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GEOLOGY OF WEST VIRGINIA,  
*No. II.*  
BY JOHN J. STEVENSON,  
Professor of Geology in the University of New York.  
Read before the American Philosophical Society, Feb. 5th, 1875.

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## NOTES ON THE GEOLOGY OF WEST VIRGINIA.

No. II. \*

By JNO. J. STEVENSON.

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF NEW YORK.

*(Read before the American Philosophical Society, February 5th, 1875.)*

During July and part of August, 1874, I made a reconnaissance of a portion of West Virginia lying between Rich Mountain and the Ohio River. In this area are included parts of Randolph, Upshur, Harrison, Lewis, Doddridge, Ritchie and Wood counties. To connect this work with that reported in my previous paper, I made some examinations in Taylor and Marion counties.

This whole region has suffered much from erosion, and its surface is a confused mass of hills and ravines apparently without system. In the eastern portion, that drained by the forks of the Monongahela River, the valleys are usually quite broad and the hills are rounded except in the vicinity of Rich Mountain, where, owing to the increasing dip, the slopes become quite sharp. In this drainage area the main streams flow across the dip, whence result the broad valleys and gentle slopes observed on Tygarts, Buckhannon, and the West Fork River. On the west side of the divide, separating the Monongahela from Hughes' River on the Little Kanawha, the conditions are different. There the streams flow, for the most part, with or opposed to the dip, so that one finds the country abrupt and the valleys narrow until he approaches the Ohio.

Between Rich Mountain and the Ohio the soil is not very rich, owing to the comparatively small quantity of limestone present. In portions of Randolph and Upshur counties, however, there is much rich land along the "bottoms," the alluvium being in a measure derived from the lower carboniferous rocks. The western portion of the area is very lean, as the soil has resulted simply from disintegration of the Upper Barren shales or sandstones, or in other localities from similar disintegration of the red argillaceous shales of the Lower Barron Group. It is said that in Doddridge, Ritchie and Wood counties, there is comparatively little land rich enough to yield forty bushels of corn per acre.

Over the greater portion of the area, the hills are covered by a dense growth of valuable timber, consisting chiefly of poplar (tulip-tree), red and other oaks, chestnut, beech and maple. The oak and poplar are quite valuable. At the west, much of this timber is floated to the Ohio by way of the Little Kanawha, not a little of it being sent down as single logs from the smaller tributaries. The magnificent timber on Rich Mountain will soon be available, as the obstructions in Buckhannon and Tygarts' Rivers are to be removed, so as to open the way to Grafton, where immense sawmills have been erected.

The availabilities of the country have not been fully tested, and for the

\* No. I was published in Trans. A. P. S., Vol. XV, p. 15.



most part, it is thinly settled. Such of the inhabitants as have means, devote themselves to raising stock or wool, while the poorer classes are wasting their substance by cutting the fine timber into staves or shingles.

Throughout this whole region, evidences of drift are entirely wanting. The superficial deposits are thin except at the east, where the debris on the hills is so thick as to render satisfactory tracing of the strata almost impossible. Along the northwest Branch of the Baltimore and Ohio Railway, one finds frequent proof of the deepening of waterways, for on top of many hills, seventy-five to one hundred feet above the present streams, there occur fresh-water shells similar to those now living in the creeks.

Rich Mountain is the western slope of a great anticlinal ridge, whose eastern slope is known as Cheat Mountain. Between the two mountains is the anticlinal valley of Tygarts' River, whose scenery can hardly be excelled. Along the central line of this valley the dip of the strata is nearly  $65^{\circ}$  northwest and somewhat less southeast. Taking the Staunton pike westwardly, we find the dip diminishing, so that on top of Rich Mountain it is only  $18^{\circ}$ . Thence the decrease is very rapid, and at Roaring Creek the strata are almost horizontal. This condition continues for nearly twelve miles along the pike; after which the northwest dip is resumed, now 120 feet to the mile, and is retained until about two miles west from Buckhannon. There it is reversed, and we meet the anticlinal fold of Laurel Hill. The plane of this axis crosses the pike about three miles west from Weston, and there the dip is again toward the northwest at the rate of nearly 150 feet per mile. This rate continues for about twenty miles, beyond which the strata become almost horizontal. The Laurel Hill anticlinal crosses the railroad not far from Flemington, and the flattening of the strata begins near Long Run Station, thirty miles farther west.

About one-eighth of a mile east from Ellenboro' and forty-five miles west from Clarksburg, a sharp fault occurs, on whose eastern side the rocks dip almost due east at an angle of  $26^{\circ}$ , while on the western side the strata are horizontal. The exact line of fault is not exposed, and there is an interval of seventy feet concealed between the points of observation. The approximate horizontality continues westward to within a mile of Petroleum, where the dip becomes eastward and rapidly increases, followed west, until just west from that station it becomes  $36^{\circ}$ . From this point almost to Laurel Junction somewhat more than one mile, the dip is very confused, but a shattered anticlinal can be traced, the rocks meanwhile dipping east or west, as the case may be, at from one to five degrees. Near Laurel Junction the dip becomes five, ten, twenty, forty or even seventy-five degrees westward. In the cut immediately west from that station the rate decreases to five degrees within a space of six feet horizontally, and soon afterwards falls to only ten feet per mile. Beyond this to the Ohio the rocks remain almost horizontal.



The section obtained in passing from Rich Mountain to the Ohio embraces the whole of the Upper Carboniferous as found in West Virginia, and, if begun on the east slope of the mountain, includes also a very large portion of the Lower Carboniferous. The anticlinal valley of Tygarts' River is cut out of the Lower Carboniferous series, which is well exposed on each wall to the crests of the mountains. On top of Rich Mountain we find the Great Conglomerate forming the crest throughout Randolph county. On the western slope of the ridge are the Lower Coals, which pass under the surface before reaching the Buckhannon River in Upshur county. The Lower Barren Group is well exposed toward the foot of the mountain near Roaring Creek, and thence westward in the bluffs for nearly forty miles; but, owing to the flattening of the dip near Roaring Creek, it is the surface series for only a few miles in the area examined. Northward from the Baltimore and Ohio Railroad, or, better perhaps, at the State line, the Upper Coal Group finds its eastern outcrop several miles from Laurel Hill, but followed southward this outcrop is seen approaching the crest of the axis until near the railroad it crosses it. Along our southern line the fold becomes very gentle, so that the Pittsburg crosses its crest and has its outcrop nearly twenty-five miles east from it. The eastern boundary of the group is very tortuous. The Upper Coals extend westward almost to the line of the Ellenboro' fault, where the Lower Barren Group is thrust up. This continues to the especially disturbed area known as the "Oil-break," in which the Lower Coal Group is exposed. Beyond the "break" to the Ohio River the only rocks exposed are those of the Lower Barren. The region lying west from the Ellenboro' fault will be described separately.

The Upper Barren Group is cut off by the Ellenboro' fault, but eastward from that for nearly twenty miles its rocks are those covering the surface, those of the Upper Coal Group being found only in the deeper ravines.

#### THE COAL MEASURES.

In this paper the terms, Upper Barren, Upper Coal, Lower Barren, and Lower Coal, as designations of the several groups into which the Coal Measures are naturally divided, are used in precisely the same sense as in my previous paper.

**UPPER BARREN GROUP.** This group, which includes all the rocks above the *Waynesburg Coal*, covers a large extent of territory, whose western line is the Ellenboro' fault. The eastern outcrop is an ill-defined line, passing a little west from Troy, in Gilmer county northward, and coinciding almost with the western line of Lewis county. It crosses the Northwestern Railroad near Wolfe's Summit, eight miles from Clarksburg, and running irregularly northeast, reaches the Baltimore and Ohio Railroad about three miles north from Fairmont, passing finally into Pennsylvania nearly four miles west from the Monongahela River.

The northwestern boundary in West Virginia is a line passing from the



Pennsylvania border near the junction of Ohio and Marshall counties, West Virginia, to a little below Moundsville, on the Ohio River. This is the overlying group in Doddridge, Tyler and Wetzel counties, as well as in the eastern half of Ritchie and the western portions of Monongalia, Marion, Harrison, Lewis and Gilmer counties.

The sudden cutting off of this group by the Ellenboro' fault and the consequent wearing away of the rocks by erosion prevent us from obtaining as full a section along this line as may be found farther north. The succession as observed here is as follows :

	<i>Ft.</i>	<i>In.</i>	
1. Sandstones and shales.....	400		
2. Black shale.....	2'		
3. Coal "Brownsville".....	3'		
4. Shale.....	20'		} Interval, 38 ft. to 28 ft.
5. Sandstone.....	5-15		
6. Shale.....	3		} Interval, 75 ft.
7. Coal.....		2	
8. Shale.....	20		
9. Sandstone and some shale....	55		

The total thickness of the group as here exposed is only five hundred and twenty feet. For comparison, I present a condensed form of the excellent section worked out by Mr. I. C. White,\* in southwestern Pennsylvania and northwestern West Virginia :

	<i>Ft.</i>	<i>In.</i>	
1. Sandstones and shales,.....	300		} 491½ ft.
2. Limestone.....	1	6	
3. Sandstone.....	190		} Interval, 95 ft.
4. Coal.....	1	6	
5. Sandstone.....	95		} Interval, 128 ft.
6. Coal.....	2		
7. Shale and sandstone.....	85		
8. Limestone.....	3		} Interval, 52 ft.
9. Shale.....	40		
10. Coal.....	1	4	} Interval, 20 ft.
11. Shale.....	10		
12. Limestone.....	2		} Interval, 60-65 ft.
13. Shale.....	40		
14. Coal "Brownsville".....	2-3	6	
15. Shale.....	20		
16. Coal.....	1		
17. Shale.....	15		
18. Sandstone.....	45-50		

In this section the total thickness is eight hundred and sixty feet. It

\* Anna's Lyceum of Nat. Hist., Vol. XI, p. 46.



will be seen, however, that in my section the strata reach far enough up to include a portion of No. 3, in Mr. White's section, so that sufficient is found in the south to afford material for comparison of conditions in the two areas. It is noteworthy that the interval between the *Waynesburg* and the *Brownsville* is much greater in the southern than the northern section.

