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CARBONIFEROUS OF THE APPALACHIAN BASIN

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(*Presented before the Society January 1, 1904*)

CONTENTS

Introduction

In a former memoir* the writer described the Lower Carboniferous or Mississippian of the Appalachian basin. In this the effort will be to describe the lowest formation of the Coal Measures or Pennsylvanian of the same basin.

The Coal Measures were studied in detail first in the Virginias and Pennsylvania by Professors William B. and Henry D. Rogers, who divided them into five groups, numbered XII, XIII, XIV, XV, and XVI, and afterwards named

XVI. Upper barren group.
XV. Upper coal group.
XIV. Lower barren group.
XIII. Lower coal group.
XII. Seral conglomerate.

This grouping, based originally on somewhat arbitrary grounds, proved so convenient that it was accepted by most of those who have written on the northern portion of the Appalachian basin. In accordance with later usages, geographical terms were introduced by the Pennsylvania geologists. Those which have the priority are

Dunkard of I. C. White,
Monongahela of H. D. Rogers,
Conemaugh of Franklin Platt,
Allegheny of J. P. Lesley,
Pottsville of J. P. Lesley,

these being equivalent to the divisions as made by the brothers Rogers.

The literature is extensive, as the Coal Measures of the Appalachian basin early attracted investigation; but the limits of this study make necessary the use of only the later studies, which superseded those made by the older geologists under less favorable conditions.

Pottsville of Lesley: Seral Conglomerate of Rogers

NOMENCLATURE

The Seral conglomerate of Rogers is between the Mauch Chunk red shales below and the lowest bed of the Allegheny above. The forma-

* Part I, "Lower Carboniferous of the Appalachian Basin," was published in this Bulletin, volume 14, pp. 15-96. The writer desires to acknowledge his great indebtedness to Dr I. C. White and Mr David White, who have granted without reserve all his requests for information. It must be understood that this statement does not commit either of those observers in favor of the writer's conclusions.

tion exhibited at Pottsville in the Southern Anthracite field, with the Buck Mountain coal bed as the roof, was taken by J. P. Lesley as equivalent to Seral conglomerate, to which he gave the name Pottsville. This term was applied in the Bituminous fields, and the typical section obtained by Doctor I. C. White in northwestern Pennsylvania was recognized by Professor Lesley as equivalent to that at Pottsville. Doctor White's section is

Homewood sandstone;
Tionesta coal bed;
Mercer group, with two or more *coal beds* and two limestones;
Upper Connoquenessing sandstone;
Quakertown shales and *coal bed;*
Lower Connoquenessing sandstone;
Sharon shales and *coal beds;*
Sharon sandstone—

a succession which is distinct in a great part of the basin.

THE ANTHRACITE STRIP

Location and extent of the fields.— In the study of the Pottsville formation the same general course will be followed as in the former memoir, but the complexity of conditions in Virginia and West Virginia renders a slight modification necessary, and that area will be examined last of all. The study begins, then, in Pennsylvania with the Anthracite strip.

The Anthracite fields are three in number, occupying small areas in northeastern Pennsylvania. The Southern, the largest, beginning at a little way from the Susquehanna river, extends eastwardly for about 70 miles. Owing to the development of a strong anticline, it forks at the west, and the whole of the Coal Measures passes out in each canoe before the Susquehanna is reached; but the synclinal basins have been traced far beyond that river by Professor Claypole, who found that the northerly basin, curving toward the south, continues through Perry and Cumberland counties into Franklin, where it is distinct until within 40 miles of the Maryland line, or to about the latitude of the Broad Top coal field, in Bedford and adjacent counties. This Southern field lies wholly east or southeast from North or Tuscarora mountain and is within the Great valley.

The Middle field, divided into the western Middle and the eastern Middle, lies next toward the north. The western Middle is practically in contact with the Southern at the most northerly point of the latter, and extends rudely parallel to it for upward of 30 miles, but reaches hardly so far westward. The eastern Middle, farther north, overlaps the western for a few miles at its west extremity and extends east almost

as far as does the Southern. It is made up of a number of small detached basins, some of which, in spite of limited extent, possess great economic importance.

The Northern field, wholly isolated, its southwestward point being at least 12 miles from the nearest portion of the eastern Middle, is a curved canoe, the curve being due to change in direction of the Appalachian strike, so that toward its northeasterly end the trend is almost east-northeast.

