. These coal benches are not confined to the topography of the Lower Coal Measures, since they are due to a general law of erosion, but are only more conspicuous in this series because the coal beds are more numerous and closer together.

Through Pennsylvania, Ohio, and the northern half of West Virginia, with few exceptions, the hill slopes of these measures, while often rather steep, are not too rugged for good arable and grazing lands, and the soils are usually rich; but in the southwestern part of West Virginia, where these rocks have increased in thickness so largely, we find a network of narrow ridges, generally capped with the Mahoning sandstone, from which the surface falls away at an angle of 25° to 40° to the beds of the streams, 1,000 or more feet below, thus practically confining the arable land to the narrow valleys, which are frequently trenched into the top members of the next underlying or Pottsville series of rocks.

It was formerly supposed that this series held valuable coal only in a broad belt around the margins of the coal field, and that in the center of the Appalachian basin, where these beds are buried under 1,500 to 2,000 feet of superincumbent strata, they contained no coals thick enough to mine; but the recent drilling of many oil and gas wells over the central portion of the field has proved the supposition to be unfounded, for the drill has many times penetrated thick beds of coal in this series at localities where they underlie the surface by an interval of more than 1,500 feet. Hence, aside from local irregularities always to be found in any coal field, there is no reason for believing that the Lower Coal Measures do not contain one or more good coal beds under nearly every portion of the Appalachian field, and where it would seem to be otherwise the inference has been founded largely on defective records of borings, in which no attention was given to the character of the beds encountered unless they proved to be "sands." But while it is true that recent drilling has shown valuable coal in this series along the central portion of the trough where it was formerly supposed to be absent, yet it is true as a general law that the coal beds of this series are thicker and better and more numerous around the margins of the Appalachian field than toward the center. This is illustrated by the



LOWER COAL MEASURES, COALBURG, KANAWHA RIVER, WEST VIRGINIA.

distribution of the Clarion and Brookville beds, which are valuable only around the margin of the coal area.

Owing to the geological position of the Lower Coal Measures, their beds have a much wider spread and are accessible over a larger area than those in the Upper Coal Measures, so that when in the distant future the upper coals and the easily accessible areas of the lower ones shall have been exhausted, there will still remain far down in the trough of the Appalachian field a great wealth of fuel which can be obtained by deep shafting. It is true that at many localities disclosed by the drill only one good bed of coal has been found in this series where it lies so deep beneath the surface, but that is also true of the surface outcrops, and many places can be found where not even one good coal bed occurs in the surface section, and many others where two are the exception.

The main strata of this series, which have been recognized and traced over a wide area in the three States with which this report deals, have received the following names in descending order:

Upper Freeport coal.	Lower Kittanning coal.
Upper Freeport limestone.	Lower Kittanning fire clay.
Upper Freeport sandstone.	Lower Kittanning sandstone.
Lower Freeport coal.	Buhrstone iron ore.
Lower Freeport limestone.	Ferriferous limestone.
Lower Freeport sandstone.	Putnam Hill limestone.
Upper Kittanning coal.	Clarion coal.
Johnstown (Cement) limestone.	Brookville coal.
Middle Kittanning coal.	

Other beds have been named in this series which have a local distribution, but those given above are the main ones which can be traced and identified over wide areas.

Prof. Orton, director of the Ohio Geological Survey, has shown that all of the main beds of the Pennsylvania Lower Coal Measures can be followed and identified entirely across the Ohio coal field to where they enter Kentucky; and the writer has recently shown (The Virginias, 1885) that they also stretch unbroken around the southeastern margin of the Appalachian field, from the Pennsylvania line down through West Virginia to the Great Kanawha, and on across the Guyandotte to the Big Sandy, so that the identifications of the main beds of coal, limestone, and sandstone of the Lower Coal Measures have now been carried from Pennsylvania to the Kentucky line, on both sides of the Appalachian field.

As illustrations of these measures, in most of the important coal regions of the area in question, we shall now present a number of vertical sections. The identifications of the several beds in these sections have been made with all the care and light at present attainable, and while it is not claimed that they are final in all cases and free from error, yet they express the best efforts of the writer, and it is confidently believed

that their publication will serve to stimulate a more careful study of the general stratigraphy by field geologists and those interested in mining enterprises, so that finally whatever of error may be embodied in these identifications will be discovered and eliminated. It is certain that the first effort to harmonize the stratigraphy over such a large area will be somewhat provisional, and hence the writer not only expects, but welcomes, the kindly criticism of his brother geologists, knowing that all will be pleased when the true order and succession of these beds are definitely determined in the several important regions of the Appalachian field.

In some cases, like that at Blossburg, where it has been impossible to identify the main coal beds with any degree of certainty, the writer has given only the local names for the beds, leaving the reader to draw his own conclusions from the general structure of the section; but there are very few cases where some one of the seams in a given section can not be reasonably determined.

We shall begin these illustrations of the Lower Coal Measures at the most northern point of the Appalachian Basin, and proceed southwestward through the field.

Section at Blossburg, Pennsylvania.—The structure of the Lower Coal Measures at the northern end of the Appalachian basin is given as follows (Fig. 50) for the Blossburg region, Tioga County, Pennsylvania, by the First Geological Survey of Pennsylvania, Final Report, Vol. II, page 520:

Blossburg, Tioga County, Pennsylvania.

[See map, B w.]

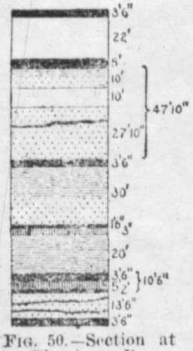


FIG. 50.—Section at Blossburg, Pa.

			Ft.	in.	Ft.	in.
1.	Coal, "Rock vein"				3	6
2.	Concealed				22	
3.	Coal, "Seymour"				5	
4.	Slate and sandstone		10			
5.	Concealed		10		47	10
6.	Sandstone, pebbly, with thin coal near top		27	10		
7.	Coal, "Dirty vein"				3	6
8.	Slate and sandstone				30	
9.	Coal				1	6
10.	Fire clay				3	
11.	Slate				20	
12.	Coal, "Bloss vein"	Coal 5′ 6″ Fire clay 5′ 0″ Coal 2′ 0″			10	6
13.	Argillaceous sandstone, with two thin coals				13	6
14.	Coal, "Bear Creek"				3	6
15.	Sandstone.					
	Total				163	10

The "Bloss vein" seems to be identical with the Lower Kittanning bed of the Alleghany River, while the "Rock vein" and "Seymour" are possibly identical with the Upper and Lower Freeport beds, respectively. This would make Nos. 7 and 9 the Upper and Middle Kittanning.

Section at Fall Brook, Pennsylvania.—At Fall Brook, 8 miles northeast from Blossburg, and the most northern development in the Appalachian coal field, the structure of the Lower Coal Measures is given as follows (Fig. 51) by Mr. Franklin Platt, in Report G, pages 166, 169, Second Geological Survey of Pennsylvania:

Fall Brook, Tioga County, Pennsylvania.

[See map, B x.]

		Ft.	in.
1.	Coal, "Seymour"	2	6
2.	Rough, sandy fire clay	2	
3.	Sandstone, massive, pebbly	50	
4.	Coal: Coal 1′ 8″; Sandstone, thin bedded 3′ 0″; Coal 0′ 7″	5	3
5.	Fire clay	1	6
6.	Sandstone	10	
7.	Slate		9
8.	Coal, "Dirty vein": Coal 1′ 3″; Slate 4′ 0″; Coal 1′ 2″; Slate 0′ 3″; Coal 0′ 10″	7	6
9.	Rough, hard fire clay	2	
10.	Gray shaly rock	20	
11.	Fire clay, with kidney ore at bottom	2	
12.	Sandstone, light gray	9	
13.	Clay slate	5	
14.	Coal, "Bloss vein"	4	
15.	Fire clay, pure	3	
16.	Sandy slate, some sandy layers	16	
17.	Coal and slate, "Bear Creek"	1	6
18.	Sandy clay	4	
19.	Sandstone.		
	Total	146	

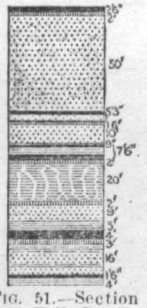


FIG. 51.—Section at Fall Brook, Pa.

Section near Karthaus, Pennsylvania.—About 65 miles southwest of Blossburg, in the northeastern corner of Clearfield County, Pennsylvania, the following section (Fig. 52) of the Lower Coal Measures is reported from the vicinity of Karthaus, by H. D. Rogers, in the First Geological Survey of Pennsylvania:

Karthaus, Clearfield County, Pennsylvania.

[See map, E t.]

		Ft.	in.
1.	Coal, Upper Freeport	6	
2.	Fire clay	2	6
3.	Sandstone, brown	45	
4.	Coal	0	10
5.	Fire clay	2	
6.	Limestone, siliceous	3	6
7.	Shale	1	
8.	Sandstone, brown	26	
9.	Coal, Lower Freeport	3	
10.	Slate	1	6
11.	Sandstone, gray, Freeport	37	
12.	Coal, Upper Kittanning	3	2
13.	Shale, containing iron ore	11	
14.	Coal, Middle Kittanning	1	
15.	Sandstone and slate	21	
16.	Coal, Lower Kittanning: Coal 1′ 0″; Slate 0′ 3″; Coal 2′ 6″	3	9
17.	Fire clay	2	6
18.	Sandstone, brown	35	
19.	Coal, Clarion	1	6
20.	Fire clay, ferruginous	3	
21.	Shales, containing iron ore band	11	9
22.	Shales and slates	22	
23.	Coal, Brookville	1	
24.	No. XII Conglomerate.		
	Total	245	

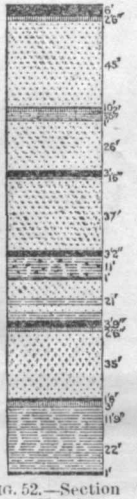


FIG. 52.—Section near Karthaus, Pa.

Section in Horton Township, Elk County, Pennsylvania.—Horton Township, Elk County, Pennsylvania, lies on the borders of Clearfield and Jefferson Counties, 30 miles west from Karthaus and about 80 miles distant west southwest from the Blossburg region. In this township Mr. C. A. Ashburner finds the following section (Fig. 53) for the Lower Coal Measures, Report RR, page 227:

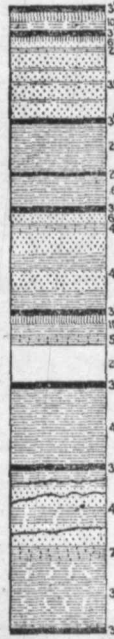


FIG. 53.—Section in Elk County, Pa.

Horton Township, Elk County, Pennsylvania.

[See map, D q.]

		Feet.
1.	Coal, Upper Freeport: Coal 3′, Fire clay and shale 10′, Coal 3′	16
2.	Fire clay and sandstone	6
3.	Limestone, Upper Freeport	2
4.	Slaty sandstone	35
5.	Coal, Middle Freeport	3
6.	Soft gray slates	25
7.	Coal, Lower Freeport: Cannel 2′, Slate 16′, Coal 3′	21
8.	Sandstone	6
9.	Limestone, Lower Freeport	4
10.	Flaggy sandstone and slates	40
11.	Coal, Upper Kittanning	3
12.	Fire clay and slate	10
13.	Limestone, Johnstown Cement	5
14.	Concealed	20
15.	Coal, Middle Kittanning	3
16.	Black slate	40
17.	Coal, Lower Kittanning	3
18.	Shale and sandstone, occasional coal streak	40
19.	Limestone, Ferriferous	7
20.	Shale and slate	35
21.	Coal, Clarion	3
22.	Massive sandstone, top of XII.	
	Total	327

Section near Brockwayville, Pennsylvania.—Snyder Township, Jefferson County, adjoins Horton, and there, near Brockwayville, Mr. Wm. G. Platt reports the following structure (Fig. 54) for the Lower Coal Measures, Report H⁶, pages 186, 187:

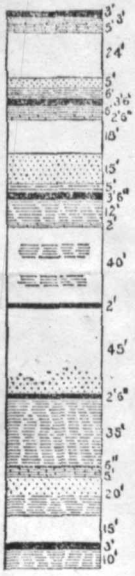


FIG. 54.—Section near Brockwayville, Pa.

Brockwayville, Jefferson County, Pennsylvania.

[See map, D q.]

		Ft.	in.
1.	Coal, Upper Freeport	3	
2.	Clay, impure	3	
3.	Limestone, Upper Freeport	5	
4.	Concealed	24	
5.	Sandstone, thin-bedded	5	
6.	Shales and slates	6	
7.	Coal, Lower Freeport	3	6
8.	Clay, impure	5	
9.	Limestone, Lower Freeport	2	6
10.	Concealed	18	
12.	Sandstone	15	
13.	Slates	5	
14.	Coal, Upper Kittanning	3	6
15.	Clay shales	12	
16.	Limestone, Johnstown Cement	2	
17.	Concealed, shales (?)	40	
18.	Coal, Middle Kittanning	2	
19.	Concealed, sandstone at base	45	
20.	Coal, Lower Kittanning	2	6
21.	Shales	35	
22.	Iron ore, Buhrstone		6
23.	Limestone, Ferriferous	5	
24.	Sandstone and shales	20	
25.	Concealed	15	
26.	Coal, Clarion	3	
27.	Shales	10	
28.	Sandstone, massive, top of XII.		
	Total	290	6

Section in Clarion County, Pennsylvania.—Clarion County lies next west from Jefferson, and Mr. H. Martyn Chance gives in Report VV, page 32, Second Geological Survey of Pennsylvania, the following as the general structure of the Lower Coal Measures in that county (Fig. 55):

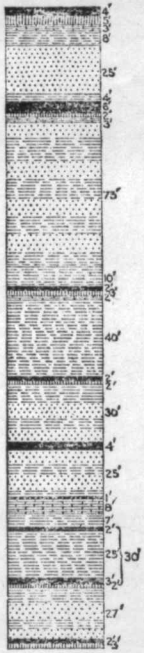


FIG. 55.—Section in Clarion Co., Pa.

Clarion County, Pennsylvania.

	[See map, E o.]	Ft.
1.	Coal, Upper Freeport	4
2.	Fire clay	5
3.	Limestone, Upper Freeport	3
4.	Shale, with ore	8
5.	Sandstone	25
6.	Shale	4
7.	Coal, Lower Freeport	6
8.	Fire clay	2
9.	Limestone, Lower Freeport	3
10.	Sandstone and shales	75
11.	Shale	10
12.	Coal, Upper Kittanning	2
13.	Fire clay or shale	3
14.	Limestone, Johnstown Cement bed	2
15.	Shaly measures	40
16.	Coal, Middle Kittanning	2
17.	Fire clay	2
18.	Shale and sandstone	30
19.	Coal, Lower Kittanning	4
20.	Sandstone and shale, with ore	25
21.	Ore, Buhrstone	1
22.	Limestone, Ferriferous	8
23.	Shale	7
24.	Clarion coal: Coal 2′ / Slaty shale 25′ / Coal 3′	30
25.	Fire clay	2
26.	Shale and sandstone	27
27.	Coal, Brookville	2
28.	Fire clay	3
29.	Massive sandstone, XII.	
	Total	335

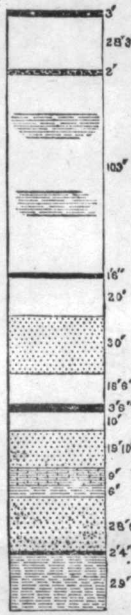


FIG. 56.—Section at Miller's Eddy, Pa.

Section at Miller's Eddy, Clarion County, Pennsylvania.—The following section (Fig. 56), made by Mr. John Haggerty, M. E., of Brady's Bend, Pennsylvania, represents the Lower Coal Measure structure at Miller's Eddy, near the mouth of the Clarion River (VV, p. 123):

Miller's Eddy, Clarion County, Pennsylvania.

	[See map, E n.]	Ft.	in.
1.	Coal, Upper Freeport	3	
2.	Interval	28	3
3.	Iron ore	2	
4.	Concealed and slate	103	
5.	Coal, Upper Kittanning	1	6
6.	Interval	20	
7.	Sandstone	30	
8.	Interval	16	6
9.	Coal, Lower Kittanning	3	6
10.	Interval	10	
11.	Sandstone	19	10
12.	Limestone, Ferriferous	9	
13.	Shales	6	
14.	Sandstone	28	6
15.	Coal, Clarion	2	4
16.	Blue shales	29	
17.	Sandstone, massive.		
	Total	312	5

Section at East Brady, Clarion County, Pennsylvania.—Mr. Haggerty also leveled another section of these measures at East Brady, in the southwestern corner of Clarion County, which is given as follows (Fig. 57) in Report VV, p. 77:

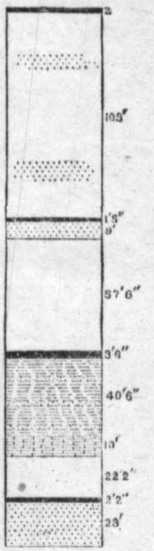


FIG. 57.—Section at East Brady, Pa.

East Brady, Clarion County, Pennsylvania.

[See map, F n.]

	Ft.	in.
1. Coal, Upper Freeport	2	
2. Concealed and sandstone	108	
3. Coal, Upper Kittanning	1	5
4. Sandstone	9	
5. Interval	57	6
6. Coal, Lower Kittanning	3	6
7. Shale, with sandstone	40	6
8. Limestone, Ferriferous	10	
9. Interval	22	2
10. Coal, Clarion	2	2
11. Sandstone	23	
12. Coal, thin, Brookville.		
13. Sandstone, No. XII.		
Total	279	3

Section near New Bethlehem, Pennsylvania.—Mr. Chance gives the following (Fig. 58) as the structure of the Lower Coal Measures in the vicinity of New Bethlehem, on the Red Bank River, in southeastern Clarion County, VV, p. 88:

FIG. 58.—Section near New Bethlehem, Pa.

Near New Bethlehem, Clarion County, Pennsylvania.

[See map, F o.]

	Ft.
1. Coal, Upper Freeport	5
2. Fire clay	3
3. Sandy shale and sandstone	42
4. Coal, Lower Freeport	7
5. Fire clay	3
6. Concealed, sandstone, and shale	65
7. Coal, Upper Kittanning	3
8. Fire clay	4
9. Shale	43
10. Coal, Middle Kittanning (?)	2
11. Fire clay	3
12. Concealed	60
13. Ore, Buhrstone	1
14. Limestone, Ferriferous	4
15. Concealed	50
16. Sandstone, top of XII.	
Total	295

Section in Brady Township, Butler County, Pennsylvania.—In the northwestern portion of Butler County (Brady Township), Mr. Chance gives, in Report V, the following section (Fig. 59) for the Lower Coal Measures down to and including the Ferriferous limestone, and the portion below that is added from an exposure in an adjoining township:

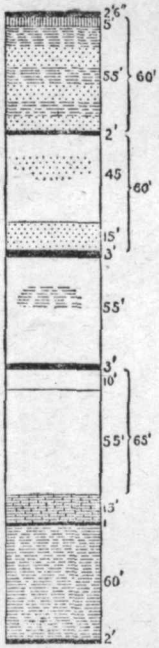


FIG. 59.—Section in Butler County, Pa.

Brady Township, Butler County.

[See map, F 1.]	Ft.	Ft.	in.
1. Coal, Upper Freeport		2	6
2. Fire clay	5	60	
3. Shale and sandstone	55		
4. Coal, Lower Freeport		2	
5. Concealed, and massive sandstone	45	60	
6. Massive sandstone	15		
7. Coal, Upper Kittanning		3	
8. Concealed, and shale		55	
9. Coal, Middle Kittanning (?)		3	
10. Concealed	10	65	
11. Iron ore	thin		
12. Concealed	55		
13. Limestone, Ferriferous		15	
14. Coal, Scrubgrass		1	
15. Shales		60	
16. Coal, Brookville		2	
Total		328	6

Section near Ore Hill Furnace, Armstrong County, Pennsylvania.—In the vicinity of Ore Hill Furnace, Armstrong County, Pennsylvania, 3 miles below the mouth of the Mahoning River, the writer found the following succession (Fig. 60):

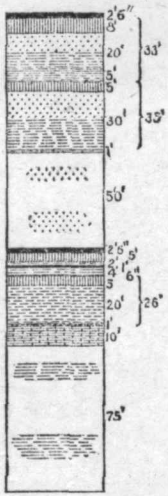


FIG. 60.—Section near Ore Hill Furnace, Armstrong County, Pa.

Ore Hill Furnace, Armstrong County, Pennsylvania.

[See map, G o.]	Ft.	Ft.	in.
1. Coal, Upper Freeport		2	6
2. Fire clay with iron ore	8	33	
3. Flaggy sandstone and shales	20		
4. Bituminous shales	5		
5. *Coal, blossom, Lower Freeport*			
6. Fire clay and limestones, Lower Freeport	5	35	
7. Flaggy sandstone and dark shales	30		
8. Limestone, gray, Johnstown Cement		1	
9. Concealed and sandstone		50	
10. Coal, Middle Kittanning		2	6
11. Fire clay		5	
12. Sandy shale		2	
13. Coal, Lower Kittanning (Coal 1′ 0″; Shale 4′ 0″; Coal 0′ 6″)		5	6
14. Fire clay	5	26	
15. Shales, brown, sandy	20		
16. *Iron ore*, Buhrstone	1		
17. Limestone, Ferriferous		10	
18. Concealed and shales to top of No. XII sandstone in Alleghany River		75	
Total		247	6

This section exhibits a rapid thinning away of the whole column, but principally in that part of it between the Upper Freeport and the Upper Kittanning coals.

Section near Centerville, Pennsylvania.—Five miles northeast from Ore Hill Furnace, the following succession (Fig. 61) is reported from the vicinity of Centerville by Mr. Wm. G. Platt, in Report H[5], Second Geological Survey of Pennsylvania, pages 163, 164.

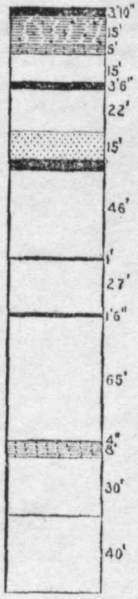


FIG. 61.—Section near Centerville, Pa.

Centerville, Armstrong County, Pennsylvania.

[See map, G o.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport		3	10
2.	Clay shales, with iron ore	15		
3.	Limestone, Freeport	5	35	
4.	Concealed	15		
5.	Coal, Lower Freeport		3	6
6.	Concealed	22		
7.	Iron ore, siliceous		37	
8.	Sandstone	15		
9.	Coal, blossom			
10.	Concealed		46	
11.	Coal, Upper Kittanning		1	
12.	Concealed		27	
13.	Coal, Middle Kittanning		1	6
14.	Concealed		65	
15.	Iron ore, Buhrstone		0	4
16.	Limestone, Ferriferous		8	
17.	Concealed		30	
18.	Cannel slate (Clarion coal)			
19.	Concealed		40	
20.	Black slate (Brookville coal).			
21.	Top of No. XII conglomerate.			
	Total		298	2

Section at Putneyville, Pennsylvania.—Five miles east of Centerville is the village of Putneyville, and from this vicinity Mr. Wm. G. Platt reports the following section (Fig. 62) of the series H[5], p. 150:

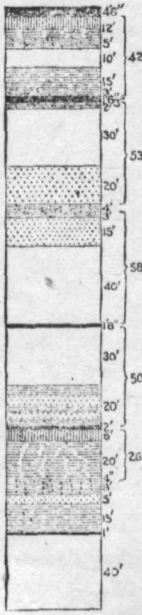


FIG. 62.—Section at Putneyville, Pa.

Putneyville, Armstrong County, Pennsylvania.

[See map, G o.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			4	6
2.	Fire clay and clay shales	12			
3.	Limestone, Upper Freeport	5		42	
4.	Concealed	10			
5.	Clay slates	15			
6.	Coal, Lower Freeport			3	
7.	Slate	1	6		
8.	Iron ore	0	3		
9.	Limestone, Lower Freeport	2		53	9
10.	Concealed	30			
11.	Sandstone	20			
12.	Coal, blossom, Upper Kittanning				
13.	Limestone, Johnstown Cement bed			4	
14.	Clay	3			
15.	Sandstone, friable	15		58	
16.	Concealed	40			
17.	Coal, Middle Kittanning			1	8
18.	Concealed	30			
19.	Slates, with sandstone layers	20		50	
20.	Coal, Lower Kittanning			2	
21.	Fire clay, impure	6			
22.	Shales	20		26	4
23.	Iron ore, Buhrstone	0	4		
24.	Limestone, Ferriferous			8	
25.	Sandstone, flaggy			5	
26.	Black slates			15	
27.	Cannel slate (Clarion coal)			1	
28.	Concealed			40	
29.	Brookville coal.				
30.	Top of No. XII, conglomerate.				
	Total			314	3

Section near Kittanning, Pennsylvania.—In the vicinity of Kittanning, Pennsylvania, the succession of the Lower Coal Measures is as follows (Fig. 63):

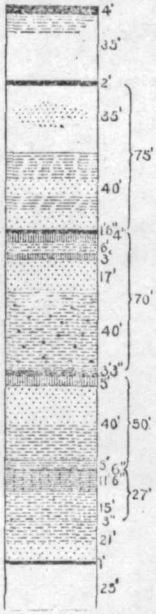


FIG. 63.—Section near Kittanning, Pa.

Vicinity of Kittanning, Pennsylvania.

[See map, G n.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			4	
2.	Shales, and concealed			35	
3.	Coal, Lower Freeport			2	
4.	Concealed, and massive sandstone	35		75	
5.	Shales and sandstone	40			
6.	Coal, slate in center, Middle Kittanning			1	6
7.	Fire clay	4		70	
8.	Sandy shales	6			
9.	Fire clay	3			
10.	Flaggy sandstone	17			
11.	Shales, dark, sandy, with iron ore	40			
12.	Coal, Lower Kittanning: Coal 1′ 10″; Slate 0′ 2″; Coal 0′ 8″; Bone 0′ 1″; Coal 0′ 6″			3	3
13.	Fire clay	5		50	
14.	Sandstone and sandy shales	40			
15.	Shales, with iron ore	5			
16.	Iron ore, Buhrstone	0	6	27	
17.	Limestone, Ferriferous	11	6		
18.	Sandy shales	15			
19.	Coal			0	3
20.	Sandy shales and sandstone			21	
21.	Coal, Clarion			1	
22.	Concealed, to top of No. XII sandstone			25	
	Total			315	

Section 5 miles south of Kittanning, Pennsylvania.—About 5 miles south of Kittanning and 1 mile below the mouth of Crooked Creek a very important exposure may be seen on the left bluff of the Allegheny River, since it gives in a clear manner the relations of the upper members of the Lower Coal Measures. The section there (Fig. 64) was carefully leveled by the writer, and reads as follows:

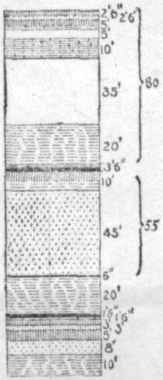


FIG. 64.—Section south of Kittanning, Pa.

Five miles below Kittanning.

[See map, G n.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport, blossom				
2.	Fire clay	2	6		
3.	Sandstone	2	6		
4.	Fire clay and shales	5			
5.	Concealed	5		80	
6.	Limestone, Upper Freeport	10			
7.	Concealed	35			
8.	Shales, bluish	20			
9.	Coal, Lower Freeport: Coal 0′ 2″; Slate 1′ 8″; Coal 1′ 8″			3	6
10.	Fire clay and shales	10		55	
11.	Sandstone, massive, pebbly, Freeport	45			
12.	Coal, Upper Kittanning			0	6
13.	Shales, dark			20	
14.	Coal, slate in center, Middle Kittanning			1	6
15.	Limestone, sandy			1	6
16.	Fire clay			3	
17.	Sandstone, flaggy			3	
18.	Fire clay			5	
19.	Sandstone, flaggy			8	
20.	Shales, dark			10	
	Total			191	

Section at Logansport, Pennsylvania.—The last section gets its special significance when compared with another one, obtained 2 miles below, on the right bank of the Alleghany River, and opposite the town of Logansport. The section there (Fig. 65) gives the following structure:

Logansport, Armstrong County, Pennsylvania.

[See map, G n.]

		Ft.	Ft.	in.
1. Coal, Upper Freeport			3	
2. Fire clay		4		
3. Limestone, Upper Freeport	Impure limestone 2′; Limy shales 4′; Limestone, good 1′; Shales 1′; Limestone, "glassy layer" 2′; Limy shales 2′; Limestone, good 2′	14	28	
4. Shales and fire clay		10		
5. Coal, Lower Freeport	Coal 2′ 0″; Fire clay, impure 2′ 4″; Coal 4′ 8″		9	
6. Concealed		11	81	
7. Very massive, grayish white, pebbly sandstone, Freeport		70		
8. Coal, Upper Kittanning			0	8
9. Dark gray shales			20	
10. Coal, Middle Kittanning	Coal 0′ 8″; Slate 0′ 2″; Coal 0′ 6″		1	4
11. Fire clay		1		
12. Limestone		1		
13. Fire clay, with limestone nodules in top		8		
14. Sandstone, shaly		7	52	
15. Concealed (shales)		15		
16. Blue shales		20		
17. Coal, Lower Kittanning	Coal 1′ 1″; Slate 0′ 1″; Coal 1′ 1″; Slate 0′ 1″; Coal 1′ 2″		3	6
18. Concealed to river level			20	
19. To base of Lower Coal Measures, about			80	
Total			298	6

FIG. 65.—Section at Logansport, Pa.

Here we find a ferruginous limestone making its appearance under what the section shows to be the Middle Kittanning coal, and it is possible that this same bed may have occasionally been identified with the Johnstown Cement limestone in this portion of Pennsylvania, which would be erroneous, since that bed belongs under the little coal, No. 8 of the section, while the Johnstown Cement bed, as correlated by Messrs. Platt and others, comes just under the Upper Kittanning coal.

The section also exhibits the great variations that may take place in the thickness of the intervals between important coal beds, that between the two Freeports being here reduced to only 28 feet.

Section at Freeport, Pennsylvania.—Freeport, on the Alleghany River, at the southern point of Armstrong County and 7 miles southwest of Logansport, is a classic locality for the upper portion of the Lower Coal Measures, and the following section (Fig. 66), taken there, is given for the purpose of illustrating the relations of the Upper and Lower Freeport coals at this typical locality:

Freeport, Pennsylvania.

[See map, G n.]

		Ft.	in.	Ft.	in.
1. Coal, Upper Freeport	Coal 2′ 8″; Slate, gray 0′ 1½″; Coal 0′ 6½″; Slate, dark gray 0′ 0½″; Coal, sulphurous 0′ 5″			3	9½
2. Fire clay		1	6		
3. Limestone, Upper Freeport		3	6		
4. Sandy shales		20		66	
5. Coal, Middle Freeport		2			
6. Sandy shales and sandstone		39			
7. Coal, Lower Freeport	Cannel slate 5′ 0″; Slaty coal 4′ 6″; Fire clay with limestone 2′ 6″; Slaty coal 2′ 6″			14	
8. Fire clay and shales		2			
9. Sandstone, massive		45		64	
10. Coaly slate, Upper Kittanning		0	4		
11. Sandstone, gray, massive		15			
12. Coal, Middle Kittanning				1	6
13. Fire clay, with limestone nodules in upper half				6	
Total				155	3½

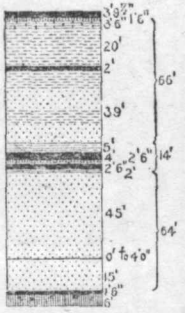


FIG. 66.—Section at Freeport, Pa.

This section shows that there is a third Freeport coal, coming nearly midway between the upper and lower ones, at this, their typical locality, a fact that has been frequently overlooked by geologists, and that has led to error in identifications. This Middle Freeport coal, as I have termed it, is not persistent; but the fact that there is such a bed in the series occasionally should lead to careful scrutiny of this portion of the column of rocks before positive identification of the Lower Freeport coal.

This latter bed, No. 7, also has elements of possible confusion in its structure here at its type locality, since, as may be seen from the section, it is a double bed, made so by 2½ feet of fire clay, in which a nodular limestone occurs. It is possible that these parting rocks may expand to several feet in some regions, and thus give two Lower Freeport coals, as indeed they are known to do.

I have included No. 11 as a part of the Freeport sandstone, since at one locality the coal bed No. 10 thins out entirely and lets Nos. 9 and 11 unite into one solid sandstone; but it is possible that No. 9 alone should be included under the name Freeport sandstone, as originally intended by Rogers.

Section near mouth of Beaver River, Pennsylvania.—In the region about the mouth of the Beaver River, the Lower Coal Measures thicken up to a considerable extent, through the local expansion of some members, as shown by the following (Fig. 67) section of the structure there:

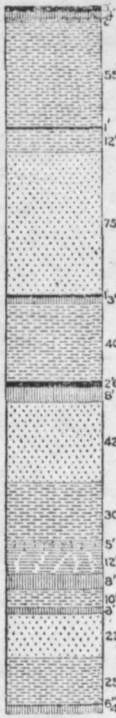


FIG. 67.—Section near mouth of Beaver River, Pa.

Near mouth of Beaver River, Beaver County, Pennsylvania.

[See map, G k.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport		3	
2.	Fire clay	4		
3.	Limestone, Upper Freeport	2	61	
4.	Shales, sandy	55		
5.	Coal, Lower Freeport		1	
6.	Shales, sandy	12		
7.	Sandstone, massive, Freeport	75	87	
8.	Coal, Middle Kittanning		1	
9.	Fire clay	3		
10.	Shales, sandy, dark	40	43	
11.	Coal, Lower Kittanning		2	6
12.	Fire clay	8		
13.	Sandstone, flaggy and massive	42	80	
14.	Shales, sandy	30		
15.	Limestone, Ferriferous		5	
16.	Black fossiliferous shales	12		
17.	Fire clay	8		
18.	Sandy shales	10		
19.	Fire clay, non-plastic	3	81	
20.	Sandstone, flaggy	23		
21.	Shales, sandy	25		
22.	Coal, Brookville		0	6
23.	Fire clay		4	
24.	Massive sandstone, No. XII.			
	Total		369	

Section at Sewickley, Pennsylvania.—At Sewickley, Alleghany County, Pennsylvania, a test hole for coal was bored by Mr. Cochran Fleming, through whose courtesy the writer had the opportunity of measuring the carefully preserved cores from the diamond drill, which gave this structure (Fig. 68) for the rocks of the Lower Coal Measures there:

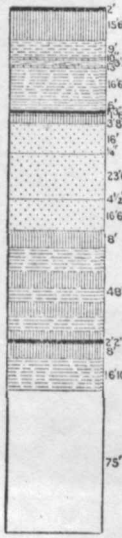


FIG. 68.—Section at Sewickley, Pa.

Sewickley, Alleghany County, Pennsylvania.

[See map, H l.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			2	
2.	Fire clay	15	6		
3.	Shales, blue, sandy	9	0		
4.	Sandstone	0	10		
5.	Fire clay	3	3	52	4
6.	Sandstone	1	3		
7.	Shales	16	6		
8.	Dark slate	6	0		
9.	Coal, slaty, Lower Freeport			1	3
10.	Fire clay, good	1	6		
11.	Fire clay, sandy	3	8		
12.	Gray, micaceous sandstone in thin layers Freeport: Sandstone 16′ 0″; Coal 0′ 0¼″; Sandstone 23′ 0″	39	6¼	44	8¼
13.	Coal, Upper Kittanning			0	4½
14.	Sandstone	16	6		
15.	Fire clay (Middle Kittanning coal horizon)	8		73	
16.	Shales, dark, interstratified with fire clay	48	6		
17.	Coal, Lower Kittanning: Coal 1′ 4″; Slate 0′ 1″; Coal 0′ 9″			2	2
18.	Fire clay, good			8	
19.	Shales, blue			16	10
20.	Interval to top of No. XII, estimated			75	
	Total			275	8

Section at Washington, Pennsylvania.—At Washington, Pennsylvania, the top of this series is 1,000 feet below the surface, and Prof. Linton, of Washington and Jefferson College, gives the following (Fig. 69) as the structure of its rocks according to the record of the Thayer oil well, the drillings from which he very carefully studied (Geological Survey of Pennsylvania, 1886, pp. 764, 765):

FIG 69.—Section under Washington, Pa.