No. 1 of the section is entirely free from limestone, and consists of compact sandstones and loose shales. At the east, the sandstones greatly preponderate, and are very coarse in grain. Westward they diminish in quantity and are replaced by the shales. These are reddish gray to yellow and usually quite fissile. The whole series is finely exposed along the Northwestern pike, about four miles west from Salem, where the road descends a long steep hill and is merely a shelf, cut out of these rocks. Near Cherry Camp, thirteen miles west from Clarksburg, the base of the series is a bright yellow fissile shale, twenty feet thick, containing many crushed specimens of an *aviculopecten*. This shale is not persistent, being wanting at all exposures examined farther to the west. The other strata seem to be entirely free from fossils.

Along the Northwestern Railroad, the *Brownsville*\* coal is first seen at the east end of Brandy Gap Tunnel, ten miles west from Clarksburg. There it was worked formerly, but the banks have been long deserted and no measurement can be made. At the west end of the tunnel the coal is seen about twenty feet above the track and nearly three feet thick. Near Cherry Camp, one mile beyond, it has been worked in the creek bank by stripping. It shows there

Shale, 2 ft.; Coal, 9 in.; Bony Coal, 5 in.; Coal, 14-16 in.; total, 2 ft. 6 in.

The shale is full of vegetable impressions, some of which are very fine. If this shale could be reached farther in the bank, where it has not been exposed to the action of the weather, the locality would no doubt yield some excellent material to the palæo-botanist. The coal is said to be of very fair quality. Some taken from the same bed where it lies exposed in the stream, about one-fourth of a mile farther west, is said to have been very good.

The next exposure was found on the Northwestern pike, somewhat more than five miles west from Salem. The bed is there more complex than at Cherry Camp, and shows the following section :

Coal, 9 in.; Shale, 2 ft.; Bituminous shale, 1 ft.; Clay, 3 in.; Coal, 1 ft. to 1 ft. 6 in.

The sandstone rests directly on the coal. The bituminous shale contains many thin plates of coal and is so carbonaceous throughout that it will burn, though poorly. The coal is said to be quite good, and is mined by stripping. Near the railroad crossing, two miles east from Smithton, this bed was formerly worked. At Smithton its outcrop is

\* So named by Mr. White, from its importance, near Brownsville, Monongalia county, West Virginia.



seen one hundred and fifteen feet above the *Waynesburg*, and near West Union it was observed in a railroad cutting, where it appears to be about one foot thick and single.

Near Pennsboro' an old opening is seen twenty feet below the level of the railroad. We there find the following section:

Sandstone,—; Shale, 10 ft.; *Coal*, 1 ft. 10 in.; Compact clay, 3-6 in.;  
*Coal*, 8 in.

The overlying shale is argillaceous below, but becomes arenaceous above and passes gradually into sandstone. The rocks are well exposed in the vicinity for nearly two hundred and fifty feet above the bed and are wholly sandstone and arenaceous shale. The coal seems to be quite good and must contain very little pyrites. The bank has been deserted for nearly twenty years, yet fragments lying on the dump are as sound and fresh-looking as though they had been thrown out within two or three days. The same bed is mined somewhat on the other side of the railroad. The coal is compact, open-burning, and leaves a pulverulent ash, quite bulky but not heavy. The bed can be traced in the vicinity of the railroad almost to Ellenboro'. The blossom is seen near the junction of the Northwestern pike and the Harrisville road. Near Harrisville its place is shown by a line of springs. On the Staunton pike it was seen only near Smithville, in Ritchie county, where it is one foot thick.

The small coal, No. 7, was observed only in the deep cut at the east end of Brandy Gap tunnel.

The shale underlying the *Brownsville* coal is variable in character and thickness. Occasionally the whole mass for thirty-five feet is argillaceous, blue to gray or drab, and quite thinly laminated. At other times, the whole interval between the *Brownsville* and the *Waynesburg* is occupied by a coarse sandstone.

The *Waynesburg* sandstone, No. 9, is a well marked and very persistent member of the series. It is ordinarily a compact and fine-grained sandstone, and at no place along the railroad is it at all conglomerate. Near Brandy Gap tunnel, where it has been largely quarried by the railroad company, its lower portion is somewhat flaggy. At Long Run, Smithton and West Union, it stands out in cliffs upon the hill sides, and is compact throughout. On the Staunton pike, it may be seen just west from Troy, where it is somewhat coarser than at the localities just mentioned.

UPPER COAL GROUP. Under this name are included all that series of rocks beginning with the *Pittsburg* and ending with the *Waynesburg* coal. Along the Northwestern Railroad the group is well exposed from Clarksburg west. The general section is approximately as follows:



	Ft.	In.	
1. <i>Waynesburg Coal</i> .....	4		} Interval, 133 ft.
2. Shale.....	8'		
3. Limestone and shale.....	6		
4. Argillaceous shale.....	20		
5. Limestone.....	1	6	
6. Arenaceous shale.....	30		
7. Limestone and shale.....	7		
8. Variegated shale.....	8		
9. Dark shale.....	6		
10. Sandstone.....	40		
11. Shale.....	6		
12. <i>Sewickly Coal</i> .....	2-3		} Interval, 41 ft.
13. Shale.....	41		
14. <i>Redstone Coal</i> .....	3-2		} Interval, 20 ft.
15. Fire-clay.....	2		
16. Limestone and shale.....	8		
17. Shale.....	10		
18. <i>Pittsburg Coal</i> .....	6-9		

The interval between the *Waynesburg* and the *Sewickly* is very much smaller than in the northern portion of the State, where it varies from one hundred and seventy-five to two hundred feet, averaging about one hundred and eighty feet. Near Morgantown, this interval is one hundred and eighty, at Fairmont almost the same,\* at Clarksburg one hundred and sixty, and ten miles west from Clarksburg, as given in the section above. The interval seems to decrease in this direction. Were this evidence absent, the character of the bed itself would leave no room for doubt respecting its identity with the *Waynesburg*.

No satisfactory exposures of this coal were observed except near the railroad. Its blossom is seen on the north side of the railroad near Clarksburg, at one hundred and sixty feet above the *Sewickly*. It is worked slightly at about nine miles west from Clarksburg, where it shows four feet of coal, divided nearly midway by a clay parting one foot thick. From this point westward, it was not seen until within two or three miles of Smithton, where there have been numerous openings, nearly all of them now deserted. At all of these, the bed is overlaid by twelve feet of dark argillaceous shale, containing vegetable impressions and holding midway, a layer of calcareous iron ore. At Smithton, the coal is worked by Mr. Smith, at whose bank the following structure is shown :

Shale, with vegetable impressions, 4 ft.; *Coal*, 2 ft. 2 in.; Clay, 3 in.; *Coal*, 2 in.; Cannel, 3 in.; Shale, dark-gray, fissile, 8 ft.; *Coal*, 1 ft. 6 in.

The coal is not very good, owing to the considerable proportion of sulphur. The bottom layer yields the best fuel, but as it is mined by strip-

\* The *Sewickly* has not been seen at Fairmont, and this calculation is based on the relation of the *Waynesburg* to the *Redstone*.



ping in the run, the superiority may be owing entirely to removal of the pyrites by the water. The same bed is mined somewhat extensively at West Union, where one finds

Shale, 2 to 8 ft.; *Coal*, Cannel, 3 in.; Clay, 2 in.; *Coal*, 31 in.; Clay, 4-11 in.; *Coal*, 6 in.; Fire-clay, 3 ft.; Shale, to road, 7 ft.

The overlying shale is drab or slate-colored, quite fissile, and contains much nodular iron ore. It exhibits vast numbers of vegetable impressions, chiefly *Neuropteris*, *Cyclopteris*, *Pecopteris* and *Sphenophyllum*. Many of these are beautifully defined and equal those from the same horizon in Monongalia county. This shale varies in thickness at the expense of the sandstone above it. The fire-clay underlying the coal passes gradually into ferruginous, slightly arenaceous shales, below which, some limestone is seen farther up the stream. The upper parting in the bed occasionally shows leaf-prints. The lower parting is variable in thickness, and sometimes holds two sheets of coal, each one inch thick. The main coal is very hard, evidently open-burning and bears much resemblance to semi-cannel. It is said to be an excellent fuel. Though showing but little pyrites, when freshly mined, it becomes streaked with copperas when exposed to the weather. In this vicinity the bed is cut by numerous vertical seams of drab clay, which are quite distinct in the solid coal.

Along the Staunton pike this bed is much degraded. Several openings have been made upon it between Smithville and Troy, but it nowhere exceeds two feet. At a short distance east from Harrisville, in Ritchie county, it is found varying from six to eighteen inches in thickness.

Northward from the railroad this coal steadily increases in thickness until near the State line it averages more than eight feet, varying from eight to eleven. It is rarely single, usually double, and frequently triple.

The rocks occupying the interval between the *Waynesburg* and the *Sewickly*, show variations which deserve some consideration. Near the State line on the Monongahela River we find here, fifty-six feet of limestone, and at Wheeling there is one mass of limestone and calcareous shale, fully one hundred feet thick. At both localities much of the limestone is compact and quite pure. Along the Northwestern pike and the railroad, not more than sixteen or twenty feet of limestone can be found, and most of this is so poor that it ought rather to be called a compact calcareous shale. Still farther south, along the Staunton and Parksburg pike, not one foot of limestone was observed in this interval. From the northern portion of the State to the railroad, the limestone diminishes and gives place to shale, but from that line southward the shale apparently disappears, and sandstones appear instead. Along the railroad the limestones were seen near Wolfe's Summit, near Smitilton and West Union. Traces of them occur east from Harrisville.