The structure is complex in these fields. At the western end of the Southern field the folds are normal and the dips are comparatively gentle, 30 degrees on the northerly and 20 on the southerly side; but eastwardly the disturbance increases; within 15 miles on the southerly side the folds are overturned, the beds are shown with southerly dips of 70 to 80 degrees, and an important fault appears near the origin of the basins. Thence the complication becomes more marked; overturned folds as well as faults are of common occurrence, and the consequent pinching and crushing of the coals renders mining problems serious. This close folding is especially notable along the southern border of the field, and the folds become more open toward the northern border.* The conditions in the Middle fields are scarcely less complicated than in the Southern, but in the Northern, overturned folds, though not unknown, are less frequent and the disturbances are less severe.†

Southern field.—The thickness of Pottsville in the southern prong of this field has been estimated at from 1,200 to possibly 1,700 feet, accurate measurements being out of the question and the calculations being made from cross-sections which in most cases are incomplete. The upper half of the formation is very massive, contrasting in this respect with the lower half. The northerly prong shows a thickness of 1,400 to 1,475 feet, the upper 600 to 700 feet, being a coarse massive conglomerate which, according to Rogers, is practically barren of coal, containing only "a few thin and profitless seams," while the lower portion, consisting of conglomerates, sandstones, and some shales, holds important coal beds. Rogers calls attention to the character of the Pottsville deposits in this prong, which do not show the coarseness characterizing them farther east, so that in the whole section the chief mass consists of argillaceous

* David White: Succession of the fossil floras of the Pottsville formation in the Southern Anthracite coal field of Pennsylvania. Twentieth Ann. Rep. of U. S. Geol. Survey, 1900, p. 835 et seq.

† The Anthracite fields were studied for the Second Geological Survey of Pennsylvania by Charles A. Ashburner, F. A. Hill, and A. D W. Smith. The reports by these geologists are given in volumes AA and in the annual reports for 1885 and 1886 of that Survey. Mr Smith prepared the summary discussion in the final report published in 1895. The work of these observers is so interwoven that it is difficult to assign to each the credit which belongs to him. The writer desires to make acknowledgment here of indebtedness to them for all information not acknowledged to others in the pages which follow.

sandstones and shales.* Within the main body of the field, eastward from the place of division, the Pottsville retains the same general features to a little beyond Tremont. The thickness here on the southerly side of the field is from 1,100 to 1,200 feet, but on the north side the cross-section indicates perhaps 200 feet additional. Near Pottsville the thickness in Sharp mountain is given as 1,200 to 1,350 feet, near Tamaqua as 850 to 1,130 feet, while in the Panther Creek district at the eastern end the variations are extreme. The difference in measurement reported by the several observers is due in great part to disagreement respecting the plane of division between Mauch Chunk and Pottsville. Some incline to take the highest red bed as marking the top of the Lower Carboniferous, while others carry Pottsville to the plane at which coarse, more or less conglomerate beds first appear. The latter seems to be the better plane as marking the beginning of land elevation at the east. The division into coarse Upper and less coarse Lower Pottsville continues throughout, but there is much more conglomerate at the east and the shales of the west are replaced there by sandstone.

Mr David White states that the pebbles in the lower part of the Pottsville within this field are rounded imperfectly, subangular fragments being not rare in the lower third. Quartz pebbles predominate, but those of sandstone and shale are not infrequent. The coarseness increases toward the east, pebbles at the west rarely being larger than a goose's egg, whereas at Hacklebarney tunnel the diameter is sometimes 5 or 6 inches. Higher up in the section the pebbles are better rounded and polished, the rocks become more arenaceous, the shales disappear, so that in the upper 200 to 300 feet the conglomerate is massive, white, persistent, and lithologically comparable to the Homewood of western Pennsylvania.†

Western Middle field.—The Mahanoy basins form the southern strip of this field, and extend eastwardly beyond the Shamokin or northerly basins, which in their turn have a greater extension toward the west. The Mahanoy near its eastern extremity is practically in contact with the Broad Mountain district of the southern field.

Within the Mahanoy basins the Pottsville is from 830 to 850 feet thick, very coarse in the upper 600 feet, while the lower portion is only moderately coarse, containing some sandstone and shale, though in the western portion conglomerates are found throughout the section. The thickness in the Shamokin basins is from 800 to 600 feet. At the western end it is about 750 feet and the rocks are almost wholly coarse con-

*H. D. Rogers: Geology of Pennsylvania, vol. ii, 1858, pp. 191–193. The chief study of the anthracite region, as given in Rogers's report, was by James D. Whelpley and Peter W. Sheafer, but no reference is made to them in the body of the report.

†David White: Op. cit., pp. 764, 765.

glomerate. The character and thickness of the formation show comparatively little variation throughout, though the field extends westwardly almost as far as the northern prong of the southern, from which it is separated by not more than fifteen miles. The most notable feature is the great decrease in thickness of the lower or less coarse division.

Eastern Middle field.—The western half of this field overlaps the western Middle as far as the eastern portion of the Mahanoy basins, while the eastern half extends a little way beyond the eastern point of the Southern. The nearest approach to the western field is in the Silver Creek basins, where one is barely 2 miles from the Mahanoy.