Under Washington, Pennsylvania.

[See map, J k.]

		Ft.	Ft.
1.	Upper Freeport coal—absent		
2.	Dark shale with limestone at bottom, Upper Freeport	12	
3.	Sandstone, dark	36	64
4.	Sandstone, white	16	
5.	Sandstone, dark, with limestone		4
6.	Sandstone, hard	19	
7.	Shale, dark	28	55
8.	Shale, variegated with dark lime	8	
9.	Limestone, Johnstown Cement .. { dark.. 3' / light . 8' }		11
10.	Shale, dark, slaty		30
11.	Shale and coal, Middle Kittanning		6
12.	Shale, slate and shells	30	
13.	Sandstone, grayish	26	
14.	Shale, gray	11	115
15.	Sandstone, grayish, shaly	29	
16.	Shale and shells	19	
	Total		285

Here there is only one coal present in the series and it would appear to be the Middle Kittanning.

Section near Carpenter's Station, Westmoreland County, Pennsylvania.—Near the main line of the Pennsylvania Railroad, in the vicinity of Carpenter's Station, Westmoreland County, Pennsylvania, a well was drilled for gas by Mr. E. M. Hukill, who thus (Fig. 70) reports the structure of the Lower Coal Measures, as published in Geological Survey of Pennsylvania, 1886, p. 726:

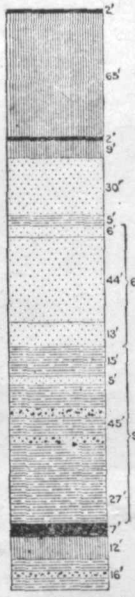


FIG. 70.—Section near Carpenter's Station, Pa.

Near Carpenter's Station, Westmoreland County, Pennsylvania.

[See map, I n.]

		Ft.	Ft.
1.	Coal, Upper Freeport		2
2.	Fire clay (shales)		65
3.	Coal, Lower Freeport		2
4.	Fire clay	9	
5.	Sandstone, gray	30	
6.	Slate	5	107
7.	Sandstone, Freeport ... { Sandstone, hard. 6' / Sandstone, soft . 44' / Sandstone, hard. 13' }	63	
8.	Slate	15	
9.	Sandstone	5	
10.	Slate and shells	45	92
11.	Slate, black	27	
18.	Coal, Clarion or Lower Kittanning		7
19.	Fire clay		12
20.	Shale and shells		16
21.	Sandstone, top of XII.		
	Total		303

Section under Murraysville, Pennsylvania.—At Murraysville, Westmoreland County, Pennsylvania, in the celebrated natural gas region, the top of the Lower Coal Measures lies 60 to 75 feet below the surface, and the structure of the series is thus given (Fig. 71) by Mr. Doubleday, from the records of a gas well on the Remaley farm, Geological Survey of Pennsylvania, 1886, p. 721:

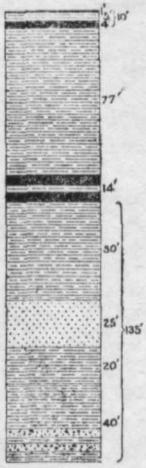


FIG. 71.—Section under Murraysville, Pa.

Under Murraysville, Westmoreland County, Pennsylvania.

[See map, I n.]

		Ft.	Ft.
1.	Coal, Upper Freeport: Coal 1′, Slate 5′, Coal 4′		10
2.	Slate		77
3.	Coal, slate in center		14
4.	Slate	50	
5.	Sandstone	25	135
6.	Slate	20	
7.	Slate and shells	40	
8.	Massive sandstone, top of XII.		
	Total		236

Section on Beaver Run, Westmoreland County, Pennsylvania.—About 9 miles northeast of Murraysville a well was drilled on Beaver Run, beginning only 4 feet below the level of the Upper Freeport coal. The record (Fig. 72) of this well, as given by Mr. J. A. Mehaffey, shows the following structure there (Pennsylvania Geological Survey, 1886, p. 728):

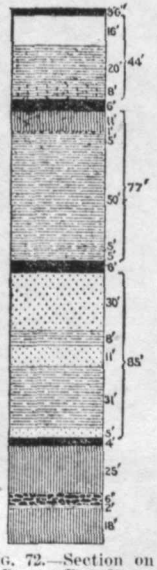


FIG. 72.—Section on Beaver Run, Pa.

Beaver Run, Westmoreland County, Pennsylvania.

[See map, H n.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport		3	6
2.	Concealed	16		
3.	Black slate	20	44	
4.	Limestone	8		
5.	Coal, Lower Freeport		6	
6.	Fire clay	11		
7.	Shell, hard	1		
8.	Shale, soft	5	77	
9.	Slate, black	50		
10.	Shale, soft	5		
11.	Slate, black	5		
12.	Coaly slate, Upper Kittanning		6	
13.	Sandstone	30		
14.	Slate, black	8		
15.	Sandstone, gray	11	85	
16.	Slate, black	31		
17.	Sandstone	5		
18.	Coal, Lower Kittanning		4	
19.	Fire clay		25	
20.	Iron ore		6	
21.	Shales, soft		2	
22.	Fire clay		18	
23.	Pebbly sandstone, top of XII.			
	Total		276	6

Section near Richmond, Pennsylvania.—In the northern portion of Indiana County, Pennsylvania, in the vicinity of Richmond village, the Lower Coal Measures exhibit the following structure (Fig. 73) according to Mr. Wm. G. Platt, H⁴, p. 266:

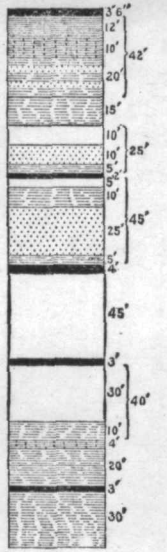


FIG. 73.—Section near Richmond, Pa.

Near Richmond, Indiana County, Pennsylvania.

		Ft.	Ft.	in.
	[See map, F p.]			
1.	Coal, Upper Freeport		3	6
2.	Clay	12		
3.	Limestone	10	42	
4.	Shales and thin sandstone	20		
5.	Coal, Lower Freeport.... Coal... thin; Shales. 15'; Coal .. thin		15	
6.	Concealed	10		
7.	Sandstone	10	25	
8.	Clay slate	5		
9.	Coal, Upper Kittanning		2	
10.	Concealed	5		
11.	Shales	10		
12.	Sandstone	25	45	
13.	Slate and shales	5		
14.	Coal, Middle Kittanning		4	
15.	Interval		45	
16.	Coal, Lower Kittanning		3	
17.	Interval	30	40	
18.	Shales	10		
19.	Limestone, Ferriferous		4	
20.	Shales and slates		20	
21.	Coal, Clarion		3	
22.	Shales		30	
23.	Sandstone, massive, top of XII.			
	Total		281	6

Section near Lockport and Bolivar, Indiana County, Pennsylvania.—In the vicinity of Bolivar and Lockport just east of the Chestnut Ridge anticlinal, Mr. Wm. G. Platt finds the following succession (Fig. 74) for these measures as given in H⁴, p. 65:

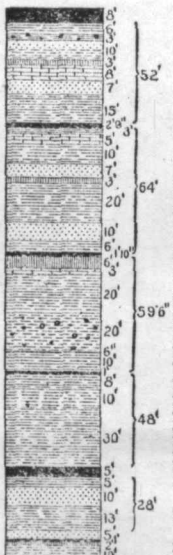


FIG. 74.—Section near Lockport and Bolivar, Pa.

Near Lockport and Bolivar, Indiana County, Pennsylvania.

			Ft.	in.
	[See map, I p.]			
1.	Coal, Upper Freeport		8	
2.	Clay shales	6		
3.	Shales, with ore masses	3		
4.	Sandstone and sandy shales	10		
5.	Fire clay, good	3	52	
6.	Limestone, impure, Upper Freeport	8		
7.	Thin bedded sandstone	7		
8.	Clay slates and shales	15		
9.	Coal, Lower Freeport		2	9
10.	Clay, impure	3		
11.	Limestone, Lower Freeport	5		
12.	Clay shales	10		
13.	Sandstone	7	64	
14.	Sandy fire clay	3		
15.	Slates and shales	20		
16.	Sandstone	10		
17.	Grayish slates	6		
18.	Coal, Upper Kittanning		1	10
19.	Fire clay, impure	6		
20.	Limestone, Johnstown cement	3		
21.	Dark slates and shales	20	59	6
22.	Sandy shales with ore nodules	20		
23.	Carbonate iron ore band	0 6		
24.	Black slates	10		
25.	Coal, Middle Kittanning		1	
26.	Slates	8		
27.	Shales	10	48	
28.	Black slate and shale	30		
29.	Coal, Lower Kittanning		5	
30.	Clay	5		
31.	Sandstone	10	28	
32.	Shales and clay slates	13		
33.	Clarion coal.... Coal..... thin; Sandstone.. 5'; Coal..... 1'		6	
34.	Fire clay		2	
35.	Shales		10	
36.	Sandstone, heavy, compact.			
	Total		2881	

Section near Laughlinstown, Pennsylvania.—In the vicinity of Laughlinstown, Westmoreland County, and 10 miles south from Bolivar, Dr. Jno. J. Stevenson (KKK, p. 135) reports the Lower Coal Measures with the following structure (Fig. 75):

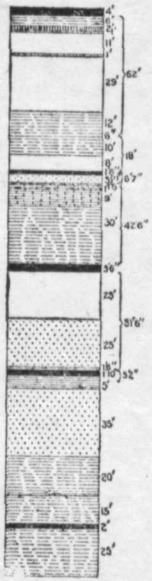


FIG. 75.—Section on Laurel Run, Pa.

Laurel Run, Ligonier Township, Westmoreland County, Pennsylvania.

	[See map, J p.]	Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			4	
2.	Clay	6			
3.	Fire clay, non-plastic	2			
4.	Sandstone	1			
5.	Concealed	11		62	
6.	Sandstone	1			
7.	Concealed	29			
8.	Shale	12			
9.	Coal, Lower Freeport			0	6
10.	Shales	10		18	
11.	Concealed	8			
12.	Coal, Upper Kittanning: Coal 1′ 6″; Shaly sandstone 5′ 0″; Coal 0′ 1″			6	7
13.	Shale	1			
14.	Limestone, Johnstown Cement: Limestone 1′ 6″; Shale 1′ 0″; Limestone 9′ 0″	11	6	42	6
15.	Shale	30			
16.	Coal, Middle Kittanning			3	6
17.	Concealed	25			
18.	Sandstone	25		51	6
19.	Shale	1	6		
20.	Coal, Lower Kittanning: Coal 1′ 10″; Clay 0′ 2″; Coal 1′ 0″; Coal, slaty 0′ 6″; Carbonaceous shale 1′ 8″			5	2
21.	Clay			5	
22.	Massive sandstone, coarse			35	
23.	Shale			20	
24.	Iron ore				
25.	Shale			15	
26.	Coal, Clarion			2	
27.	Shale			25	
28.	Top of No. XII.				
	Total			295	9

Section on Cucumber Run, Stewart Township, Fayette County, Pennsylvania.—In this same basin (Ligonier) and on southwestward near the Youghiogheny River, in Fayette County, the Lower Coal Measures exhibit the following structure (Fig. 76) on Cucumber Run, as reported by Stevenson (KKK, p. 89):

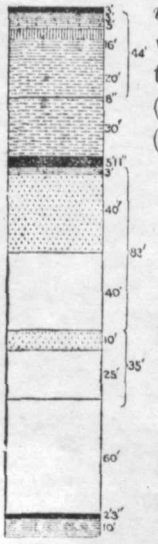


FIG. 76.—Section on Cucumber Run, Fayette County, Pa.

Cucumber Run, Stewart Township, Fayette County, Pennsylvania.

	[See map, K n.]	Ft.	Ft.	in.
1.	Coal, Upper Freeport		3	
2.	Clay	3		
3.	Limestone, Freeport	5		
4.	Fire clay, Bolivar, and shale	16	44	
5.	Shale, sandy	20		
6.	Coal, Lower Freeport (?)		0	8
7.	Shale, sandy		30	
8.	Coal, Upper Kittanning(?): Coal 2′ 3″; Clay 0′ 4″; Coal 3′ 4″		5	11
9.	Clay	3		
10.	Sandstone, Freeport(?)	40	83	
11.	Concealed (mostly sandstone)	40		
12.	Coal, Middle Kittanning		blossom	
13.	Sandstone	10	35	
14.	Concealed	25		
15.	Coal, Lower Kittanning		blossom	
16.	Concealed		60	
17.	Coal, Clarion or Brookville		2	3
18.	Shale and clay		10	
19.	Sandstone, massive, top of XII.			
	Total		273	10

Section at Newburg, West Virginia.—Newburg, on the Baltimore and Ohio Railroad, in Preston County, West Virginia, is situated at the center of the same coal basin as Bolivar, Ligonier, etc., and there a deep shaft reveals the following structure (Fig. 77) for the Lower Coal Measures:

Shaft at Newburg, Preston County, West Virginia.

[See map, O m.]

		Ft. in.	Ft. in.
1. Coal, Upper Freeport	Coal ..... 3′ / Coal and slate .. 2′ 4″		5 4
2. Shales		8	
3. Sandstone		18	
4. Limestone, Upper Freeport		8	
5. Shales		6	45
6. Iron ore		1	
7. Shales		4	
8. Fire clay (horizon of Lower Freeport coal)			2
9. Shales, gray		14	
10. Shale, dark		11	
11. Shale, gray		9	108
12. Sandstone, Freeport		74	
13. Coal, Upper and Middle Kittanning	Coal ..... 1′ 0″ / Slate ..... 0′ 3″ / Coal, slaty. 2′ 0″ / Fire clay .. 2′ 0″ / Coal, good. 2′ 0″		7 3
14. Fire clay and shales with iron ore nodules			15
15. Coal, Lower Kittanning	Coal .....0′ 10″ / Shale, gray .....0′ 10″ / Coal .....0′ 6″ / Coal, bony .....0′ 3″ / Coal, main bench .4′ 6″ / Black slate .....0′ 6″ / Coal .....2′ 0″		9 5
16. Sandstone and shale			38
17. Pebbly sandstone, top of XII.			
Total			230

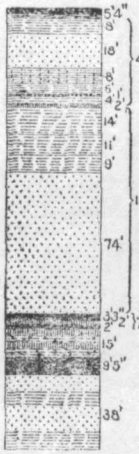


FIG. 77.—Section at Newburg, W. Va.

Here the Upper Freeport coal lies 150 feet below drainage and 700 feet below the tops of the immediate hills.

No. 13 appears to represent both the Upper and Middle Kittanning coal beds, which are brought practically together, and also very close to the Lower Kittanning bed by the thinning away of intervening rocks.

The interval under the Lower Kittanning bed here is revealed by a diamond drill hole which was put down 150 feet below the latter stratum.

The Lower Freeport coal is not present, but its horizon is clearly indicated by the bed of fire clay, No. 8, at 45 feet under the Upper Freeport coal.

The Freeport sandstone, No. 12, has a large development, and where it comes to the surface, 4 miles above Newburg, is nearly 100 feet thick.

Section at Johnstown, Pennsylvania.—Johnstown, Pennsylvania, lies just east of the Laurel Hill anticline, and the Lower Coal Measures have there been splendidly exposed through the mining operations of the Cambria Iron Company. The following section (Fig. 78) of the rocks in that region is given by the chief engineer of the Cambria Company, Mr. John Fulton (H³, pp. 308, 309):

Vicinity of Johnstown, Cambria County, Pennsylvania.

[See map, I q.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			3	0
2.	Fire clay	1			
3.	Shales	5			
4.	Sandstone	10			
5.	Shales	5			
6.	Kidney ore	0	10	54	10
7.	Shales	15			
8.	Sandstone	15			
9.	Shales	3			
10.	Coal, Lower Freeport			2	6
11.	Shale	0	6		
12.	Limestone, Lower Freeport	3			
13.	Iron-stained shales	17		45	6
14.	Sandstone, gray, micaceous	21			
15.	Slates	4			
16.	Coal, Upper Kittanning			3	6
17.	Fire clay	0	9		
18.	Limestone, Johnstown Cement	5			
19.	Fire clay, impure	7		39	9
20.	Slates, with iron ore	8			
21.	Slate	8			
22.	Black slates, with iron ore	11			
23.	Coal, Middle Kittanning (Coal 0′ 3″; Slate 1′ 0″; Coal 0′ 3″)			1	6
24.	Thin black slates	13			
25.	Coal	0	9		
26.	Fire clay	4		40	9
27.	Sandstone, gray	13			
28.	Sandstone, wavy, gray	4			
29.	Iron-stained slates	6			
30.	Coal, Lower Kittanning			3	6
31.	Fire clay	3			
32.	Gray slates and shales	21			
33.	Massive black shales	15			
34.	Gray sandstone	5			
35.	Massive black slate	5		60	0
36.	Coal, thin				
37.	Black slates	1			
38.	Gray sandstone	4			
39.	Thin gray slates	6			
40.	Coal, Clarion (Coal 4′ 6″; Slate 0′ 6″; Coal 1′ 10″)			6	10
41.	Fire clay			3	0
42.	Gray slates			28	0
43.	White massive sandstone, top of XII.				
	Total			292	8

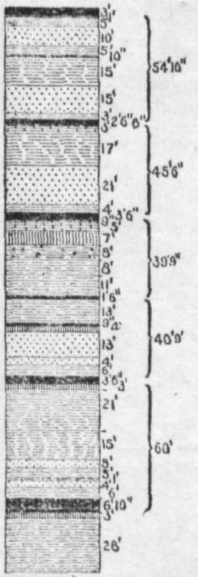


FIG. 78.—Section near Johnstown, Pa.

Section at Conemaugh, near Johnstown, Pennsylvania.—The writer compiled a section of the Lower Coal Measures at Conemaugh and elsewhere in the vicinity of Johnstown, which differs only in minor details from that of Mr. Fulton. It reads as follows (Fig. 79):

FIG. 79.—Section at Conemaugh, Pa.

Near Johnstown, Pennsylvania.

[See map, I q.]	Ft.	in.	Ft.	in.
1. Coal, Upper Freeport			3	6
2. Fire clay and sandy shales			40	
3. Coal, Lower Freeport			0	7
4. Shales and sandy beds			20	
5. Sandstone, massive			40	
6. Coal, Upper Kittanning			3	
7. Shale	0	6		
8. Limestone, Johnstown Cement: Limestone 2′ 6″; Shale and iron ore 1′ 6″; Limestone 4′ 6″	8	6	44	0
9. Dark sandy shales with iron ore	35			
10. Coal, Middle Kittanning: Coal and slate 0′ 6″; Slate 0′ 6″; Slaty coal 0′ 10″			1	10
11. Shales, drab	15			
12. Coal	1			
13. Impure fire clay	5		71	
14. Sandstone, gray micaceous	45			
15. Sandy shales	5			
16. Coal, Lower Kittanning			3	
17. Shales, sandy			30	
18. Coal, Clarion			5	
19. Fire clay			5	
20. Concealed and shales			15	
21. Top of XII.				
Total			281	11

Section in Jackson Township, Cambria County, Pennsylvania.—In Jackson Township, Cambria County, 8 miles northeast of Johnstown, a well was once drilled for oil, and I obtained from the contractor the following record (Fig. 80) of the strata representing the Lower Coal Measures. It is chiefly important as giving the total thickness of the series in a vertical measurement:

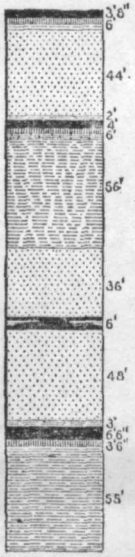


FIG. 80.—Section in Jackson Township, Cambria County, Pa.

Jackson Township, Cambria County, Pennsylvania.

[See map, I q.]

	Ft.	in.
1. Coal, Upper Freeport	3	8
2. Fire clay and slate	6	
3. Sandstone, gray	44	
4. Slate, drab	2	
5. Coal, Lower Freeport	4	
6. Fire clay and limestone	6	
7. "Soapstone" (shale)	56	
8. Sandstone, gray	36	
9. Coal and slate, Lower Kittanning	6	
10. Sandstone, gray	48	
11. Shale	3	
12. Coal, Clarion	6	6
13. Fire clay	3	6
14. Slate, gray	55	
15. Hard sandstone, top of XII.		
Total	279	8

Section on Ben's Creek, Cambria County, Pennsylvania.—Near the eastern border of Cambria County, along the waters of Ben's Creek, in Washington Township, the following section (Fig. 81) is reported by Mr. Franklin Platt (H², p. 48):

Ben's Creek, Cambria County, Pennsylvania.

[See map, I q.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			4	4
2.	Fire clay	6			
3.	Black slates and shales	15			
4.	Limestone, Upper Freeport	7		55	
5.	Interval	15			
6.	Sandstone	12			
7.	Coal, Lower Freeport: Coal 0′ 2″; Sandstone 2′ 0″; Fire clay and shale 6′ 0″; Coal 2′ 0″			10	2
8.	Fire clay	2			
9.	Limestone, Lower Freeport	2	6		
10.	Shales, iron-bearing	15			
11.	Coal, smut	0	2		
12.	Fire clay, shales, with ore balls	5		38	11
13.	Coal, smut	0	3		
14.	Fire clay	1			
15.	Slates and shales	6			
16.	Black slates	7			
17.	Coal, Upper Kittanning			2	6
18.	Fire clay	1	9		
19.	Drab shales	25			
20.	Sandstone, fine grained	30		56	9
21.	Black slate	0	3		
22.	Coal, slaty, Middle Kittanning			2	
23.	Fire clay				
24.	Sandstone	5			
25.	Fire clay, shale	10		20	
26.	Black slate	5			
27.	Coal, Lower Kittanning			3	
28.	Sandstone and shale			18	
29.	Coal, Clarion			5	
30.	Fire clay	5			
31.	Sandstone	0	10		
32.	Dove-colored shale, with ore	10		20	10
33.	Sandstone	3			
34.	Fire clay, shale	2			
35.	Coal, Brookville			1	8
36.	Fire clay				
37.	Concealed			25	
38.	Top of XII.				
	Total			263	2

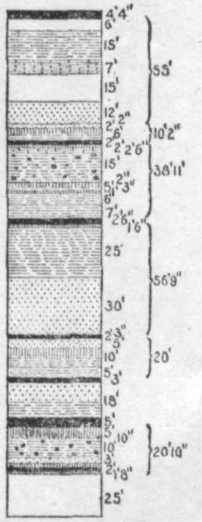


FIG. 81.—Section on Ben's Creek, Cambria County, Pa.

Section near Stoyestown, Pennsylvania.—In the vicinity of Stoyestown, on Stony Creek, Somerset County, Pennsylvania, near the center of the basin between the Viaduct and Negro Mountain anticlines, the series exhibits the following structure (Fig. 82) according to Mr. Franklin Platt (H³, p. 129):

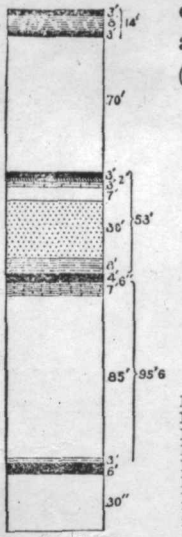


FIG. 82.—Section near Stoyestown, Pa.

Stoyestown, Somerset County, Pennsylvania.

[See map, J q.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport: Coal 3′, Shale 8′, Coal 3′			14	
2.	Interval			70	
3.	Black slates			?	
4.	Coal, Lower Freeport	3			
5.	Fire clay	2			
6.	Limestone, Lower Freeport	3		53	
7.	Interval	7			
8.	Sandstone, massive	30			
9.	Black slates	8			
10.	Coal, Upper Kittanning			4	
11.	Black slate	0	6		
12.	Limestone, Johnstown Cement	7			
13.	Fire clay	?		95	6
14.	Interval	85			
15.	Black slates	3			
16.	Coal, Clarion			6	
17.	Interval, concealed			30	
18.	Top of No. XII.				
	Total			272	6

Section at Pinkerton Point, Pennsylvania.—On the Castleman River at Pinkerton Point, in the southern portion of Somerset County, a very complete section of the Lower Coal Measures was obtained by Mr. Franklin Platt along the Baltimore and Ohio Railroad, near Shoo Fly Tunnel, and is reported as follows (Fig. 83) (H³, pp. 202, 203):

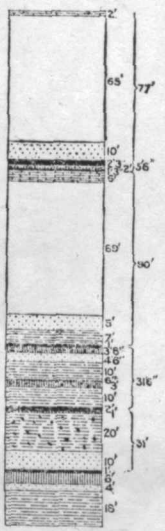


FIG. 83.—Section at Pinkerton Point, Somerset County, Pa.

Pinkerton Point, Somerset County, Pennsylvania.

[See map, L o.]

		Ft.	in.	Ft.	in.
1.	Upper Freeport Coal (absent)				
2.	Limestone, ferruginous, Upper Freeport	2		77	
3.	Interval	65			
4.	Sandstone	10			
5.	Coal, Upper Kittanning: Coal 2′ 3″, Shale and fire clay 2′ 0″, Coal 1′ 3″			5	6
6.	Limestone, Johnstown Cement	6		90	
7.	Interval	69			
8.	Sandstone	8			
9.	Black slate	7			
10.	Coal, Middle Kittanning			1	
11.	Fire clay, with ore	3	6	31	6
12.	Sandstone	4	6		
13.	Black slates	10			
14.	Coal	0	6		
15.	Fire clay with iron-ore balls	3			
16.	Slate and clay	10			
17.	Coal, Lower Kittanning			2	
18.	Fire clay	1		31	
19.	Shales, with ore balls	20			
20.	Sandstone, brownish	10			
21.	Coal, Clarion			1	
22.	Fire clay			6	
23.	Sandstone			4	
24.	Slates, dark colored			18	
25.	Massive sandstone, top of No. XII.				
	Total			267	

Section near Cresson, Pennsylvania.—An oil boring near Cresson, on the summit of the Alleghany Mountains, gives the following measurements (Fig. 84) for the Lower Coal Measures (H² page 30):

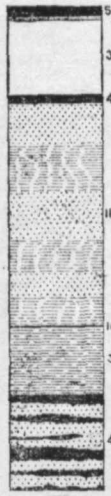


FIG. 84.—Section near Cresson, Pa.

Boring at Cresson, Cambria County, Pennsylvania.

[See map, II r.]

	Ft.	in.
1. Coal, Upper Freeport	5	
2. Limestone, Upper Freeport	2	
3. Mixed drilling	39	
4. Coal, Lower Freeport	4	
5. Shelly "soapstone" (sandstones and shales)	115	
6. Cannel coal	0	10
7. Slate	35	
8. Coal, mixed with sandstone	49	
9. Hard sandstone (No. XII).		
Total	249	10

Section at Bennington, Pennsylvania.—Just over the crest of the Alleghany Mountains, at Bennington, Blair County, the following section (Fig. 85) of this series has been carefully worked out by Mr. John Fulton and Franklin Platt (H², pp. 3, 4):

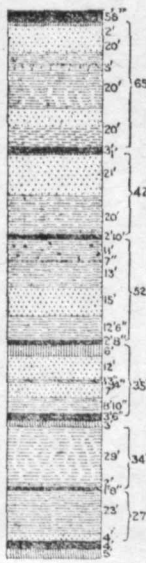


FIG. 85.—Section at Bennington, Pa.

Bennington, Blair County, Pennsylvania.

[See map, II r.]

	Ft.	in.	Ft.	in.
1. Coal, Upper Freeport			5	6
2. Fire clay, impure	2			
3. Sandstones and black slates	20			
4. Limestone, Upper Freeport	3		65	
5. Ferruginous slates and shales	20			
6. Sandstones and sandy shales	20			
7. Coal			3	
8. Fire clay	1			
9. Sandstone, drab	21		42	
10. Black slates	20			
11. Coal, Upper Kittanning			2	10
12. Drab slates, with iron balls	11			
13. Sandstone	0	7		
14. Blue slates	13		52	1
15. Sandstone, massive	15			
16. Slates	12	6		
17. Coal, Middle Kittanning: Coal 0′ 6″; Slate 0′ 6″; Coal 1′ 8″			2	8
18. Fire clay, impure	6			
19. Sandstone	12			
20. Slate	1	3	35	5
21. Coal	0	4		
22. Sandstone	7			
23. Black slates	8	10		
24. Coal, Lower Kittanning			3	6
25. Fire clay, good	3			
26. Shales	29		34	
27. Black slates	2			
28. Coal, Clarion			1	8
29. Slates	23		27	
30. Gray sandstone	4			
31. Coal, Brookville			4	
32. Fire clay			5	
33. Sandstone, massive, No. XII.				
Total			283	8

Section at Clearfield, Pennsylvania.—At the town of Clearfield, Clearfield County, Pennsylvania, the following section (Fig. 86) was made by the writer:

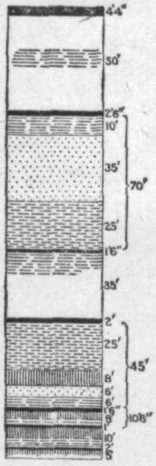


FIG. 86.—Section at Clearfield, Pa.

Clearfield, Pennsylvania.

[See map, E s.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport: Coal, bony 1′ 3″; Coal, good 1′ 6″; Slate 0′ 1″; Coal 1′ 6″		4	4
2.	Concealed, and shales		50	
3.	Coal, Lower Freeport		2	6
4.	Shales	10		
5.	Sandstone, massive, gray, Freeport	35	70	
6.	Shales, sandy	25		
7.	Coal, Middle Kittanning		1	6
8.	Shales, and concealed		35	
9.	Coal, Lower Kittanning		2	
10.	Sandy shales	25		
11.	Fire clay	8	45	
12.	Sandstone, flaggy	6		
13.	Shales, dark	6		
14.	Coal, Clarion: Coal, slaty 1′ 6″; Fire clay and shales 8′ 0″; Coal, good 1′ 0″		10	6
15.	Fire clay and shales		10	
16.	Coal, Brookville: Coal, slaty 0′ 4″; Shale 0′ 12″; Coal 0′ 8″		2	
17.	Fire clay and concealed		5	
18.	Hard massive sandstone, top of No. XII, in bed of Susquehanna River.			
	Total		237	10

Section near Morrisdale, Pennsylvania.—Near Morrisdale, Clearfield County, the following section (Fig. 87) is reported by Mr. H. Martyn Chance (H[7], p. 61):

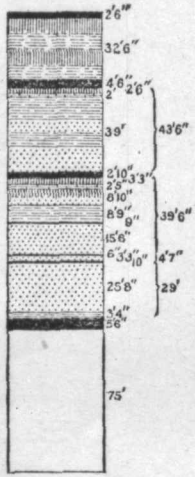


FIG. 87.—Section near Morrisdale, Pa.

Near Morrisdale, Clearfield County, Pennsylvania.

[See map, F t.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			2	6
2.	Fire clay and shales			32	6
3.	Coal, Lower Freeport			4	6
4.	Fire clay	2	6		
5.	Limestone, Lower Freeport	2		43	6
6.	Slate and sandstone	39			
7.	Coal, Upper Kittanning			2	10
8.	Fire clay	3	3		
9.	Limestone, Johnstown Cement	2	5		
10.	Fire clay and sandstone with iron ore	8	10	39	6
11.	Black slate	8	9		
12.	Coal	0	9		
13.	Sandstone	15	6		
14.	Coal, Middle Kittanning: Coal 0′ 6″; Sandstone 3′ 3″; Coal 0′ 10″			4	7
15.	Sandstone	25	8	29	
16.	Slate	3	4		
17.	Coal, Lower Kittanning			5	6
18.	Interval to top of No. XII, estimated, about			75	
	Total			239	5

Section at Sterling Mines, near Houtzdale, Pennsylvania.—At the Sterling mines of R. H. Powell's Sons & Co., Clearfield County, a diamond-drill boring was sunk through the Lower Coal Measures, beginning 10 feet below the level of the main coal mined in that region. I copied the record of this bore hole from the office of the company, and it, combined with the surface exposures, gives the following succession (Fig. 88):

Boring at Sterling Mines, near Houtzdale, Clearfield County, Pennsylvania.

[See map, G s.]

		Ft.	Ft.	in.
1. Coal, Upper Freeport	Bone coal 0′ 10″; Coal, sometimes a thin slate in center 4′ 6″		5	4
2. Concealed		10		
3. Surface material in drill hole		16	42	
4. Dark slate		16		
5. Coal, Lower Freeport	Black shale and coal 1′ 6″; Shale, sandstone, and slate 8′ 6″; Soft shale 1′ 0″; Sandstone 1′ 0″; Coal 1′ 0″		13	
6. Sandy shale		5		
7. Hard sandstone, Freeport		31	50	
8. Dark slate		14		
9. Coal, Upper Kittanning			3	
10. Fire clay		2	33	
11. Dark slate		31		
12. Coal, Middle Kittanning			1	
13. Slate		3		
14. Sandy shale		9	19	
15. Slate		7		
16. Coal, Lower Kittanning			4	
17. Fire clay		1		
18. Slate		9	63	
19. Sandstone, close, hard		32		
20. Shales		21		
21. Coal, Clarion			3	6
22. Hard slate			4	6
Total			241	4

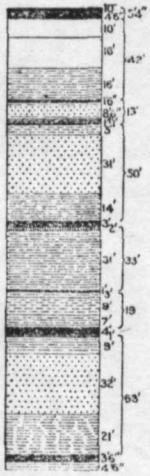


FIG. 88.—Section at Sterling Mines, near Houtzdale, Pa.

The coal at the top of this last section has been identified as the Lower Freeport bed, throughout the Clearfield region, by Messrs. Platt, Chance, and other Pennsylvania geologists; but it seems to me that this section, taken in connection with the one at Clearfield (Fig. 86), tends to prove that the coal in question is the Upper Freeport. This interpretation is further confirmed by the presence of the Lower Mahoning sandstone on above No. 1, and a thin coal, the Mahoning bed, at 60 to 80 feet above the latter, while crowning the hills is the Upper Mahoning sandstone, whose top is 100 feet above No. 1. Then, too, the structure of the coal itself is the same as the Upper Freeport, a few miles distant, where it is mined along the Pennsylvania Railroad, in the edge of Blair County.

Section at Shoup's Run, Broad Top Basin, Huntingdon County, Pennsylvania.—In the Broad Top coal basin, Shoup's Run, Huntingdon County, Pennsylvania, the Lower Coal Measures exhibit the following structure (Fig. 89), as given by the writer in T³, Geological Survey of Pennsylvania, page 46:

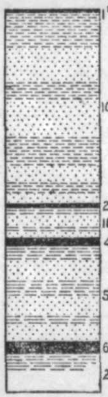


FIG. 89.—Section at Shoup's Run, Broad Top Basin, Huntingdon County, Pa.

Shoup's Run, Broad Top Basin, Huntingdon County, Pennsylvania.

[See map, J t.]

		Ft.
1.	Coal, Upper Freeport	1
2.	Sandy shales and sandstone	100
3.	Coal, Upper Kittanning	2
4.	Shales and sandstone	16
5.	Coal, Middle Kittanning	4
6.	Shales and shaly sandstone	50
7.	Coal, Lower Kittanning	6
8.	Shales and concealed	20
9.	Massive conglomerate.	
	Total	199

Section in East Broad Top Basin, Huntingdon County, Pennsylvania.—In the East Broad Top region of Huntingdon County the structure is thus (Fig. 90) given by Mr. H. N. Sims (T³, p. 68):

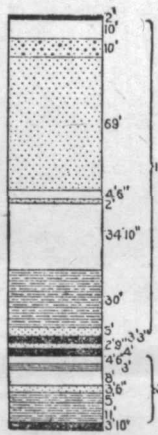


FIG. 90.—Section in East Broad Top Basin, Huntingdon County, Pa.

East Broad Top Basin, Huntingdon County, Pennsylvania.

[See map, J t.]