The *Sewickly* coal was identified at only two localities. At Clarksburg,



it occurs two feet six inches thick, and seventy feet above the Pittsburg. No attempt has been made to ascertain its value. On Wolfe's Summit, eight miles west from Clarksburg, the coal is only two inches thick. This bed seems to have as little persistence as the coals of the Barren Group, when traced southwardly. It has not been found at Fairmont, in Marion county.\* No traces of it occur along the Staunton pike, in Gilmer county, and I cannot speak with certainty respecting its presence in either Lewis or Upshur county. It is, however, by no means improbable that the small coal above the Pittsburg in the latter county, is the Sewickly, and not the Redstone.

The interval between the *Sewickly* and the *Redstone* is entirely free from limestone. It is occupied by shale, none of which is calcareous. At Wheeling this space is filled with limestone, and on the Monongahela River near the State line, it contains thirty-one feet of limestone. On the Staunton pike the shales are replaced by flaggy sandstones.

The *Redstone* is a wide-spread and persistent coal, though rarely of economical value in West Virginia. At Fairmont, in Marion county, it is three feet thick and of good quality, but is not mined. Between that town and Clarksburg, its blossom is frequently seen in the roadside, and at the latter place it is six inches thick at the outcrop. At Wilsonburg, four miles west from Clarksburg, it is barely one foot thick, while at Coketon, two miles beyond, it is four feet, and of excellent quality. Where last seen toward the west, at Wolfe's Summit, it is only three inches thick. A thin coal, varying from one to two feet, is found above the *Pittsburg* in Upshur county. Whether or not this is the Redstone, the material in my possession is not sufficient to decide.

The rocks occupying the interval between the *Redstone* and the *Pittsburg* are subject to great variations in character and thickness. At Fairmont the interval is eighty feet, at Pruntytown, seventy-five, at Bridgeport, sixty-five, and at Weston, somewhat less. At all of these localities which lie along a nearly northeast and southwest line, the interval is occupied by sandstone and shale at the base, and limestone on top. Westward from such a line passing through Morgantown, Fairmont, Bridgeport and Weston, the distance between the coals rapidly diminishes. At Clarksburg, it is twenty-five feet, occupied by shale or sandstone; at Wilsonburg, it is the same, filled with argillaceous shale; at Coketon, it is twenty-eight feet; while at Wolfe's Summit, it is twenty feet, the rocks being shale and limestone. A similar condition exists in the vicinity of Morgantown, as stated in my previous paper.

The limestone disappears altogether before reaching the Staunton pike, so that with the exception of a few scattered nodules no limestone occurs among the strata of this group along that line.

\* In my previous paper, I stated that it occurred at Fairmont. I had misunderstood the statement made to me by Ex-Governor Pierpoint, respecting the coals of that vicinity.



*Pittsburg Coal.* The eastern limit of this bed aside from small outlying areas, is marked by a line beginning near Cheat River, on the Pennsylvania border, and extending west of south to Fairmont, and crossing the Tygarts' Valley River, a little above that town. Thence irregularly to Pruntytown, where it turns east by south to Flemington. From this point it follows a south-southeast course, almost to Tygarts' River, thence southward, crossing the Buckhannon River near the Upshur county line. There it again turns east by south, and so continues almost to the middle fork of that river, when the course changes to southwest, and so remains to the line between Upshur and Lewis counties. From this locality to where the bed crosses Pocatatico Creek near the Great Kanawha River, I have not followed it. The extreme eastern exposure occurs in Upshur county, about five miles east from Buckhannon, on the Staunton pike.

The extreme western line of exposure begins at the Pennsylvania line, nearly two miles west from Monongahela River, crosses that river about a mile below Fairmont. It lies a little west from the West Fork River, crossing Harrison county from Shinnston to Wolfe's Summit, on the Northwestern Railroad. Thence it runs southwestward through Lewis county, reaching Gilmer, near Troy, on the Staunton pike, and crossing the Little Kanawha, just below Glenville.

Owing to the abruptness of the Laurel Hill anticlinal, the area in which this bed is available is very narrow at the north, hardly more than six or seven miles wide. Southward the anticlinal becomes gentler and this area rapidly increases in width until along the Staunton pike the coal is available for a distance of nearly forty miles. The bed attains its greatest thickness toward the north, and diminishes toward the south and southeast.

In Monongalia county, this bed is double, except where overlaid by sandstone. This characteristic prevails in Pennsylvania and Ohio, as well as in the Ohio Panhandle of West Virginia. But southward from Fairmont this division is rarely marked by a distinct clay parting, though the difference between the upper and lower benches sufficiently proves that the bed is still double. Occasionally, however, as at Shinnston and near the tunnel east from Clarksburg a well-defined clay parting separates the two branches.

In Upsher county the openings are quite numerous in the vicinity of Buckhannon, and the *Pittsburg* is the only source of supply for a large area. The coal varies from three feet nine inches to four feet, and is said to be of very fair quality. Though the parting is exceedingly thin, the upper and the lower benches are very distinct, the former being hard and leaving a bulky red ash, the latter being soft and clean, yielding a white ash. In the northern part of the county, very near the Barbour county line, the coal is mined on the Westfall property, where it shows

*Coal*, 32 in.; Parting,  $\frac{1}{8}$  in.; *Coal*, 34 in.; total, 5 ft. 6 in.

Though very thin, the parting is persistent. The upper bench is quite



hard and contains a good deal of bony semi-cannel, but the proportion of good clean coal is quite large. It burns well, but leaves a bulky ash. The lower bench is a remarkably clean coal. Layers of apparently pure bitumen are seen, two to four inches thick, structureless, showing no lamination, and breaking with beautifully conchoidal fracture. At this opening the coal is exceedingly good, and shows no pyrites under a glass. It does not disintegrate upon exposure, nor does it exhibit streaks of copperas. Near this opening is the Connolly bank. At the time when it was examined, this had not been fully opened, and only five feet of coal were exposed. The appearance is somewhat strange, as no division into benches can be made out, and the bed seems to be homogeneous. The coal is pure throughout, and evidently very rich in volatile combustible matter. The coal from these banks would yield an excellent coke, and would be exceedingly profitable in gas-making.

In Lewis county, this bed is easily accessible, and it is worked quite extensively to supply local demand. Openings were examined only along the Staunton road, though many were seen on the West Fork River, both above and below Weston. In the central portion of the county the thickness varies from four feet six inches to nearly eight feet, increasing northward. The bed is apparently single, but close examination shows the existence of two benches, the upper being invariably harder and less pure than the lower. Owing to the thinness of this bed in the southern portion of the county, many persons do not believe it to be the *Pittsburg*, but refer to that horizon the *Upper Freeport*, which appears to be quite thick in the river near Weston.

In Gilmer county the coal is mined near Glenville, where it is from four to five feet thick. About one mile east from Troy, an opening shows the following section :

Shale, gray, 8 ft.; *Coal*, 29 in.; Parting,  $\frac{1}{2}$  in.; *Coal*, 38 in.; total, 5 ft. 7 $\frac{1}{2}$  in.

The coal is very good and shows but little pyrites. The upper bench is quite compact and leaves a red ash. The lower is softer and burns more readily, leaving a not bulky, white ash. About one-half mile farther east is a bank in which the coal is seven feet at the mouth, and farther in is said to reach nine feet. Near the county line the coal is again opened, but there it is barely five feet thick.

In Harrison county, openings are quite numerous along the railroad, and the coal is mined extensively for shipment. Notwithstanding the presence of a good deal of pyrites, it finds a ready market as a gas coal.

At Clarksburg, one of the most extensive openings shows the structure of the bed as follows :

*Coal*, 3 ft. 6 in.; Parting,  $\frac{1}{8}$  in.; *Coal*, 5 ft. 4 in.; total, 8 ft. 10 in.

Excepting four inches at the bottom, the lower bench is a fine clean



coal, while the upper bench is somewhat bony, quite hard and bears much resemblance to the ordinary roof coal of this bed as seen farther north and northwest. The parting varies from  $\frac{1}{8}$  in. to  $1\frac{1}{2}$  in. and is persistent in all the openings in this vicinity. In the lower bench there occur three thin partings, twelve, fifteen and eighteen inches respectively from the bottom, between which is the soft coal, the "bearing-in bench" of the miner. The character of this lower bench is precisely the same with that of the lower division of the Pittsburg throughout northern Ohio. Some pyrites occur here, but the quantity is not great. The upper bench contains a layer of "slate," four inches thick and irregular in its place. On the north side of the railroad the seam is much troubled by sandstone horsebacks, some of which are quite extensive, having been traced for more than half a mile across the entries of different openings. In one bank such a horseback was found, eight feet wide. It was followed for five hundred yards, but showed no sign of thinning out. Along the whole distance, it has not only cut out the coal, but has also trenced the fire-clay and sandstone below. It is said to be more compact than the overlying sandstone.

At Wilsonburg, four miles west from Clarksburg, the coal shows an average thickness of seven feet six inches, but near the mouth of the main entry increases to eight feet four inches. The parting is black clay, and varies from  $\frac{1}{8}$  to 2 in. The coal at the base for one foot is very poor and hardly marketable, but the remainder of the lower bench is a very fine coal, containing, it is true, much nodular pyrites; but this is easily separated. There are no well-defined minor partings in this bench. The upper bench is quite hard and contains much splint coal. It is said to be quite as good for gas-making as the lower portion is, so that all parts of the bed are shipped together, the single foot at the base excepted, as that is too sulphurous.

At Coketon, the bed varies from five to seven feet. For three inches at the bottom the coal is very bad, but the whole bed above is taken out for shipment. The upper bench is heavy, compact and leaves much ash. The parting is one inch thick and consists of hard carbonaceous clay. Pyrites occur plentifully throughout the bed, but, being in nodules, is readily removed. The roof is a slickensided clay.

Where the bed disappears, near Wolfe's Summit, it is six feet thick and roofed with ten feet of argillaceous shale. East from Clarksburg, it is mined at Bridgeport and several other localities, but only to supply local demand. Numerous banks are worked in a small way along the West Fork River, and on the road to Shinnston, in this county. They show no material difference from those already described.

In Taylor county, openings were seen near Pruntytown and Flemington, in each case near the eastern outcrop of the coal. At Pruntytown, the bed is single and nearly eight feet thick. Above it is a dull reddish-gray shale, on which rests a massive sandstone. The coal, for the most part is somewhat inferior here, as the roof is very thin and usually not



sound. At Flemington the thickness is eight feet. There are no distinct partings, and the roof is a shaly sandstone, which occasionally forms a troublesome horseback. The coal from the banks here is said to be very good and to command a ready market for use in gas-making.

LOWER BARREN GROUP. It will be remembered that in the section given in my former paper, eight strata of limestone, having in all a maximum thickness of thirty feet, were represented as belonging to this group. These disappear southwardly, so that at Clarksburg only two remain, one underlying the *Pittsburg* coal, and the other about one hundred feet below it. Still farther south, in Lewis county, we find that only the upper one holds out, and that disappears long before reaching the Great Kanawha River. Even the fossiliferous limestone, which, in the Ohio Reports, I have named the *Crinoidal Limestone*, thins out finally before reaching the Northwestern Branch of the Baltimore and Ohio Railroad, though it is persistent in Ohio, Pennsylvania and northern West Virginia. The fossiliferous shales accompanying this limestone were traced to near Pruntytown, in Taylor county, beyond which, southward, they were not seen. Not far from Pruntytown, they yield beautiful specimens of *Productus prattenianus*, *Nucula ventricosa*, *Nucula (?) anodontoides*, *Yoldia carbonaria*, *Yoldia stevensoni*, *Edmondia aspenwalensis*, *Pleurotomaria (?) tumida* and *Bellerophon mckeanus*.

Southward to the railroad and east from the Laurel Hill axis, the shales increase greatly, but farther toward the south and especially along the axial line they are replaced by sandstone, so that on the Staunton pike, where the whole section is fully exposed for three hundred feet below the *Pittsburg* coal, the only rocks are sandstones. East from the axis the shales predominate, and for the most part are of a deep brick-red color. The same color characterizes them in the disturbed region at the west.

In Upshur and Randolph counties, between Buckhannon and Beverly, the Lower Barren Group seems to contain no coal, but in the vicinity of the former village, there is a small seam about forty feet below the *Pittsburg*. Between Buckhannon and Clarksburg another is seen about one hundred feet below that coal, and it occurs also at the latter place.

The thickness of this group shows little variation along the eastern border, and is not far from four hundred feet.

LOWER COAL GROUP. In Upshur and Randolph counties, it is impossible to procure a detailed section of this group without the expenditure of very much more time than was at my disposal. The whole country is deeply buried under debris, and connected exposures are rare. The rapid and somewhat irregular increase of dip near Rich Mountain, and the long stretches of "concealed," along the roads and streams render the building of a section exceedingly difficult. It is, however, sufficiently evident that this group, barely two hundred feet thick, near the Pennsylvania line, has rapidly developed so as to be in these counties



scarcely less thick than on the Great Kanawha River, where it is nearly nine hundred feet from the Conglomerate to the top of the Mahoning Sandstone. The following partial section, beginning with the Mahoning Sandstone, is said to have been obtained in a salt well bored on Buckhannon River:

1. Rock.....	60 ft.
2. <i>Coal</i> .....	15 ft.
3. Shale .....	32 ft.
4. Sandstone.....	40 ft.
5. <i>Coal</i> .....	4 ft.
6. Rock.....	160 ft.
7. <i>Coal</i> .....	4 ft.
8. Sandstone .....	40 ft.
9. <i>Coal</i> .....	3 ft.
10. Sandstone.....	120 ft.
Total.....	478 ft.

The boring clearly stopped far short of the base as it did not reach the large and very persistent coal bed resting on the Conglomerate. As nearly as can be determined, the thickness of the whole group is not far from seven hundred feet.

No. 1 of the section, the Mahoning Sandstone, is ordinarily separated from the underlying coal by from six to ten feet of shale. It is a coarse sandstone, with numerous lines of pebbles, arranged parallel to the general plane of bedding. Some portions show extensive cross-bedding, and occasionally the rock is a coarse conglomerate. It is of uneven texture, and weathers into irregular cavities. Rude casts of vegetable stems are of common occurrence, and a thin coal is sometimes found about forty feet from the base.

No. 2 is the *Upper Freeport Coal*. Its changes in Upshur, Randolph and Barbour counties are very interesting. East from Buckhannon, on the Beverly road, it is first seen at the Sand Run crossing, in a deserted opening. The shale above it is dark, fissile, and about seven feet thick. Above this is the Mahoning Sandstone. The first satisfactory exposure is on Roaring Creek, at the foot of Rich Mountain, where the coal is worked and shows the following section:

	<i>Ft.</i>	<i>In.</i>
1. Shale, drab, argillaceous.....	10	
2. <i>Coal</i> .....		4
3. Shale, dark, argillaceous.....	2	4
4. <i>Coal</i> .....		10
5. Clay, carbonaceous .....		1
6. <i>Coal</i> .....		10
7. Clay .....		$\frac{1}{4}$
8. <i>Coal</i> .....		9



	<i>Ft.</i>	<i>In.</i>
9. Clay.....		$\frac{1}{4}$
10. <i>Coal</i> , semi-cannel.....	1	1
11. Clay.....		$\frac{1}{2}$
12. <i>Coal</i> , mostly semi-cannel.....	3	2
13. Clay, slickensided.....		4
14. <i>Coal</i> .....	1	9
15. Shale, drab.....		4
16. <i>Coal</i> , poor, seen.....	1	11
	<hr/>	<hr/>
Total.....		

Of this section, the portion from No. 4 to No. 14, inclusive, yields a coal, fairly good, but of very uneven quality. It is a good fuel, and carelessly examined, appears to be quite clean. Under a glass it shows many minute crystals of pyrites, and when exposed to the weather, soon becomes streaked with copperas, so that its commercial value is at least doubtful. On Sand Run, several miles south from the crossing of the Beverly road, a remarkable expansion of the bed is exposed in the bank of the stream. The section is as follows :

	<i>Ft.</i>	<i>In.</i>
1. Bituminous shale.....	5	
2. <i>Coal</i> .....		7
3. <i>Cannel</i> , poor.....	2	6
4. Shale, slightly carbonaceous.....	4	
5. <i>Coal</i> , slaty.....	1	10
6. Shale, slightly carbonaceous.....	1	3
7. <i>Coal</i> , partly cannel.....	2	2
8. Clay, drab.....		8
9. <i>Coal</i> , bony.....		6
10. Clay.....		8
11. <i>Coal</i> , slaty.....	1	1
12. Clay, with streaks of <i>Coal</i> .....	1	2
	<hr/>	<hr/>
Total.....	21 ft.	6 in.

In all this, the only coal which is fit for any purpose is No. 7, and even that is good for fuel only in case nothing else can be had. Yet this enormous mass of bituminous shale and bad coal has aroused great expectations throughout Upshur county. Its vastness, as reported on by a voluntary committee of the Legislature, is said to have caused a number of the legislators to look with favor upon Buckhannon as the site for the State Capital. The prevailing opinion respecting this bed is that its value is incalculable, whereas it is utterly worthless. Passing over to Grassy Run, another tributary to Buckhannon River, we find this bed mined on the property of Mr. G. Marple. Only a portion is exposed, giving the following section :



	<i>Ft.</i>	<i>In.</i>
1. Arenaceous shale .....	4	
2. Bony <i>Coal</i> .....		3
3. Parting.....		$\frac{1}{2}$
4. <i>Coal</i> .....		11
5. Clay parting .....		$\frac{1}{2}$
6. Bony <i>Coal</i> .....		6
7. Slate .....		11
8. Bony <i>Coal</i> .....	1	4

The coal from this bank is not very highly esteemed. About a mile farther down the run, an exposure in a bluff is as follows:

	<i>Ft.</i>	<i>In.</i>
1. <i>Cannel</i> , very poor .....	4	
2. <i>Coal</i> , bony .....	1	11
3. Clay, slickensided.....	2	2
4. <i>Coal</i> , semi-cannel .....		8
5. Shale, carbonaceous .....		3
6. Sandstone .....		$3\frac{1}{2}$
7. <i>Coal</i> .....		4
8. <i>Cannel</i> , poor.....	1	1
9. <i>Coal</i> , slaty .....		11
10. <i>Coal</i> , good .....	1	4
11. Clay .....		9
12. <i>Coal</i> , bony.....		4
13. Clay.....		6
14. <i>Coal</i> .....		5
15. Shale, drab .....		8
16. <i>Coal</i> .....	1	6
17. Clay, slickensided with remains of plants and streaks of coal, seen.....	1	
Total.....	18 ft.	$1\frac{1}{4}$ in.

A similar section occurs on Buckhannon River about ten or eleven miles above the village of Buckhannon, but it is unnecessary to give it here. The coal is visible at many points along Roaring Creek to Tygart's River, and on that stream to within a few miles south from Grafton. On Roaring Creek, Mr. Jabez Woolley has measured it at three exposures, where he found the thickness eight, twelve and twenty feet respectively. Wherever it falls below twelve feet, it contains coal in sufficient bulk to be workable. The quality seems to be quite inferior throughout this region. Ex-Gov. Pierpoint informs me that some years ago it was proposed to mine this bed on Tygart's River, seven or eight miles above Grafton. The coal exhibited was very handsome, and to the naked eye showed no evidence of pyrites, but as soon as it was put under a glass it proved to be loaded with minute crystals of that mineral. It was thought



unnecessary to resort to chemical analysis for further information, and the enterprise was abandoned.