		Ft.	in.	Ft.	in.
1.	Coal and slate, Upper Freeport			2	
2.	Concealed	10			
3.	Conglomerate, small pebbles	10			
4.	Massive, light gray, pebbly sandstone, slightly argillaceous at top	69			
5.	Concealed	4	6	165	4
6.	Sandstone, micaceous	2			
7.	Concealed to top of shaft	34	10		
8.	Dark gray slate with iron ore balls	30			
9.	Sandstone, micaceous, dark gray	5			
10.	Coal, Upper Kittanning: Coal 2′ 7″; Black slate 0′ 5″; Coal 0′ 3″			3	3
11.	Sandstone, slaty			2	9
12.	Coal, Middle Kittanning			4	
13.	Concealed	4	6		
14.	Blue clay shales	3			
15.	Concealed	8			
16.	Yellow shaly sandstone	3	6	35	
17.	Dark gray sandy slate	5			
18.	Black slate, sandy	11			
19.	Coal, Lower Kittanning: Coal, top bench 1′ 6″; Hard slate, parting 0′ 4″; Coal, bottom bench 2′ 0″			3	10
	Total			216	2

Section in Broad Top Basin, Bedford County, Pennsylvania.—In the Broad Top Basin of Bedford County, Pennsylvania, the structure is thus (Fig. 91) given by Stevenson (T[3], pp. 59 and 60):

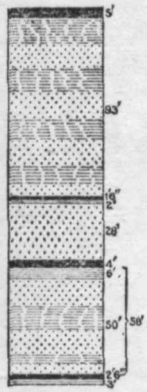


FIG. 91.—Section in Broad Top Basin, Pa.

Broad Top Basin, Bedford County, Pennsylvania.

[See map, J t.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport		5	
2.	Shales and sandstones		93	
3.	Coal, Upper Kittanning		1	6
4.	Clay		2	
5.	Sandstone		28	
6.	Coal, Middle Kittanning		4	
7.	Clay	6	56	
8.	Sandstone and shale	50		
9.	Coal, Lower Kittanning		2	6
10.	Clay		3	
11.	No. XII, conglomerate.			
	Total		195	

Section at Piedmont, West Virginia.—In the vicinity of Westernport, Maryland, where the North Potomac cuts across the Cumberland or George's Creek coal basin, the Lower Coal Measures exhibit the following succession (Fig. 92):

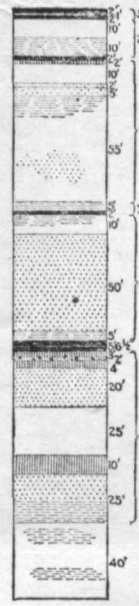


FIG. 92.—Section at Piedmont, W. Va.

Piedmont, Mineral County, West Virginia.

[See map, N p.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport: Coal 2′; Shale and bone 1′; Coal 2′		5	
2.	Concealed	10	20	
3.	Shale, bluish	10		
4.	Coal, Lower Freeport		2	
5.	Fire clay	2	74	
6.	Concealed	10		
7.	Sandstone, hard	2		
8.	Sandstone, shaly	5		
9.	Shales, sandstone, and concealed	55		
10.	Coal, Upper Kittanning: Bituminous slate 5′; Coal 2′		7	
11.	Dark shales, and concealed	10	65	
12.	Massive sandstone, gray	50		
13.	Shales, drab	5		
14.	Coal, Lower Kittanning: Coal, slaty 1′ 0″; Coal, bony 0′ 8″; Coal, good 1′ 4″; Slate, hard 0′ 1″; Coal, good 2′ 6″		5	6½
15.	Fire clay, sandy	3	89	
16.	Shales, with nodular iron ore	2		
17.	Fire clay, impure	4		
18.	Flaggy sandstone	20		
19.	Concealed	25		
20.	Fire clay, sandy	10		
21.	Flaggy sandstone and sandy shales	25		
22.	Concealed, and sandy shales		40	
23.	Top of No. XII.			
	Total		307	6½

Section near Maple Swamp water tank, West Virginia Central Railroad, Mineral County, West Virginia.—Near Maple Swamp water tank, on the West Virginia Central Railroad, Mineral County, West Virginia, these beds exhibit the following structure (Fig. 93):

FIG. 93.—On North Potomac at Maple Swamp Water Tank, West Virginia Central Railroad.

On North Potomac at Maple Swamp water tank, West Virginia Central Railroad.

[See map, N p.]

		Ft.	in.
1. Coal, Upper Freeport	Coal 0′ 5″; Bone and slate 1′ 4″; Coal 2′ 6″	4	3
2. Concealed		60	
3. Coal, Lower Freeport		1	2
4. Concealed		55	
5. Coal, Upper Kittanning		1	
6. Concealed, and slate		45	
7. Coal, Lower Kittanning	Coal 3′ 0″; Slate 2′ 0″; Coal 1′ 5″	6	5
8. Concealed, and sandstone		85	
9. Coal, Clarion		2	6
10. Shales, and concealed		45	
11. Massive sandstone, top of No. XII.			
Total		305	4

Section near Thomas, West Virginia.—At the head of the North Potomac and on the Cheat River side of the great Alleghany watershed, we get a fine exposure of the Lower Coal Measures in the vicinity of Thomas, Tucker County, West Virginia. The exposures have been made by the mining and grading operations of the West Virginia Central Railroad, and there the section reads as follows (Fig. 94):

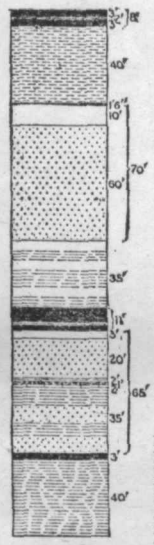


FIG. 94.—Near Thomas, Tucker County, W. Va.

Near Thomas, Tucker County, West Virginia.

[See map, O o.]

		Ft.	Ft.	in.
1. Coal, Upper Freeport	Coal 3′; Bone and bony coal 2″; Coal 3′		8	
2. Sandy shales, weathering reddish			40	
3. Coal, Lower Freeport	Coal 2″; Shale 4′; Coal 12″		1	6
4. Concealed		10	70	
5. Massive pebbly sandstone, Freeport		60		
6. Coal, streak, Upper Kittanning				
7. Fire clay and shales			35	
8. Coal, Middle and Lower Kittanning	Coal, good 1′ 5″; Slate 0′ 4″; Coal, good 1′ 0″; Slate 0′ 3″; Coal, good 3′ 6″; Shale, gray 1′ 6″; Coal, slaty 3′ 0″		11	
9. Concealed		5		
10. Massive sandstone		20		
11. Shales		2		
12. Iron ore, buhrstone		1	65	
13. Limestone, ferriferous		2		
14. Shales and sandstone		35		
15. Coal, Clarion			3	
16. Shales			40	
17. Sandstone, top of No. XII.				
Total			273	6

Section near Moatsville, Barbour County, West Virginia.—Near Moatsville, Barbour County, West Virginia, on the Tygart's Valley River, the following section of the Lower Coal Measures is exposed (Fig. 95):

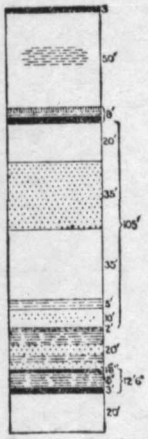


FIG. 95.—Section near Moatsville, W. Va.

Near Moatsville, Barbour County, West Virginia.

	Ft.	Ft.	in.
[See map, O m.]			
1. Coal, Upper Freeport		3	
2. Concealed, and sandy shales		50	
3. Coal, Lower Freeport.. Slaty coal and slate 0′ 6″; Shale and fire clay.. 4′ 0″; Coal 2′ 0″; Dark bony clay 0′ 3″; Coal 1′ 3″		8	
4. Concealed	20		
5. Sandstone, massive, gray	35		
6. Concealed	35	105	
7. Dark blue shale	5		
8. Flaggy sandstone and concealed	10		
9. Limestone, gray, Campbell's Creek		2	
10. Shales, and massive sandstone		20	
11. Coal, Lower Kittanning.... Coal... 1′ 6″; Shales. 8′ 0″; Coal... 3′ 0″		12	6
12. Concealed		20	
13. White pebbly sandstone, top of No. XII.			
Total		220	6

Section near Valley Falls, West Virginia.—In the vicinity of Valley Falls, Taylor County, West Virginia, where the Chestnut Ridge anticline brings the series above water level, the following succession is visible (Fig. 96):

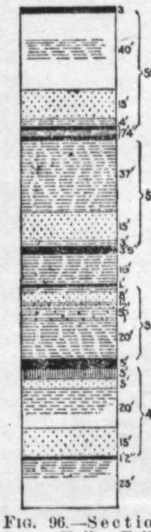


FIG. 96.—Section near Valley Falls, W. Va.

Valley Falls, Taylor County, West Virginia.

	Ft.	Ft.	in.
[See map, N 1.]			
1. Coal, Upper Freeport		3	
2. Concealed and shales	40		
3. Sandstone	15	59	
4. Blue shales	4		
5. Coal, Lower Freeport.. Coal 0′ 3″; Slate, gray 0′ 6″; Coal 1′ 3″; Shale 2′ 11″; Coal, bony cannel. 0′ 6″; Shale, gray 0′ 8″; Coal 1′ 3″		7	4
6. Dark shales	37		
7. Sandstone, Freeport	15	55	
8. Shales, blue	3		
9. Coal, Upper Kittanning.. Coal 3′ 1″; Shale, gray. 0′ 1″; Coal, bony.. 0′ 7″		3	9
10. Shales, dark grayish		16	
11. Coal, Middle Kittanning		1	
12. Shales and flaggy sandstone	8		
13. Limestone, siliceous	1		
14. Sandstone, flaggy	2	37	
15. Shales, containing iron ore nodules	5		
16. Limestone, dark blue, Campbell's Creek	1		
17. Shales	20		
18. Coal, Lower Kittanning		5	
19. Fire clay	5		
20. Sandstone, flaggy	20	45	
21. Sandy shales, and concealed	20		
22. Sandstone, hard, micaceous	15		
23. Coal, Clarion.. Coal.. 0′ 2″; Shale. 0′ 10″; Coal.. 0′ 2″		1	2
24. Shales, and concealed		25	
25. Sandstone, massive, top of No. XII.			
Total		258	3

In this last section, and also in the preceding one (Fig. 95), a bed of impure, siliceous limestone occurs in the shale interval above the Lower

Kittanning coal. It occupies the same geological horizon as the thin, siliceous limestone above the Campbell's Creek (Lower Kittanning) coal on the Big Kanawha River, and hence I have identified it with that stratum.

Section near Nuzum's Mill, Marion County, West Virginia.—Farther down the stream (Tygart's Valley River) the following structure (Fig. 97) was observed on the right bank, below Nuzum's Mill, Marion County, West Virginia:

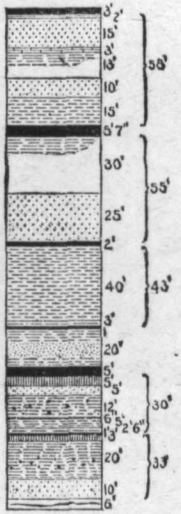


FIG. 97.—Section near Nuzum's Mill, Marion County, W. Va.

Near Nuzum's Mill, Marion County, West Virginia.

[See map, N l.]

	Ft.	in.	Ft.	in.
1. Coal, Upper Freeport			3	
2. Clay	2			
3. Sandstone	15			
4. Limestone, Upper Freeport	3		58	
5. Shales and concealed	13			
6. Sandstone, coarse	10			
7. Shales, sandy, drab	15			
8. Coal, Lower Freeport			5	7
9. Shales and concealed	39		55	
10. Massive sandstone, Freeport	25			
11. Coal, Upper Kittanning			2	
12. Shales, dark, sandy, with limy beds	40		43	
13. Black slate	3			
14. Coal, slaty, Middle Kittanning			1	
15. Shales and sandy beds			20	
16. Coal, Lower Kittanning			5	
17. Fire clay	5			
18. Sandstone, flaggy	5			
19. Dark shales with iron ore nodules	12		30	
20. Iron ore, Ferriferous limestone horizon	0	6		
21. Dark shales	5			
22. Black slate	2	6		
23. Coal, Clarion			0	1
24. Fire clay, sandy	3		33	
25. Dark shales, with iron ore nuggets near middle	20			
26. Flaggy sandstone	10			
27. Concealed and coal blossom, Brookville			6	
28. No. XII, conglomerate.				
Total			261	8

Section under Clarksburg, West Virginia.—From the records of the Despard gas well boring, at Clarksburg, Harrison County, West Virginia, as furnished by T. M. Jackson, civil engineer, we get the structure of the Lower Coal Measures there, as follows (Fig. 98):

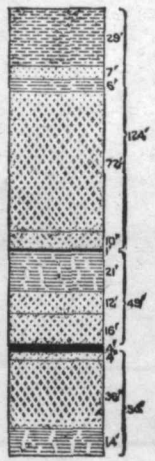


FIG. 98.—Section under Clarksburg, W. Va.

Under Clarksburg, West Virginia.

[See map, O k.]

	Ft.	Ft.
1. Upper Freeport coal		absent
2. Shales, sandy	29	
3. Sandstone, white	7	
4. Shales	6	124
5. Sandstone, white, Freeport	72	
6. Sandstone, dark	10	
7. Coal, Middle Kittanning		1
8. Shale, black	21	
9. Sandstone, gray	12	49
10. Sandstone, white	16	
11. Coal, with slate, Lower Kittanning		4
12. Sandstone, hard, gray	4	
13. Sandstone, hard, white	36	54
14. Shale	14	
15. Top of No. XII, white sandstone.		
Total		232

The Lower Kittanning bed is here more than 1,000 feet below the summits of the hills.

Section under Parkersburg, West Virginia.—At Parkersburg, Wood County, West Virginia, the following structure (Fig. 99) is given by the record of the Camden Consolidated Oil Company's drill hole, on the authority of R. A. Cole, superintendent:

FIG. 99.—Section under Parkersburg, W. Va.

Under Parkersburg, West Virginia.

[See map, N f.]	Ft.
1. Upper Freeport coal	absent
2. Shales, gray and black	170
3. Coal, Lower Kittanning	7
4. Shales, gray	98
5. Top of No. XII.	
Total	275

The Lower Kittanning bed is the only one in the series here, but it has a good thickness, though lying 1,100 feet below the bed of the Ohio River, and 1,500 feet under the surface of the hill summits.

Section under Wheeling, West Virginia.—Under Wheeling, West Virginia, where the top of the series is more than 400 feet below water level, the record of the Central Glass Company's drill hole for gas gives the following structure (Fig. 100):

FIG. 100.—Section under Wheeling, W. Va.

Under Wheeling, West Virginia.

[See map, K j.]	Ft.
1. Coal, Upper Freeport—556 feet under Pittsburg coal and 450 feet under Ohio River level	7
2. Sandstone and shales	96
3. Coal, Upper Kittanning	5
4. Shales and sandstone	112
5. Top of No. XII.	
Total	220

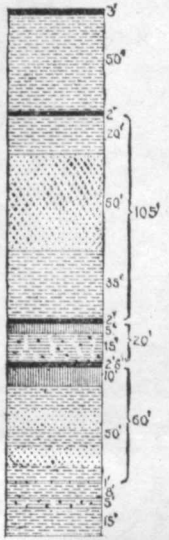


FIG. 101.—Section at mouth of Little Beaver.

Section at mouth of Little Beaver, on the Pennsylvania-Ohio State line.—At the mouth of Little Beaver, on the Pennsylvania-Ohio State line, and the northern point of the West Virginia "Pan-Handle," the structure is as follows (Fig. 101):

Ohio and Pennsylvania line, mouth of Little Beaver.

[See map, G j.]	Ft.	Ft.	In.
1. Coal, Upper Freeport		3	
2. Sandy shales		50	
3. Coal, Lower Freeport		2	
4. Sandy shales	20		
5. Sandstone, massive	50	105	
6. Sandy shales	35		
7. Coal, Middle Kittanning		2	
8. Fire clay	5	20	
9. Shales, containing nodules of iron ore	15		
10. Coal, Lower Kittanning		2	6
11. Fire clay	10	60	
12. Sandy shales and shaly sandstone	50		
13. Limestone, Ferriferous		1	
14. Sandy shales		8	
15. Bituminous shale, Clarion coal		5	
16. Shales, sandy		15	
17. Massive sandstone, top of No. XII.			
Total		273	6

Section near Sprucevale, Columbiana County, Ohio.—Northward up the Little Beaver the column of rocks is very much the same as at the Ohio River, as may be seen from the following section (Fig. 102) taken near Sprucevale, Columbiana County, Ohio:

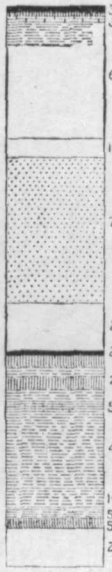


FIG. 102.—Section near Sprucevale, Columbiana County, Ohio.

Near Sprucevale, Columbiana County, Ohio.

[See map, G j.]

		Ft.	Ft.
1.	Coal, Upper Freeport		3
2.	Fire clay		2
3.	Limestone, Upper Freeport		3
4.	Shales, and concealed		60
5.	Coal, Lower Freeport	blossom	
6.	Concealed		10
7.	Sandstone, massive, Freeport		75
8.	Coal, Middle Kittanning	thin	
9.	Concealed		25
10.	Coal, Lower Kittanning		2
11.	Fire clay and shales		25
12.	Limestone, siliceous, Upper Ferriferous		5
13.	Shales, gray	40	50
14.	Shales, dark	10	
15.	Limestone { Lower Ferriferous / Putnam Hill }		1
16.	Coaly shales, Clarion		5
17.	Fire clay		5
18.	Concealed, to top of No. XII		20
	Total		291

Here we get the beginning of an important feature in Ohio Lower Coal Measure stratigraphy, viz: a duplication of the Ferriferous limestone. The lower bed, No. 15, occupies the regular horizon of the Pennsylvania "Ferriferous" bed, but there comes in above it here a stratum, No. 12, of siliceous limestone, not seen anywhere in Pennsylvania, but becoming the ore-bearing limestone of the Ohio series, and known as the "Gray" limestone, the ore on its top being of the same character as the Buhrstone ore of Pennsylvania and apparently identical with it.

Prof. Orton, director of the Ohio Geological Survey, thinks that on entering Ohio the Great Ferriferous limestone of Pennsylvania splits into two portions, the upper part representing the "Gray" limestone and the lower or blue portion of the Ferriferous representing the "Putnam Hill" bed of Ohio. This seems to be the most probable view of the matter, though it is barely possible that the lower or Putnam Hill stratum is an entirely new deposit, and has no representative in Pennsylvania, or this may be true with reference to the upper limestone, No. 12.

Section between New Lisbon and Leetonia, Ohio.—In going northwestward from Sprucevale, a very rapid change takes place in the lower portion of the column, since it rapidly contracts, as will be seen from the following section (Fig. 103), made in the vicinity of the cement works, between New Lisbon and Leetonia, Ohio:

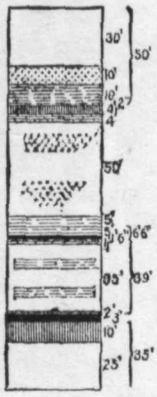


FIG. 103.—Section between New Lisbon and Leetonia, Ohio.

Between New Lisbon and Leetonia, Ohio.

	[See map, G i.]	Ft.	Ft.	in.
1.	Coal, Upper Freeport (not seen)			
2.	Concealed	30		
3.	Sandstone	10	50	
4.	Shales, chocolate	10		
5.	Coal, Lower Freeport		0	2
6.	Fire clay		4	
7.	Limestone, Lower Freeport		4	
8.	Concealed, and sandstone		50	
9.	Shales		5	
10.	Coal, Lower Kittanning—Cannel slate 5′ 0″; Coal 1′ 6″		6	6
11.	Slate	1		
12.	Limestone and iron ore, Upper Ferriferous	1		
13.	Concealed, and shales	35	39	
14.	Limestone, fossiliferous—Lower Ferriferous; Putnam Hill	2		
15.	Coal, Clarion		3	
16.	Fire clay	10		
17.	Interval to top of No. XII	25	35	
	Total		196	8

Section near Zanesville, Ohio.—In the vicinity of Zanesville, Muskingum County, Ohio, the section of the Lower Coal Measures reads as follows (Fig. 104), at the type locality of the Putnam Hill limestone (Vol. V, Ohio Geology, p. 96):

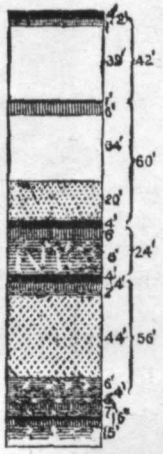


FIG. 104.—Section near Zanesville, Ohio.

Zanesville, Muskingum County, Ohio.

	[See map, K e.]	Ft.	Ft.	in.
1.	Coal, Upper Freeport		4	
2.	Fire clay	2		
3.	Limestone, Upper Freeport	1	42	
4.	Concealed	39		
5.	Coal, Lower Freeport		1	
6.	Fire clay	6		
7.	Concealed	34	60	
8.	Sandstone, Freeport	20		
9.	Coal, Middle Kittanning		4	
10.	Fire clay	6		
11.	Shales, with ore nodules	18	24	
12.	Coal, Lower Kittanning		4	
13.	Fire clay	4		
14.	Limestone, Upper Ferriferous	2	56	
15.	Sandstone	44		
16.	Shales	6		
17.	Limestone—Lower Ferriferous; Putnam Hill		4	
18.	Shales, dark		3	
19.	Coal	thin		
20.	Fire clay and dark shales		7	
21.	Coal, Clarion		1	6
22.	Fire clay, shales, and concealed, to base of Lower Coal Measures		15	
	Total		225	6

Section near Shawnee and McCuneville, Ohio.—In the vicinity of Shawnee and McCuneville, Perry County, Ohio, these beds exhibit the following structure (Fig. 105):

Vicinity of Shawnee and McCuneville, Perry County, Ohio.

[See map, M d.]

		Ft.	in.
1.	Coal, Upper Freeport (not seen)		
2.	Fire clay and shales containing "Buchtel" ore	15	
3.	Limestone, Upper Freeport	2	6
4.	Shales, and concealed	25	
5.	Coal, Lower Freeport	1	6
6.	Clay, with iron ore	10	
7.	Concealed, and shales	25	
8.	Coal, Middle Kittanning: Coal 2′ 0″; "Mother" coal 0′ 4″; Coal 4′ 0″; Bony coal 0′ 6″; Slate, dark gray 0′ 3″; Coal 1′ 6″; Slate 0′ 1″; Coal 3′ 0″	10	8
9.	Clay, with calcareous ore	10	
10.	Concealed, and shales	20	
11.	Coal, Lower Kittanning		
12.	Clay	5	
13.	Ferriferous ore and flint	1	
14.	Sandy shales	40	
15.	Limestone: Lower Ferriferous / Putnam Hill	1	
16.	Fire clay	10	
17.	Massive sandstone, top of No. XII.		
	Total	176	8

FIG. 105.—Vicinity of Shawnee and McCuneville, Perry County, Ohio.

Section near Buchtel, Ohio.—In the vicinity of Buchtel, at the line of Hocking and Athens Counties, the Lower Coal Measures exhibit this structure (Fig. 106):

Hocking Valley, near Buchtel, Athens County, Ohio.

[See map, N c.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport: Coal, slaty 1′ 3″; Shale 0′ 3″; Coal 1′ 3″; Shale 0′ 3″; Coal 1′ 3″; Shale 0′ 3″; Coal 1′ 3″		5	9
2.	Fire clay and shale	5		
3.	Limestone, Freeport	5	50	
4.	Concealed, and shales	40		
5.	Coal, Lower Freeport: Coal 1′ 6″; Slate 0′ 1″; Coal 1′ 6″		3	1
6.	Concealed		30	
7.	Coal, Middle Kittanning: Bone coal 0′ 6″; Coal 2′ 0″; Slate 0′ 3″; Coal 1′ 9″; Slate 0′ 1″; Coal 1′ 6″		6	1
8.	Concealed		30	
9.	Coal, Lower Kittanning		1	
10.	Concealed		10	
11.	Iron ore		1	
12.	Limestone, Ferriferous		2	
13.	Interval to top of No. XII		40	
	Total		178	11

FIG. 106.—Hocking Valley, near Buchtel, Athens County, Ohio.

Section on Meeker's Run, near Nelsonville, Ohio.—On Meeker's Run, near Nelsonville, Athens County, Ohio, the structure of the Lower Coal Measures is thus (Fig. 107) given by Prof. Orton in Vol. III, Ohio Geology, page 926:

On Meeker's Run, near Nelsonville, Athens County, Ohio.

[See map, N c.]

		Ft.	in.
1.	Coal, Upper Freeport	4	
2.	Fire clay	3	
3.	Shales	5	9
4.	Buchtel ore	1	3
5.	Shales	6	
6.	Straitsville ore	1	
7.	Shawnee or Buff limestone (Upper Freeport)	2	6
8.	Sandstone	14	6
9.	Coal, Lower Freeport	1	0
10.	Shales	4	0
11.	Limestone, Lower Freeport — Ore 0′ 6″; Limestone 1′ 0″	1	6
12.	Sandstone	12	6
13.	Coal, Upper Kittanning	3	
14.	Fire clay	1	6
15.	Sandstone	15	6
16.	Shale	3	6
17.	Coal — Middle Kittanning, Nelsonville seam	6	11
18.	Fire clay	3	
19.	Shale	5	
20.	Snowfork ore	0	8
21.	Sandstone	27	
22.	Coal, Lower Kittanning	2	
23.	Fire clay	4	
24.	Shales	6	
25.	Place for Baird ore		
26.	Place for Gray limestone		
27.	Interval to No. XII sandstone	30	
	Total	165	1

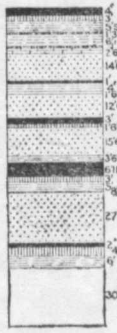


FIG. 107.—Section on Meeker's Run, Athens County, Ohio.

Section at Panther Hill, Scioto County, Ohio.—Farther to the southwest, in Panther Hill, near Mt. Vernon Furnace, Scioto County, Ohio, these rocks are given as follows (Fig. 108) in Vol. V, Ohio Geology, p. 1038:

Panther Hill, Mt. Vernon Furnace, Scioto County, Ohio.

[See map, Q a.]

		Feet.	Feet.
1.	Coal, blossom, Upper Freeport		
2.	Shale, sandy	11	
3.	Concealed	15	38
4.	Sandstone, shaly	12	
5.	Coal, blossom, Lower Freeport		
6.	Fire clay	7	
7.	Shale	8	39
8.	Sandstone	20	
9.	Slate	4	
10.	Coal, Middle Kittanning		
11.	Shales, with iron ore (kidney)	16	45
12.	Sandstone, massive	29	
13.	Coal, Lower Kittanning — Coal blossom; Sandstone, shaly 7; Coal blossom		7
14.	Concealed	8	
15.	Sandstone, white	6	18
16.	Shale	4	
17.	Iron ore, "Baird," buhrstone		
18.	Limestone, Ferriferous		6
19.	Coal	blossom	
20.	Sandstone, white		6
21.	Coal, Clarion		
22.	Shale		16
23.	Coal, Brookville	blossom	
24.	Sandstone, top of No. XII.		
	Total		175

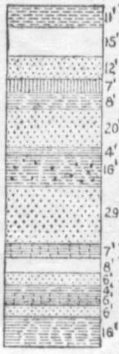


FIG. 108.—Panther Hill, Mt. Vernon Furnace, Scioto County, Ohio.

Section near Ironton, Ohio.—From the vicinity of Ironton, Ohio, Prof. Orton reports the following structure (Fig. 109) for the Lower Coal Measures (Vol. III, Ohio Geology, p. 928):

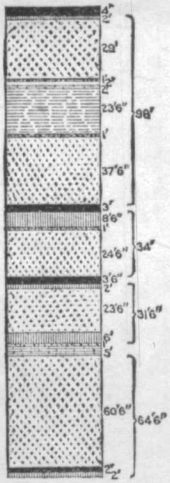


FIG. 109.—Section near Ironton, Ohio.

Ironton, Lawrence County, Ohio.

[See map, R b.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport			4	
2.	Fire clay	2			
3.	Conglomerate and sandstone	29			
4.	Little yellow kidney or Monitor furnace ore	1			
5.	Concealed	2		98	
6.	Buff limestone	2			
7.	Shales	23	6		
8.	Yellow kidney ore (Moxahala)	1			
9.	Heavy sand rock	37	6		
10.	Coal No. 6 (Sheridan coal), Middle Kittanning			3	
11.	Fire clay	8	6		
12.	Black kidney ore	1		34	
13.	Sand rock	24	6		
14.	Coal No. V (New Castle), Lower Kittanning			3	6
15.	Fire clay	2			
16.	Sand rock	23	6	31	6
17.	Fire clay	6			
18.	Limestone ore			1	
19.	Gray limestone, Ferriferous			5	
20.	Sand rock, Hearthstone quarries	60	6		
21.	Conway coal No. 3, C. (Brookville)	2		64	6
22.	Fire clay	2			
23.	Top of No. XII, sandstone.				
	Total			244	6

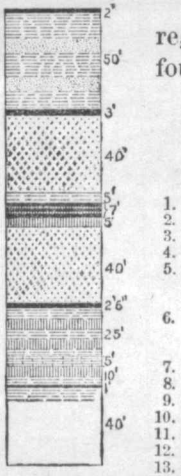


FIG. 110.—Section in southern Ohio, near Ironton.

Section in southern Ohio, near Ironton.—In the same region of Ironton, but at a different locality, the writer found the following structure (Fig. 110):

In southern Ohio, above Ironton.

[See map, S b.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport		2	
2.	Shales and sandy beds		50	
3.	Coal, Lower Freeport		3	
4.	Massive sandstone	40	45	
5.	Shale	5		
6.	Coal, Middle Kittanning: Coal 1', Fire clay 1', Coal 1', Fire clay 2', Coal 2'		7	
7.	Fire clay	5	45	
8.	Sandstone, massive	40		
9.	Coal, Lower Kittanning		2	6
10.	Shales and fire clay		25	
11.	Limestone, Ferriferous		5	
12.	Fire clay and shales		10	
13.	Coal, Clarion		1	
14.	Shales, and concealed		40	
15.	Massive sandstone, top of No. XII.			
	Total		235	6

This section differs but little from that found in western Pennsylvania. The "Buhrstone" or "Baird" ore, which was not noted in this, is present in other sections at its proper horizon on top of No. 11. The Putnam Hill, or lower division of the Ferriferous limestone, seems to have disappeared, either by coalescing with the upper one or failure of deposition, and the same appears to be true of the Upper Kittanning coal, unless it is to be found in the upper layers of the complex Middle Kittanning No. 6, which is not improbable.

Section at Charleston, West Virginia.—As we leave the northwestern margin of the Appalachian field in southern Ohio, and pass southeastward toward the other or eastern side of the same, the Lower Coal Measures thicken up quite rapidly, as will be seen from the line of sections which will now be given along the Great Kanawha River. The following one (Fig. 111), from the mouth of Elk River, at Charleston, is the record of Edwards gas well No. 3. It begins at the level of the Upper Freeport coal, and the record was obtained from Mr. W. S. Edwards, the superintendent of the gas company:

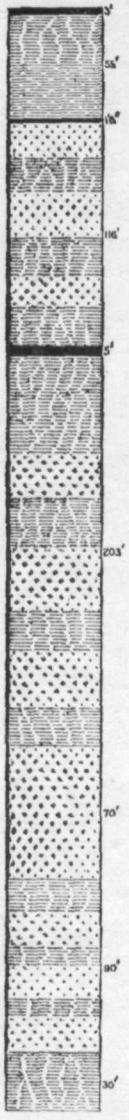


FIG. 111.—Section under Charleston, W. Va.

Under Charleston, Kanawha County, West Virginia, by bore hole near mouth of Elk River.

[See map, S f.]

		Ft.	in.
1.	Coal, Upper Freeport	3	
2.	Shales and slates	55	
3.	Coal, Lower Freeport	1	6
4.	Sandstone and shales	116	
5.	Coal, slaty, Upper Kittanning	5	
6.	Shales and sandstone	203	
7.	Sandstone, coarse, with gas and water	70	
8.	Coal, Clarion		
9.	Shales and sandstone	90	
10.	Shales	30	
11.	Top of No. XII, white sandstone.		
	Total	573	6

The thickness of the measures is here about three times greater than in the Hocking Valley, 100 miles north from Charleston. Just where this rapid thickening begins has not yet been determined, owing to the absence of reliable borings between the Hocking Valley and Charleston, but it is probable that the most of it comes in from the Ohio River southward to Charleston, since the borings at Pomeroy and Hartford City disclose no unusual thickness of the Lower Coal Measures.

The identification of coal No. 8 in the above section is open to question, as it may possibly represent the Lower Kittanning bed.

There may have been other beds of coal passed through by the drill in the well from which this section is taken, since it is seldom that drillers for oil and gas exercise much care in examining the drillings for coal.

Section at mouth of Lick Run, near Charleston, West Virginia.—Near the mouth of Lick Run, 2 miles south of Charleston, a well was bored for gas, by Mr. Hulings, and from the superintendent, Colonel Jordan, I obtained the following record (Fig. 112) by combining it with the 70 odd feet of rocks exposed above the mouth of the boring:

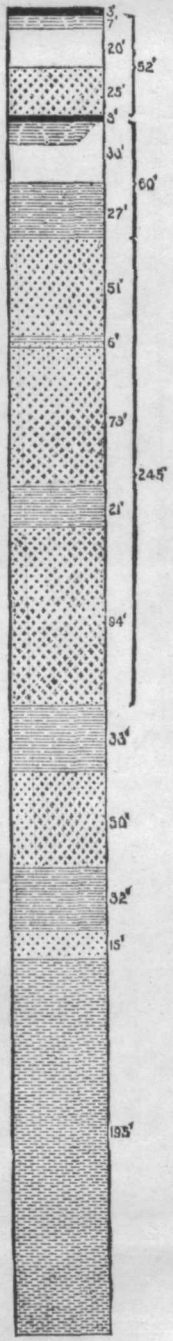


FIG. 112.—At mouth of Lick Run, two miles above Charleston, W. Va.

At mouth of Lick Run, two miles above Charleston, Kanawha County, West Virginia.

[See map, T f.]

		Feet.	Feet.
1.	Coal, Upper Freeport		3
2.	Shales	7	52
3.	Concealed	20	
4.	Sandstone, massive	25	
5.	Coal, Lower Freeport		3
6.	Shales and concealed	33	60
7.	Blue slate	27	
8.	Sandstone, Freeport: Blue sandstone, hard 51'; Slate and sandstone 6'; Sandstone, hard 73'; Slate 21'; Sandstone, hard 94'		245
9.	Slate, blue		33
10.	Sandstone		50
11.	Slate		32
12.	Sandstone, white		15
13.	Sandy shale, dark blue		195
14.	White pebbly sandstone, top of No. XII.		
	Total		688

Colonel Jordan states that no particular search was made for coal here, and hence several beds may have been passed unnoticed. It is also possible that the top of No. XII is placed about 100 feet too low by the section above, since the ordinary driller frequently neglects to note changes in the character of the strata through which the drill passes; hence it is quite probable that a considerable thickness of No. 13, which the drillers called "sandy shale," may have been really the top portion of the No. XII series.

The Freeport sandstone, No. 8, exhibits an unusual development here, and it is possible that the lowest division included in No. 8 is not really a member of this stratum, but belongs lower in the series.

No. 10 is probably a representative of the Kittanning sandstone.

Section at Dickinson salt works, Kanawha County, West Virginia.—In the vicinity of Malden, 6 miles above Charleston, the rapid rise of the strata on the northwestern slope of the Brownstown anticlinal has brought nearly all of the Lower Coal Measures to the surface, and the rest of the column is supplied from the records of the Edwards gas well No. 2, at the Dickinson salt works. The combined section reads as follows (Fig. 113):

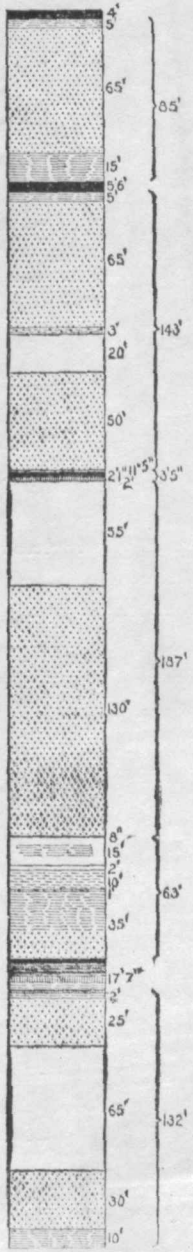


FIG. 113.—Section at Dickinson salt works, Kanawha County, W. Va.

Dickinson salt works, Kanawha County, West Virginia.

[See map, T f.]		Ft.	Ft.	in.
1. Coal, Upper Freeport, slaty			4	
2. Shales		5		
3. Sandstone, massive		65	85	
4. Shales		15		
5. Coal, Lower Freeport	Coal, slaty 1′ 6″; Rock 0′ 6″; Coal 1′ 6″; Shale 0′ 6″; Coal, slaty 1′ 6″		5	6
6. Shales		5		
7. Sandstone, massive		65		
8. Sandy shales, with iron ore nodules		3	143	
9. Concealed		20		
10. Sandstone, massive		50		
11. Coal, Upper Kittanning	Coal, slaty 0′ 5″; Slate, black 0′ 11″; Coal 2′ 1″		3	5
12. Fire clay, sandy		2		
13. Concealed		55	187	
14. Sandstone, massive		130		
15. Coal	Cedar Grove; Middle Kittanning		0	8
16. Concealed, and shales		15		
17. Sandstone		2		
18. Sandy shales		10	63	
19. Limestone, siliceous, Campbell's Creek		1		
20. Shales and sandstone		35		
21. Coal, Campbell's Creek, Lower Kittanning	Coal 2′ 0″; Shales 1′ 2″; Coal 0′ 4″; Fire clay and shales 1′ 10″; Coal and slate 0′ 8″; Coal 0′ 10″; Slate 0′ 2″; Coal 1′ 8″; Fire clay and shales 7′ 0″; Coal, slaty 0′ 6″; Fire clay 1′ 2″; Coal 0′ 3″		17	7
22. Shales		2		
23. Sandstone, massive		25		
24. Concealed in bore hole		65	132	
25. Sandstone, white		30		
26. Shales		10		
27. White sandstone, top of No. XII.				
Total			641	2

This section would seem to confirm the statement made in connection with the Lick Run boring, viz, that a part of the last interval given there should more properly be credited to No. XII, the next series below the Lower Coal Measures.

The Campbell's Creek, or Lower Kittanning coal, is here very much split up with slate and shales, but on the Malden side of the Kanawha it is a good bed, from which 4 to 6 feet of coal is obtained with only the two parting slates.

This is the type locality of the Campbell's Creek limestone No. 19.

Section near Brownstown, West Virginia.—In the vicinity of Brownstown and near the Burning Spring, 9 miles above Charleston, another gas well was drilled (Edwards No. 1) and its record combined with the surface exposures in that vicinity gives the following succession (Fig. 114):

Near Brownstown, three miles south from Malden.

[See map, T f.]

		Ft.	in.	Ft.	in.
1.	Coal, Upper Freeport, slaty			5	
2.	Concealed	10			
3.	Sandstone, massive, gray	95			
4.	Shales, and concealed	30			
5.	Sandstone, massive, gray	40		375	
6.	Sandy shales, and concealed	23			
7.	Sandstone, gray, micaceous	160			
8.	Concealed	15			
9.	Coal (Cedar Grove), Middle Kittanning			3	4
10.	Concealed, and sandstone			100	
12.	Coal. Lower Kittanning. Coal	2	6		
	Campbell's Creek. Shales and sandstone	20	0	24	10
	Coal	2	4		
13.	Shales	3			
14.	Sandstone, massive	25			
15.	Concealed	5		74	
16.	Coaly shale	1			
17.	Fire clay, sandstone, and concealed	40			
18.	Coal, Brownstown			2	
19.	Shales	5			
20.	Sandstone, massive	30		70	
21.	Sandy shales and flaggy sandstone	35			
22.	Limestone, siliceous, Ferriferous			1	
23.	Shales, sandy	15			
24.	Slate, black	6	6	45	6
25.	Shales	7			
26.	Sandstone, and concealed	23			
27.	Coal, Clarion (Eagle)			3	
28.	Sandstone	25			
29.	Slate, gray	8		98	
30.	Sandstone, gray	40			
31.	Slate, dark	25			
32.	White sandstone, top of No. XII.				
	Total			801	8

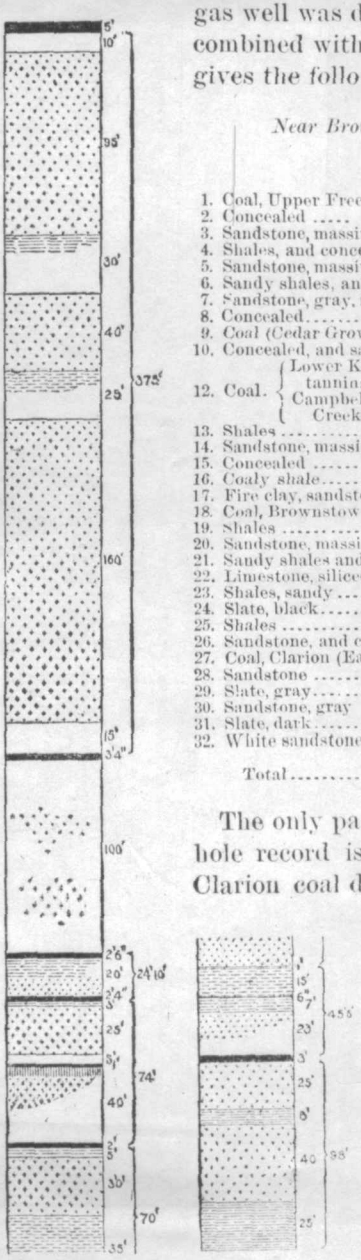


FIG. 114.—Section near Brownstown, three miles south from Malden, W. Va.

The only part of this series dependent on the bore hole record is the last 100 feet, or that from the Clarion coal down, the rest of it all being exposed above the bed of the Kanawha in the region of Brownstown.

By comparing this with the Charleston section (Fig. 111) it will be seen that the whole column has thickened southward at the rate of about 25 feet to the mile. It will also be observed that with this thickening a new coal, the Brownstown, makes its appearance in the series. This is one of a local group of two or three coals which appear in the column of rocks around the southeastern margin of the coal field between the Lower Kittanning bed and the Ferriferous limestone, which would seem to be represented by No. 22 of the section. These coals are of little economic importance, as they are usually thin and slaty.

Section at mouth of Armstrong Creek, on the Big Kanawha River, West Virginia.—At the mouth of Armstrong Creek, 25 miles south from Charleston, the whole column of the Lower Coal Measures is above water level, and a high point almost vertically above the Kanawha River catches the top members of the same, so that here a very fine exposure of the series gives the following structure (Fig. 115):

Mouth of Armstrong Creek, on the Big Kanawha River.

[See map, U g.]

		Ft.	Ft.	in.
1.	Coal, Upper Freeport			3
2.	Sandstone, and concealed	170		
3.	Sandstone, massive	60		
4.	Concealed, and sandstone	115	372	
5.	Limestone, siliceous	2		
6.	Sandstone, massive, gray	25		
7.	Coal, Middle Kittanning, Cedar Grove: Coal 6″; Shale 8″; Coal 5″; Shale 6″; Coal 4″		2	5
8.	Fire clay, and concealed	5		
9.	Sandstone, massive	20		
10.	Shales, concealed, and sandstone	20		
11.	Concealed	20		
12.	Sandstone and shales	20	165	
13.	Sandstone, massive	25		
14.	Shales, and concealed	20		
15.	Sandstone	25		
16.	Sandy shales	10		
17.	Coal, Lower Kittanning: Coal 1′ 1″; Slate 0′ 1″; Coal 0′ 6″; Sandy shales 12′ 0″; Coal, "Peerless" 2′ 0″; Shales, bluish 15′ 0″; Coal, sulphurous 0′ 5″; Slate 0′ ½″; Coal 0′ 6″; Coal, splint 0′ 11″; Parting 0′ ½″; Coal 0′ 7″; Slate 0′ ½″; Coal 2′ 10″		36	
18.	Fire clay			5
19.	Sandstone and shales			35
20.	Coal, Browns-town: Coal 1′ 0″; Shale 2′ 6″; Coal 0′ 10″; Shales and sandstone 15′ 0″; Coal 1′ 2″		20	6
21.	Concealed, and sandy shales	40		
22.	Limestone, siliceous, Ferriferous	1	51	
23.	Shales	10		
24.	Coal, Clarion (Eagle): Coal 0′ 8″; Shales 1′ 4″; Coal, slaty 0′ 6″; Shales, sandy 20′ 0″; Coal 0′ 2″; Shales 0′ 8″; Coal 2′ 10″		26	2
25.	Shales and sandy beds			20
26.	Coal, Little Eagle			1 6
27.	Fire clay and shales	5		
28.	Sandstone, massive	10	55	
29.	Shales, sandy	40		
30.	Limestone, fossiliferous, Eagle			1
31.	Dark shales, fossiliferous	5	80	
32.	Shales, sandstones, and concealed	75		
33.	Bituminous shale			2
34.	Shales	30		
35.	Limestone, siliceous	1	131	
36.	Shales, sandstone, and concealed	100		
37.	Sandstone, massive, top of No. XII.			
	Total	1,006		7

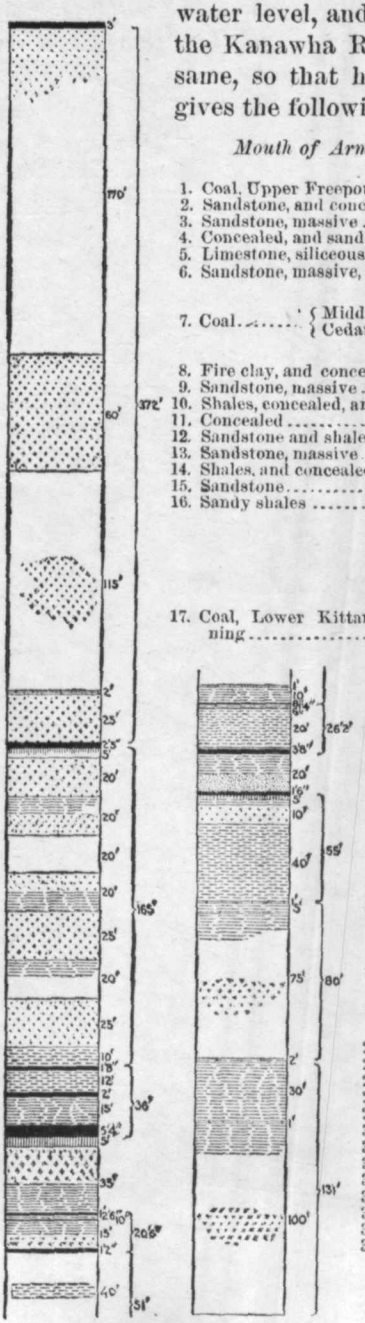


FIG. 115.—Section at mouth of Armstrong Creek, on the Big Kanawha River.

Here both the Lower Kittanning and the Clarion coals show in their structure the effect of the general thickening up of the whole column of rocks. Three miles north from this, the Clarion or Eagle coal is a good bed, which, with its partings of slate, is only 4½ feet thick, but the partings gradually thicken and new ones come in till the structure shown in No. 24 is obtained.

A small coal which has been termed the Little Eagle comes into the section in this region, and seems to have a wide distribution around the southern margin of the coal field. It is a very pure coal and may be a lower member of the Clarion bed.

The Eagle limestone, No. 30, was named from a mining village 3 miles below the locality of this section, where it is finely exposed in the cuts of the Chesapeake and Ohio Railroad. It and the shales below it are crowded with the Lower Coal Measures fossils, the general facies of the fauna being very similar to that found in connection with the Ferriferous limestone in western Pennsylvania, but the general section forbids the supposition that it is identical with the latter. At one time I entertained the idea that it might be the representative of the Putnam Hill limestone, of Ohio, but a closer study of the Ohio section renders that hypothesis untenable, since the Putnam Hill bed belongs above the Clarion coal and not below, as does the Eagle limestone.

No. 33 is a very bituminous shale, since lubricating oil was once manufactured therefrom, and it may possibly represent the Brookville coal of Pennsylvania.

A comparison of this section with those on the other side of the Appalachian basin at Buchtel (106) and Shawnee (105) will show the wonderful expansion of these beds from 175 feet at the latter localities to a thickness of more than 1,000 feet at Armstrong's Creek, and the same thing is shown graphically in map, Section C. That such a great expansion of these measures should show only the same number of workable coal beds as the section at Shawnee was hardly to be expected, but it is true beyond question. The coal beds themselves give evidence of this great expansion of the general column in the slates and other impurities with which they are interstratified.

The interval (165 feet) which here separates the Middle and Lower Kittanning coal beds appears excessive, since it is only 100 feet a few miles below, but there can be very little doubt of the figures given, and as there are no coal beds between Nos. 7 and 17, it is evident that No. 7 must be the Middle Kittanning.

The top member of the Pottsville conglomerate is in the bed of the Kanawha, where the section shown in Fig. 115 ends.

Section at Guyandotte Mountain, Raleigh County, West Virginia.—That the Lower Coal Measures keep their greatly expanded measurement on southwestward from the Kanawha River is shown by the following section (Fig. 116) made by Captain Miller, chief engineer of the Trans-Flat-Top Land Association. It begins at the summit of Guyandotte Mountain, Raleigh County, West Virginia, and was measured along the turnpike eastward to the foot of the mountain:

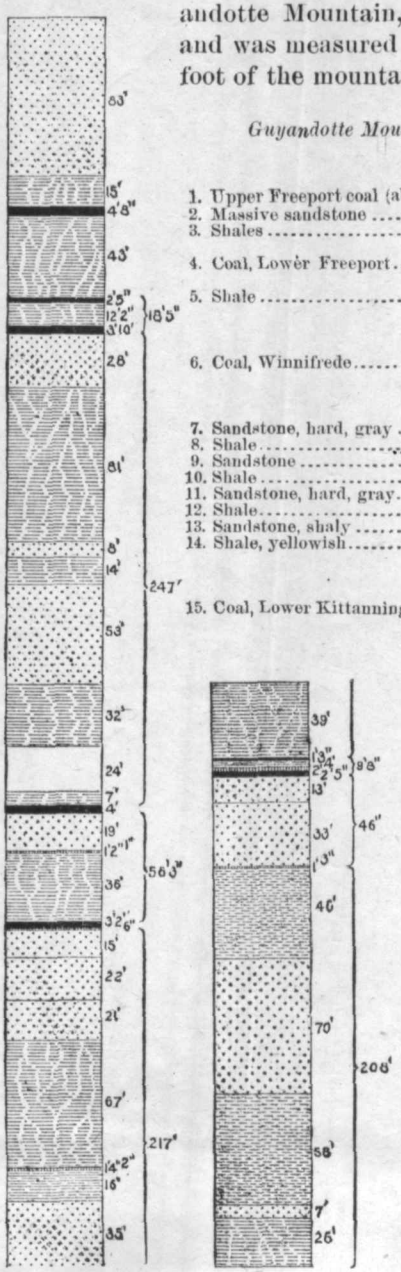


FIG. 116.—Section at Guyandotte Mountain, Raleigh County, W. Va.

Guyandotte Mountain, Raleigh County, West Virginia.

	[See map, W g.]	Ft. in.	Ft. in.
1.	Upper Freeport coal (absent)		
2.	Massive sandstone		83
3.	Shales		15
4.	Coal, Lower Freeport: Coal 3′ 10″; Slate 0′ 1″; Coal 0′ 9″		4 8
5.	Shale		43
6.	Coal, Winnifrede: Coal 2′ 5″; Shale 12″ 2″; Coal 1′ 3″; Slate 0′ 2″; Coal 2′ 3″; Slate 0′ 1″; Coal 0′ 1″		18 5
7.	Sandstone, hard, gray	28	
8.	Shale	81	
9.	Sandstone	8	
10.	Shale	14	
11.	Sandstone, hard, gray	53	247
12.	Shale	32	
13.	Sandstone, shaly	24	
14.	Shale, yellowish	7	
15.	Coal, Lower Kittanning: Coal 0′ 7″; Slate 0′ 1″; Coal 0′ 9″; Slate 0′ 0½″; Coal 1′ 1″; Slate 0′ 4″; Coal 1′ 1½″		
16.	Sandstone, soft, yellow	19	
17.	Coal	0	1
18.	Fire clay	1	2
19.	Shales, yellowish	36	56 3
20.	Coal, Brownstown: Coal 0′ 1″; Fire clay 2′ 0″; Coal 1′ 1″		3 2
21.	Fire clay	0	6
22.	Sandstone, soft, yellow	15	
23.	Sandstone, hard, gray	22	
24.	Sandstone, soft, yellow, micaceous	21	
25.	Shales, yellowish	67	
26.	Coal	0	2
27.	Fire clay	1	4
28.	Slate, black	16	217
29.	Sandstone, soft, yellow	35	
30.	Shales, yellow	39	
31.	Coal, Eagle (Clarion): Coal 1′ 3″; Slate 4′ 0″; Fire clay 2′ 0″; Coal 0′ 1″; Clay 0′ 3″; Coal 0′ 9″; Clay 0′ 2″; Coal 0′ 1″; Clay 1′ 0″; Coal 0′ 1″		9 8
32.	Sandstone, hard, gray	13	
33.	Sandstone, soft, yellow	33	46
34.	Coal, Little Eagle		0 3
35.	Fire clay	1	
36.	Shales, sandy, yellow	46	
37.	Sandstone, soft, yellow	70	
38.	Shales, sandy, yellowish	58	208
39.	Sandstone, flaggy	7	
40.	Shales, yellow	26	
41.	Pebbly sandstone, top of No. XII.		
	Total		955 5

It is possible that the horizon of the Upper Freeport coal should have been placed higher than the section shows, since the coal is not present and the place given it is only a surmise.

Section near Oceana, Wyoming County, West Virginia.—In the vicinity of Oceana, Wyoming County, West Virginia, and the neighboring region, the Lower Coal Measures present the following structure (Fig. 117):

Wyoming County, West Virginia.

[See map, W f.]

		Ft.	in.	Ft.	in.
1.	Upper Freeport coal (not seen)				
2.	Sandstone, and concealed			100	
3.	Coal, Lower Freeport: Coal 0′ 1″; Shale 0′ 4″; Coal 0′ 10″; Bony coal 0′ 4″; Coal 2′ 1″			3	8
4.	Sandstone, and concealed			155	
5.	Cannel slate mixed with coal, Upper Kittanning			3	
6.	Concealed			2	
7.	Sandstone, massive			70	
8.	Coal, Middle Kittanning: Coal 1′ 6″; Shale 0′ 5″; Coal 0′ 8″	2	7		
	Shales and sandstone	20			
	Coal, good 2′ 6″; Shale, gray 0′ 2½″; Coal 0′ 3½″; Shale, gray 0′ 10″; Coal 0′ 9″	4	7	27	2
9.	Concealed, and sandstone	20			
10.	Coal	0	9		
11.	Fire clay and shales	5		85	9
12.	Sandstone, massive	50			
13.	Shales, dark, slaty	10			
14.	Coal, Lower Kittanning: Coal 1′ 0″; Slate 10′ 0″; Coal 1′ 8″; Slate, dark 0′ 6″; Coal 1′ 2″; Slate 0′ 4″; Coal 4′ 0″; Slate 5′ 3″; Coal 0′ 10″			24	9
15.	Massive sandstone	100			
16.	Concealed	40		160	
17.	Shales	20			
18.	Coal, Brownstown: Coal 1′ 7″; Slate 1′ 4″; Coal 0′ 2″; Slate 0′ 8″; Coal 0′ 4″; Slate 0′ 4″; Coal 0′ 6″; Slate 1′ 8″; Coal 1′ 0″			7	7
19.	Sandstone, and concealed			70	
20.	Coal, Eagle (Clarion): Coal 3′ 4″; Slate 0′ 4″; Coal 2′ 0″			5	8
21.	Concealed, and shales			65	
22.	Coal, Little Eagle			2	3
23.	Shales and sandstones	75		80	
24.	Shales, gray, with fossil plants	5			
25.	Coal			1	10
26.	Concealed, and shales and sandstone			100	
27.	Coal, blossom			30	
28.	Shales				
29.	Massive sandstones, top of No. XII.				
	Total			993	8

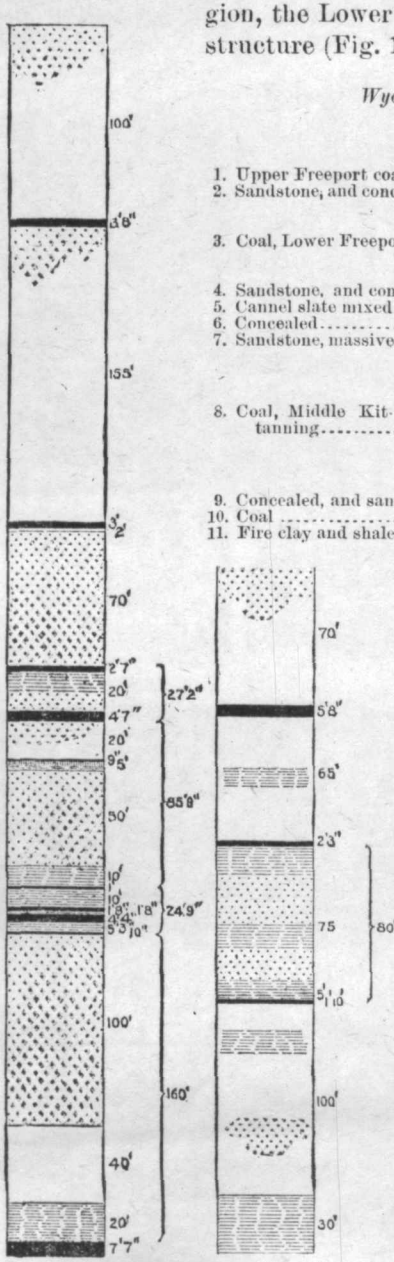


FIG. 117.—Section near Oceana, Wyoming County, W. Va.

No. 20 is known as the "coking coal" in the Wyoming region, since it has the typical structure of such coal, and looks very much like the same (Eagle) bed on the Kanawha.

The Little Eagle bed No. 22 is also very good coal here, and its interval below the main seam has increased from 20 to 65 feet.

Section at mouth of Blaine Creek, Lawrence County, Kentucky.—In passing southward up the Big Sandy River, at the southwestern line of West Virginia, the Lower Coal Measures thicken up at about the same rate as they do along the Kanawha, as will be seen from the following sections. The first one (Fig. 118) is from a surface measurement, combined with the record of Rigdon gas well No. 2, at the mouth of Blaine Creek, 20 miles above the mouth of the Big Sandy River, and reads as follows:

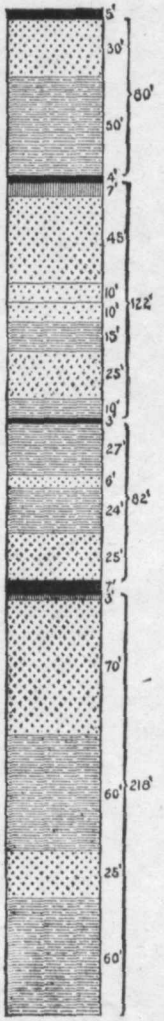


FIG. 118.—Section at mouth of Blaine Creek, Ky.

Mouth of Blaine Creek, twenty miles above mouth of Big Sandy River, Kentucky.

[See map, T b.]

		Feet.	Feet.
1.	Coal and black slate, Upper Freeport		5
2.	Sandstone	30	80
3.	Slate, black	50	
4.	Coal, Lower Freeport		4
5.	Fire clay	7	122
6.	Sandstone, white	45	
7.	Sandstone, dark gray	10	
8.	Sandstone, white	10	
9.	Slate, black	15	
10.	Sandstone, dark	25	
11.	Slate, black	10	
12.	Coal, Middle Kittanning		3
13.	Slate	27	82
14.	Sandstone, gray	6	
15.	Slate, black	24	
16.	Sandstone, gray	25	
17.	Coal, Lower Kittanning		7
18.	Fire clay	3	218
19.	Sandstone, gray	70	
20.	Slate, gray	60	
21.	Sandstone, gray	25	
22.	Slate, black	60	
23.	Sandstone, white, top of No. XII.		
	Total		521

For the carefully kept record of this boring I am indebted to Mr. F. H. Oliphant, now the chief geologist of the South Penn Oil Company.

Section near Old Peach Orchard, Lawrence County, Kentucky.—In the vicinity of Old Peach Orchard, on the Louisa fork of Big Sandy River, Kentucky, the surface measurements, combined with the records of oil and gas borings near by, give the following structure (Fig. 119):

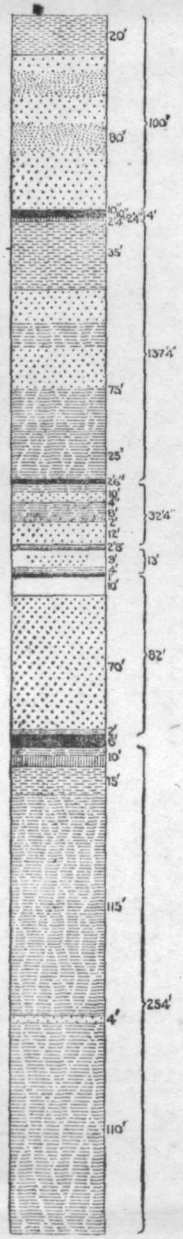


Fig. 119.—Section near Old Peach Orchard, Ky.

Near Peach Orchard, Kentucky.

	[See map, V b.]	Ft.	in.	Ft.	in.
1.	Upper Freeport coal (absent)				
2.	Sandy shales	20		100	
3.	Sandstone and sandy beds	80			
4.	Coal ... Lower Freeport, or Winnifrede, Peach Orchard bed: Coal 0′ 10″; Shale 0′ 10″; Coal 2′ 4″			4	
5.	Fire clay, siliceous	2	4		
6.	Sandy shales	35		137	4
7.	Massive sandstone and shaly micaceous beds	75			
8.	Blue sandy shales	25			
9.	Coal, Upper Kittanning: Cannel 1′ 0″; Clay 0′ 6″; Coal, slaty 1′ 0″			2	6
10.	Shale and sandstone	10		32	4
11.	Coal	0	4		
12.	Sandy shale, blue	8			
13.	Limestone	2			
14.	Sandstone, shaly	12			
15.	Coal: Coal 0′ 6″; Shale 1′ 6″; Coal 0′ 8″			2	8
16.	Concealed, and shaly sandstone	9		13	
17.	Black slate	4			
18.	Coal, splint, Middle Kittanning			1	
19.	Concealed	10		82	
20.	Hard sandstone	70			
21.	Blue shale	2			
22.	Coal, Lower Kittanning			6	
23.	Shales and fire clay	10		254	
24.	Sandy shale	15			
25.	Black shales	115			
26.	Sandstone	4			
27.	Dark shale	110			
28.	White sandstone, top of No. XII.				
	Total			634	10

The place of the Upper Freeport coal here is determined with comparative certainty by the massive Mahoning sandstones, which come in above No. 1, and also by the occurrence of the Mahoning coal, with its characteristic structure, at 235 feet above the Peach Orchard bed, and 135 feet above where the horizon of the Upper Freeport has been placed.

No. 15 is very probably a "split" from the Middle Kittanning bed, No. 18, and should be regarded as a part of the latter.

The Lower Kittanning bed, No. 22, is given as reported from a bore hole at "Old" Peach Orchard, by Prof. Shumard, who examined the drillings at the time the boring was made, and the rest of the section below this is from a deep boring made for gas, about 3 miles distant, the record of which was obtained from Mr. F. H. Oliphant, the civil engineer under whose superintendence the deep well was bored.

There has been much variance of opinion among geologists who have examined the Peach Orchard coal bed as to its horizon in the series, some placing it as far down in the column as the Clarion coal, but this section shows that it is either the Lower Freeport coal of the Pennsylvania column or else one that is probably a "split" from the latter, viz, the Winnifrede bed of the Kanawha series.

Section near Warfield, Kentucky.—In the vicinity of Warfield, Kentucky, opposite the line of Logan County, West Virginia, and 60 miles above the mouth of the Big Sandy, the following structure (Fig. 120) is obtained by combining the surface observations with the records of of the Warfield gas wells:

Warfield, Kentucky, on Tug Fork of Big Sandy River.

[See map, V b.]

		Ft.	in.	Ft.	in.
1.	Upper Freeport coal (not seen)				
2.	Massive sandstone, and concealed			150	
3.	Coal, Winnifrede: Coal 0′ 5″; Sandy shales 10′ 0″; Fire clay 2′ 0″; Coal, splint 1′ 2″; Clay 0′ 1″; Coal, splint 1′ 4″; Clay 0′ ½″; Coal 0′ 9″			15	9
4.	Concealed, and sandstone	25			
5.	Limestone, siliceous	4		59	
6.	Shales, sandstone, and concealed	30			
7.	Coal, cannel, Upper Kittanning			2	
8.	Sandstone, and concealed	30			
9.	Limestone, siliceous	1		51	
10.	Sandstone, and concealed	20			
11.	Coal, blossom, Middle Kittanning				
12.	Concealed, and sandstone			65	
13.	Limestone, siliceous			2	
14.	Sandstone, massive	20			
15.	Shale	0	3		
16.	Coal	0	4	70	7
17.	Sandstone and shales	40			
18.	Sandstone, massive	10			
19.	Coal, Lower Kittanning: Coal 0′ 4″; Shale 0′ 10″; Coal 4′ 0″			5	2
20.	Concealed, and sandstone			45	
21.	Limestone, siliceous			2	
22.	Shales and sandstones to top of No. XII			320	
	Total			787	6

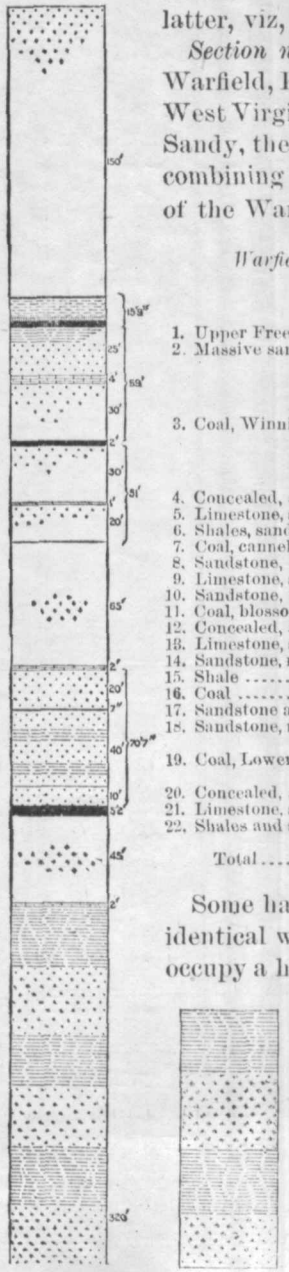


FIG. 120.—Section at Warfield, Ky., on Tug Fork of Big Sandy River.

Some have supposed that No. 3 of this last section is identical with the Peach Orchard bed, but it seems to occupy a horizon a few feet below the latter, and I have therefore referred it to the Winnifrede bed of the Kanawha column.

No. 19, which is locally known as the "Warfield" coal, is the same one as No. 22 of Section 119, and the representative of the Lower Kittanning bed.

The "siliceous" limestones, Nos. 13 and 21, may possibly represent the Campbell's Creek and Ferriferous beds respectively.

Section on Tug Fork of Big Sandy River, Logan County, West Virginia.—Near the mouth of Knox Creek, at the southern edge of Logan County, 50 miles by the river above Warfield, the following section (Fig. 121) was constructed on the West Virginia side of Tug River, by adding to the upper portion of the section there the part which has been removed by erosion:

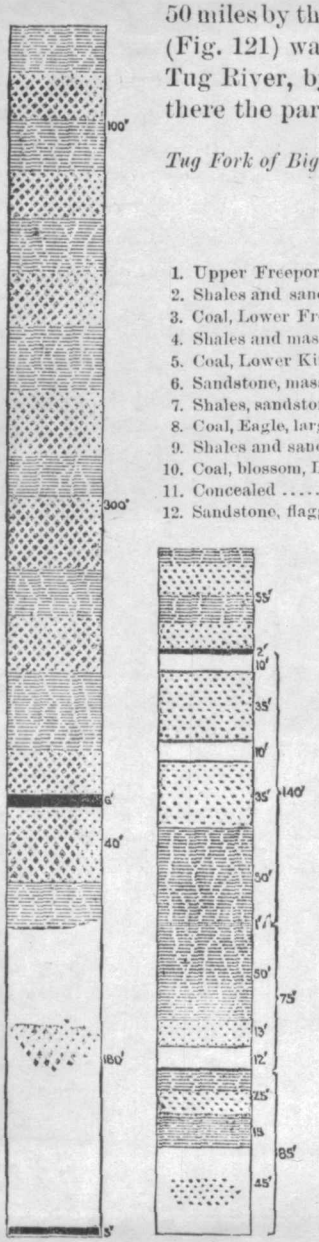


FIG. 121.—Section on Tug Fork of Big Sandy River, near mouth of Knox Creek, southern edge of Logan County, W. Va.

Tug Fork of Big Sandy River, near mouth of Knox Creek, southern edge of Logan County, West Virginia.

[See map, W d.]

	Ft.	Ft.
1. Upper Freeport coal (absent)		
2. Shales and sandstone		100
3. Coal, Lower Freeport		
4. Shales and massive sandstone		300
5. Coal, Lower Kittanning, large blossom		6
6. Sandstone, massive		40
7. Shales, sandstone, and concealed		180
8. Coal, Eagle, large blossom		5
9. Shales and sandstone		55
10. Coal, blossom, Little Eagle		2
11. Concealed	10	
12. Sandstone, flaggy	35	
13. Concealed	10	140
14. Sandstone, gray	35	
15. Shales, soft, gray	50	
16. Limestone, blue, impure (Eagle?)		1
17. Shales, dark blue	50	
18. Sandstone	13	75
19. Concealed	12	
20. Coal		1
21. Shales and flaggy sandstone	25	
22. Slates, dark	15	85
23. Concealed, sandstone, and concealed	45	
24. Massive coarse sandstone, top of No. XII.		
Total		990

CHARACTERISTIC HORIZONS.

THE UPPER FREEPORT COAL.

As may be seen by the sections just given, a very important coal bed comes at the summit of the Lower Coal Measures column, and marks the latter off from the Barrens above. This coal, which was named the Upper Freeport coal by Rogers, has a very wide distribution in the Appalachian field and is the source of much valuable coal and coke. The coal is not entirely persistent, however, being frequently too thin to mine, and from large areas it is absent entirely, though its horizon in the measures can then still be determined, and generally without much difficulty. The bed is probably more regular and persistent in Pennsylvania than

in either of the other two States (Ohio and West Virginia), but even there it is not always found in workable condition, being thin or wanting in some portions of nearly every county where its outcrop extends.

One of the main features which characterizes this bed is its complexity, since it is always separated into two or more benches by divisions of slate. This complexity of structure is illustrated at the type locality (Section 66), and so far as the writer knows it is never entirely absent anywhere in the Appalachian field, whenever the bed is thick enough to mine. These parting slates vary in both number and thickness in different regions, so that there is nothing characteristic about them over the whole field, but yet in any particular district or coal basin their number and position in the bed are quite regular.