Near Weston, in Lewis county, this coal is said to occur in the bed of West Fork River, which is very probable, as the river cuts through the Laurel Hill anticlinal north from Weston. Following this anticlinal northward, we find it rapidly increasing in sharpness, so that at Valley Falls, where it is cut by Tygart's River, the Great Conglomerate is in the bed of the stream, and the Mahoning Sandstone barely crosses the crest unbroken. Near this point, at Nuzum's Mills, probably forty miles from Weston, the following section of the Lower Coal Group is obtained:\*

	<i>Ft.</i>	<i>In.</i>
1. Sandstone .....	60	
2. <i>Coal</i> .....	3	
3. Sandstone .....	30	
4. Limestone.....	3	
5. Sandstone .....	30	
6. <i>Coal</i> , U. Freeport .....	5-6	
7. Sandstone .....	45	
8. <i>Coal</i> .....	2	
9. Fire-clay, compact.....	1	
10. Sandstone and shale.....	65	
11. <i>Coal</i> .....		6
12. Shale .....	15	
13. <i>Coal</i> .....	0-3	
14. Fire-clay, compact .....	3	to 6
15. Iron ore.....	2	to 6
16. Shale.....	15	
17. Great Conglomerate.....		
Total.....	—	—

The *Upper Freeport* here shows, *Cannel*, 1 ft.; Bituminous *Coal*, 4 to 5 ft. It is somewhat inferior owing to the presence of much sulphur, but is a good strong fuel. On Prickett's Creek, in the same county (Marion), the *cannel* is at the bottom, and in greater quantity. Extensive arrangements were made here, years ago, for distilling oil from the coal, but the discovery of petroleum brought the enterprise to premature dissolution. On Booth's Creek, in Monongalia county, some old openings are still accessible. One a little way north from the creek shows:

Clay, 1 ft.; *Coal*, 1 ft. 11 in.; Clay, 8 in.; *Coal*, 2 ft. 9 in.; Clay, 2½ in.;  
*Coal*, 1 ft. 1 in.

A deserted opening near the old furnace on this stream gives:

*Cannel*, 1 ft.; Carbonaceous shale, 11 in.; *Coal*, slaty, 4 in.; Clay, 7 in.;  
*Coal*, 2 in.; Clay, 4 in.; *Coal*, seen, 4 ft.

\* This section and the remaining notes on the Upper Freeport Coal were dropped by the printer in making up my previous paper on West Virginia.



The coal at the base is certainly much thicker than is stated. The old props lying in the deserted entry are somewhat more than five feet long. Another exposure near the mouth of the creek shows the bed much degraded, giving the following section :

*Coal*, 1 ft. 9 in.; *Clay*, 3 in.; *Coal*, 6 in.; *Shale*, 2 in.; *Coal*, 1 in.

The roof here is sandstone. Elsewhere upon the creek it is shale, which abounds in vegetable impressions. The coal from these openings is said to be very good fuel though it contains considerable proportion of sulphur. It contains much volatile combustible matter and cokes readily in heaps.

Returning to Upshur county, we find underlying the *Upper Freeport* Coal a sandstone about fifty feet thick, more or less flaggy, and apt to change into arenaceous shale. Below this is a thin tough limestone, not very pure, which seems to represent the Freeport Limestone. It was seen on the Staunton pike near Roaring Creek and on Sand Run. Between the limestone and the coal below, the sandstone is coarse and flaggy. The interval varies from twenty to thirty feet.

The next coal, No. 5, of the salt-well boring, was seen at only two localities, one on Roaring Creek, near the Staunton pike, and the other on Sand Run, near the great exposure of the *Upper Freeport*. It is a persistent bed and quite regular in thickness, varying little from four feet throughout this vicinity. The coal is irised, exceedingly rich in bituminous matter, and containing not a large amount of sulphur. It burns nicely and cokes well. No regular workings were found, and only "crop" coal could be examined. This is extremely brittle, so that, unless it improve greatly under the hill, it will hardly prove fit for shipping.

The beds, No. 7 and No. 9, of the boring have not been identified at any locality. Three miles east from Roaring Creek, and five hundred feet higher than the opening on the *Upper Freeport*, the blossom of a coal-bed occurs at the roadside. This is probably one of the lower beds, but the question cannot easily be determined, as eastward the dip increases rapidly in steepness, and the whole western slope of the mountain is so deeply buried under shingle and so thoroughly paved with fragments of sandstone and conglomerate, that connected exposures cannot be found.

East from this blossom, almost two-thirds of a mile distant along the pike, and very near the crest of the ridge, a coal-bed is worked. The mouth of the mine is three hundred feet higher than the blossom in the roadside. In the interval along the road everything is concealed except occasional exposures of sandstone. The bed near the crest is dipping northwestward at twelve degrees, so that the space between it and the coal above would be nearly five hundred feet, provided the dip does not vary. It is perhaps better to regard the interval as about four hundred feet. The coal is within a few feet of the conglomerate, but the inter-



vening rock is concealed. At the opening made by Mr. S. B. Hart, near the pike, the bed exhibits the following structure :

Shale, —.; *Coal*, sulphurous, 4 in.; Black clay, 1 in.; *Coal*, 3 ft. 6 in.; Clay, 1 in.; *Coal*, 1 ft. 7 in.; total, 5 ft. 7 in.

The bottom coal is very inferior, being about one-half slate, and containing a notable proportion of pyrites. The bench next above it is a good fuel, though rather soft and toward the base somewhat sulphurous. It is extensively mined to supply Beverly and the adjacent country. I made as careful search for other outcrops as is possible in a wild region, covered with loose rocks and a dense forest. No other was found, unless the bed exposed at the head of Casseday's Fork of Buckhannon River be the same. This occurs near the crest of the ridge on the west slope, about ten miles south from the Staunton road. It is a large bed, and is most likely this coal. There is no doubt that this is the same with that found on the conglomerate in Marion and Monongahela counties. If it be as irregular in thickness here as in northern West Virginia and Ohio, its outcrop will be traced only with great difficulty.

Aside from the *Freeport*, itself reduced almost to nothing, no limestones were seen in this group. As in the other groups, the limestones disappear southward. They occur in Pennsylvania, but thin out rapidly after coming into West Virginia.

#### THE GREAT CONGLOMERATE.

This rock forms the crest of Rich Mountain for nearly sixteen miles, within the region examined. For the most part it is a coarse sandstone loaded with pebbles from  $\frac{1}{8}$  of an inch to 2 inches in diameter. Along the Staunton pike it shows some layers of slightly micaceous and very compact sandstone near the bottom. Here it is greatly increased in thickness. Near the northern line of the State it is barely three hundred and fifty feet thick, but in Randolph county, it is not less than six hundred. This expansion continues southwardly, as shown by the observations of Professor Fontaine, in the New River region. On Rich Mountain it contains no fossils, but in portions there are vast numbers of quartz crystals, some of them three-fourths of an inch long, and beautifully terminated at both extremities.

On the Staunton pike, along the eastern slope of the mountain, there was seen midway in the conglomerate, what appeared to be the blossom of a coal-bed. As I had observed no evidence of coal in the conglomerate northward from this locality, this exposure was studied with some care, but nothing definite could be ascertained. Six miles farther south, on the same side of the mountain, a small coal-bed occupies this place on the property of Mr. Bradley. There it is three feet thick, quite soft, but of excellent quality, and being almost free from sulphur, is highly prized by blacksmiths. Another opening has been made on the ridge near the bridle path, seven miles south from the Staunton pike, and a



third is seen near the same path, three miles farther south. These openings hardly deserve the name, as only a few sackfuls of coal have been taken from each. In all of them the coal shows the same character.

This little bed is of much interest. Here in the vicinity of the Staunton pike is the northern termination or better, perhaps, the beginning of the important group of "conglomerate" coals so fully described by Prof. Fontaine, in West Virginia, which farther southward become the main source of supply in Tennessee. In the northern portion of the State no coal occurs in the conglomerate. The local geologist, quoted by Prof. Fontaine and myself, who asserted that two beds occur in this group, is an ignorant man, who regarded the Tionesta Sandstone as part of the conglomerate, and so placed the Tionesta coals in this group.

#### LOWER CARBONIFEROUS.

My observations in the Lower Carboniferous were made along the east slope of Rich Mountain at two or three localities between the Staunton pike and the Huttonsville bridle-path, a distance of somewhat more than ten miles north and south. The results therefore are not of much importance.

The red shales were seen on the Staunton pike. There they are in part quite arenaceous, and are almost a thinly laminated shaly sandstone. Their thickness cannot be accurately determined at that exposure, but I take it to be little more than fifty feet. They do not appear to contain any important deposit of iron ore, such as occurs near the Pennsylvania line. Six miles south from the Staunton pike, the shales are entirely wanting, and the conglomerate rests directly on the limestone. The line of contact is finely exposed at several localities but at none better than at a place nearly two-thirds of a mile north from Mr. Bradley's house, where the limestone and conglomerate are seen in contact along a bluff for about thirty feet.

The shales are of a deep red color, and the micaceous sandy layers are almost as deep red as the pressed brick on our house-fronts. As a whole, this series bears very close resemblance to the red shales of the Lower Barren Group, and might easily be mistaken for them. About fifteen miles north from the Staunton pike, at the gap made by Tygart's River on its passage through Rich Mountain, Mr. J. Woolley found these shales two hundred feet thick; their identity being certified by the conglomerate above and the limestone below. Within twenty miles south from that locality they have wholly disappeared.

The rapid thickening of the limestone is remarkable, contrasting strangely in this respect with those of the Coal Measures. Near the State line on Cheat River the limestone mass is barely one hundred feet thick, as ascertained by boring. In Randolph county, I saw a continuous exposure of nearly four hundred feet. A space of two hundred feet is concealed, and below that a calcareous shale occurs, so that the thickness is not less than seven hundred feet. In Pocahontas and Greenbrier



counties, the expansion is greater, reaching in the former to eight hundred feet. On the Staunton pike the topmost layers are exceedingly pure and very compact. They yield an excellent lime, and are the source of supply for the whole region to a distance of nearly twenty miles. Farther south the upper layers are quite impure, and are nearly calcareous shale. On the property of Mr. Bradley, a seam of coal occurs amid some shales in this mass, about two hundred and fifty feet below the conglomerate. It is two inches thick, quite impure and very sulphurous. It is seen in a little run below Mr. Bradley's house.