Another peculiarity of the coal is that it nearly always cokes well whenever attaining anything like its normal thickness and hence in several regions is locally known as the "coking vein." There are many districts where this bed will produce coke but little if any inferior to that of the Pittsburgh, in the famous Connellsville basin, and when the latter is exhausted the next source of supply to the Pittsburgh and Pennsylvania region generally must come largely from this horizon. Still another feature of this coal is its tenderness, and by this it can often be distinguished from the very hard Mahoning coal next above (which often rivals this bed in size), since as a rule the coal from the Upper Freeport horizon does not bear much handling without breaking up most of the lumps, although they often come out of the mine with large size. This is true of the bed everywhere in Pennsylvania and West Virginia (except in the southwestern part of the latter State, where it is often a splint coal), and Prof. Orton reports the same thing as characterizing it all over the Ohio field.

There is frequently a layer of impure cannel or highly bituminous slate in the roof of this coal, and in the Great Kanawha region a fine deposit of cannel coal occurs at this horizon. This is true of the Cannelton locality, but whether any of the cannel deposits on Coal River, south from the Kanawha, belong at this same geological level is as yet undetermined, since the latter have not been sufficiently studied, though the flora would indicate that the Peytona deposit belongs at the horizon of the Upper Kittanning coal.

The several sections that have already been given (Nos. 50–121), indicate the structure of the Upper Freeport bed in many regions, but there remain others where it is equally important, and some of these will now be given.

Section at McCoy shaft, near Gallitzin, Cambria County, Pennsylvania.—Some large coke plants have recently been put into operation on this bed along the line of the Pennsylvania Railroad and its branches on the summit of the Alleghany Mountains in Cambria and Clearfield

Counties. At the McCoy shaft, near Gallitzin, the coal has the following structure, according to the superintendent's statement:

	Ft.	in.	Ft.	in.
Black slate and bone coal	0	8		
Coal	4	0		
Slate, gray	0	2	6	5
Coal	1	0		
Slate	0	3		
Coal	0	4		

Section near eastern end of old Portage Railroad tunnel, at Gallitzin, Pennsylvania.—Near the eastern end of the old Portage Railroad tunnel, at Gallitzin, the coal is well exposed, and there shows as follows:

	Ft.	in.	Ft.	in.
Coal	0	4		
Dark slate and bony coal	0	2		
Coal	3	0	5	8
Slate, gray	0	2		
Coal	1	2		
Slate and slaty coal	0	10		

According to Messrs. Chance and Platt, this coal is but poorly represented in the present mining regions of Clearfield and Jefferson Counties, Pennsylvania, but it is possible, as already suggested in connection with section 88, that in some cases, at least, the Upper Freeport coal may have been erroneously referred to the horizon of the Lower Freeport.

Section at Mount Equity mine, Bedford County, Pennsylvania.—In the Broad Top field this coal is finely developed in Bedford County, where it is known as the "Kelly seam," and exhibits the following structure at the Mt. Equity mine, according to Stevenson, Report T^2, Second Geological Survey of Pennsylvania, page 62:

	Ft.	in.	Ft.	in.
Coal	2	1		
Parting				
Coal	0	7		
Parting				
Coal	1	2	7	2
Parting				
Coal	1	0		
Clay	2	0		
Coal	0	4		

Although this bed is so well developed in Bedford County, yet when followed northward into Huntingdon, only 10 miles distant, it thins away to only 1 foot or even less.

Followed southward from Cambria County along the Alleghanies, this coal becomes quite thin and slaty in Somerset, and where the bed enters Maryland near the northern end of the Georges Creek basin, it is only 3 to 4 feet thick and quite slaty, there being a layer of bony, worthless coal, 1 foot thick, just above the middle.

This poor condition of the bed seems to be maintained southward along the Georges Creek basin to Piedmont (Section 92) and up the North Potomac (Section 93) to near its source (Section 94) before the coal becomes valuable again, since there the whole bed thickens up to 8 feet, and is extensively mined at Thomas, on the West Virginia Central Railroad, in spite of the fact that 2 feet of bony, worthless coal still remains near the center of the bed.

In the Ligonier basin of Westmoreland and Fayette Counties, Pennsylvania, Prof. Stevenson reports this bed of inferior quality, being filled with knife edges of slate and containing too much sulphur for the manufacture of coke, though it often has a good thickness. This condition of affairs is continued southward along the Ligonier basin into Preston County, West Virginia, until we begin to approach the vicinity of Cheat River, when a great change takes place in the character of the coal, the sulphur and thin slates disappearing and the whole becoming a most valuable coking coal.

Section at Posten's bank, near Masontown, Preston County, West Virginia.—The section at Mr. Posten's bank, 2 miles from Masontown, Preston County, shows the following structure:

	Ft.	in.	Ft.	in.
Coal, slaty	1	3		
Coal, good	3	0		
Slate, gray	0	3		
Coal, good	1	3	9	7
Shale	0	10		
Coal, good	3	0		

This is near the center of the basin, and the coal is there thicker than the average.

Section at Hartley's bank, near Masontown, Preston County, West Virginia.—The following from the side of the trough near Masontown, at Mr. Hartley's bank, will better represent the average thickness of this coal in the Preston basin:

	Ft.	in.	Ft.	in.
Slaty coal	1	3		
Coal, good	3	5		
Shale, gray	0	2		
Coal, good	1	3	8	7
Shale, gray	1	0		
Coal, good	1	6		

The first parting below the top is usually called the "little" slate, while the next one is known as the "big" slate.

This is the same coal that has long been coked for the manufacture of iron at Irondale, Preston County, and also near Austin, on the Baltimore and Ohio Railroad. At both of these localities the coal below the "big" slate is not taken out on account of the expense of mining the latter.

Southward from the Baltimore and Ohio Railroad this bed again splits up with numerous slate partings, and when it comes out to day-

light, on the Valley River, at Philippi, the coal is 4 feet thick, but so slaty as to be almost valueless, and only 20 to 25 feet above the Lower Freeport coal.

Section at Wilson's mine, Roaring Creek, Randolph County, West Virginia.—Southward from Philippi it increases in thickness, and when we come to the eastern side of the Belington basin the bed has a total height of 10 to 15 feet, and is locally known as the Roaring Creek vein. Its structure there is shown by the following section at Mr. William Wilson's mine, in the northern edge of Randolph County, and about 1 mile east from the Valley River, at the mouth of Roaring Creek:

	Ft.	in.	
Coal, slaty, impure	1	6	
Shales, dark	2	0	
Coal, "upper bench"	2	8	
Slate and bony coal	1	3	Feet.
Coal, "breast"	3	1	14
Slate, gray	0	6	
Coal, "mining ply"	1	8	
Clay and slate	0	4	
Coal, "bottom," slaty	1	0	

At some localities the "bottom" and "mining ply" benches form one layer of coal 3 to 4 feet thick, but as a rule the "bottom" portion is slaty and worthless, while the "mining ply" and the "breast" layers furnish very good fuel, the "upper bench" being frequently slaty and otherwise impure.

Followed still farther southward along the eastern side of the Appalachian field, through Randolph, Upshur, Lewis, Webster, Nicholas, Fayette, Kanawha, Lincoln, Cabell, and Wayne Counties, West Virginia, this coal bed presents the features shown in the sections given below.

Section on Stone Coal Run, Upshur County, West Virginia.—In Upshur County, 10 miles west from the Roaring Creek region, the Upper Freeport coal is exposed on Stone Coal Run, a tributary of the Big Sandy, which empties into the Buckhannon River. Here the following structure is visible:

	Ft.	in.		Ft.	in.	
Black slate	2	6	Roof.			
Coal	1	0				
Bony coal	0	8				
Coal	2	0		14	8	Ft. 22
Black slate	3	0				
Coal	1	0				
Gray slate	4	6				
Coal	1	5	Main bench.			
Slate, dark	1	4				
Coal	1	10				
Slate, dark	0	5		7	4	
Coal, slaty	0	5				
Slate, gray	0	6				
Coal	1	5				

This is the locality of the celebrated "22-foot" coal bed of Upshur County. The detailed structure above given does, indeed, exhibit a bed of this enormous thickness, but it is so split up with slate as to be practically worthless.

Section on the Buckhannon River, Upshur County, West Virginia.—Still further west from this, on the main Buckhannon River, one-fourth of a mile above Grassy Run and 9½ miles from Buckhannon town, in a cut on the West Virginia and Pittsburgh Railroad, the following section is exhibited:

			Feet.
Massive sandstone (Lower Mahoning)			35
Upper Freeport coal	Cannel slate	12′ 0″	17
	Coal	2′ 0″	
	Shale	2′ 0″	
	Coal	1′ 0″	
Gray shale			3
Concealed			10
Massive sandstone in bed of Buckhannon River			5

Here the coal has almost entirely disappeared in the great mass of cannel slate at the top, which, of course, contains a large quantity of bituminous matter.

Section at Lloyd Wamsley's bank, Upshur County, West Virginia.—About 10 miles south from the last locality we come to an area of this coal between the main Buckhannon River and its middle fork, where it has regained a structure more nearly normal, viz:

	Ft.	in.
Cannel slate	0	7
Coal	2	7
Slate, black	0	4
Coal	0	8
Shale, gray	0	8
Coal, soft	1	7

Mr. Bryan's bank, one half mile northwest, exhibits the following:

	Ft.	in.
Cannel slate	0	6
Coal	2	0
Bony coal	0	6
Coal	3	0

Section at Current's farm, Upshur County, West Virginia.—A few miles south of this, near the Randolph County line this coal passes into the air on the land of Mr. Current, where it exhibits the following:

	Ft.	in.	Ft.	in.
Sandstone			25	
Coal	1	0	6	8
Slate, blue	2	2		
Coal	0	2		
Clay	0	10		
Coal	0	6		
Sand rock	1	0		
Coal, visible	1	0		

Section near Hacker's Valley P. O., Webster County, West Virginia.—Southward from this, through the edge of Randolph, the coal has been eroded by the waters of the Buckhannon, but beyond Helvetia and the Florence Pass we come to an elevated plateau, from which the Buckhannon, Little Kanawha, and Holly (a tributary of the Elk) Rivers all take their rise, and here, in Webster County, 7 miles northeast from Hacker's Valley post-office, we catch an outlier of this coal with the following structure:

	Ft.	in.	Ft.	in.
Bony coal	0	6		
Coal, good	1	3		
Bony coal	1	2	5	7
Coal, good	2	8		

Section on the Little Kanawha River, Lewis County, West Virginia.—About 10 miles northwest from this last locality the same coal exhibits the following structure (according to William S. Stevenson) in the hills along the Little Kanawha River, where the left branch of that stream cuts across the panhandle of Lewis County:

	Ft.	in.	Ft.	in.
Slaty coal	5	0		
Coal, hard	2	8		
Slate	0	8	9	0
Coal, softer	1	8		

Section on the Holly River, Webster County, West Virginia.—In the summit of the hills near Anderson's mill, on the left branch of Holly River, Webster County, we find the Upper Freeport coal with the following structure on the land of Mr. Marcum Cougar:

	Ft.	in.	Ft.	in.
Coal, hard	3	2		
Slate, dark	0	4		
Coal, soft	1	4	6	10
Bony coal	0	4		
Coal, soft	1	8		

Section at Powell Mountain, Nicholas County, West Virginia.—To the southwest from this there are no more openings on this coal until we come to Powell Mountain, in Nicholas County, although a "7-foot" bed of coal is frequently "reported" in the hills where the Upper Freeport ought to be found. But in Powell Mountain it has been mined for a long time on the Weston and Gauley Bridge turnpike, where it exhibits the following structure:

	Ft.	in.	Ft.	in.
Coal, blossom				
Shales, gray	10	0		
Coal, splinty	2	0	14	3
Black slate	0	3		
Coal, splinty	2	0		

Here the character of the coal begins to change to the hard, splinty variety which distinguishes the coals of the Kanawha Valley.

Section on Stroud Creek, Nicholas County, West Virginia.—A few miles east from this, on the waters of Stroud Creek, this bed shows the following section on the land of Dr. D. M. Lewis:

	Ft.	in.	Ft.	in.
Cannel	0	5		
Coal, splint	4	0		
Soft coal	0	4		
Black slate	0	1		
Coal	0	6		
Black, coaly slate	0	6	12	10
Gray slate	3	0		
Coal, soft	1	10		
Clay	1	0		
Coal, soft	0	10		
Slate	0	1		
Coal	0	3		

Sections on Mumble-the-peg Creek, Nicholas County, West Virginia.—On Mumble-the-peg Creek, half way between Powell Mountain and Nicholas Court-House, we find an opening in the Upper Freeport coal on the land of Mr. Herold, where it shows the following structure:

	Ft.	in.	Ft.	in.
Coal	1	6		
Shales	5	0		
Cannel	0	8	13	10
Coal, splinty	2	6		
Slate, black	1	8		
Coal, splinty	2	6		

At another bank, 300 yards west from the last, the following is seen:

	Ft.	in.	Ft.	in.
Coal, blossom				
Shale, gray	2	0		
Bony cannel	0	6	7	4
Coal, splinty	2	1		
Slate, black	0	3		
Coal, splinty	2	6		

At this locality, as well as in Powell Mountain and on Stroud Creek, a very good quality of splint coal is obtained from this bed.

From Nicholas Court-House on southwestward to the Great Kanawha River no openings have been examined along the crop of this coal, but at Cannelton, in Fayette County, we find it a valuable bed of cannel coal with a thickness of 1½ to 4 feet, while 2 to 2½ feet of bituminous coal rests immediately on the latter.

Two miles below Cannelton, at the mouth of Upper Creek, the bed thickens to 11 feet, but the layers of coal are so interstratified and diluted with slate and muddy sediment that the whole is worthless. A few miles farther down the Kanawha, at East Bank and Crown Hill, a portion of this great bed becomes the excellent splint coal, 3 to 4 feet thick, which is mined at those localities, but farther down this river the bed again becomes impure and remains practically worthless from Coalburg on down until it disappears under the river at Charleston.

West from the Kanawha we have no information about this coal until we reach the Guyandotte River in Cabell and Lincoln Counties, but it is possible that some of the Coal River cannel belongs at this horizon.

Section on the Guyandotte River, Cabell County, West Virginia.—On the Guyandotte River the Upper Freeport coal rises above water level about two miles above the "Falls Dam." It is first opened and mined at the mouth of Stone Coal Run, where it exhibits the following structure:

	Ft.	in.	Ft.	in.
Coal	0	4		
Slate	0	2		
Coal	0	7	3	6
Slate and bony cannel	0	9		
Coal, visible	1	8		

Another opening a short distance up the run gives the following:

	Ft.	in.	Ft.	in.
Massive sandstone			25	0
Cannel slate	1	0		
Slate	0	3	5	3
Coal, good	4	0		

This latter section very probably belongs immediately on top of the first opening, since the interval between the two banks is concealed.

The coal is known in this region as the "big bed." On the Caldwell tract, opposite Camp Branch, this coal exhibits the following section in the bluff overlooking the Guyandotte:

		Ft.	in.	Ft.	in.
Sandstone, visible				10	0
Coal, Upper Freeport	Coal, slaty	1′	0″	10	5
	Coal	1′	6″		
	Slate	0′	1″		
	Coal	2′	0″		
	Slate	0′	2″		
	Coal	0′	9″		
	Shale	0′	9″		
	Coal	0′	8″		
	Slate	0′	6″		
	Coal	3′	0″		

As will be perceived, the coal contains much slaty material and the layers of coal themselves are inclined to be bony and impure, approaching the type which this bed exhibits in the vicinity of the Kanawha Mining Company's plant on the Big Kanawha River.

Sections on Cove Creek, Wayne County, West Virginia.—As we pass from the Guyandotte in Lincoln County westward across the divide to the waters of Twelve Pole, a great change takes place in the Upper Freeport bed, and on Cove Creek we find it split into two portions with 30 feet of rock between, and the lower bench a fine quality of cannel coal 3 to 4 feet thick at some openings.

At another locality the following is seen:

	Ft.	in.		
Coal blossom	2	0		
Shales and sandstone	30	0	Ft.	in.
Shale	0	6	36	10
Coal, splint	1	8		
Cannel, good	1	4	4	10
Coal, bony	1	4		

On the opposite side of Cove Creek we see:

	Ft.	in.		
Massive sandstone				
Coal	0	6		
Slate	0	4	Ft.	in.
Coal	1	6	5	4
Cannel	3	0		

From this point a belt of cannel coal at the horizon of this bed extends in a general westerly direction nearly across Wayne County, being found on all of the main branches of Twelve Pole. It is possibly identical with the celebrated Moses Fork cannel and other cannel deposits in Kentucky. This belt of cannel varies much in width, but it is often 2 or 3 miles across, and while the bed is not entirely persistent, it is seldom less than 20 inches thick. It is quite pure and will compare favorably with the celebrated Kanawha cannel, which comes at the same geological horizon.

On the left branch of Twelve Pole, one-half mile above the mouth of Brush Creek, this cannel coal shows as follows:

	Ft.	in.	
Massive sandstone			
Coal, bituminous	0	10	Ft.
Rock, dark	0	8	4
Cannel	2	6	

On Little Laurel, a branch of Hezekiah Creek (tributary of the left fork of Twelve Pole), the cannel exhibits the following:

	Ft.	in.		
Sandstone				
Coal, bituminous	1	0		
Bone coal	0	8	Ft.	in.
Cannel	3	1	5	5
Bone coal	1	8		

On Saw Pit branch of Cove Creek the following section was measured:

	Ft.	in.	Feet.
Coal, blossom	2	0	27
Sandstone	25	0	
Coal	0	6	8
Slate, gray	0	1	
Coal, bituminous	1	3	
Cannel	1	7	
Coal, splint	1	0	
Slate and slaty coal	0	5	
Coal	0	5	
Slate	0	2	
Coal, splint	0	8	
Slate, blue	0	5	
Coal, splint	1	6	

In Sugar Camp Hollow, a short distance above Jesse Queen's, the Upper Freeport coal exhibits the following structure:

	Ft.	in.	Ft.	in.	Ft.	in.
Sandstone, massive						
Coal	2	4				
Slate	0	2				
Coal, splint	1	2				
Slate, gray	0	4				
Coal	0	2				
Slate, gray	0	4	8	11		
Coal, splint	0	8				
Slate, gray	0	4				
Coal	1	6				
Slate, dark	0	9			25	5
Coal	0	7				
Slate	0	6				
Coal	0	1				
Shaly sandstone	15					
Coal	1	6				

On Trough Creek, near James Rainey's, this coal exhibits the following:

	Ft.	in.	Ft.	in.	Ft.	in.
Massive sandstone						
Cannel slate	0	5				
Coal, splinty	1	9	3	3		
Slate	0	1				
Coal, splint	1	0				
Flaggy sandstone and shale	15	0			24	7
Cannel slate	0	8				
Coal	2	1				
Slate	0	2	6	4		
Coal	0	10				
Shale, gray	0	6				
Coal	2	1				

At Greene Porter's, on the right bank of Twelve Pole, the Upper Freeport bed shows the following:

	Ft.	in.	Ft.	in.
Coal	1	0	7	4
Clay	0	5		
Shale and coal	0	9		
Coal	1	10		
Bony coal and slate	1	0		
Coal	2	4		

From this point on west to the Kentucky line on the Tug River nothing is known of the Upper Freeport coal, and at Warfield it seems to be absent from the section, but this may possibly be due to the fact that its horizon there overtops the summit of the hills.

In western Pennsylvania there are large areas, especially in Beaver County, where this coal is either absent or else too thin to mine; so it enters Ohio not as a persistent bed, but occurring in patches, and this characteristic seems to remain with it there, from the Pennsylvania line entirely across the State to the Kentucky border at Ironton.

Even along the Ohio River from the Pennsylvania line down to where this bed dips below the same, it is generally absent, and Prof. Orton thinks it is still absent in the Steubenville shafts, the coal mined there being the Lower Freeport bed, instead of the Upper Freeport as was formerly supposed.

In eastern Ohio it is known as bed No. 6 in the Ohio scheme of numbers, but in other portions of the State, as Prof. Orton has shown, it was often called No. 7. The following list of Ohio names for this bed will indicate regions in that State where the bed becomes prominent: "Big Vein" of Salinesville, "Dell Roy," "Cambridge," "Alexander," "Bayley's Run," "Norris," "Happy Hollow," "Waterloo."

Section near Kenova, West Virginia.—After passing beneath the Ohio River above Steubenville, this bed never emerges from the same until within 2 miles of the Kentucky line, and if the Steubenville shaft coal be the Lower Freeport, then the Upper one is absent over a wide region along the Ohio River, for it appears to be absent in several borings, notably at Parkersburg and Pomeroy. It is reported from a boring at Huntington, however, as 10 feet thick, though where it comes up to the level of the Chesapeake and Ohio Railroad at the east end of the Big Sandy bridge, 10 miles below Huntington, the bed is worthless, as shown by the following structure there:

	Ft.	Ft.
Coal	1	5
Shale	3	
Coal, slaty	1	

Section in Ritchie County, West Virginia.—Where this bed is brought to the surface on the Volcano anticlinal in Ritchie County, West Virginia, it has the following structure, according to Stevenson:

	Ft.	in.	Ft.	in.
Coal	2	6	6	8
Sandstone, gray	3	6		
Coal	0	8		

THE UPPER FREEPORT LIMESTONE.

Below the coal just described, at an interval which varies from 0 to 40 feet, there comes a limestone which was named from the same locality as the coal. It is quite generally distributed in Pennsylvania, northern West Virginia and Ohio, but in the southwestern part of West Virginia it appears to be absent, since it has never been reported from the region along the Big Kanawha and its tributaries, nor from the region between that and the Big Sandy.

The limestone is usually of a light gray color on fresh fracture, but some of the layers are always buffish when weathered, owing to included iron. Frequently the rock presents a brecciated aspect, as if made from the broken fragments of an older limestone.

Fossils are rare in this bed except a minute univalve which looks as if it might be of fresh water origin. Some layers of this stratum generally contain a considerable amount of carbonate of magnesia, and occasionally enough to constitute it a good rock for the manufacture of hydraulic cement.

The thickness varies from 1 foot up to 30 feet as a maximum, though the average might be placed at 5 to 8. It makes an excellent lime for fertilizing purposes, and is much sought after to enrich the barren soil lands above, though it is occasionally mined for use in blast furnaces, as on the Alleghany River between Freeport and Kittanning, where it is unusually thick.

In Ohio this bed has been given several names, as "Shawnee," "White," "Buchtel," etc. There, also, as in Pennsylvania and West Virginia, it occasionally becomes iron-bearing and some or all of its layers develop into iron ore, which is known in Ohio as the "Buchtel" ore, and in Pennsylvania as the "Summit" ore.

THE BOLIVAR FIRE CLAY.

When the Upper Freeport limestone is absent, or but slightly represented, there occasionally comes into the section at its horizon a bed of excellent fire clay, which from having long been mined near Bolivar, Westmoreland County, Pennsylvania, is generally known as the Bolivar clay. As there developed it shows a fine quality of non-plastic clay which is used in the manufacture of fire brick and gas retorts. It also occurs in several other regions of Westmoreland County, as well as in Fayette and other Pennsylvania counties.

This clay has been reported as valuable at only two or three points in Ohio, viz, in Jefferson and Muskingum Counties, while in West Virginia it is known to be valuable in only one region, viz, on Deckers Creek, in Preston and Monongalia Counties.

THE UPPER FREEPORT SANDSTONE.

As a rule the main portion of the interval between the Upper and Lower Freeport coals is occupied by sandy shales or thin flaggy layers of sandstone, separated by shales, but occasionally a bed of massive sandstone makes its appearance at this horizon and it has received the name of Upper Freeport Sandstone. It is quite prominent in some portions of Pennsylvania, but appears to be generally absent in Ohio. It is also conspicuous along the Great Kanawha and in all the region of West Virginia, southwest from there, sometimes attaining a thickness of 75 feet, while in Pennsylvania it is seldom more than 30 feet.

When this sandstone is not present as a massive rock there occasionally occurs a thin bed of coal in the interval between the Upper and Lower Freeport coals, and I have termed it

THE MIDDLE FREEPORT COAL.

This bed is shown in Section 66 at the typical Freeport locality, and as already stated in connection therewith, its presence in other sections may have led to some confusion in identifications. It is not a regular member of the series, however, and is probably never much thicker than at Freeport, viz, 2 feet.

The interval between the Upper and Lower Freeport coals varies greatly in thickness, running up sometimes to 80 and again thinning away to 20-odd feet, as shown in Section 65.

THE LOWER FREEPORT COAL.

This bed is quite as variable, or even more so than the Upper Freeport above. The rule is that whenever one of these beds has a fair development the other is poor or worthless, but in addition to this uncertainty, they are both frequently thin, or practically absent from the section at the same time, so that no one should look upon any of these coal beds as being continuously valuable over wide areas.

As shown in Section 66 at the type locality of this bed, it is even more complex in its structure than the Upper Freeport above, being split into two well defined layers separated by a stratum of clay and limestone. It is quite probable that this dividing layer may at times thicken up greatly as all other rocks do, and separate the two layers of coal by an interval of several feet, thus making two apparently distinct coal beds, but which should really be classed as members of one.

If Messrs. Chance and Platt are correct in the identifications of the Lower Freeport coal in Jefferson and Clearfield, there are large areas in both of these counties where this coal is quite valuable, since it is 4

to 7 feet thick and of excellent quality, though it is always separated into two or three benches by partings of slate.

The upper portion of the Lower Freeport bed often has a tendency to become cannelly, as at Freeport, and some highly bituminous shale is frequently present at this horizon, even when the coal is absent.

Another very fine development of the Lower Freeport coal is in the vicinity of Fairmont, Clarion County, Pennsylvania, where according to Chance it is 5 to 7 feet thick without any partings, and furnishes an excellent quality of gas coal, as it does in the Reynoldsville region of Jefferson County.

In Ohio the reputation of the coal as a patchy deposit is fully sustained, since Prof. Orton says of it (Vol. V, p. 166, Ohio Geological Survey), "this is a seam the horizon of which can be followed throughout the entire field, but which becomes workable at comparatively few points."

In eastern Ohio it is called No. 5, but in Stark County and southwestward it is known as No. 6a, while the synonyms, "Whan" "Steubenville Shaft," "Roger," "Hamden Furnace," and "Hatcher" indicate localities where the bed becomes important.

If the "Steubenville Shaft" bed really represents this coal instead of the Upper Freeport, then there is quite a large field of it along the Ohio River, for it is found of good thickness in every boring as far south as Moundsville, West Virginia, where it underlies the Ohio by more than 600 feet.

Section near Philippi, Barbour County, West Virginia.—In Preston, Monongalia, Mineral, and Tucker Counties, West Virginia, this bed is quite thin and often absent entirely, so it is not mined till we go south into Barbour County, where it thickens up and in the vicinity of Philippi exhibits the following structure:

	Ft.	in.	Ft.	in.
Coal	1	10	5	10
Slate	0	8		
Coal	0	6		
Slate and coal	0	10		
Coal	2	0		

Nothing is known of the Lower Freeport from Philippi on southwestward along the eastern margin of the Appalachian field until the Great Kanawha River is reached, except in the Roaring Creek field, where it is only 2 feet thick and 25 feet below the upper bed.

But from the fact that this coal becomes one of the principal beds in the Kanawha region, and from there on southwestward into Kentucky, it is inferred that it is also a valuable bed at some points between Philippi and the Big Kanawha.

On this latter stream the Lower Freeport appears to be the parent of two valuable beds known respectively as the Coalburg and Winnifrede veins. The former certainly belongs to this horizon, and the latter

probably does, though formerly I was inclined to refer it to the horizon of the Upper Kittanning. The Lower Coal Measures thicken up so greatly in that region, however, and the intervals separating the Coalburg and Winifrede beds from the top of the series and from each other vary so much that it seems more probable they are both members of the complex Lower Freeport coal. The Coalburg and Winifrede beds are themselves complex, being always separated into two or three benches by layers of very hard slate or bony coal locally known as "nigger head." They usually furnish the variety of coal known as "splint," and the Kanawha "splint" is highly prized as a general domestic fuel. These two beds are quite irregular in their thickness and one or both are often too thin to mine, but they appear to be much more regular and persistent southwest from the Kanawha than the Upper Freeport, since they furnish valuable coal clear across to the Big Sandy River, the celebrated Peach Orchard coal of Kentucky coming at the horizon of either the Coalburg or Winifrede bed, or both combined. This latter view is the more probable, since at the tunnel near the New Peach Orchard mine the coal is seen splitting up till it is scattered through more than 40 feet of rock material.

Section of bed at Coalburg, Kanawha County, West Virginia.—The following section shows the variations in the structure of the Coalburg bed at its typical locality:

Splint coal	6	in. to	10	ft.
"Nigger head"	4	in. to	8	in.
Splint coal	2½	ft. to	3½	ft.
Shale	1	ft. to	8	ft.
Soft coal	1	ft. to	1½	ft.

Section at Winifrede, Kanawha County, West Virginia.—The structure of the Winifrede coal at Winifrede is as follows:

	Ft.	in.	Ft.	in.
Gray splint	0	5		
Soft coal	0	5		
Gray splint	0	3		
Soft coal	0	3	4	10
Gray splint	1	2		
Soft coal	1	3		
Slate	0	5		
Soft coal	1	8		

I do not know of any locality in the Kanawha Valley where both the Winifrede and Coalburg beds are mined one above the other in the same hill, for when one is good the other happens to be worthless, and this is so constantly true that, were it not for the fact that the Coalburg bed is only 100 feet below the Kanawha black flint while the Winifrede seam is 175 to 200 feet below the same datum line, I would be strongly inclined to believe that they were one and the same coal.

Section at mouth of Blaine Creek, Lawrence County, Kentucky.—In descending the Big Sandy River the Lower Freeport sinks below water

level at the mouth of Blaine Creek, 6 miles below Louisa, where it exhibits the following structure:

	Ft.	in.	Ft.	in.
Massive sandstone				
Coal	0	10	7	10
Fire clay	5	0		
Sandy shale	2	0		
Coal	0	10		
Shale with iron ore	1	0		
Coal, slaty	1	0	5	7
Shale, blue	1	3		
Coal	1	6		

THE LOWER FREEPORT LIMESTONE.

The conditions preceding the spread of a great coal marsh seem to have been eminently fitted for the production of limestone deposits, especially in the Pennsylvania and Ohio regions, for, with few exceptions, a limestone is found close under every coal bed, and this is true of the Lower Freeport horizon. This limestone very much resembles the one under the Upper Freeport coal, except that it is usually thinner and more earthy. It also contains the same univalve fossil, and no others, so far as the writer is aware, thus showing that it too is a fresh-water deposit. It contains a considerable quantity of carbonate of magnesia and occasionally, as at the locality of Section 103, furnishes material for the manufacture of hydraulic cement.

Considerable iron ore is also found at this horizon, and the limestone is generally of a buffish cast from the disseminated iron. From this fact it and the Upper Freeport limestone above are generally called the "buff" limestones in southern Ohio.

In West Virginia this limestone has not been recognized anywhere in the northern part of the State, and it is certainly absent entirely along the Great Kanawha. An impure limestone is sometimes found in connection with the Peach Orchard coal of Kentucky, which is possibly identical with the Lower Freeport.

THE LOWER FREEPORT SANDSTONE.

The next lower stratum that has a general distribution over the Appalachian field is known as the Lower Freeport sandstone. Section 66 shows the thickness and structure of this sandstone at its typical locality, and there it is seen to be double, with a coal embedded in its lower portion, the whole being 62 feet thick. That the 15 feet of sandstone under the coal at Freeport belongs properly with the main sandstone above is known from the fact that at one locality the coal is seen disappearing entirely and then the two beds of sandstone unite into one solid mass.

This rock is always of a grayish white color, generally quite hard, often containing pebbles as well as much feldspar, which decomposing permits the rock to disintegrate readily and weather into fantastic

shapes. It is more persistent as a massive rock than the Mahoning even, but unlike the latter it is seldom used for building purposes. This is owing to its hardness, coupled with the fact that it will not stand the weather well, and also it is often so gnarly and twisted in its bedding that it will not split evenly.

This sandstone is never less than 30 feet thick in the Pennsylvania region, and it frequently rises to 75 and even 100 feet in some localities, making a bold cliff or bluff wherever its outcrop is above drainage, and thus becoming a conspicuous feature in the topography of the Lower Coal Measures.

Throughout a large portion of Beaver County, Pennsylvania, this sandstone is 75 to 80 feet thick, and near its center is a very hard calcareo-siliceous layer 2 or 3 feet thick, which may possibly represent the Johnstown Cement limestone in other portions of the State.

The sandstone maintains about the same thickness throughout eastern Ohio as in Beaver County, and continues on around to southern Ohio with a thickness of 30 to 50 feet.

It enters West Virginia from Pennsylvania as a very massive bed, 50 to 75 feet thick in Monongalia and Preston Counties, while in Tucker, Taylor, Barbour, and Randolph, it is still thicker and more pebbly even than the Pottsville conglomerate. Southwestward through Randolph, Webster, Braxton, and Clay, this sandstone keeps on increasing in thickness, and when the Big Kanawha is reached it has swelled out in a wonderful manner, becoming 250 to 300 feet thick, and remaining the same across to the Big Sandy, often crowning the hills and ridges with cliffs weathered into turreted and chimney-shaped forms. When attaining this immense thickness it often consists of three or four sandstones, with shales and two or three coal beds interstratified.

This rock has produced a small quantity of oil at Fairview, Marion County, West Virginia, and is generally known as the "gas sand," in the drillers' parlance, since it often produces considerable quantities of natural gas.

THE UPPER KITTANNING COAL.

Throughout several counties of Pennsylvania a third bed of good coal occurs at 80 to 120 feet below the top of the series, and to this Messrs. Chance, Platt, and other Pennsylvania geologists, have given the name Upper Kittanning, though the bed in question is not workable at Kittanning or anywhere near that town, as may be seen from Sections 60–66 along the Alleghany River, since it is thin and unimportant in that region. The Messrs. Platt at one time identified this coal with the Lower Freeport bed in Cambria, Clearfield, and Jefferson Counties, calling the coal which is now termed Lower Freeport there the Middle Freeport, and it is barely possible that this first arrangement of the stratigraphical order was the correct one in many regions, since, as already shown (see 66), there is a Middle Freeport coal even

at Freeport, and in addition the Lower Freeport bed is itself so complex that either half of it might at any time separate from the other and both become independent beds.

But however the questions suggested may turn out, the fact remains that at many localities in Pennsylvania, at least, there are three distinct coal beds between the Ferriferous limestone and the Lower Freeport coal, as shown in Sections 64, 65, and 66.

Westward in Ohio, however, the Upper Kittanning coal appears to be either wanting entirely in most cases or else coalesced with the Middle Kittanning bed, since Prof. Orton finds no place for it as a regular member of the Ohio series, but puts it down as a synonym for the Lower Freeport seam. (See Vol. V, p. 126, Ohio Survey.)

In West Virginia the Upper Kittanning bed first appears in the sections along the Tygart's Valley River (96 and 97), where it is 2 to 3½ feet thick, and a rather fair coal; but it appears to be absent entirely in the Newburg shaft, Preston County, unless it is combined with the Middle Kittanning there, while in the North Potomac basin near Davis it is represented by a mere streak. In the Kanawha field two or three thin beds come at this horizon, and one of them is frequently cannel, and the same horizon can be recognized on the Guyandotte River, in Wyoming County (Section 117).

Chance says that it is the main cannel horizon in Pennsylvania, the New Bethlehem, North Washington, and Murrinsville cannel deposits coming at this horizon. If the Darlington cannel, of Beaver County, comes at this same horizon, then the interval separating the Upper and Middle Kittanning beds has there thinned entirely away, and thus brought the two into direct contact. This might well be, since the Darlington cannel rests directly on 2 feet of bituminous coal, below which, through a shale interval of 30 feet, comes the undoubted Lower Kittanning coal, underlaid by its great bed of fire clay. This would account for the absence of the coal in Ohio, if it really does unite with the Middle Kittanning before crossing the Pennsylvania-Ohio line.

This bed appears to attain its greatest importance in Pennsylvania, along the eastern border of the coal field through the counties of Jefferson, Clearfield, Cambria, and Somerset, where it has been fully described by Messrs. Platt and Chance. The general sections already given show the horizon and structure of this bed at numerous points, so that no further description of it is necessary.

THE JOHNSTOWN (CEMENT) LIMESTONE.