The fossils obtained from this limestone were found chiefly in the upper layers and are similar to those procured in Monongalia county. The most common are *Spirifer Leidyi*, *Athyris subquadrata*, *Productus elegans*, *Productus pileiformis*, *Hemipronites crassus*, *Allorisma sp.*, and *Straparollus planidorsatus*. These show the rock to be of the same age as the Chester group of the west. I had in my possession several fine specimens of *Lithostrotion canadense*, which were said to be from Randolph county, and I expected to find the St. Louis group well defined. No species belonging to that group fell under my observation, and I doubt whether the *Lithostrotion* came from this portion of West Virginia.

The strangest feature in the Lower Carboniferous of this region is the entire disappearance of the sandstones and shales usually found between the limestone and conglomerate. Judging from Rogers' reports, one would expect to find them, not merely persistent but greatly expanded, as compared with more northern localities. At Westernport, on the Potomac, they are six hundred and fifty feet thick, and in Pocahontas county, that adjoining Randolph on the south, they are twelve hundred and sixty feet. Yet in Randolph county they disappear completely. A local anticlinal must have existed here during the latter portion of the Lower Carboniferous period.

#### THE DISTURBED REGION.

By this title I designate that portion of West Virginia lying between the line of the Ellenboro' fault and the Ohio River, which includes about midway between its east and west boundaries the especially broken tract known as the "oil-break."

The line of the Ellenboro' fault crosses the Staunton pike near Webb's Mills, on Hughes River. Northward it passes a little west from Harrisville and crosses the railroad about one-fourth of a mile east from Ellenboro'. Its place is entirely concealed on the Northwestern pike, though its presence there is indicated by the change in the character of the rocks. How far northward it extends I am unable to say, but if it continue in that direction, it should cross the Ohio River not far from New Martinsville. The best information within my reach leads me to suppose that it disappears long before reaching the Ohio. Southward this fault certainly disappears long before reaching the Great Kanawha River, for, according to Dr. Briggs, the *Pittsburg* coal shows a continuous outcrop



across the State through Braxton, Clay, Kanawha and Putnam counties to the Ohio River. Indeed, in every respect the disturbance from east to west in this region seems to have been greatest in the vicinity of the line followed by the railroad. Near Ellenboro' the fault is quite abrupt and is seen to good advantage in the creek's bed, about one-fourth of a mile from the station. On its eastern side the rocks of the Upper Barren Group are seen turned up and dipping at  $26^{\circ}$ , while on the west side the strata of the Lower Barren Group lie almost horizontally. The direction of the fault is about N.  $10^{\circ}$  E. Mag., and the upper rocks dip S.  $80^{\circ}$  E. Mag.

From this fault westward, the strata are almost horizontal, or have an easterly dip so slight that it cannot be determined by the barometer, until the edge of the oil-break is reached where they are abruptly turned up at a high angle. Within the "break," a narrow strip, nowhere more than two miles wide, the dip is irregular, but shows traces of anticlinal structure, and at no time exceeds  $5^{\circ}$ . On the west side the conditions seen at the east are repeated. The strata are sharply upturned and dip toward the west. The angle of dip quickly diminishes and soon becomes only ten feet per mile. About five miles east from Parkersburg, another fault occurs, quite as sharp as that at Ellenboro', with the upturned rocks dipping westward. Beyond this, the rocks are almost horizontal to the Ohio River.

On each side of the oil-break the strata belong to the Lower Barren Group, as far east the Ellenboro' fault and as far west as the fault near Parkersburg. What the rocks between this fault and the Ohio River are, can be determined only by approaching them from Ohio. Before entering into a discussion of the "break," it is well to describe these rocks as they occur east and west from it.

*Lower Barren Group outside of the Oil-break.* Near Ellenboro', and almost directly on the edge of the fault a boring was made several years ago in search of oil. No record has been preserved, but the enterprise proved unsuccessful. Both fresh and salt water were found, and a little oil was obtained. The rocks appeared to be much shattered. At first the drill descended nearly twenty feet each day, and farther down many crevices were struck, in which the tools would drop four or five feet instantly. Five hundred feet down, the drill stuck fast and the work was abandoned.

Along the railroad, westward from Ellenboro' to near Petroleum, the section appears to be :

1. Debris, with nodular limestone.....	75 ft.
2. Coal.....	1 ft.
3. Flaggy sandstone.....	40 ft.
4. Red shales.....	10 ft.
5. Sandstone.....	15-25 ft.
6. Red and blue shale.....	25 ft.
7. Sandstone.....	10 ft.
8. Red shales and sandstone.....	300 ft.



The limestone and coal both were seen near Ellenboro', as well as in the hills near a deep cut three miles farther west. This coal, I take to be the same with that whose blossom is seen in the roadside between Harrisville and Cornwallis Station, not far from the former place. The sandstones, Nos. 5 and 7, are soft, light gray, somewhat feldspathic and contain much mica. The upper is the more compact and durable. Both may be seen near Cornwallis Station, where the upper stratum is quarried extensively by the railroad company for building purposes. The lower one is apt to become flaggy. No. 8 is first seen near Cornwallis, and is the prevailing rock exposed in the cuttings from that place to near Petroleum, except near Silver Run Summit, four miles east from Petroleum, where the grade of the road brings one into the upper members of the group. The shales greatly predominate. When freshly exposed, they resemble a reddish shale enclosing nodules of sandstone. The whole, however, is a mass of slightly arenaceous clay shale, without definite bedding, of dull red color, with brownish patches, and readily breaking up into coarse powder on exposure. The color is characteristic, and once seen cannot fail to be remembered. No such shale occurs in the Upper Barren Group. It does occur in the Lower Barren Group along Buckhannon River and the Staunton pike, in Upshur county. No other group resembles it except the Red Shales of the Lower Carboniferous. Near Petroleum we find under it a sandstone, which, doubtless, belongs to the Lower Coal Group.

Along the Northwestern pike only the upper members of the group are exposed, until one approaches the eastern slope of this "break."

Southward from the railroad the rocks show the same character. At a short distance west from Harrisville a boring was made for oil. It was continued to the depth of five hundred feet and then abandoned. No record of it is accessible. I am informed that for most of the distance the drill passed through red shales, and that two very thin beds of coal or carbonaceous shale were passed through. On the Staunton pike, these rocks are well exposed for nearly twenty miles, by the road. They are said to contain two very thin beds of coal. Of one of these I saw the blossom about three miles west from Webb's Mills. It seems to be about ten inches thick. A very notable feature just east from the break is a sandstone, about twenty feet thick, resting on shale.

Leaving aside, for the present, all reference to the strata involved in the slopes of the oil-break, we pass across the break to the west, where we find a similar series of rocks, differing only in this, that the red tint is not the only one in the shale, many portions along the railroad having a bluish cast.

Upon the line of the railroad, west from Laurel Junction, we find the rate of dip quickly decreasing to less than one degree. Before reaching the tunnel, one mile west from the Junction, the blossom of a thin coal is seen in a low cut. This is probably two hundred feet higher than the rocks in the Junction cut, and is overlaid by a mass of bluish-red shale



and sandstone. From the tunnel westward to Walker's Station, the grade of the road falls, and meantime the dip becomes barely ten feet per mile. Nearly one mile east from Walker's, a thin coal is seen which may be traced through several cuts. It is eight inches thick, very slaty, and is no doubt the same with that just mentioned. Above it, in the hills is a succession of sandstones and red shales. Similar rocks occur all the way to Parkersburg. No break or fault was seen along the railroad, but in a well bored near Claysville, the strata are said to have been found much shattered. On the Northwestern pike the exposures are very incomplete; no succession can be made out, but there are evidences of at least two small breaks in continuity of the rocks.

Upon the Staunton pike, the exposures are quite as satisfactory as those along the railroad, for the road runs in the valleys cut by the Little Kanawha and Hughes' Rivers. Starting up the Little Kanawha from Parkersburg, we find at five miles from that city a well-marked break or fault, very similar to that observed at Ellenboro'. Up to this point the westward dip is almost zero; but here at once it increases to  $25^{\circ}$ . The exposure is at the roadside, in a cut. East from this break the strata are horizontal, at least no dip in any direction can be made out with the barometer. On both sides the rocks are apparently the same. Sandstones and brownish red, slightly arenaceous shales. Judging from their lithological characters alone, one would regard them as belonging to the same group. At a short distance below Newark, the road passes through a cut, in which is exposed a series of sandstones and dark-red shales, in all about one hundred and twenty-five feet thick. On top there is a handsome, light olive sandstone, which is quarried to supply material for building the locks on the river. Though soft, it is said to be quite durable.

At Greenville, where the road crosses Hughes' River, the same shaly sandstones and shales are seen in the river bluffs, and at some distance farther on, the massive sandstone appears in the hills, twenty feet thick and standing out as a cliff. Huge fragments of it have fallen off and lie strewn over the hillside, and in the river channel. It has been used here for building purposes, and serves well, as it is not very hard, dresses easily and is quite durable. This rock is seen along the road to within one mile of Freeport P. O., where the exposures become obscure, as we are approaching the western boundary of the oil-break. It is the same sandstone with that already mentioned as occurring just east from the break on this pike.

**THE OIL-BREAK.** This name is given to an irregular tract, from one to nearly two miles in width, having a general trend of  $N. 10^{\circ} E.$  Mag., and with the strata on its sides, dipping  $N. 80^{\circ} W.$  and  $S. 80^{\circ} E.$  Mag. I have been able to examine it along the Staunton pike, the Northwestern Railroad, and the Northwestern pike, as well as at several points between these lines, embracing in all about fifteen miles of its length. The region of greatest disturbance is in the neighborhood of the railroad;



north and south from this line the abruptness diminishes. Its extent southward is not well determined. Col. Byrne, State Superintendent of Instruction in West Virginia, informed me that he had traced it to the Great Kanawha River, near Charleston. This seems hardly possible, for at the Great Kanawha, in that vicinity, there is no anticlinal, certainly there is no break. It is, however, by no means improbable that the remarkable horizontality of the strata there may result from the flattening out of this anticlinal in that direction, so that if the flattening occur gradually southward, the anticlinal might be traced to that river.