Lying only 2 to 5 feet below the coal just described, there occurs, over a wide region in Pennsylvania, a bed of magnesian limestone, which Mr. Franklin Platt named the Johnstown Cement, from its occurrence at the city of Johnstown, Cambria County. It is almost an exact counterpart of the Lower Freeport limestone of the counties farther west in physical aspect, chemical composition, fossils, and everything else, and

this is one of the facts which, taken in connection with the entire absence of this limestone in the western tier of counties and in Ohio, has sometimes led to the suspicion that possibly the Johnstown Cement and the Lower Freeport limestone of Butler and Beaver Counties are identical. Still there are other facts of stratigraphy which appear to forbid such an hypothesis, and hence, until it can be shown otherwise by more positive demonstration, we must accept the stratigraphical horizon given the Johnstown Cement first by Messrs. Platt, whose labors moved it up from the horizon of the Ferriferous limestone, to which the First Geological Survey of Pennsylvania had erroneously assigned it. The stratum ranges in thickness from 1 to 8 feet, and when it is 5 feet or more some of the layers often make good lime for agricultural or other purposes; but when the bed is only 1 to 3 feet thick it is usually too impure to slake well. This stratum has not been recognized at any point within West Virginia with which the writer is familiar, and it thus appears to be generally absent from the series in that State.

THE MIDDLE KITTANNING COAL.

Whatever uncertainty may exist concerning the exact horizon of the coal which has just been described under the name of Upper Kittanning, there is none with reference to the next lower bed, for it is such a constant member of the series that its relations to the other rocks are seen in nearly every section. This bed was formerly called the Upper Kittanning, until Messrs. Platt and Chance discovered that the coal last described was a member of the Kittanning group, and then the coal in question was lowered to the name of Middle Kittanning.

In the vicinity of Kittanning (Section 63), and along the Alleghany River below (Sections 64, 65, and 66), this bed is thin and unimportant, but west from this it thickens up and is the most important seam in Butler, Lawrence, and Beaver Counties, the coal being quite pure and highly esteemed for gas, steam, and domestic purposes, though it seldom exceeds 4 feet in thickness, and is often much less. This is the famous "Clinton," "Rock Point," and "Hog Hollow" coal along the Beaver River. It is always divided by one or more thin slate partings, one of which is usually near the bottom.

Eastward from Butler County, through Armstrong, Clarion, Jefferson, and Clearfield, this bed, according to Platt and Chance, declines much in thickness and value, so that it is seldom mined, except occasionally for domestic purposes.

Still farther eastward, however, in the Broad Top coal field of Huntingdon and Bedford Counties, it thickens up and is apparently represented by the "Barnet" coal of that region.

Southward from Pennsylvania, in Maryland and northern West Virginia, this coal is sometimes thick enough to mine, though seldom exceeding 2½ to 3 feet. At the southern end of the North Potomac

coal basin it practically unites with the Lower Kittanning below, and is mined with the latter where that bed is opened near Thomas; but at the Davis mine, further south, the parting slates have thickened up to 20 feet and separated it from the Lower Kittanning again.

Section at Newburg, Preston County, West Virginia.—In the deep shaft at Newburg, Preston County, West Virginia, this coal has the following structure and relations to other beds:

		Ft.	in.	Ft.	in.
1. Lower Freeport sandstone					
2. Coal, Middle Kittanning	Coal	1	0	7	3
	Slate	0	3		
	Coal, slaty	2	0		
	Clay	2	0		
	Coal, good	2	0		
3. Fire clay and shales				15	0
4. Coal, Lower Kittanning, with several partings				9	5

Here it is possible that both the Upper and Middle Kittanning beds are represented in No. 2, and they are only 15 feet above the Lower Kittanning coal.

In the Great Kanawha field, this bed, although only 3 to 4 feet thick, is very pure and valuable, being known there under the names of "Cedar Grove," "Trimble," "Arno," and others.

In the Wyoming County section (117) two beds are often found at this horizon, separated by 20 feet of shales, but the lower one appears to be the main coal. The same thing is seen in the Peach Orchard section (119), where the lower one is a "splint" coal, thin, but of excellent quality.

In Ohio this coal becomes the most important bed of all the coals in that State, according to Prof. Orton, since it is almost constantly workable from where it enters Columbiana County on the east to where it leaves the State near Ironton at the southwest. The numerous names it has received in Ohio will serve to illustrate its importance in the mining industry there, of which the following is a partial list: "No. 4, in Ohio and Yellow Creek Valleys at the east; "No. 6," in Stark County and southwestward; "Hammondsville Strip Vein," "Onasburg," "Pike Run," "Dennison," "Coshocton," "Upper Zanesville," "Upper New Lexington," "Nelsonville," "Straitsville," "Great Vein" of the Hocking Valley, "Carbondale," "Mineral City," "Upper Zaleski," "Washington Furnace," "Sheridan," etc.

The tracing of this bed through Ohio, and its identification at many points where it had formerly been confused with other beds, is due largely to the labors of Prof. Orton, the present efficient director of the Ohio Geological Survey. The structure of the coal where it attains a considerable thickness, as in the Hocking Valley, is always quite complex, there being several parting slates, as may be seen from Sections 105 and 106.

Section in Hocking Valley, Ohio.—The following, from Vol. V, Ohio Geology, will serve to illustrate the general structure of this bed when at its maximum development:

	Ft.	in.		
Top coal	2	7		
Soft coal, rejected	0	4		
Coal	4	2		
Bone coal, rejected	0	6	Ft.	in.
Second slate	0	2	11	8
Coal	1	6		
First slate	0	1		
Coal	2	4		

Section at New Straitsville, Perry County.—The following is the structure at New Straitsville, p. 954, loc. cit.:

	Ft.	in.	
Coal	1	2	
Bone coal	0	2	
Coal	4	0	
Soft coal	0	4	Ft.
Slate	0	3	10
Coal	2	1	
Slate	0	1	
Coal	1	11	

According to Orton this bed changes in character from a good coking coal in eastern Ohio to an open-burning one from New Lexington southwestward. The reader will find the coal fully described in Vol. V, Ohio Geology.

The interval separating the Middle Kittanning coal from the Lower Kittanning bed varies greatly both in thickness and composition in the different regions of the Appalachian field. In western Pennsylvania and eastern Ohio the interval is usually only 20 to 30 feet and generally occupied with dark slates or shales holding iron nodules, and it seldom surpasses 40 feet anywhere in Pennsylvania, while in northern West Virginia it locally thins away to an insignificant parting, but to the southwestward in the Great Kanawha region, and from there across to the Big Sandy, it often swells up to 100 feet and occasionally attains a thickness of 165 feet (Section 115), with some massive sandstone at several horizons. In southwestern Ohio a massive sandstone 30 to 40 feet thick often occupies the interval to the exclusion of shales.

In the Great Kanawha region a siliceous limestone makes its appearance in this interval and seems to have quite a wide distribution in that region and southwestward to the Big Sandy. It is well exposed near the mouth of Campbell's Creek, and I have designated it the Campbell's Creek limestone from that locality. This stratum seems to be present even in northern West Virginia, since in Sections 95 and 96, at Moatsville and Valley Falls, respectively, a bed of siliceous limestone occurs 20 feet above the Lower Kittanning coal.

Along the Tug Fork of Big Sandy there are siliceous limestones at

several horizons above the Campbell's Creek bed, as shown in Section 119, there being two and sometimes three within the horizon of the Lower Freeport sandstone, so that these must not be confounded with the one in question.

The bottom layers of this shale interval immediately above the Lower Kittanning coal are nearly always filled with fossil plants. They occur in great variety and abundance wherever the rock material in the roof of the underlying coal is a shale, and this is the horizon par excellence for the collector of plants from the Lower Coal Measures.

These beds have been thoroughly explored at only one locality in the Appalachian field, viz, Cannelton, Beaver County, Pennsylvania, where Mr. I. F. Mansfield has collected systematically for Prof. Lesquereux during several years, the results of which are recorded in Report P, Vols. I and II, Second Geological Survey of Pennsylvania. The list includes a large number of species, several of which are peculiar to that locality.

THE LOWER KITTANNING COAL.

The next lower bed of this series, though formerly named simply the Kittanning coal by Rogers, is now called the Lower Kittanning. Although seldom attaining any unusual thickness, it is probably the most persistent bed in the entire Appalachian field, and has a workable thickness over a larger area than any other. In Pennsylvania it furnishes from 3 to 4 feet of valuable fuel over large areas in every county where its outcrop is due. Of course, like all other coals, it thins down locally and becomes worthless over considerable areas, but the barren patches on the horizon of the Lower Kittanning bed are fewer and smaller than those at the horizon of any other coal in the entire Lower Coal Measures. If the Middle Kittanning is the more important coal in Ohio, the Lower surpasses it in Pennsylvania and West Virginia, so that the difference in favor of the former in Ohio is much more than offset in the latter two States. This coal is also a composite seam, and when it acquires considerable thickness is often split into several divisions by separating slates. In the Pennsylvania field these slates are usually mere knife edges, and add but little to the total thickness of the bed, except in the eastern portion of the field, where in Clearfield, Bedford, and Huntingdon it often has a layer of impure fire clay or gray shale separating the bottom member from the middle one.

The "Fulton vein" of the Broad Top field appears to be identical with this coal, though the writer was formerly inclined to regard it as identical with the Clarion (see T^3, Second Geological Survey of Pennsylvania), and bed "A" of the Tipton Run series is probably the same.

The "Bloss vein" of Tioga County seems to be referable to this same horizon both with reference to structure and its position in the column of rocks (Sections 50 and 51).

In the Georges Creek field of Maryland this is often known as the "6-foot" bed, and its structure there is given in Section 92. From Elk

Garden southward along the North Potomac to where this bed passes under drainage level, near Gorman, it is so badly split up with slate as to be rather valueless, but where it emerges to daylight again on the other side of the Cheat-Potomac divide, near Thomas, it has become a splendid vein nearly 11 feet thick, as shown in Section 94, from which 6 feet of excellent coal is mined without taking out the bottom member. As already stated, the bed attains its great thickness in this region by the thinning away of the shales which usually separate the Middle and Lower Kittanning beds, thus permitting the two practically to unite into one. The coal from it here is prized for smithing purposes quite as highly as the celebrated Blossburg bed, with which it appears to be identical. It has also been successfully coked in this Tucker County field, since it is nearly always a good coking coal everywhere.

Section at Newburg, Preston County, West Virginia.—In the deep shaft at Newburg, Preston County, West Virginia, the Lower Kittanning has the following structure:

	Ft.	in.	Ft.	in.
Coal	0	10	9	5
Shale, gray	0	10		
Coal	0	6		
Bony coal	0	3		
Coal	4	6		
Black slate	0	6		
Coal	2	0		

Sections 95 and 96 show the structure of this bed where it is brought to the surface by the Chestnut Ridge anticlinal, on the Tygart's Valley River, below Grafton, West Virginia, and, as will be seen, it is there about 5 feet thick.

On the Great Kanawha River, above Charleston, this is one of the principal coal beds, and has long been known there as the Campbell's Creek vein. At this locality on Campbell's Creek the coal is 4 to 6 feet thick with only two parting slates, but in passing southward up the Kanawha new partings come in and the old ones thicken up until the bed, with its included rock partings, swells out to a thickness of nearly 50 feet, and two of the members are mined independently, the upper one being known as the Peerless bed and the lower one as the Blacksburg. The upper member never exceeds 3 feet, and is usually about 20 feet above the Blacksburg member, which is often 4 to 5 feet thick and is the "Coal Valley gas vein." On the Mount Carbon property, 25 miles south from Campbell's Creek, the 20 feet of shales which usually separate the Peerless and Blacksburg members of the Lower Kittanning coal thin away to a few inches locally, and both are taken out of the same drift. This is also the condition of affairs at the famous Anstead mines of the Hawk's Nest Coal Company on top of Gauley Mountain. At the head of Cabin Creek, a tributary from the south bank of the Big Kanawha, the Peerless and upper half of the Blacksburg member come completely together, forming a bed of excellent gas coal 5½ feet thick.

In Wyoming County, West Virginia, this coal, which is locally called the "Cook vein," has a good development, the whole seam with its parting slates being about 25 feet thick, as may be seen from Section 117, but the main portion of the bed is about 7 to 8 feet thick, separated into three layers by slate partings of 4 to 6 inches thick.

This coal rises above the level of the Tug Fork of Big Sandy about 3 miles below Warfield and 30 above Louisa. It has been mined to some extent for local use at Warfield, and is known in that region as the "Warfield coal." Its structure there is given by Section 119. Above Warfield it dips down under the stream and does not come up again for about 10 miles, or some distance above the mouth of Pigeon Creek, but from there on up Tug River it is constantly accessible for about 40 miles, until the southward rise of the rocks throws the coal above the tops of the hills near the mouth of Ben Creek, 95 miles above the mouth of Tug. Along this line the coal is seldom less than 3 feet thick and frequently 4 to 5 feet, with only one slate parting 3 to 5 inches thick. At the mouth of Lick Creek and 60 miles from Louisa this coal is 100 feet above the river, and reported 6 to 7 feet thick, with only one thin slate near the center.

In Ohio the Lower Kittanning coal is almost as persistent as in Pennsylvania, rarely being absent entirely from the section, and generally having a thickness of 3 feet, with a maximum of 5.

In the deep oil-borings across southwest Pennsylvania and northern West Virginia this coal is quite persistent, being frequently reported at a depth of 1,500 to 1,800 feet beneath the surface.

The following list of names has been given it in Ohio: Coal No. 3 in Ohio Valley and along Yellow Creek, No. 4 at Leetonia, No. 5 in Stark County and southwestward; also "Creek vein," "Potter's vein," "Leetonia," "Mineral Point," "Lower New Lexington," "Newcastle," etc. This coal is often neglected in Ohio even when it has a thickness of 2½ to 3 feet, because of the great development of the Middle Kittanning coal only a few feet above. Both of these beds have now, through the labors of Newberry, Orton, Roy, and others, been traced from the Pennsylvania line clear across Ohio to where they pass into Kentucky at Ironton, and have been so well described by Orton in Vol. V, Ohio Geology, that it is unnecessary for the writer to dwell on them longer.

THE KITTANNING FIRE CLAY.

Lying directly under the last described coal there comes in many regions a great bed of splendid fire clay which often overshadows the coal in value, since many millions of dollars are invested in manufacturing the several lines of articles which can be made from this clay. The bed has been named from Kittanning, where it is mined, and here as well as at many localities in Ohio the clay does not all immediately underlie the coal, but some of it is found a few feet lower and nearly on top of the Ferriferous limestone.

Eastward from the Alleghany River this clay does not appear to be very important, but westward from that point it is generally present, and attains its maximum development along the Beaver, and westward from there down the Ohio; the famous potteries at New Brighton, Rochester, East Liverpool, New Cumberland, and other points in these valleys all deriving their clay from this horizon.

In the Beaver County region the thickness is generally about 8 to 10 feet, but occasionally runs up to 15 and down to 5. It often consists of two portions, an upper "soft" clay and a lower "hard" clay, the latter being used in the manufacture of fire brick, etc. In western Pennsylvania and eastern Ohio this clay bed is often a very valuable element in settling questions of stratigraphy which would otherwise be extremely difficult of solution; in fact it is valuable for this purpose clear across the Ohio coal field, since, according to Orton, although not entirely persistent, yet it furnishes valuable clay mines in every county of its outcrop from the Pennsylvania line across to the Kentucky border.

In West Virginia (except along the Upper Ohio River) the deposit is seldom of value, being too siliceous, and it has been developed in only one region, viz, near the locality of Section 97, at Nuzum's, on the Tygart's Valley River. Here along the crown of the Chestnut Ridge anticlinal the coal above locally disappears, and then a valuable bed of hard clay replaces it, but when the coal comes in again the clay disappears, just as it often does in Ohio, when the hard flinty clay is present. The Glade Fire Brick Works at Nuzums manufacture a good fire brick from this bed.

THE KITTANNING SANDSTONE.

The interval between the Lower Kittanning coal and the Ferriferous limestone varies greatly in thickness, sometimes only the clay bed just described intervening, and again the interval thickens up to 50 to 75 feet or even more. Whenever the interval attains anything like these last figures we generally find a massive sandstone between the coal and the limestone, and to this has been given the name Kittanning. It sometimes, as on Buffalo Creek, Butler County, Pennsylvania, develops into a great cliff rock of massive and even pebbly sandstone, cutting out the underlying limestone (Ferriferous). It often furnishes good quarry stone, and a rock occupying this horizon in the series has been quarried and used in building the Government lock and dam near Coal Valley, on the Great Kanawha River. In this region the interval between the Lower Kittanning coal and the Ferriferous limestone thickens up to 150 feet, and a local bed of coal, the Brownstown, comes into the series about half way in the interval. In Wyoming County and westward from there the Kittanning sandstone thickens to 100 feet, as seen in Section 117.

THE BUHRSTONE IRON ORE.

Resting immediately on top of the Ferriferous limestone there occurs over a very wide area a deposit of iron ore. In Pennsylvania it is often

underlaid with cherty material, and hence long ago received the name of "Buhrstone ore," but it is there also called Ferriferous ore. In Ohio it has a wide distribution and is known under several names, among which are "Baird" ore, "Gray" ore, "Limestone" ore.

The ore generally lies in immediate contact with the limestone, in a slab-like sheet one-half to 1 foot thick, but occasionally, as in Lawrence County, Pennsylvania, on the Houck farm, it locally thickens up to 20 feet, entirely replacing the underlying limestone, while again it is absent over wide areas, or represented by nodules scattered through the overlying shales. When the Ferriferous limestone is absent, its place in the series can often be correctly assigned from the existence of this ore, as is the case in Section 97, at Nuzum's Mills, West Virginia. This bed was formerly the main ore from which the charcoal furnaces of western Pennsylvania drew their supplies, and it is still the main feeder for these furnaces in southern Ohio. In northern West Virginia some iron ore occurs at this horizon in Monongalia and Preston Counties, and a few inches of it may be seen near the coke ovens on Glady Fork, below Thomas, Tucker County, but in the Great Kanawha region and southward toward the Big Sandy it appears to be completely absent as a distinct stratum, though nodules of iron sometimes come at this horizon.

THE FERRIFEROUS LIMESTONE.

The occurrence of the iron ore just described resting upon a bed of limestone over a wide area suggested the name "Ferriferous" which the early geologists applied to the limestone as well as the ore.

This is the most important and widely distributed limestone of the entire Coal Measure column, important both in an economic sense and as a stratigraphical horizon which with ordinary care can be unfailingly recognized by geologists as well as anyone else interested in determining the correct order of the rocks. It differs from the other limestones that we have had so far in the Lower Coal Measures, in being a genuine marine deposit, abounding in fossil crinoids, corals, brachiopods, lamellibranchs, univalves, etc., a list of the more common forms of which is given on pages 46 and 47, Report QQ, Second Geological Survey of Pennsylvania.

In Pennsylvania this limestone is confined to the counties west from Chestnut Ridge, attaining its maximum development in Clarion, Armstrong, Butler, Beaver, and Lawrence, where it is frequently 25 feet thick, or even more, and seldom less than 10 except it has locally thinned away entirely.

This limestone enters Ohio at Lowellville on the Mahoning River with a thickness of 15 feet, but westward it changes very much from its Pennsylvania type, becoming reduced in thickness, sometimes entirely absent, and occasionally splitting into two beds separated by 15 to 50 feet of shales, the lower one of which has been called the Putnam Hill limestone from its occurrence in an eminence of that name at

Zanesville. In one way or another, however, it has been satisfactorily traced by Orton across the Ohio field to where it enters Kentucky from Hanging Rock.

A layer of flint or "buhrstone" is often incorporated with the top of this bed in Pennsylvania, and the same thing holds true for Ohio, but below this the rock is generally gray for 10 to 15 feet and of great purity, being especially prized as a flux in the smelting of iron ore, and used almost exclusively for this purpose in the Pittsburgh region. The lower portion of the stratum is generally of a bluish color, and its layers are shaly, being interstratified with thin films of clay and other impurities, and occasionally a distinct bed of shale separates the blue layers from the gray above. Hence it seems very probable that, as Prof. Orton once suggested, this shale layer probably increases in thickness through some regions of Ohio, thus separating the upper portion, as the "Gray" limestone, from the lower or blue part, which has been called the Putnam Hill. On one point, however, in this connection, the writer cannot fully agree with Prof. Orton, and that is concerning the presence of workable coal beds between these two divisions of the limestone. There is certainly none at Zanesville, the typical locality for the Putnam Hill limestone (Section 104), neither is there any at Shawnee (Section 105), nor at New Lisbon (Section 103), nor Sprucevale (Section 102), so that it appears more probable that the supposed workable coal between the two layers of the limestone is founded upon an error in identification.

Another characteristic of this limestone is that when it becomes thin and impure it almost always exhibits the "cone-in-cone" structure, though there are other horizons in the Coal Measures which show the same feature, notably the Mercer limestones.

The most northern point at which this limestone has been found in Pennsylvania is in the southern portion of McKean County, where Mr. Ashburner identifies with it a siliceous limestone occurring in the vicinity of Clermont.

In the North Potomac coal basin this limestone has been seen by the writer near Gorman, Garrett County, Maryland, and also below Thomas, along Glady Fork of Black Water. In each case, however, the deposit is entirely different from the marine type of western Pennsylvania and Ohio, and resembles more the fresh water limestones under the Freeport coals, since no marine fossils were observed at either locality; in fact there is no point in West Virginia or Maryland where the marine type of this limestone is known to exist, so far as the writer is aware.

Along the Great Kanawha River, in the vicinity of Cannelton, a bed of siliceous limestone occurs 75 to 100 feet under the Lower Kittanning coal, and it has been identified with the Ferriferous limestone horizon as shown in Section 115. It occasionally exhibits the "cone-in-cone" structure but is not fossiliferous.

Immediately under the Ferriferous limestone in western Pennsyl-

vania there are often 5 to 10 feet of black fossiliferous shales, especially when the limestone is thin or locally wanting, so that the horizon can thus be frequently recognized without the presence of the limestone since the fossils in the shales are practically the same as in the latter.

THE CLARION COAL.

Mr. H. Martyn Chance has recently shown (VV, Second Geological Survey of Pennsylvania) that the coal bed which comes so close under the Ferriferous limestone in western Pennsylvania, and was formerly called the Scrub-grass coal, is really an off-shoot from the Clarion, and hence it is unnecessary to retain the name Scrub-grass, which should be replaced with Upper Clarion.

The main bench of the Clarion coal occurs through western Pennsylvania at an interval of 10 to 30 feet below the Ferriferous limestone. Its usual thickness is about 3 feet, though it often swells to 4 or 5. When well developed it generally contains one or two parting slates, and one of them thickening up causes the upper bench to approach the Ferriferous limestone, and it was then taken for a separate coal by the geologists of the First Pennsylvania Survey, but, as Chance suggests, this should be called the Upper Clarion bed in view of its origin. This upper member is thick enough to mine in only a limited area around the northern outcrop of the same in Clarion, Butler, and Jefferson Counties.

The Lower or main Clarion bed is of considerable importance in Pennsylvania, and generally furnishes some areas of good fuel in nearly every county where its outcrop occurs, though as a rule the coal is rather high in both ash and sulphur.

In eastern Ohio this bed acquires some importance in the vicinity of Leetonia and New Lisbon, and is there often parted by a vein of fire clay 1 to 4 feet thick, the upper coal alone being mined, and varying in thickness from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet. Prof. Orton has also shown that the Canfield cannel of Mahoning County belongs to the horizon of the Clarion bed.

Westward from the eastern tier of Ohio counties, the Clarion coal disappears according to Orton and is of no more importance until Vinton and Jackson are reached, but this conclusion is based upon his present view of the Putnam Hill limestone, which he once regarded as a "split" from the Ferriferous of Pennsylvania, but which he now appears to reject, since he puts the Clarion coal between this latter limestone and the upper or "Gray" one, and identifies the coal underlying the Putnam Hill limestone as the Brookville bed of Pennsylvania. The writer has elsewhere expressed his doubt of the existence of any workable coal between these two limestones, believing that the identifications on which the conclusion was founded are erroneous, so that if we substitute Clarion coal for "Brookville" in Prof. Orton's Ohio series,

all difficulties concerning the disappearance of the Clarion coal between eastern Ohio and Perry County vanishes, and the Clarion becomes one of the regular and persistent beds of the series clear across Ohio as it does in Pennsylvania. In the Zanesville section (104) the writer has indicated his views as to the equivalency of these members of the Ohio series.

The Clarion coal attains its maximum thickness in Stark County, Ohio, where it is 6 feet thick and a very fair steam coal, according to Orton.

In northern West Virginia this bed is generally present in the section, but is usually slaty and too impure to be valuable, so that it has never been mined in that part of the State.

Section near Eagle, Fayette County, West Virginia.—Along the Great Kanawha River a coal bed, which appears to come at this horizon, has been largely developed for coking purposes in the vicinity of Eagle, Fayette County, and hence is locally known as the Eagle vein. Where best developed there, it varies from 3½ to 4½ feet in thickness, and is a splendid coking coal, having the following structure in the vicinity of Eagle:

	Ft.	in.	Ft.	in.
Coal	1	2		
Shale	0	3		
Coal	0	3	4	9
Shale	0	3		
Coal	2	10		

In passing up the Kanawha from Eagle the upper shale parting of this bed gradually thickens till at the mouth of Armstrong Creek, 3 miles above, it becomes 20 feet thick and the coal has the structure given in Section 115.

The interval between this bed and the Lower Kittanning varies between 120 and 200 feet along the Great Kanawha, thickening up to the latter figures at Brownstown (Section 114), but southward from this in Wyoming County the interval swells still further to 230 feet in the vicinity of Oceana, as shown in Section 117, where the coal in question has a thickness of 5 to 6 feet and is known as the "coking" vein. There is evidently a wide area of this coal between the Kanawha and Big Sandy Rivers in which it will prove a valuable coking coal.

A bed of excellent fire clay often underlies the Clarion coal both in Pennsylvania and Ohio, being second in value only to the Kittanning clay above, and often rivaling it in thickness.

The interval below the clay down to the next coal bed (Brookville) varies greatly both in thickness and in the rock material which occupies it. Occasionally the series ends with the Clarion underclay, which rests immediately on top of the next lower or Conglomerate Measures, while again, shales and a sandstone termed by Chance the Clarion sandstone occupy this interval, which in Pennsylvania is seldom more than 30 to 50 feet thick.

In Ohio the interval below the Clarion clay down to the top of the Pottsville Measures is seldom more than 30 feet, the same being true in northern West Virginia, as may be seen from Sections 96 and 97.

On the Great Kanawha River the interval from the Clarion or Eagle coal down to the top of the Pottsville Measures thickens to nearly 300 feet, and consists of a succession of shales and sandstones, in which occur two thin limestones and two or three thin coal beds. None of the latter attain a thickness of 3 feet, however, anywhere between the Kanawha and Big Sandy Rivers, so that the workable coals of this series in that region really end with the Clarion (Eagle) bed.

Two or three rocks in this interval of 300 feet in southwestern West Virginia require more particular notice. One of them, and the uppermost, is a very pure seam of coal, which at Eagle comes only 20 feet below the main Eagle bed, and is 1½ feet thick. I have termed it the Little Eagle coal, since it is possibly a "split" from the main bed above. To the south it appears to be quite persistent, since it occurs in Wyoming County in every section; but the interval separating it from the Eagle bed has there swelled to 65 feet (Section 117) and the coal has thickened to 27 inches of the same excellent fuel as on the Kanawha.

THE EAGLE LIMESTONE.

Another rock worthy of mention in this Kanawha series is an impure limestone which occurs near Eagle at an interval of 75 feet under the Eagle coal. It is only about 1 foot thick, quite dark, fossiliferous, and exhibits the "cone-in-cone" structure to a wonderful degree, being locally known as "black marble." The stratum is immediately underlaid by dark shales, which are crowded with marine fossils of the same type as those found in connection with the Ferriferous limestone in Pennsylvania and Ohio; in fact, so many of the species are identical, and the limestone itself so closely resembles the Ferriferous when thin, that sometimes I have been inclined to think that the two beds may possibly be identical, though this would seem to be impossible from the structure of Section 115, in which the whole lower coal series is exposed both above and below this stratum. If it should turn out to be identical with the Ferriferous, however, then the Eagle coal would be the Lower Kittanning, instead of the Clarion, and the Campbell's Creek bed the Middle Kittanning, or Nelsonville seam of Ohio, instead of the Lower Kittanning. The reader will understand the difficulty of correlation when he remembers that the lower coal series is less than 200 feet thick in the Hocking Valley, Ohio, while here, only 120 miles southward, the same series has swelled out to 1,000 feet.

The fossiliferous type of the limestone and its accompanying fossiliferous shale have never been seen by the writer, except in the vicinity of Eagle, and hence I have preferred to regard it as a local deposit below the horizon of the Ferriferous, since the fossils of the Lower Coal Measures have the same general facies at all horizons.

THE BROOKVILLE COAL.

At the very base of the Lower Coal Measures, except the intervening underclay, there occurs in Jefferson, Clarion, and some other counties of Pennsylvania, a bed of usually slaty and otherwise impure coal, which was long ago named the Brookville bed, from its supposed occurrence near the town of that name in Jefferson County. This coal acquires some local importance around the northern margin of the coal field in Jefferson, Clarion, Butler, and Mercer Counties, but southward and westward it thins away and is often absent even as an impure bed, there being no coal whatever at this horizon where the Pennsylvania series enters Ohio; and if I am correct in identifying Prof. Orton's "Brookville" coal, (Vol. V, Ohio Geology) with the Clarion of Pennsylvania, then the Brookville coal is generally absent, or at least seldom workable anywhere in that State.

Very frequently the Brookville coal is represented in Pennsylvania by only a bed of black slate or coaly shale, resting on the top of the Conglomerate Measures, and this is the case in northern West Virginia, there being no workable coal at this horizon anywhere in that State, so far as the writer is aware. Even in the Kanawha field, where this lower portion of the column is so greatly thickened, the largest coal bed referable to the Brookville horizon is the one in the Wyoming County section (117), and this is only 22 inches.

On the Great Kanawha a bed of very bituminous shale (Section 115), from which lubricating oil was once manufactured, may possibly represent the Brookville coal horizon, since it is the lowest bituminous stratum in the series there.

Below this coal in Pennsylvania, and resting immediately on the top of the Conglomerate series, there is sometimes a good bed of fire clay, and Mr. Chance refers to this horizon the clay which is mined so extensively in Clearfield County, at Blue Ball, Wallaceton, and other points along the line of the Tyrone and Clearfield Railroad.

CHAPTER VI.

THE POTTSVILLE CONGLOMERATE SERIES.

THICKNESS, CHARACTER, AND EXTENT.

Beneath the lowest member of the last described series there comes in a group of rocks (No. XII) which are nearly always so different from those in any other portion of the Carboniferous system that all geologists have regarded them as worthy of being placed in a distinct series. To this series several names have been given. The early geologists of Pennsylvania called it the "Seral" or "Great" Conglomerate, while in Virginia it has generally been named the No. XII Conglomerate, or simply No. XII. Prof. Lesley has in recent years, however, given it the geographical designation of Pottsville Conglomerate, from the great development of the series near the town of that name, while Prof. Fontaine, following the Pennsylvania custom of naming the several coal series after prominent rivers along which the beds are exposed, has suggested the name New River series, from that region of West Virginia where its coal beds attain a great development.

But since only one geographical name is admissible for the series, and as the term Pottsville is now so well ingrafted upon geological nomenclature through the numerous reports of the Second Geological Survey of Pennsylvania, it is thought best to retain it for the series, and at the same time retain New River for the name of the coal group which attains such prominence along that stream, thus putting it on a par with the Mercer group, which occurs in the upper portion of the series.

As exhibited everywhere in Pennsylvania and West Virginia, this series is very sharply set off from the Lower Coal Measures above and the Lower Carboniferous below, since in both cases there is a great change in the lithology, so that the geologist finds no difficulty in determining where the Pottsville series begins as well as where it ends.

The series as a whole possesses a large amount of hard, white, or grayish white sandstone, much of which is often conglomeritic. The sandstones are harder, more compact, and siliceous than any in the Lower Coal Series above. Bowlders of these sandstones take a smooth polish when rolled along river beds, but this is not the case with most sandrocks above this horizon.

The fossil contents are also different from those of any sandstones above, since here for the first time in descending the column of rocks

do we find sigillariæ and the large lepidodendra very abundant in sandstones.

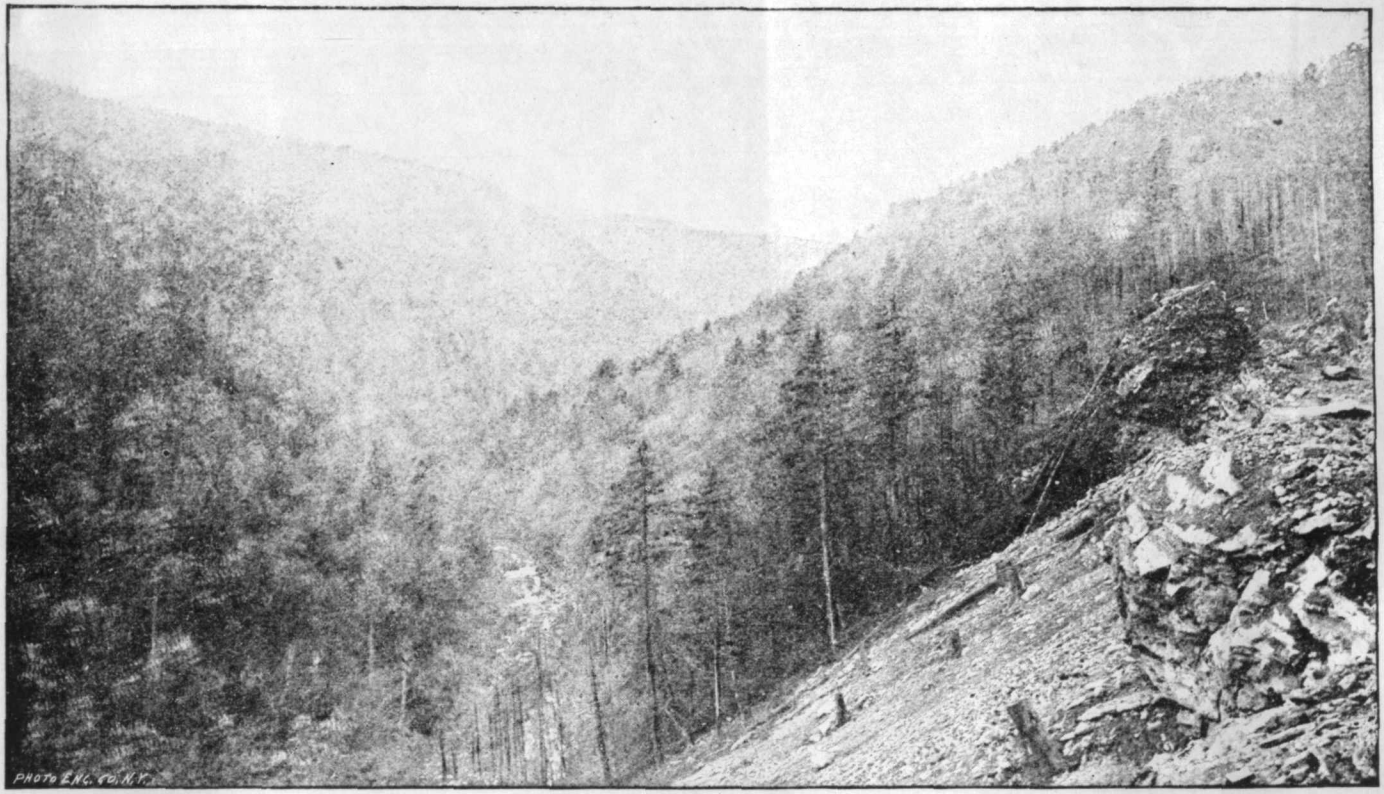
At the base of the series the change in lithology and life remains is even more abrupt, since with the disappearance of the white or gray sandstones and conglomerates, limestones, red shales, and green micaceous sandstones appear, in which plant remains are rare and the fossil trees are all small.