Northward, where the break crosses the Ohio River near Cow Run, it is said to be a gentle anticlinal, over which the upper rocks pass unbroken; and this belief is supported by Dr. Briggs' section along the Ohio.\* In that section the whole mass between Wheeling and Pomeroy is referred to the Upper Coal Group, and the *Pittsburg* coal is regarded as being at no point more than two hundred and fifty feet under the river. There is certainly an error somewhere in this work, since in that portion of West Virginia, fronting on the river, a little south from Marietta, the surface rocks belong to the Lower and not the Upper Barren Group, for I have found the section along the Staunton pike to be the same on both sides of the break, and along the railroad it is practically the same. I have no records of borings made west from the break, but two on the east, one near Ellenboro' and the other near Harrisville, were driven five hundred feet and passed all the way through shales and sandstones, cutting at most only two streaks of coal. If these rocks belonged to the upper series, the *Pittsburg* coal should have been struck at about three hundred feet from the surface near Ellenboro', and at much less near Harrisville. At Wolfe's Summit, eight miles west from Clarksburg, the *Pittsburg* goes under, dipping northwestward, at the rate of somewhat more than one hundred feet per mile. From that place westward to Ellenboro', the strata of the Upper Coal and Upper Barren Groups are followed without a break, the dip continuing northwest all the way, though gradually diminishing in sharpness. At Ellenboro', the rocks change and the dip becomes slightly eastward. From this line we find only the characteristic red shales with the accompanying sandstones until we reach the oil-break where the rapidly-increasing dip brings us into the Lower Coal Group. As will be shown farther on, the rocks within and the steeply-sloping sides of the break form a continuous and uninterrupted series with those outside. If this series between the oil-break and the Ellenboro' fault belong to the Upper Barren Group, what has become of the Lower Barren and Upper Coal Group? Neither of these is found along the Staunton pike, where the whole structure is very clearly exposed. It is absolutely certain that the *Pittsburg* coal appears nowhere between the Ellenboro' fault and the one a little way east from Parkersburg, except possibly in isolated patches on tops of the very highest hills.

\* Rogers' Report Geol. Virginia, for 1840.



Dr. Briggs' statement can be accounted for only by supposing that the Ellenboro' fault disappears long before reaching the Ohio, and that the oil-break itself flattens out rapidly, so as to become a low anticlinal near the river, over which the upper groups may pass unbroken. Still this does not wholly remove the difficulty. What the conditions may be above Marietta, along the river, I do not know, never having examined that region; but I do know that rocks belonging to the Lower Barren Group are found near Valley Mills, in Wood county, three miles from the river and seven miles northeast from Parkersburg. In that vicinity, I was unable to discover any rocks belonging to the upper groups.

The oil-break passes through Wirt, Ritchie and Pleasants counties. Beginning at the south, let us see the structure in the vicinity of the Staunton pike, which runs along Hughes' River. The section of the west slope is very prettily exposed on Fox's Run, about one mile north from the Staunton pike, where we find :

1. Red shales .....	not measured.
2. Shaly sandstone.....	20 ft.
3. Red shales .....	105 ft.
4. Shaly sandstone.....	30 ft.
5. Red shales ....	50-60 ft.
6. Sandstone, shaly to massive.....	65 ft.
7. Chert .....	5-12 ft.

No. 1 is not far from one hundred feet thick, and on it rests the massive sandstone already mentioned as seen along the pike west from the "break." Nos. 4, 5, 6 and 7 are wholly involved in the abrupt side, and No. 3, partially so. The sandstones are all of a dull red color, and in the wells bored just outside of the break, the whole mass was recorded as red shale. On the east side of the break the exposure is yet more satisfactory, as the road passes along the river bank, so low down as to exhibit the flexure in the flint where the dip abruptly decreases from  $35^{\circ}$  to  $3^{\circ}$ . The sandstones and shales of the preceding section are seen in the hill above the flint, thus proving indisputably that the rocks on each side of the "break" belong to the same horizon.

There is no evidence of faulting on either side. The succession from the inner portion of the abruptly tilted strata outward to the horizontal strata is unbroken and perfectly clear.

Within the break the rocks are almost horizontal and not much broken. They describe a flattened anticlinal, for beginning inside and proceeding outwards, say on the west side we find the dip first horizontal, then  $2^{\circ}$  or  $3^{\circ}$ , then  $28^{\circ}$ , then  $56^{\circ}$ , then  $3^{\circ}$  or  $5^{\circ}$ , and finally outside almost horizontal. A similar condition is found on the eastern edge. Along the line of section the chert is the last to show the abrupt dip.

If now we ascend the hill from Fox's Run and go east about one-third of a mile we find near Mr. Sharpnack's steam-mill, the sandstone and



chert almost horizontal. The sandstone is the highest rock in the hill. The section is as follows:

1. Sandstone .....	60 ft.
2. Chert.....	6-12 ft.
3. Shale and limestone.....	9 ft.
4. Black shale .....	3 ft.
5. Coal.....	6-12 inches.
6. Shale and sandstone.....	120 ft.
7. Sandstone to river.....	not measured.

The chert is light-red to yellow, and in some cases dove colored. It is quite compact, and forms a striking feature in both sides of the break as well as on the hills within it. It is well exposed on the pike, where it has been used for macadamizing the road. The limestone in No. 3, occurs in nodules, varying from two inches to two feet in diameter. It is variegated and extremely compact. If a sufficient quantity could be obtained, this would be valuable as an ornamental marble for indoor use, since it receives a beautiful polish. The coal is sulphurous and slaty. It can be seen on the pike near each edge of the break. The sandstone, No. 1, is said to contain a coal, eight inches thick. The black shale overlying the coal No. 5, is quite rich in fossils. In a few minutes, I obtained from it a large number of individuals belonging to the following species: *Chonetes granulifera*, *Solenomya* sp., *Schizodus* sp., *Pleurotomaria grayvilliensis*, *Bellerophon montfortianus*, *Bellerophon percarinatus* and *Euomphalus subrugosus*. From this shale some very fine specimens of a *Nautilus*, allied to *N. occidentalis*, have been procured.

Near Freeport P. O., midway in the break, a well was bored to the depth of fifteen hundred feet, but the record seems to be wholly lost. All accounts agree in stating that for several hundred feet before the work was stopped, the drill passed through nothing but red shale. In a boring made near the middle of the break, thin coals are said to have been met at sixty, eighty and one hundred and twenty feet, respectively, from the surface. By comparing the results of two borings made here by Mr. J. Lillie, I make out the following partial section within the break:

1. Sandstone .....	60 ft.
2. Chert.....	6-12 ft.
3. Shale and limestone.....	9 ft.
4. Shale.....	3 ft.
5. Coal.....	6-12 in.
6. Shale.....	30 ft.
7. Sandstone .....	59 ft.
8. Shale.....	41 ft.
9. Sandstone .....	105 ft.
10. Shale.....	9 ft.
11. Sandstone .....	76 ft.



12. Shale.....	14 ft.
13. <i>Coal</i> .....	3 ft.
14. Shale.....	20 ft.
15. Sandstone .....	27 ft.
16. Shale.....	6 ft.
17. Shale, black .....	10 ft.
18. Shale.....	50 ft.
19. Sandstone.....	20 ft.
Total.....	<hr/> 553 ft. <hr/>

Oil was found in Nos. 9 and 19. The *coal*, No. 13, is said to be very soft and in appearance to resemble the Grahamite. It is not exposed everywhere and has been found only in borings.

Respecting the horizon of these rocks there is no room for doubt. The chert is undoubtedly the same as that found on the Great Kanawha River, immediately below the Mahoning Sandstone. Here, as so frequently elsewhere in West Virginia, that sandstone holds a thin bed of coal. The shale below the chert is rich in species of fossils, which, in the Appalachian region, are thus far utterly unknown at every horizon above the middle of the Lower Barren Group. Such a fossiliferous shale is very often found between the Mahoning Sandstone and the immediately underlying coal. From the sandstone down, the whole facies is that of the Lower Coal Group, and at an inconsiderable depth the shales of the Lower Carboniferous are reached.

Along the line of the Northwestern Railroad, the conditions are much more complicated, and one finds some difficulty in working out the true structure. Here the uplifting agency was exerted much more energetically than on any other line, whether north or south from the railroad.

Approaching Laurel Junction from the west, we pass through the Lower Barren Group. The strata are dipping westward very slightly until we approach the station, when the dip instantly changes to 30°, and within a very short distance increases to 75°. It then declines almost as rapidly to 2° or 3°. On the east side of the break near Petroleum, the conditions are similar, the easterly dip suddenly increasing from a fraction of one degree to twenty, and then to thirty-six degrees. On each side of the break the uplifted rocks are certainly not far from eight hundred feet thick, and they may possibly be somewhat more. The disturbed conditions renders it difficult to make a good estimate. In these rocks we find near Laurel Junction a thin coal bed, one foot, separated by about ten feet of shale from a slaty coal, barely eight inches thick. Both coals are badly broken, fire-clay and shale having been forced into them. From information given me by Prof. Fontaine, I am inclined to think that this same double bed is seen a little farther east in another cut, still sharply upturned. Near Petroleum, a similar bed is involved in the abruptly sloping rocks, and a little east from that village a thin coal is occasionally worked, which is said to be double and to resemble the one



under consideration. There seems to be no room for doubting that the coal near Laurel Junction and that at Petroleum are the same.

Prof. Fontaine, nearly two years ago, made a very careful section along the railroad from Laurel Junction to the middle of the break, where the summit of the anticlinal is shown. He has very kindly submitted his notes to me without restriction. In the main, the results of my observations do not differ from those previously obtained by him. I do not reproduce the section, as the details are unimportant here.