The Pottsville being composed mainly of very hard sandstones, the grains of which are cemented by silica and peroxide of iron, becomes almost indestructible by ordinary atmospheric influences, and has thus proved a most important factor in determining the topography of the Carboniferous system. Whenever these beds come to the surface in West Virginia and Pennsylvania, wild and rugged scenery is sure to be found. Rapid rivers, high waterfalls, great cliffs, and barren regions generally, mark the lines where these rocks emerge to daylight. The loftiest peaks of the Alleghany Mountains owe their origin to this friendly mantle, while its upturned edges have preserved many coal basins from complete destruction. The deep gorges, narrow cañons, and wild scenery of the Alleghany, Youghiogheny, Cheat, Monongahela, New, Guyandotte, and Big Sandy Rivers are all carved out of these rocks. The Falls of the Yough, Cheat, Tygart's Valley, Kanawha, and the "Roughs" of the Guyandotte and Big Sandy are all made by these same beds.

It was formerly supposed that a vast sheet of pebbly material underlaid all of the true Coal Measures, and that it was destitute of coal; but the recent work of the Second Geological Survey of Pennsylvania has shown that the series is very complex, consisting of several distinct sandstone members, between which occur shales, several coal beds, and occasionally some limestone.

In Ohio it happens that the upper members are not so massive as in Pennsylvania or West Virginia, while the coal beds which are prominent only around the margins are well developed there, so that the Ohio geologists have classed the upper portion with the Lower Coal Measures, and retained only the lowest member of the series, viz, a stratum termed the Sharon Conglomerate, as the representative of the whole series elsewhere. I shall show in the following pages that the whole series is easily recognized in Ohio, and that the western Pennsylvania type of these measures can be traced across Ohio, and hence for the sake of uniformity in nomenclature the Ohio geologists should cut off 100 to 150 feet from the bottom of their Lower Coal Measure column and combine it with the Sharon Conglomerate below, thus making several members for the series instead of a single stratum.

The coals of the Pottsville series, unlike those in the measures above, are persistent and valuable only around the margins of the Appalachian coal field, and for the most part only where their outcrops are above the level of the principal drainage streams, so that the conditions for-



THE POTTSVILLE CONGLOMERATE TOPOGRAPHY IN BLACKWATER CANYON, TUCKER COUNTY, WEST VIRGINIA.

merly supposed to apply to the Lower Coal Measures do actually prevail with reference to the coal in this series, since hundreds of carefully kept well records testify to the absence of any workable coal beds in this series over all except the outer rims of the Appalachian field. This same fact is visible to the eye in passing inward toward the center of the field down any one of the great rivers which drain into the Ohio. The Sharon coal disappears southward along the Shenango and Mahoning rivers long before its horizon dips down to water level; the New River coals fade out of the section before their outcrops touch the stream to the north; the great bed at Pocahontas does not extend indefinitely down the Guyandotte and Tug rivers, but only 20 to 30 miles, until it dwindles away to a bed too thin to mine, so that should a shaft be sunk to these beds 30 or 40 miles from their southern or northern outcrops respectively, the same massive, pebbly, white sandstones would be found, but instead of inclosing valuable coal beds they would hold only thin streaks of coal and some black slates.

Another peculiarity about these interconglomerate coals is the great difference in quality between those around the southern rim of the Appalachian field and those around its northern border, for in western Pennsylvania and across Ohio they are all open burning, hard, and generally known under the name of "block" coals, which can be used in furnaces in the raw state, while to the south, through West Virginia, Virginia, and on into Tennessee and Alabama, these same coals are very soft and tender, always cementing and making good coke. This difference is connected with different conditions of accumulation, there probably being less moisture in the great peat swamps at the north, and the vegetable accumulations taking place not under water, but partially at least in the open air. This much would be indicated by the innumerable films of mineral charcoal which characterize the northern coals and render them non-cementing. To the unequal rate of subsidence on the two sides of the Appalachian basin is doubtless owing the conditions which brought about the difference in the character of the coals.

Another peculiarity is the great purity of these early formed coals, their freedom from injurious quantities of ash and sulphur, both at the north and south. This also appears to be due to the conditions attending their deposition rather than to any difference in vegetable tissues, since just previous to the spread of these early coal marshes the whole Appalachian region was sheeted with a thick layer of clean gravel and white sand, thus effectually covering up the muddy deposits of a former epoch and causing the streams which drained into the peat bogs of that time to be pure and clear like our own mountain brooks of the present.

The thickness of the Pottsville series varies greatly in different portions of the Appalachian basin. In the bituminous regions of Pennsylvania, and everywhere in Ohio, they rarely exceed 300 feet and seldom go below 150; but southwestward through West Virginia they begin to swell out, reaching 700 feet at the head of Black Water, in

Tucker County; 1,400 on the New River in Fayette, and probably 1,800 at the Kentucky line on the Tug River, in McDowell. Map Section C will exhibit the manner and rate at which these beds thicken southeastward from their northwestern outcrop in Ohio. The data for its construction were obtained from surface measurements and oil-well borings, several of which have been recently made along the Great Kanawha.

This series is also the repository of much salt water, as well as some oil and gas. The celebrated brines on the Great Kanawha, as well as at Pomeroy and many other localities along the Ohio River, come in its basal members, while the "first gas sand" of the Cannonsburg and Hickory region of Washington County, Pennsylvania, is found in the upper half of the same. This rock is also gas-bearing near Glover's Gap, on the Dodd farm, and near Mannington, Marion County, West Virginia, on the Snodderly farm.

We shall now give a number of sections in different portions of the Appalachian field, illustrating the character and thickness of the Pottsville series, and, as with the Lower Coal Measures, shall begin at the northeastern end of the field and proceed southwestward to the Kentucky line.

Section in Fox Township, Elk County, Pennsylvania.—The following section (Fig. 122) exhibits the structure of these beds in Fox Township, Elk County, Pennsylvania, as given by Ashburner (Report RR, p. 186, Second Geological Survey of Pennsylvania):

FIG. 122.—Section in Fox Township, Elk County, Pa.

Fox Township, Elk County, Pennsylvania.

[See map, D r.]

		Ft.	in.
1.	Sandstone, Homewood	35	
2.	Coal 1′ 2″; slate, black 0′ 3″; Coal 1′ 6″; Slate, black 0′ 3″; Coal 1′ 6″	4	8
3.	Slate and fire clay	15	
4.	Coal 1′ 8″; Slate 3′ 0″; Coal 1′ 3″	5	11
5.	Sandstone Conoquenessing	50	
6.	Shale and slate	10	
7.	Conglomerate	50	
8.	Shales of No. XI		
	Total	170	7

As will be observed, the series is thin in this region, and it seems to decrease still more in Tioga County further to the northeast, where it is less than 100 feet and all in one solid bed.

Section at Clearfield, Clearfield County, Pennsylvania.—At the town of Clearfield, in the county of the same name, a well was once bored for salt. It begins near the top of these measures, and the record shows the following structure (Fig. 123), as given in Report H, Second Geological Survey of Pennsylvania:

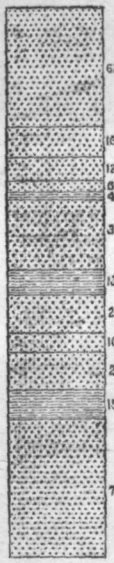


FIG. 123.—Section at Clearfield, Clearfield County, Pa.

Clearfield, Pennsylvania, from boring.

[See map, E s.]

		Ft.	Ft.
1.	Sandstone, ferruginous	62	
2.	Sandstone, brown	16	96
3.	Sandstone, light colored	12	
4.	Sandstone, coarse, iron-stained	6	
5.	Slate, black, mixed with sand		4
6.	Sandstone, iron-stained, crumbly		37
7.	Slate, soft gray		13
8.	Sandstone, iron-stained, crumbly	20	
9.	Sandstone, white	10	50
10.	Sandstone, grayish white	20	
11.	Slate, dark		15
12.	Sandstone, light gray		73
13.	Shales, and red beds of No. XI.		
	Total		288

Section near Brookville, Jefferson County, Pennsylvania.—In the vicinity of Brookville, Jefferson County, Pennsylvania, these beds exhibit the following structure (Fig. 124), as learned from surface observations combined with the record of the Brookville Gas Company's well No. 2:

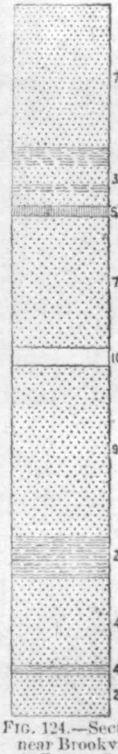


FIG. 124.—Section near Brookville, Jefferson County, Pa.

Brookville, Jefferson County, Pennsylvania.

[See map, E p.]

		Ft.	in.
1	Sandstone, massive, Homewood	75	
2.	Shales and sandstone	30	
3.	Coal	0	2
4.	Fire clay	5	
5.	Sandstone, massive	70	
6.	Concealed	10	
7.	Sandstone, massive	90	
8.	Slate	20	
9.	Sandstone, hard	46	
10.	Slate	4	
11.	Sandstone, hard	22	
12.	Red shales of No. XI.		
	Total	372	2

Here the series has thickened considerably, and the triple structure of its sandstones so often found in Pennsylvania becomes prominent. No. 4 appears to occupy the horizon of the Mount Savage fire clay.

FIG. 125. — Section near Patton Station, Clarion County, Pa.

Section near Patton Station, Red Bank Township, Clarion County, Pennsylvania.—Near Patton Station, Red Bank Township, Clarion County, Pennsylvania, the rocks of this series exhibit the following structure (Fig. 125), according to Mr. H. Martyn Chance (Report VV, p. 116, Second Geological Survey of Pennsylvania):

Patton Station, Red Bank Township, Clarion County, Pennsylvania.

[See map, E o.]

		Feet.
1.	Sandstone, hard, massive, Homewood	40
2.	Shale, with a streak of coal	20
3.	Iron ore bed	1
4.	Shale	15
5.	Sandstone	25
6.	Shale, with kidney iron ore	35
7.	Sandstone and shale	50
8.	Shale, with sandy layers and ore balls	40
9.	Sandstone, with interbedded thin shales	40
10.	Red shale.	
	Total	266

Section at Kellersburg, Armstrong County, Pennsylvania.—Near Kellersburg, Armstrong County, Pennsylvania, these measures have the following structure (Fig. 126), according to Mr. William G. Platt (H 5, p. 194, Second Geological Survey of Pennsylvania):

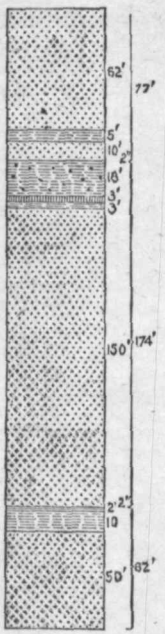


FIG. 126.—Section at Kellersburg, Armstrong County, Pa.

Section at Kellersburg, Armstrong County, Pennsylvania.

[See map, F o.]

	Ft.	Ft.	in.
1. Sandstone, massive, Homewood	62		
2. Shales	5	77	
3. Sandstone	10		
4. Coal (Mercer group)		0	2
5. Shales with iron ore	18		
6. Fire clay	3	174	
7. Shales	3		
8. Sandstone (Connoquenessing)	150		
9. Coal (New River group)		0	2
10. Clay	2		
11. Shales	10	62	
12. Sandstone	50		
Total		313	4

Here two prominent coal horizons are represented by mere streaks, the upper one being that of the Mercer group of western Pennsylvania and Ohio, while the lower is the Sharon coal horizon of the latter States and the New River group of West Virginia.

Section under Pittsburgh, Pennsylvania.—Under Pittsburgh, Pennsylvania, we learn the structure of this series from the careful record (Fig. 127) of the Jones & Laughlin gas well No. 2, as given in the Pennsylvania Geological Survey, 1886, p. 734:

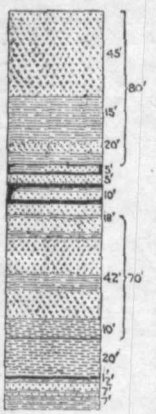


FIG. 127.—Section under Pittsburgh, Pa.

Under Pittsburgh, Pennsylvania; boring.

[See map, I m.]

	Feet.	Feet.
1. Sandstone, white, massive, Homewood	45	
2. Slate, black, trace of coal	15	80
3. Slate, dark, with sand shells	20	
4. Coal and slate, with white sandstone		5
5. Sandstone, grayish white, fine		5
6. Coal, coal slate, and white sandstone		10
7. Sandstone and black slate	18	
8. Sandstone, grayish white, slate in center	42	70
9. Sandy shale, dark	10	
10. Coal		Trace.
11. Sandy shale, dark		20
12. Coal		1
13. Sandy shale, dark		2
14. Sandstone and black slate		7
15. Slate, black, sandy, trace of coal		7
16. Limestone, Lower Carboniferous.		
Total		207

Section under Murraysville, Pennsylvania.—Under Murraysville, Westmoreland County, Pennsylvania, the structure is thus exhibited (Fig.

128) by the record of the Philadelphia Company's gas well No. 49, McCutcheon farm, according to William S. Stevenson, assistant superintendent of the company:

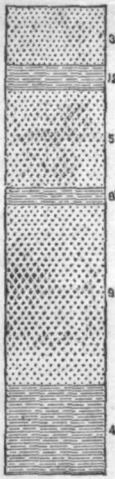


FIG. 128.—Section under Murraysville.

Under Murraysville, Westmoreland County, Pennsylvania (boring).

[See map, I n.]

	Feet.
1. Sandstone, gray, hard, close	30
2. Slate, black, soft	12
3. Sandstone, gray, hard, close	50
4. Slate, black, soft	8
5. Sandstone, gray, hard, close	90
6. Slate, black, soft	45
7. Red shale of No. XI.	
Total	235

Section under Washington, Pennsylvania.—Under Washington, Pennsylvania, the structure is thus given (Fig. 129) by Prof. Linton from the careful record he kept of the Thayer oil well (Geological Survey of Pennsylvania, p. 765, 1886):

Under Washington, Pennsylvania (boring).

[See map, J k.]

	Ft.	in.	Ft.	in.
1. Sandstone, Homewood: Sandstone, fine gray 9′; Sandstone, white micaceous 32′; Sandstone, white and dark mixed 17′; Sandstone, white, fine 29′			87	
2. Coal			1	6
3. Sandstone, white, hard, salt water	66	6		
4. Sandstone, fine, white and dark	15			
5. Shale, very dark, hard shells	13		110	6
6. Sandstone, white, fine	10			
7. Shale, black	4			
8. Sandstone, white, fine	2			
9. Shale, black, and coal			2	
10. Sandstone, close grained	1			
11. Shale and slate	13		29	
12. Shale and shells	15			
13. Shale, black, top of Lower Carboniferous beds.				
Total			230	

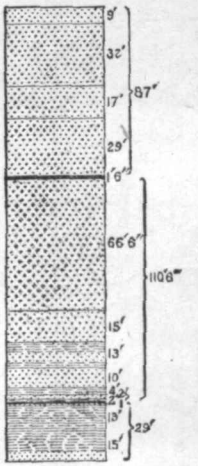


FIG. 129.—Section under Washington, Pa.

Here, as at Pittsburgh (Section 127), a careful record discloses thin representatives of the Mercer and New River coal groups Nos. 2 and 9, respectively.

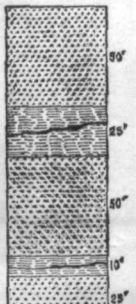


FIG. 130.—Section in Broad Top basin, Huntingdon County, Pa.

Section in Broad Top basin, Huntingdon County, Pennsylvania.—In the Broad Top basin of Huntingdon County, Pennsylvania, the structure of these beds is as follows (Fig. 130), according to Report T³, p. 69, Second Geological Survey of Pennsylvania:

Broad Top basin, Huntingdon County, Pennsylvania.

[See map, I t.]

	Feet.
1. Sandstone, slightly pebbly, Homewood	50
2. Shales, with a coal bed	25
3. Sandstone, pebbly	50
4. Shales, with a coal	10
5. Sandstone, pebbly	25
Total	160

The triple structure of the sandstones with intervening coal horizons is noteworthy here.

Section near Wellersburg, Pennsylvania.—At the northern end of the Georges Creek or Cumberland coal basin, near Wellersburg, Somerset County, Pennsylvania, these beds show the following structure (Fig. 131) in the gap of Gladden's Run, through the easternmost ridge of the Alleghanies:

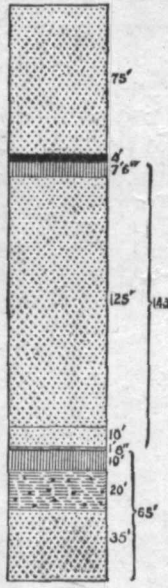


FIG. 131.—Section near Wellersburg, Pa.

Gladden's Run, Somerset County, Pennsylvania.

[See map, L q.]

		Ft. in.	Ft. in.
1.	Sandstone, massive, Homewood		75
2.	Coal, Mount Savage		4
3.	Fire clay, Mount Savage	7 6	
4.	Sandstone, pebbly	125	143 6
5.	Sandstone, dark, shaly	10	
6.	Shale	1	
7.	Coal	0′ 1″	
	Slate	0′ 4″	0 8
	Coal	0′ 3″	
8.	Fire clay, impure, sandy	10	
9.	Shales, dark, with iron ore	20	65
10.	Sandstone, massive	35	
11.	Red beds of No. XI.		
	Total		288 2

This section shows the horizon of the famous Mount Savage fire clay to be in the Mercer coal group. No. 4 represents the Connoquenessing sandstones, while No. 7 is probably at the horizon of the Sharon coal.

Section near Piedmont and Westernport, Mineral County, West Virginia.—The Pottsville conglomerate beds thicken very rapidly in passing southward from the Pennsylvania line through Maryland and West Virginia along the Alleghany Mountain region. This is shown by the following section (Fig. 132), taken on the North Potomac, at Piedmont and Westernport, where that stream cuts through the East Front Ridge of the Alleghanies:

Near Piedmont, Mineral County, West Virginia.

[See map, N p.]

		Ft.	Ft. in.
1.	Sandstone, massive, Homewood		20
2.	Coal		2
3.	Shales, dark, containing fossil plants	45	
4.	Sandstone, hard, massive	40	
5.	Shales, and concealed	30	127
6.	Sandstone, flaggy	10	
7.	Shale	2	
8.	Coal		1 6
9.	Fire clay, dark, sandy	12	
10.	Sandstone, flaggy	10	22
11.	Coal		1 6
12.	Shale, with nodular iron ore	2	
13.	Shales and flaggy sandstone	40	87
14.	Sandstone, white, pebbly, very hard	45	
15.	Shale, with streaks of coal		5
16.	Concealed shales and sandstones	145	
17.	Sandstone, massive	10	
18.	Shales, bituminous	10	195
19.	Sandstone, flaggy	10	
20.	Sandstone, massive	20	
21.	Coal		1
22.	Sandstone		4
23.	Fire clay and shale		3
24.	Sandy shales to top of No. XI red beds		4
	Total		473

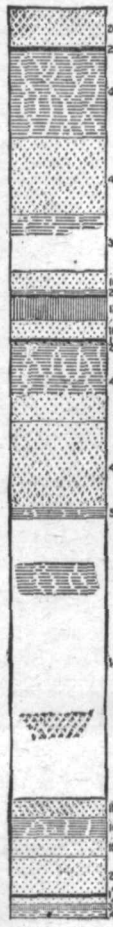


FIG. 132.—Section near Piedmont, Mineral County, W. Va.

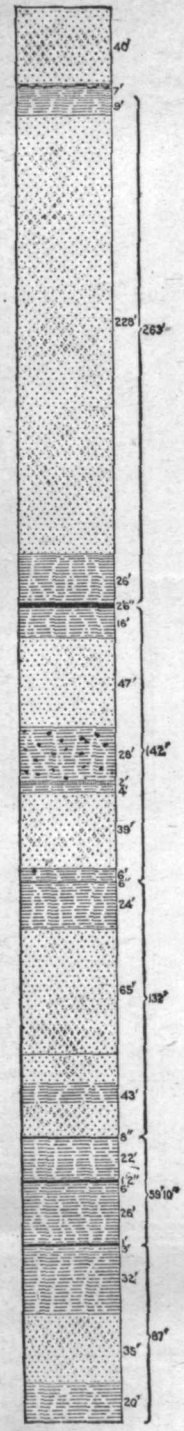


FIG. 133.—Section at mouth of North Fork of Black Water, W. Va.

Section on Black Fork of Cheat River, Tucker County, West Virginia.—In Tucker County, West Virginia, 50 miles south-southwest from Piedmont, in the gap made by the Black Fork of Cheat River through the central portions of the Alleghany Mountains, these beds exhibit a much greater thickness than at Piedmont, as will be seen by the following section (Fig. 133) made there by Mr. James Parsons, chief engineer of the West Virginia Central Railroad:

Mouth of North Fork of Black Water, Tucker County, West Virginia.

[See map, P *o.*]

		Ft.	in.	Ft.	in.
1.	Sandstone, Homewood			40	
2.	Coal, slaty and bituminous shale			7	
3.	Shale, dark	9			
4.	Sandstone, massive, pebbly	228		263	
5.	Brown shale	26			
6.	Coal (Nuttall)			2	6
7.	Shale, drab	16			
8.	Sandstone, massive	47			
9.	Shales with iron nodules	28			
10.	Fire clay	2		142	
11.	Shale	4			
12.	Sandstone, fine grained, flaggy	39			
13.	Shale	6			
14.	Coal			0	6
15.	Shale	24			
16.	Sandstone, massive	65		132	
17.	Sandstone and shales	43			
18.	Coal	0	8		
19.	Shale, brown	22			
20.	Coal	1	2		
21.	Bituminous shale, with coal streaks	6		59	10
22.	Brown shale	26			
23.	Coal	1			
24.	Bituminous shale, with coal streaks	3			
25.	Shale	32			
26.	Sandstone, massive	35		87	
27.	Shale, brown	20			
28.	Red beds, top of No. XI.				
	Total			733	10

Here we find the entire interconglomerate coal group represented. No. 2 comes apparently at the Mercer horizon and is the "Railroad" vein along the Potomac.

No. 6 comes at the horizon of the Nuttall bed of New River, while Nos. 14 to 24 represent the lower ones along that stream as well as the great Pocahontas vein of McDowell and Mercer Counties, West Virginia.

Section near Rowlesburg, West Virginia.—A fine section of the Conglomerate coals is exposed in the cuts of the Baltimore and Ohio Railroad, near the summit of Cheat River grade, 4 miles west from Rowlesburg, Preston County, West Virginia (Fig. 134):

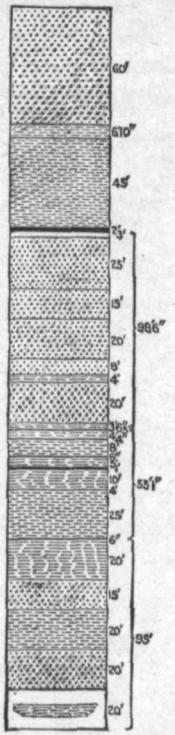


FIG. 134.—Section near Rowlesburg, W. Va.

Along the Baltimore and Ohio Railroad, Cheat River grade, four miles west from Rowlesburg, Preston County, West Virginia.

	[See map, N n.]	Ft.	in.	Ft.	in.
1.	Sandstone, massive, coarse, yellowish, Homewood			60	
2.	Coal: Coal 0′ 5″; Shales, sandy 6′ 0″; Coal 0′ 5″			6	10
3.	Shales, brown, sandy			45	
4.	Coal, slaty			2	
5.	Shales	3			
6.	Sandstone, massive	25			
7.	Sandstone, flaggy	15			
8.	Sandstone, massive, grayish white	20			
9.	Sandstone, flaggy	8		98	6
10.	Shales, brown	4			
11.	Sandstone, grayish white	20			
12.	Shale, brown	3	6		
13.	New River coal beds: Coal 0′ 5″; Shale, gray 4′ 0″; Coal 0′ 4″; Shales, drab, sandy 8′ 0″; Iron ore 0′ 6″; Shales 5′ 0″; Coal 1′ 0″; Shales 10′ 0″; Coal 0′ 4″; Shales, brown, sandy 25′ 0″; Coal 0′ 6″			55	1
14.	Shales, brown	20			
15.	Sandstone	15			
16.	Shales, buff, sandy	20		95	
17.	Sandstone, massive, pebbly	20			
18.	Concealed, and shales	20			
19.	Top of No. XI, red shales.				
	Total			362	5

Nos. 2 and 4 represent the Mercer coal group, Nos. 6 to 12 the Connoquenessing sandstones, while No. 13 represents the New River coal group.

Section near mouth of Sandy Creek, Preston County, West Virginia.—Farther northwest, down Cheat River, and in the center of the Ligonier basin, the Pottsville series exhibits the following structure (Fig. 135) near the mouth of Sandy Creek, Preston County, West Virginia:

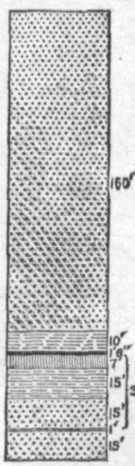


FIG. 135.—Section near mouth of Sandy Creek, Preston County, W. Va.

Near mouth of Sandy Creek, on Cheat River, Preston County, West Virginia.

	[See map, M m.]	Ft.	Ft.	in.
1.	Sandstone, massive, very pebbly near middle		160	
2.	Shales, dark		10	
3.	Coal: Coal 0′ 10″; Shale 0′ 3″; Coal 0′ 5″		1	6
4.	Fire clay	7		
5.	Slate, black, fissile	15	37	
6.	Sandstone, gray	15		
7.	Shale, with streak of coal		1	
8.	Sandstone, grayish white		15	
9.	Green and red shales of No. XI.			
	Total		224	6

Here, as frequently happens, the Mercer coal group disappears entirely, while the Homewood and Connoquenessing sandstones unite into one solid mass. Nos. 3 to 7 represent the New River coal group.

Section on Booth's Creek, Taylor County, West Virginia.—The structure of the Pottsville beds in the region along the line between Taylor and Marion Counties, West Virginia, is learned from a boring made for oil on Booth's Creek, Taylor County, by Mr. John L. Steele, to whom I am indebted for the following record (Fig. 136):

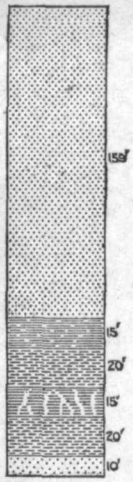


FIG. 136.—Section on Booth's Creek, Taylor County, W. Va.

Booth's Creek, Taylor County, West Virginia (boring).

[See map, O l.]

	Ft.
1. Sandstone, hard, white, pebbly	159
2. Black slate	15
3. Shale, gray and sandy	20
4. Shale, black	15
5. Shale, gray, sandy	20
6. Sand, gray, pebbly	10
7. Red beds of No. XI.	
Total	239

Here the structure is very much like that of the previous section on Cheat River, and the thickness is also nearly the same.

Section under Clarksburg, West Virginia.—Under Clarksburg, Harrison County, West Virginia, the succession is given as follows (Fig. 137), from the record of the Despard gas well, on the authority of Prof. T. M. Jackson:

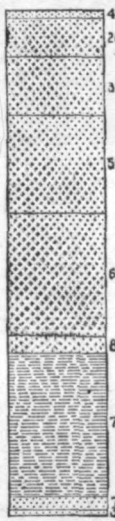


FIG. 137.—Section under Clarksburg, W. Va.

Clarksburg, West Virginia (gas well).

[See map, O k.]

	Ft.	Ft.
1. Sandstone, black	4	
2. Sandstone, white	20	
3. Sandstone, gray	30	174
4. Sandstone, white	50	
5. Sandstone, gray	62	
6. Sandstone, dark	8	
7. Shale, black		72
8. Sandstone, white		7
9. Sandstone, gray		3
10. Red beds of No. XI.		
Total		256

Section near Farmington, West Virginia.—Under the central portion of Marion County, West Virginia, the structure is shown by the record of the Hukill oil boring near Farmington (Fig. 138), as given in Second Geological Survey of Pennsylvania, 1886 (pp. 782, 783):

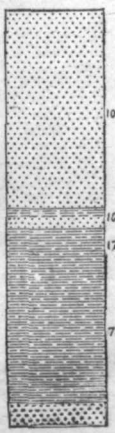


FIG. 138.—Section near Farmington, W. Va.

Farmington, West Virginia (oil boring).

[See map, M l.]

	Ft.
1. Sandstone	100
2. Shell	10
3. Slate	17
4. Black slate	70
5. Sandstone	12
6. Red beds of No. XI.	
Total	209

Section under Wellsburg, West Virginia.—Under Wellsburg, Brooke County, West Virginia, the Barclay gas well No. 1 gives the following (Fig. 139) for these beds on the authority of Mr. Barclay:

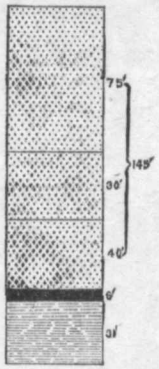


FIG. 139.—Section under Wellsburg, W. Va.

Wellsburg, West Virginia (gas boring).

[See map, J j.]

	Ft.	Ft.
1. Sandstone, white	75	
2. Sandstone, gray	30	145
3. Sandstone, blue	40	
4. Coal		6
5. Slate and shale		31
Total		182

The coal reported in this section comes at the horizon of the Sharon bed of Ohio and Pennsylvania, but it was probably nearly all coaly slate or else a local thickening, since other borings put down in this region do not report it at all.

Section in Mercer County, Pennsylvania.—Along the northwestern margin of the Appalachian field in the counties of Lawrence and Mercer, bordering the Ohio State line, a series of workable coal beds make their appearance in the Pottsville series and extend along the margin of the field clear through to southern Ohio. The general section of the Pottsville series of Mercer County, Pennsylvania, given in Q³ (p. 33), Second Geological Survey of Pennsylvania, shows the succession of these coal groups as follows (Fig. 140):

FIG. 140—Section in Mercer County, Pa.

Mercer County, Pennsylvania.

[See map, E k.]

	Ft.	in.	Ft.	in.
1. Sandstone, Homewood			50	
2. Shales			5	
3. Iron ore			2	
4. Limestone, Mercer, Upper			2	6
5. Coal, Mercer, Upper	2	6		
6. Shales	25			
7. Iron ore	2			
8. Limestone, Mercer, Lower	2	6	44	6
9. Shales	10			
10. Coal, Mercer, Lower	2	6		
11. Shales	10			
12. Iron ore	1			
13. Shales	5		66	
14. Sandstone, Connoquenessing, Upper	40			
15. Shales with iron ore	10			
16. Coal, Quakertown			2	
17. Shales	40			
18. Sandstone, Connoquenessing, Lower	30		100	
19. Shales, Sharon, iron bearing	30			
20. Coal, Sharon			4	
22. Fire clay and shales			5	
23. Sharon Conglomerate, base of No. XII			20	
Total			301	

Section near Quakertown, Mahoning County, Ohio.—Where the Ohio-Pennsylvania State line crosses the Mahoning River, near Quakertown, these beds exhibit the following structure (Fig. 141):

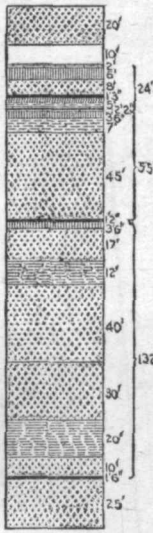


FIG. 141.—Section near Quakertown, Ohio.

Ohio-Pennsylvania line on Mahoning River.

	{See map, F k.}	Ft.	in.	Ft.	in.
1.	Homewood sandstone			20	
2.	Concealed			10	
3.	Limestone, Upper Mercer	2			
4.	Fire clay	6			
5.	Sandstone, shaly	8			
6.	Coal, slaty, Middle Mercer	1	3		
7.	Fire clay and sandy shales	5		24	5
8.	Limestone, Lower Mercer	1			
9.	Shales	0	6		
10.	Coal, Mercer, Lower	0	8		
11.	Fire clay	3	6		
12.	Shales, sandy	7		55	6
13.	Sandstone, Connoquenessing, Upper	45			
14.	Coal, Quakertown			1	2
15.	Fire clay and shales	3	6		
16.	Sandstone, Connoquenessing, Lower: Sandstone 17', Shales 12', Sandstone, flaggy 40', Sandstone, massive 30'	99		132	6
17.	Blue shales, with iron ore balls	20			
18.	Sandstone, massive	10			
19.	Coal, Sharon, and bituminous slate			1	6
20.	Sandstone, flaggy, to base of No. XII			25	
	Total			270	1

The Sharon coal of these sections (140, 141) represents the New River coal group of West Virginia, since the Mercer group above does not furnish valuable coal in that region, but only thin slaty beds.

Section in Holmes County, Ohio.—In Holmes County, Ohio, these beds are given as follows (Fig. 142), in Vol. V, Ohio Geology, p. 837:

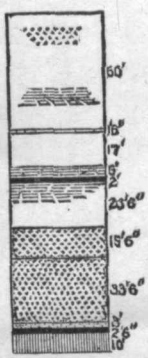


FIG. 142.—Section in Holmes County, Ohio.

Holmes County, Ohio.

	{See map, H e.}	Ft.	in.
1.	Interval, sandstone and shales	60	
2.	Limestone, Lower Mercer	1	6
3.	Coal, Lower Mercer		
4.	Concealed	17	
5.	Gray shales	6	
6.	Coal	2	
7.	Gray shale and concealed	23	6
8.	Sandstone, Upper Connoquenessing	15	6
9.	Coal, Quakertown	blossom	
10.	Sandstone, shaly, Lower Connoquenessing	33	6
11.	Coal, thin		
12.	Sandstone	3	
13.	Coal, Sharon	2	6
14.	Fire clay	10	
15.	Lower Carboniferous beds.		
	Total	174	6

Section in Washington County, Ohio.—In Washington County, Ohio, the Pottsville measures are given as follows (Fig. 143) by Mr. F. W. Minshall, from the record of the Epler oil boring:

FIG. 143.—Section in Washington County, Ohio.

Epler oil boring, Washington County, Ohio.

[See map, M g.]

	Ft.
1. Sandstone	24
2. Shales	20
3. Coal	
4. Shales	70
5. White, pebbly sandstone	60
6. Black shales	4
7. Lower Carboniferous beds.	
Total	178

Section at Parkersburg, West Virginia.—The Camden Consolidated Oil Company, in boring at Parkersburg, West Virginia, found the following structure (Fig. 144), according to Mr. R. A. Cole, the superintendent:

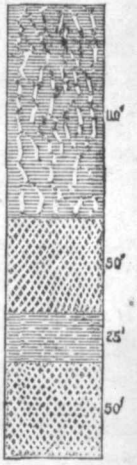


FIG. 144.—Section under Parkersburg, W. Va.

Parkersburg, West Virginia (boring).

[See map, O f.]

	Ft.
1. Shales, gray	110
2. Sandstone, hard, white	50
3. Slate, black	25
4. Sandstone, hard, gray	50
5. Shales of No. XI.	
Total	235

Section near Burning Springs, West Virginia.—Near Burning Springs, Wirt County, West Virginia, these same beds have this succession (Fig. 145), as found in the Simpson oil boring by Mr. Minshall:

FIG. 145.—Section near Burning Springs, W. Va.

Simpson well, Wirt County, West Virginia.

[See map, P g.]

	Ft.
1. Sandstone	36
2. Coal	
3. Sandstone	16
4. Shales	94
5. Coal	
6. Sandstone	10
7. Shales	44
8. Sandstone	10
9. Shales	86
10. Coal	
11. Conglomerate	40
12. Shales	16
13. Limestone, Subcarboniferous.	
Total	352

The Burning Springs section (Fig. 145) shows a rapid increase in the thickness of these beds towards the southeast, since they are just twice as thick here as in Washington County, Ohio (Section 143), 50 miles distant.

Section near Jackson Furnace, Jackson County, Ohio.—In Jackson County, Ohio, the Pottsville series has the following structure (Fig. 146) near Jackson furnace, as given in the Ohio Geological Survey, 1870 (p. 158):

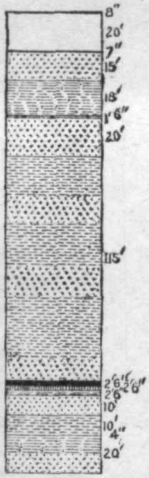


FIG. 146.—Section near Jackson Furnace, Jackson County, Ohio.

Jackson Furnace, Jackson County, Ohio.

[See map, P b.]

		Ft.	in.
1.	Iron ore	0	8
2.	Interval	20	
3.	Iron ore	0	7
4.	Coarse sandstone	15	
5.	Coal	trace	
6.	Shale	18	
7.	Iron ore	0	6
8.	Clay, shale	1	
9.	Sandstone, coarse	20	
10.	Sandy shales and laminated sandstone	115	
11.	Coal	2	6
12.	Fire clay	2	6
13.	Clay, shale	2	6
14.	White sandstone	10	
15.	Sandy shale	10	
16.	Coal	0	4
17.	Shales and sandstones to base of No. XII	20	
	Total	238	7

Section at Hanging Rock, Sciota County, Ohio.—In the vicinity of Hanging Rock, Ohio, the Pottsville series has the following structure (Fig. 147):

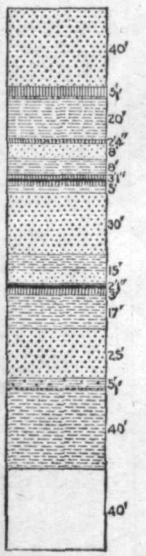


FIG. 147.—Section at Hanging Rock, Sciota County, Ohio.

Hanging Rock, Sciota County, Ohio.

[See map, R a.]

		Ft.	in.
1.	Sandstone, massive	40	
2.	Fire clay	5	
3.	Limestone and iron ore, Upper Mercer	1	
4.	Shales	20	
5.	Coal, Upper Mercer	0	4
6.	Fire clay, sandy	2	
7.	Sandstone, shaly	8	
8.	Shales, drab	8	
9.	Coal, Lower Mercer: Coal 0′ 5″; Fire clay 1′ 4″; Coal 1′ 4″	3	1
10.	Fire clay and shales	5	
11.	Sandstone, Connoquenessing, Upper, massive, coarse, yellowish	30	
12.	Sandy shales and shaly sandstone	15	
13.	Coal, Quakertown: Coal 0′ 5″; Slate 0′ 3″; Coal 1′ 5″	2	1
14.	Fire clay	3	
15.	Sandy shales	17	
16.	Sandstone, Lower Connoquenessing, massive	25	
17.	Shales, dark blue, with iron ore	5	
18.	Iron ore, sandy	1	
19.	Blue sandy shales	40	
20.	Interval to base of Pottsville beds under river, from drill hole (E. B. Willard)	40	
	Total	270	6

Here the Mercer group, together with the Quakertown coal, is distinctly recognizable at the very southern border of Ohio, while the Connoquenessing sandstones and the dark blue Sharon iron-bearing shales below look exactly like the same beds in eastern Ohio. The base of the series was given me here from the record of a bore-hole put down by Mr. E. B. Willard, superintendent of the Hanging Rock Coal Company.

Section on Big Sandy River, Lawrence County, Kentucky.—Twenty miles up the Big Sandy River, and near the mouth of Blaine Creek, the succession of the series is as follows (Fig. 148) according to the record of Rigdon gas well No. 2, as furnished by Mr. F. H. Oliphant:

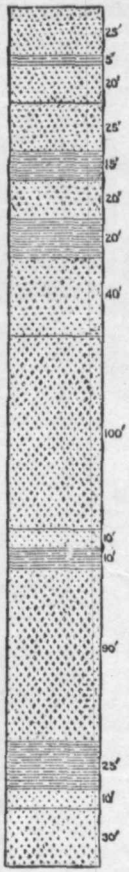


FIG. 148.—Section under Big Sandy River near mouth of Blaine Creek.

Under Big Sandy River at mouth of Blaine Creek (boring).

[See map, V b.]

		Ft
1.	Sandstone, white	25
2.	Slate, black	5
3.	Sandstone, white	20
4.	Sandstone, dark gray	25
5.	Slate, gray	15
6.	Sandstone, dark	20
7.	Slate, gray	20
8.	Sandstone, dark gray	40
9.	Sandstone, white, salt water	100
10.	Sandstone, dark blue	10
11.	Slate, black	10
12.	Sandstone, white	90
13.	Slate, black	25
14.	Shells	10
15.	Sandstone, hard blue	30
16.	Limestone, Lower Carboniferous.	
	Total	445

This section exhibits the beginning of the great southeastern thickening of the Pottsville series along the Big Sandy, but we have not sufficient data southward from Blaine Creek to trace the rate of increase along the Tug Fork, since even the top of the Pottsville does not rise to daylight on that stream for 100 miles above the mouth of Blaine. When the bottom series does finally come to the surface at the southern edge of McDowell County, West Virginia, it is not less than 1,500 feet thick, and may possibly be 2,000, since the Kentucky geologists claim the latter thickness for these measures on the headwaters of the Big Sandy.

There is no point along the Tug River in West Virginia where a vertical measurement can be made; hence, if the exact thickness is ever determined it must be by a boring.

The black slates, Nos. 2, 11, and 13 of the above section, probably represent the interconglomerate coal beds.

Section under Charleston, Kanawha County, West Virginia.—On the Great Kanawha River some recent borings for gas have supplied the necessary data there, thus giving measurements at two points before the whole formation comes to the surface. The first one of these is the record of the Edwards gas well No. 3, bored at Charleston, West Virginia, which gives the following structure (Fig. 149) for these beds, according to Mr. William S. Edwards:

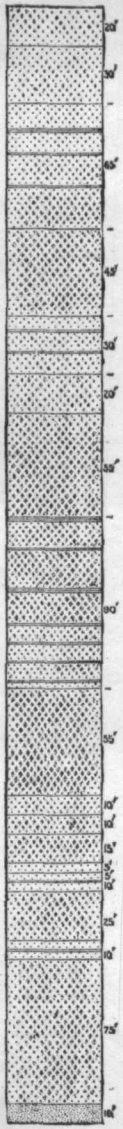


FIG. 149.—Section under Charleston, Kanawha County, W. Va.

Under Charleston, Kanawha County, West Virginia (boring).

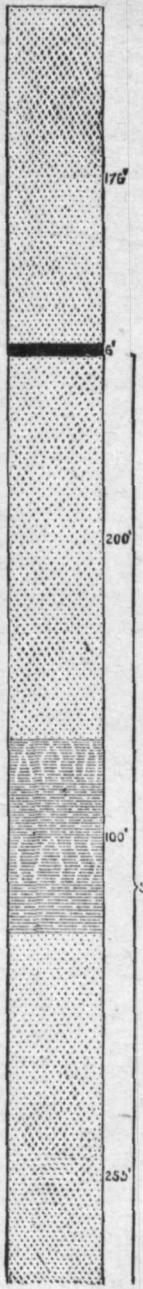
[See map, T f.]

	Ft.
1. Sandstone	20
2. White sandstone	30
3. Hard sandstone and shells	65
4. White sandstone	45
5. Black sandstone and shells	30
6. White sandstone	20
7. Hard sandstone	55
8. Hard black shells and gas	90
9. White sandstone	55
10. Black sandstone	10
11. White sandstone	10
12. Black sandstone	15
13. White sandstone	5
14. Hard shells	10
15. White sandstone	25
16. Sandshell, hard	10
17. White sandstone	75
18. Black sand	10
19. Lower Carboniferous limestone.	
Total	580

Here the Pottsville series has thickened to about three times its size at the northwestern outcrop of these beds in Ohio, 100 miles distant. Whether the thickening is gradual or abrupt is not known, and can not be until more borings are made. It is probably gradual from the center of the great Apalachian trough, 50 miles northwest of Charleston.

The interconglomerate coal beds appear to be entirely absent from the above section, since not even black slates are present according to the driller's record.

Section at Burning Spring, Kanawha County, West Virginia.—At Burning Spring, 9 miles south from Charleston, the record of Edwards gas well No. 1 gives these beds as follows (Fig. 150):



Burning Spring, Kanawha County, West Virginia (boring).

[See map, T f.]

	Ft.	Ft.
1. Sandstone, hard white		176
2. Coal, hard		6
3. Sandstone, hard white, salt water	200	
4. Shale and slates, light colored	100	555
5. Sandstone, very hard and white, with salt water	255	
6. Slate, black		2
7. Sandstone, hard white		50
8. Sandstone, blue hard		50
9. Limestone, Lower Carboniferous		
Total		839

No. 2 represents the Mercer coal group, though no coal thick enough to mine ever occurs at this horizon to the southward, where these beds rise above water level.

The New River coals belong in Nos. 4 and 6 of the section, but they here contain no coal whatever, though only 40 miles north from the New River coal field.

The series has here increased 259 feet in thickness in 9 miles, a very rapid rate, and possibly indicating that the great thickness (580 feet) found under Charleston may have been abruptly instead of gradually acquired.

In this boring a considerable flow of natural gas was obtained in the top of the Pocono sandstone, or "Big Injun" oil sand, at a depth of about 1,000 feet. This is the locality where natural gas was first used for manufacturing purposes in the United States, as far back as 1841. It was utilized for evaporating salt water. One of the gas wells found here, according to report, displaced for fuel 2,000 bushels of coal daily during a period of ten years. The last well, however (bored in 1887), does not produce much over 500,000 cubic feet of gas daily. The most productive wells were situated near the crest of the anticline which crosses the Kanawha River at Burning Spring.

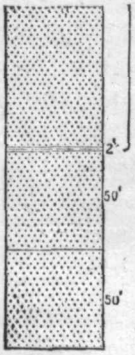


FIG. 150.—Section at Burning Spring, Kanawha County, W. Va.

Section near Nuttallburg, Fayette County, West Virginia.—Passing on southward up the Kanawha and New Rivers, there is no opportunity to get another measurement of the Pottsville series until all of its members have risen above the level of New River, in the vicinity of Nuttallburg, Fayette County, West Virginia, 50 miles distant from Burning Spring, where the following succession occurs (Fig. 151):

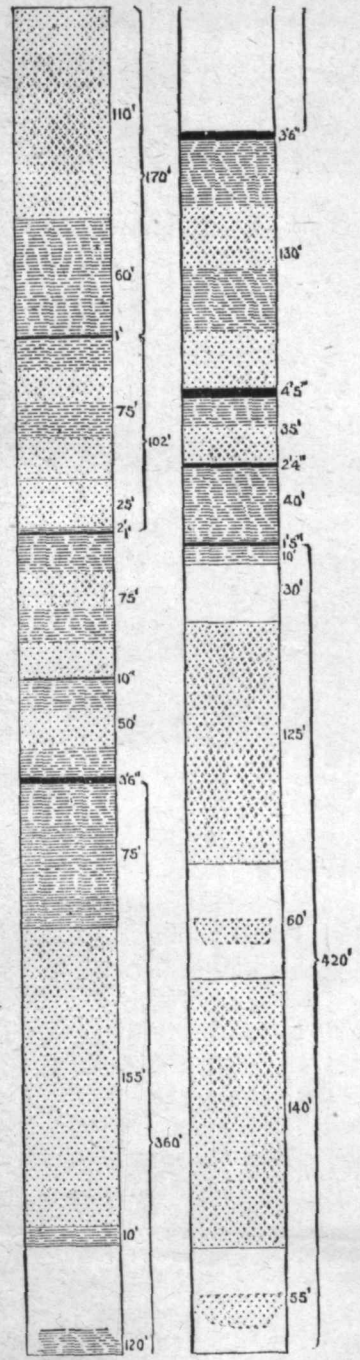


FIG. 151.—Section in vicinity of Nuttallburg, Fayette County, W. Va.

Vicinity of Nuttallburg, Fayette County, West Virginia.

[See map, U. h.]

		Ft.	Ft.	in.
1.	Sandstone, massive, pebbly, Homewood	110	170	
2.	Shales	60		
3.	Coal		1	
4.	Sandy shales and sandstone	75		
5.	Sandstone	25	102	
6.	Black slate	2		
7.	Coal		1	
8.	Shales and sandstone		75	
9.	Coal		0	10
10.	Shales, sandstone and shales		50	
11.	Coal, Nuttall		3	6
12.	Shales and slates	75		
13.	Sandstone, massive	155	360	
14.	Slates, dark	10		
15.	Concealed, and shales	120		
16.	Coal, Fire Creek		3	6
17.	Shales and sandstone		130	
18.	Coal, Quinnimont (?) Coal	1' 0"	4	5
	Slate	0' 3"		
	Coal	2' 0"		
	Slate	0' 2"		
	Coal	1' 0"		
19.	Shales and sandstone		35	
20.	Coal, slaty		2	4
21.	Shales		40	
22.	Coal		1	5
23.	Shales	10		
24.	Concealed	30		
25.	Sandstone, massive	125		
26.	Concealed, and sandstone	60	420	
27.	Sandstone, massive	140		
28.	Concealed, and sandstone to top of No. XI shales	55		
	Total		1,400	0

No. 11, the Nuttall coal, is the highest member of the New River group that ever furnishes valuable coal along that stream. Its place in the Pottsville series is 400 feet below the top, and the other thin coals above it belong to the Mercer group.

Whether No. 18 is identical with the Quinnimont, or whether this latter coal is the same as the Fire Creek, No. 16, are questions yet unsettled.

Just what represents the Pocahontas coal of McDowell and Mercer Counties in this section, or whether it is represented at all is uncertain, but No. 18 may possibly come at that horizon.

Section on Crane Creek, Mercer County, West Virginia.—At the extreme southern edge of the Appalachian field in Mercer County, West Virginia, the following section (Fig. 152) of the Pottsville series was obtained upon the waters of Crane Creek by adding 400 feet to the summit of the column for the estimated thickness of beds removed by erosion:

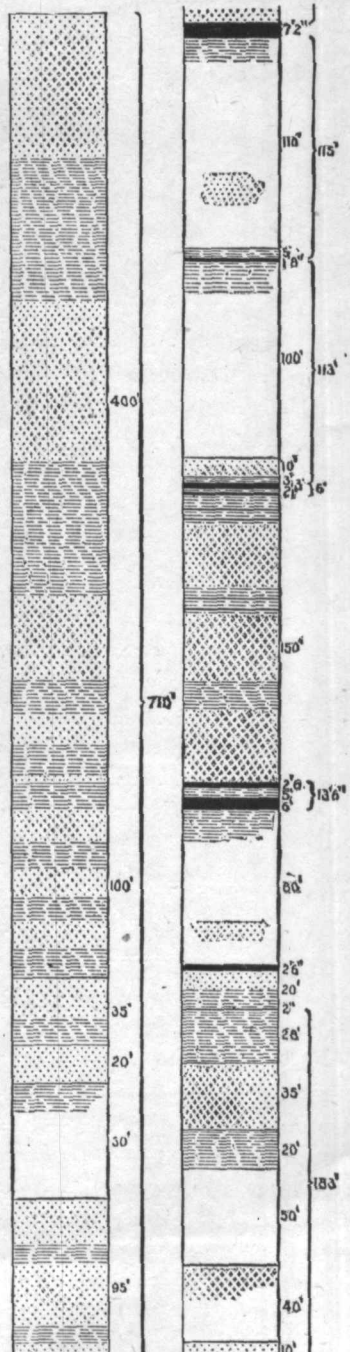


FIG. 152.—Section on Crane Creek, Mercer County, W. Va.

Crane Creek, Mercer County, West Virginia.

[See map, Y g.]	Ft.	Ft. in.
1. Sandstones and shales, here eroded from top of No. XII (estimated)	400	
2. Shales and sandstones	100	
3. Sandstone and shales	35	710
4. Sandstone, gray	20	
5. Shales, and concealed	60	
6. Sandstone, massive, and shales	95	
7. Coal: Coal 0′ 2″; Shales 2′ 6″; Coal 2′ 4″; Shale 0′ 6″; Coal 1′ 8″		7 2
8. Shales, sandstone, and concealed	110	115
9. Shales	5	
10. Coal, good		1 8
11. Shales, and concealed	100	
12. Sandstone	10	113
13. Shale	3	
14. Coal: Coal 3′; Shale 2′; Coal and slate 1′		6
15. Concealed, with shales, sandstones, and two thin coals		150
16. Coal, Pocahontas (No. III): Coal 2′ 6″; Shale 5′ 0″; Coal 6′ 0″		13 6
17. Shales, sandstone, and concealed		80
18. Coal (No. II)		2 6
19. Sandstone and shales		20
20. Coal (No. I)		0 2
21. Shales	28	
22. Sandstone, gray	35	
23. Shales, dark	20	183
24. Concealed	50	
25. Sandstone, and concealed	40	
26. Sandstone, gray, massive	10	
27. Green, limy, fossiliferous shales, top of Lower Carboniferous.		
Total		1,402

The interval added to the top of the Pottsville in this section is only an estimate at best, and the amount may not be near large enough, since the Kentucky geologists report the series as 2,000 feet thick not many miles southwest from this region.

The separate coal beds of this section can not yet be satisfactorily correlated with those on New River (Section 151). At one time the writer was inclined to believe that No. 7 might be the equivalent of the Nuttall vein, and that No. 16 of this section was probably identical with No. 18 of the Nuttallburg section

(151), but the Pocahontas coal lies 200 feet nearer the base of the Pottsville series than No. 18 does on New River, and hence unless this part of the series thins away towards the southwest, which seems improbable, the possibility of identity is rather slender. The mining operations of the next few years, however, may be depended upon to settle the question, since it has a more than scientific interest.

A cursory examination of the sections given will show that the Pottsville series generally has something like the following structure:

Sandstone (Homewood).
Coal group (Mercer).
Sandstones (Connoquenessing).
Coal group (New River).
Sandstone (Sharon).

Of course when the series attains such an excessive thickness as on the New River, for instance, the structure is more complicated than the above scheme would indicate, and yet even then a general agreement can usually be made out.

Having now glanced at the general structure of these measures, we shall take up the more important members and describe them in detail.

CHARACTERISTIC HORIZONS.

THE HOMEWOOD SANDSTONE.

The Pottsville series is nearly everywhere capped with a coarse sandstone, which is quite different in texture and general appearance from any of the sandstones in the Coal Measures above. In the vicinity of Homewood, Beaver County, Pennsylvania, this rock attains a thickness of 150 feet, and was named from that locality. It is generally quite massive, making great cliffs along the streams and covering the summits with huge blocks arranged in "rock cities." While usually quite hard, it generally splits well and makes excellent building stone, the blocks from it being almost indestructible. Although generally of a yellowish or buffish gray tinge, it occasionally consists of almost pure white quartz grains, and hence sometimes supplies glass sand of excellent quality. This might be called the "cascade" member of the Pottsville series, since it so often produces water-falls.

In Pennsylvania it is generally 30 to 50 feet thick, but occasionally, as at Homewood and other points, it thickens up to 75 or even 150 feet.

Westward, in Ohio, the rock thins down and is often only 15 to 20 feet thick, but still distinctly recognizable as a heavy bedded, coarse sandstone, filled with fossil stems and trunks of trees, mostly lepidodendron and sigillaria. It is seen in the bed of Little Beaver near its mouth, and frequently between that point and Fredericktown. It is the quarry rock in Coshocton County referred to in Vol. V (p. 104), Ohio Geology, where it is 30 feet thick and of the same type so often found in Pennsylvania. From this point on across Ohio, to Ironton and

Hanging Rock, it is frequently seen, and at the latter point makes one of the great cliffs in the steep hillside which gave name to the place, being there 40 feet thick.

Along the Great Kanawha this rock comes to water level at the mouth of Armstrong Creek, and from there on up that stream, as well as up the New and Gauley rivers, is a great cliff rock 150 to 200 feet thick. It crowns the walls of the New River cañon at Hawk's Nest and other points to Nuttallburg and beyond, where it seems to change suddenly in character southward from that, becoming soft and easily disintegrating to a heap of coarse, brown sand.

On the Tug fork of Big Sandy this stratum makes great cliffs along the hills through the "roughs" of Tug, and sinks below that stream at the mouth of Ben's Creek, 95 miles above Louisa.

Ohio Pyle Falls, on the Youghiogheny River, is made by this rock, and the upper portions of the great cascades on the Black Water and Glady forks of Cheat pour over the same stratum.

It is the gas-bearing member in western Pennsylvania and northern West Virginia.

THE MERCER GROUP.

In western Pennsylvania a group of coals associated with two fossiliferous limestones makes its appearance directly under the Homewood sandstone, and extends almost uninterruptedly across the Ohio field to Hanging Rock. It was first fully described from the vicinity of Mercer, Pennsylvania, and named from that locality. When well developed the group presents the succession seen in Section 140, and is 40 to 50 feet thick.

The two limestones are very much alike, except the Lower Mercer is a little darker blue than the Upper, and is the more persistent. Both are crowded with fossils and are frequently cherty, some of the famous "flint ledges" of Ohio being made by one of these beds. Each limestone usually carries an iron ore on its top of the variety known as "block" ore. The Upper Mercer is known as the Zoar limestone in many portions of Ohio, and its ore is called by several terms, among which are "Dunkel Block," "Franklin Block," "Main Block," "Big Red Block," etc. The Lower Mercer was formerly known as the "Blue" limestone, and its corresponding ore as the "Blue Limestone Block," "Little Block," etc.

The Mercer coals are generally two, the upper one coming under the Upper Mercer limestone and the lower one under the Lower Mercer limestone. Occasionally there is also a coal on top of each limestone, but these beds are sporadic, and hence do not merit a designation, though Orton has applied the name "Tionesta" to the upper one in Ohio, as the writer did in Report Q^2, on Lawrence County, Pennsylvania.

These Mercer coals are generally rich in ash, and are seldom mined on a commercial scale, although they are quite persistent from western

Pennsylvania all around the northern margin of the Ohio coal field. Both of them occasionally become cannel in Ohio, the upper being the Strawbridge cannel of Holmes County and the Bedford cannel of Coshocton, according to Orton, while the lower coal is the Flint Ridge cannel of Licking County. Neither of these beds seldom exceeds 3 feet in thickness, and they are more frequently only 1 or 2.

Eastward from Mercer and Lawrence Counties, Pennsylvania, the limestones disappear from this group and the coals thin away, except around the northern rim of the coal field, where, in McKean County, the Alton coal group of Ashburner probably represents the Mercer coals, so that usually only one is left, and it is generally quite impure. This bed has received a different name for nearly every locality where it attains workable thickness. Rogers called it the Tionesta coal in Forest County, Pennsylvania, and it is the Mount Savage bed of Somerset. Along the north Potomac River it frequently appears in the cuts of the West Virginia Central Railroad, and is there known as the "Railroad seam." It has been mined for local use just above Valley Falls, Taylor County, West Virginia, where it lies near water level, and is 4 feet thick, with a slate near center. It always presents a coarse structure, and no first-class fuel is ever obtained at this horizon. Along the New River, and through all the country between it and the Tug Fork, only an insignificant coal, 1 to 2 feet thick, occurs at this level.

The famous Mount Savage fire clay of Pennsylvania and Maryland comes within the limits of the Mercer group, and directly underlies the Mount Savage coal, which it occasionally replaces.

THE CONNOQUENESSING SANDSTONES.

Below the Mercer group there comes the great sandstone horizon par excellence of the Pottsville series. This group is generally triple, there being a massive sandstone at top, then a coal and shale interval, below which is another massive sandstone. These sandstones were first studied by the writer along the Connoquenessing River, in Lawrence County, Pennsylvania, and they were designated from that stream. The Massillon sandstone of Newberry represents only a portion of the group; otherwise it would have precedence in nomenclature.

Each of these sandstone members is from 40 to 50 feet thick, though occasionally the shale and coal separating them thins out and they coalesce into one mass 150 to 200 feet thick, or even more. They are generally quite hard, the quartz grains being finer and more compactly arranged than in the Homewood sandstone above. The color is more frequently yellowish white than any other, though sometimes it is gray.

The Quakertown coal comes between the two sandstone members of the group. It seldom exceeds 2 feet in western Pennsylvania or eastern Ohio, and unless it should be the "Jackson shaft," or "Wellston" coal, it does not seem to attain much importance in that State, though it is often present in the series as a thin bed, being represented in the

Hanging Rock section (147) by number 13, which is only 2 feet thick, slate and all.

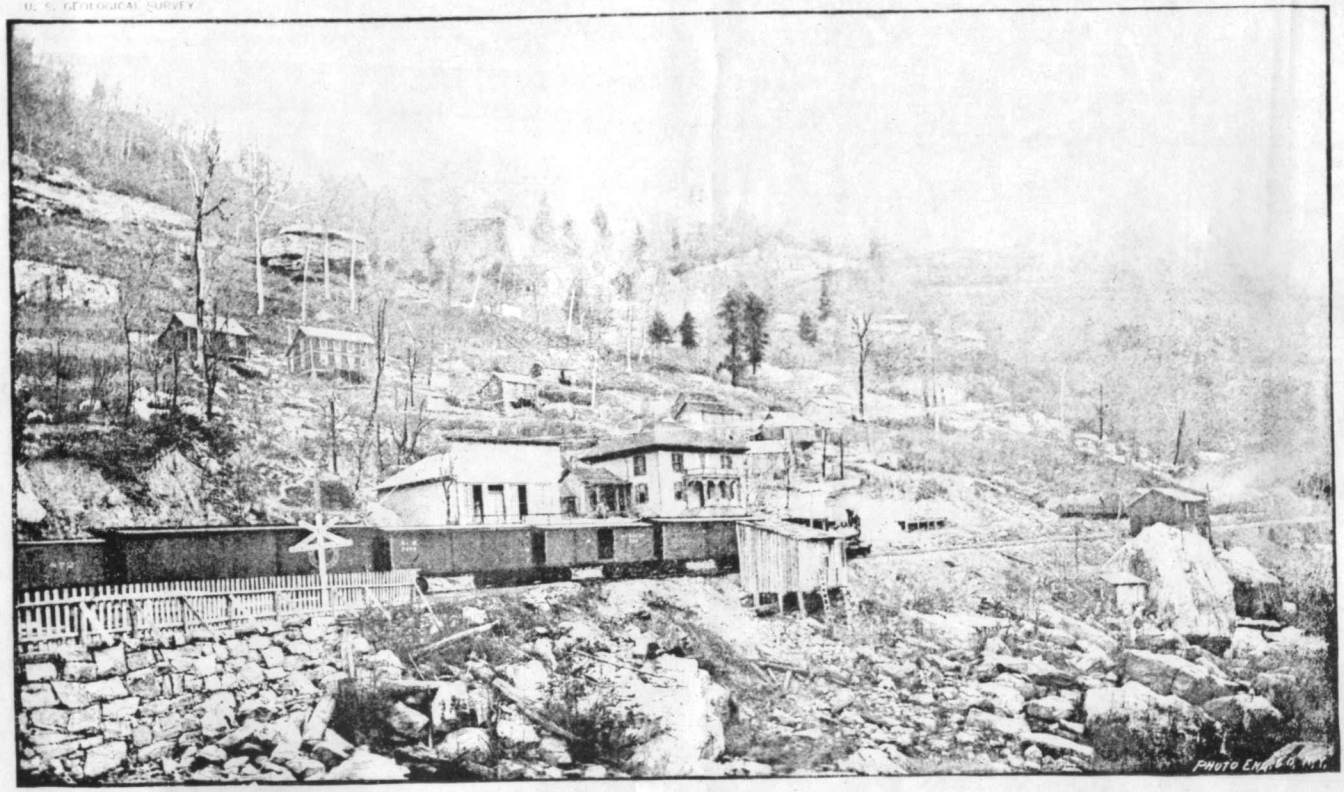
East from the Mahoning River no workable coal is known at this horizon in Pennsylvania, though a thin coal or black slate is often present.

THE NEW RIVER COAL GROUP.

The great development of coal in the middle and lower half of the Pottsville series along New River, West Virginia, has given name to this group. Although there are thin representatives of the group in nearly every section of the Pottsville which is exposed in Pennsylvania, yet only around the northwestern margin of the field in that State is any valuable coal found at this horizon, namely, the Sharon coal of Mercer County. This bed occurs in pockets and isolated basins, in the western part of Mercer, where it is 3 to 5 feet thick, and a "block," or open-burning coal of great purity. It enters Ohio in the same patchy condition, and extends through Mahoning, Trumbull, Portage, Summit, Stark, Medina, and Wayne Counties of northeastern Ohio, and it is probably the "Jackson shaft" or "Wellston" seam of Jackson County in southern Ohio. In all cases it is the same open-burning, pure fuel, very low in ash and sulphur.

This Sharon bed and its thin rider appear to represent all the coals in the New River group, and hence it can not be called identical with any one of them, though according to Prof. Fontaine the flora of the Sharon roof shales is very similar to that found in the roof of the Quinnimont bed on New River. These roof shales of the Sharon coal through western Pennsylvania and across Ohio are a very characteristic feature. They begin directly under the Connoquenessing sandstones, and are often 40 to 50 feet thick, of a dark blue color, and generally contain much iron ore (carbonate) in nuggets and bands. These shales show the same character at Hanging Rock (Section 147), in southern Ohio, as they do on the Mahoning at the east.

In passing southward from Pennsylvania, along the Alleghany Mountain region, one of these New River beds thickens up to 3 feet in Garrett County, Maryland, just east from the West Virginia line, and has there been mined for local use on the land of Mr. Browning. It comes near the base of the Pottsville series, is quite soft and pure, and exhibits the same coking type as these coals all do on New River. One of these beds is also workable along Shaver's Fork of Cheat River, east from the Beverly Valley. This coal group, which is well shown in the Black Water section (133) of Tucker County, grows in importance southwestward through Randolph, Webster, Greenbrier and Nicholas Counties, into Fayette, where at Nuttallburg on New River we find the type section of the group (No. 151), which there incloses three workable coal beds besides several too thin to be of economic importance. The three workable beds are, in descending order, the Nuttall, Fire Creek, and Quinnimont, with the intervals separating them shown in Section 151.



THE POTTSVILLE CONGLOMERATE CLIFFS AND DÉBRIS ON NEW RIVER, WEST VIRGINIA, NEAR FAYETTE.

These coals vary from 3 to 5 feet in thickness along New River, and are the ones from which the celebrated New River coke is now manufactured. The Nuttall is the most regular and persistent, being the only one which dips below water level at the north with a workable thickness.

They are all quite soft, very low in ash and sulphur, and rich in fixed carbon, making coke of the greatest purity.

The Fire Creek and Quinnimont beds are quite irregular in their distribution and thickness, but both of them furnish much good coal on New River. I have termed the lowest bed the Quinnimont, but the stratigraphical horizon of the Quinnimont seam is not yet settled, since it may prove identical with the Fire Creek bed, but all the coal operators agree that there are three workable coals on New River, and that Nos. 11, 16, and 18 of Section 151 are these three beds, whatever their identity with reference to the Fire Creek and Quinnimont localities may be.

Southwestward from Fayette County towards Raleigh, Mercer, and McDowell, the New River coals still continue to increase in thickness and importance, culminating in the great bed at Pocahontas, in the edge of Virginia.

Section on Crane Creek, West Virginia, near Pocahontas, Virginia.—Section 152 shows the succession of these coals on Crane Creek, a tributary of Blue Stone, a few miles northeast from Pocahontas. Here the Pocahontas coal is divided into two benches by a layer of shale 5 feet thick, but at Pocahontas it exhibits the following structure:

	Ft.	in.	Ft.	in.
Coal	9	6	10	8
Shale	0	4		
Coal	0	10		

There is a bony streak about 2 feet below the top of the coal, but it is not rejected in mining.

Section at head of South Elk Horn Creek, McDowell County, West Virginia.—Across the Flat Top Mountain divide from Pocahontas, around the head of South Elk Horn Creek, in McDowell County, this coal exhibits the following structure:

	Ft.	in.	Ft.
Coal	3	8	9
Bony coal	0	8	
Coal	2	3	
Slate	0	1	
Coal	2	4	

Section on East Branch of Simmons Creek, Mercer County, West Virginia.—On the east branch of Simmons Creek this coal shows as follows:

	Ft.	in.	Ft.	in.
Coal	2	2	8	10
Slate, blue	0	4		
Coal	6	4		

Section on west branch of Flipping Creek, Mercer County, West Virginia.—On the Walker tract, west branch of Flipping Creek, the coal has this structure:

	Ft.	in.		
Coal	2	6	Ft.	in.
Dark shales	10	0	18	6
Coal	6	0		

Section on Pinnacle Fork of the Guyandotte River, Wyoming County, West Virginia.—Just before this coal passes under the level of the Pinnacle Fork of the Guyandotte River west from Flat Top Mountain it exhibits the following structure:

	Ft.	in.		
Massive sandstone				
Coal	1	4	Ft.	in.
Fire clay	3	0	14	8
Sandy shale	5	0		
Coal	5	4		

This coal was numbered III in the original section published from Pocahontas by Maj. Jed. Hotchkiss, and it is frequently known by that name. Major Hotchkiss thinks the Pocahontas bed identical with the Quinnimont of New River, but the writer can not yet satisfactorily correlate this bed with any of the New River coals which have been mined.

The coal from the Pocahontas seam is quite as pure and valuable for coke and general fuel purposes as any in the New River field, and, in fact, is the same kind of coal.

Two other beds of 4 to 5 feet in thickness occur in the hills above the Pocahontas vein, but so far they have not been mined to any extent, as they are not regular in thickness and the great bed below monopolizes the present mining operations.

THE SHARON CONGLOMERATE.

The interval below the Sharon coal in Ohio and western Pennsylvania down to the base of the Pottsville series is often occupied by a massive conglomerate, and when it is absent the coal with its under-clay rests directly on the Lower Carboniferous beds. This conglomerate stratum was considered a separate member of the series by the Ohio geologists and as representing the entire No. XII conglomerate of Rogers in Pennsylvania.

But later studies have shown that it is simply the basal member of this series. When well developed in Ohio it is very coarse, being a mere mass of pebbles from a pea to an egg in size. There is no single stratum around the southeastern margin of the Appalachian field that will exactly compare with the Sharon conglomerate in physical aspect, though local streaks in all these great sandstones are quite as pebbly, but just as the Sharon coal is represented by several beds in the New River section, so the Sharon conglomerate, only 20 to 40 feet thick in

Pennsylvania and Ohio, is on New River represented by 300 to 400 feet of shales, sandstones, and conglomerates.

In northern Pennsylvania the Olean conglomerate of Bradford County and the Garland conglomerate of Warren have been shown by Mr. John F. Carll to be identical with the Sharon stratum, and they also resemble it very much in physical characters. The coarse type of the Sharon conglomerate appears to be confined to the northwestern rim of the Appalachian field, since it disappears southward under the other members of the series.

THE LOWER CARBONIFEROUS BEDS.

Below the base of the Pottsville series come the red shales and limestones of the Mauch Chunk series, and then succeed the gray sandstones of the Pocono, the lowest series of the Carboniferous system.

Thin coals occur locally in both of these members of the Lower Carboniferous in Pennsylvania and West Virginia, but nowhere in these States, nor in Ohio, does any merchantable bituminous coal exist in this portion of the Carboniferous.

The Tipton Run coals of Blair County, Pennsylvania, have been cited as occurring in the Pocono sandstone series for the last thirty-five years, and this conclusion is reiterated by Mr. Ashburner in a special report made as late as 1885 (Pennsylvania Geological Survey, Annual Report, 1885, p. 250), but a single glance at the fossil plants occurring in the roof shales of the coals now mined there proves that they belong to the Lower Coal Measures, or Alleghany River series, and not to the Pocono, their apparent stratigraphical position being the result of displacement, so that although the Pocono series is reported to contain valuable coal beds in Montgomery County, Virginia, it certainly does not in any of the three States covered by this report, and hence a further consideration of the Lower Carboniferous beds is not germane to this publication.

INDEX.

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IN THE BITUMINOUS COAL REGIONS OF

PENNSYLVANIA, WEST VIRGINIA, AND OHIO.

BY

I.C.WHITE

1888.

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