Within the break, that is, in that portion where the rocks lie somewhat irregularly horizontal, a *coal* is seen in several cuts. The section in connection with it varies slightly, owing to crushing, while the coal itself exhibits every evidence of having been subjected to strong pressure. The following sections were obtained at different points upon the railroad. No. I, being by Prof. Fontaine, and No. II, by myself:

I.	II.
1. Massive sandstone.....12'+	1. Sandstone, massiye.... 25'
2. Black arenaceous shale.. 5''-4'	2. Shale ..... 2'-4'
3. <i>Coal</i> ..... 30''	3. <i>Coal</i> .....15''-23''
4. Gray sandstone..... 3½'	4. Sandstone and shale.... 6'
5. <i>Coal</i> ..... 8''	5. <i>Cannel</i> ..... 10''
6. Black shale..... 3'	6. Clay ..... 3''
7. Flaggy sandstone..... —	7. <i>Coal</i> ..... 8''-12''
	8. Shale to track..... 6'

At the base of the massive sandstone there is a thin layer of conglomerate made up of rounded pebbles, one-half inch in diameter and cemented by oxide of iron. The shale contains no impression of plants. This seam is evidently the same as that mined near Volcano, about one mile north from the railroad, where the section to the coal, as obtained in a well, is shale 40'; sandstone, 40'-50'; *Coal*, 3'-5'. The *coal* is double and very irregular in thickness. Below it the rocks are principally sandstone to a depth of nearly five hundred feet, beyond which are reddish shales, which have been bored to seven hundred feet more without reaching their base. Two thin coals have been found within the break above this main bed, but they are not persistent.

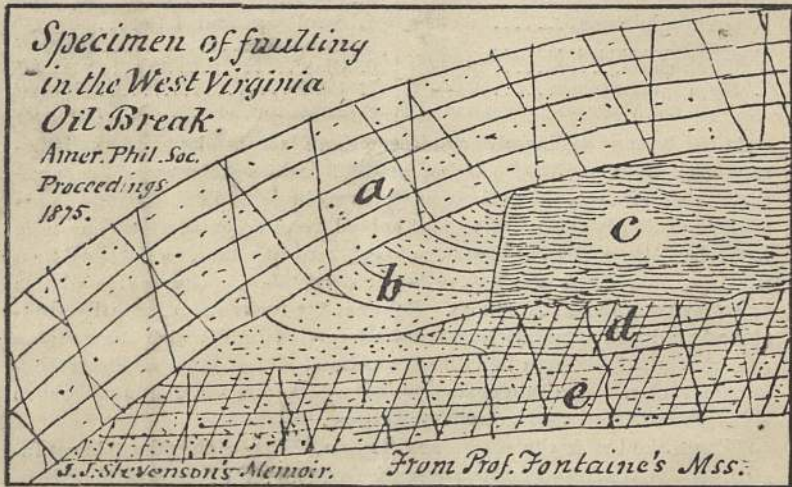
Within the break the strata are thrown about in considerable confusion, and well-marked faults are not infrequent along the railroad line. One of these is exhibited in following figure, which, as well the description, I take from Prof. Fontaine's manuscript, the details being more satisfactorily given than in my own notes.

The fracturing of the rocks is especially marked on the western side of the break. The superintendent of one of the oil companies informed me that, on that side, it has never been found necessary to "torpedo" the wells, while that expedient is necessarily resorted to on the east side. The anticlinal structure is well shown west from Petroleum in the first cut which exposes the *coal*.

There is no room to doubt that the original structure here was that of an anticlinal, but certainly there is no true anticlinal now. This is easily shown by reference to only a few facts.



East and west from the break along the railroad, the rocks do not differ materially in character from those in similar position along the Staunton pike, where the relations are very clear. They are, therefore, of Lower Barren age. Borings made near the pike, say twelve miles south from the railroad, show the thickness of the Lower Coal Group and the Conglomerate to be not far from six hundred feet, and borings immediately north from the railroad show about the same thickness. In the several cuts near Laurel Junction on the railroad, there are exposed several hundred feet of strata dipping at angles varying from ten to seventy-five degrees. These cannot belong wholly to the Lower Barren Group, for by far the greater portion has no equivalent in that group, being sandstone clearly underlying the mass of shales. From what we know of the Coal Measures in this portion of the trough, it is deemed impossible for the Barren Group to increase so enormously within barely twelve miles. The greater portion of these upturned rocks must belong to the Lower Coal Group, and must be identical with the shattered fragments arranged in rude horizontality between the sides of the break.



“‘a’—rather heavy bedded gray sandstone, weathering reddish brown; ‘b’—thin sandstone plates, placed on each other like saucers, and abutting on ‘c,’ which is a bluish fine shale; ‘d’ and ‘e’ are dark heavy bedded sandstones.”

Such being the case, it is evident that we have here the remains of an anticlinal. All the conditions go to show that the upheaval was not slow, but very violent, even explosive. It seems as though the rocks had been blown out with such force as to fracture them on the crest of the anticlinal and as though the fragments, thus produced, had fallen into the broad gulf and keyed up the sides. In conversation, Prof. Fontaine has compared the conditions with those which would result if the top of a hollow anticlinal was battered in, and the simile is a good one. What the na-



ture of the agency producing the disturbance was, it is difficult to determine. It certainly was exerted over a broad area, extending in the region examined from the line of the Ellenboro' fault to the Ohio River. Fissures are frequent throughout this area, the most notable one being that containing the Grahamite. This has been fully described by Prof. Fontaine in the American Journal of Science.

The oil is obtained chiefly from rocks, which I regard as belonging to the Great Conglomerate. The grade, for which this region is particularly noted, is of heavy specific gravity and is known as lubricating oil. Lighter oils are obtained, but occur at a greater depth than the others.

*Appendix.* Since writing this paper I have received from Dr. W. H. Sharp, of Volcano, West Virginia, the records of eighteen borings made in different portions of the oil break. A comparison of these leaves no room for doubt that the strata within the break, though apparently horizontal, are badly broken up, in many places even dove-tailing or not infrequently crushed into irregular masses. This is sufficiently evident from the variations in the interval between two well marked strata,—the coal-bed, already mentioned, and a limestone at some distance below. It is possible, however, to make an approximate estimate of the thickness of the rocks, for several wells bored at somewhat distant localities show a close agreement. I give condensed sections of four borings. No. I is near the eastern edge; No. II is in similar position, but one mile farther south; Nos. III and IV are near the central line of the "break" and were made on lots 56 and 33 of the Volcanic Company's tract:

I.		II.	
1. Coal .....	3'	1. Coal .....	3'
2. Shale .....	7'	2. Interval not given in detail, but chiefly Gray Sandstone .....	233'
3. Sandstone.....	23'		
4. Dark Shale.....	63'		
5. Gray Sandstone.....	79'		
6. Light Shale.....	33'		
7. Gray Sandstone.....	24'		
8. Shale and S. S.....	81'		
9. Aren. Shale and L. S... 77'			
10. Limestone .....	22'	3. Limestone .....	25'
11. Shale .....	101'	4. Shale and Sandstone....	123'
	} 387 feet.		
12. Sandstone.....	32'	5. Sandstone.....	12'
13. Variegated Shale.....	388'+	6. Variegated Shale.....	213'+
	} 133 ft.		} 135 ft.
III.		IV.	
1. Coal and Shale .....	8'	1. Coal and Shale.....	11'
2. Sandstone .....	80'	2. Sandstone .....	17'
3. Dark Shale.....	32'	3. Dark Shale.....	12'
4. Gray Sandstone.....	16'	4. Sandstone.....	58'
5. Shale.....	128'	5. Shale.....	48'
6. Sandstone.....	170'	6. Shale and S. S.....	23'
	} 426 feet.	7. Sandstone.....	82'
		8. Sandstone and S.....	56'
		9. Sandstone .....	42'
		10. Limestone .....	17'
7. Limestone.....	8'	11. Sandstone &c.....	39'+
8. Sandstone and some Shale.....	128'+		



In these sections the interval varies from 233 to 426 feet. In another boring, which passes through both the coal and the limestone, the distance is 364 feet. Two other wells were driven to a depth of 386 and 397 feet respectively below the coal, without reaching the limestone. In all these wells the succession of strata is strikingly similar, though there is no resemblance in the thickness of individual layers. It seems quite probable that the interval is not far from three hundred feet, making all due allowance for exaggerated thickness owing to irregular dip of the rocks. The abrupt variations in the interval can be accounted for only by supposing that the strata are not only broken, as they usually appear in many of the railroad cuttings, but also actually crushed by lateral pressure, as indeed is shown in one of the illustrations given above. That this crushing is a common phenomenon appears from the frequent occurrence of the term "floating sand" in the records.

The record of one boring gives, as overlying the limestone, "18 feet of sandstone and coal." Since this coal is referred to in no other record, I am inclined to regard the statement as an error. Above the main coal and separated from it by a thin stratum of shale, there is in every instance a sandstone, whose thickness appears to vary from 20 to 80 feet. On this in two localities and eighty-five feet above the main bed is a thin coal, two feet thick, and, at one place, still another seam, of similar thickness occurs sixty-three feet higher. Above are shales for a considerable distance, probably two hundred feet. These borings confirm the conclusion, previously given, that the main coal is the Upper Freeport of Pennsylvania, the No. VI of Ohio.

Eleven of the borings pass through the limestone and five others show by their sections that they have stopped not far short of it. In fourteen of these, the overlying rock is described as sandstone and in the other two as sandy shale. In twelve instances the sandstone is more or less conglomerate. Respecting the limestone I have no direct information. It is seen in a run near the railroad, a short distance east from Laurel Junction, but no search has been made in it for fossils. Under the limestone, sandstone occurs in ten borings and black shale in one. In four instances the sandstone is quite conglomerate. Below the sandstone is the variegated shale, whose thickness is unknown. Near the Staunton pike it is more than seven hundred feet.

This succession leaves no room to doubt that the overlying rock is the Great Conglomerate, that the limestone is the Lower Carboniferous limestone (Umbral) and that the underlying rocks are the Waverly Conglomerate and shales (Vespertine).

Oil is found in the Great Conglomerate as well as in the shales and conglomerate of the Waverly. The heavy lubricating oil, for which this district has been celebrated, occurs at the upper horizon, while the lighter oils are obtained at greater depths. Dr. Sharp informs me that extensive "water-veins" are seldom encountered in the borings.