The Pottsville is but 300 to 400 feet thick in the Silver Creek basins—a rapid decrease from the 830 feet in the eastern Mahanoy basin, only 2 or 3 miles away at the south. In the Beaver Meadow basins, north from the last, the mass is a conglomerate, almost 300 feet, interrupted only by a thin coal bed and a bed of black shale. In the Green Mountain basin, west from the last, the thickness is the same, but the bottom 100 feet is less coarse. The Hazleton basins, north from Beaver meadow, show 290 to 300 feet of Pottsville; Black creek and Big Black Creek basins show coarse sandstones and conglomerates, about 200 feet at the west, but increasing eastward to about 290 feet. Still farther north, in the Woodville-Cross Creek basins, one finds at the eastern end 260 feet, mostly conglomerate; near Drifton, borings show much variation—200 to 260 feet—in some cases practically conglomerate throughout; in others, some shales and sandstones. Farther west, in the Little Black Creek basins, the thickness is not far from 240 feet, and the rock is mostly conglomerate, while northward, in the Upper Lehigh and Pond Creek basins, the thickness becomes 180 and then 165 feet—sandstone above and conglomerate below. Evidently the whole of the lower division and not a little of the upper division have disappeared.

Northern field.—The western division of this field is about 12 miles north from the nearest point in the eastern Middle and about 32 miles from the southern border of the Southern field.

According to Mr Smith, the Pottsville is 60 feet thick at the western extremity of the field, but increases eastwardly until it becomes 250 feet near Nanticoke. The rock is very coarse, the pebbles ordinarily as large as a hickory nut, but in many localities as large as a hen's egg. Farther eastward, near Wilkesbarre, the thickness is not far from 200 feet, Mr Winslow's section, in Solomon's gap, showing 220 feet of conglomerate broken only by 14 feet of sandstone and 3 feet of shale. In the Pittston region the thickness is from 163 to 235 feet, while in the Scranton region it varies from 250 feet on the southerly side of the field to 230 at Scranton and about 200 on the northwesterly side. Thus far the rocks have been

mostly coarse, and the Pottsville ridges are prominent features of the topography; but beyond the Scranton region the coarseness diminishes, so that in the next division the rock is mostly coarse sandstone to fine conglomerate, with occasional pebbly layers, and the thickness varies from 162 to 247 feet. At the northeasterly extremity of the field the thickness decreases from 220 feet, near Carbondale, to 125 feet near Forest City, and the rock becomes a coarse sandstone with "pea conglomerates."

Coal beds of the Anthracite fields.—Having passed in review the general characteristics of the Pottsville rocks, one is prepared to take up consideration of the coal beds.

The Pottsville coal beds of the Anthracite fields are usually spoken of as the "Lykens Valley beds," owing to their importance within the district of that name in the western part of the Southern field.

Detailed information respecting the Dauphin area or southern prong of the Southern field is no longer available. This region was studied nearly 70 years ago by Mr Richard C. Taylor, when mines were in operation, but the coal was found to be so badly broken as to be unprofitable, the mines were abandoned, and later writers have depended almost wholly on Mr Taylor's descriptions.

Recent studies by Mr David White have shown that Mr Taylor was misled by the topographical conditions toward the eastern portion of the area, and that the beds there referred by him to the Pottsville interval are for the most part of Allegheny age. Mr White has shown, however, that the Pottsville is present in that region, but the coal beds have not been exploited, and nothing is known respecting them. It is well to introduce here the typical section obtained at Pottsville by Mr White. Somewhat condensed, it is

	Feet.	Inches
1. *Buck Mountain coal bed*	0	0
2. Coarse conglomerate sandstone	43	6
3. *Coal bed*	0	6
4. Shale with plants	23	0
5. *Coal bed*	0	8
6. Shales and flags	22	0
7. Conglomerate with shale, 8 feet	125	6
8. *Coal* and shale with plants (N)	2	0
9. Sandstone and conglomerate	31	0
10. *Coaly* shale with plants (M)	1	8
11. Conglomerate with shale, 2 feet 6 inches	127	6
12. Dark shale with plants (L)	8	0
13. Sandstone and conglomerate	26	0
14. *Coal bed*	0	6
15. Sandstone	6	3
16. *Coal bed*	1	0
17. Conglomerate sandstone	30	0

	Feet.	Inches
18. Dark shale with plants (K)	3	0
19. Pebbly sandstone	12	0
20. Dark shale with plants, *coal*, 6 inches (J)	8	6
21. Conglomerate with shale 3 feet	25	9
22. *Coal bed*	0	6
23. Conglomerate sandstone	29	8
24. Conglomerate shale with plants (I)	20	0
25. Dark shale with plants (H)	11	8
26. Sandstone and conglomerate, plants (G)	37	0
27. Fireclay and shale with plants (F)	6	0
28. Conglomerate and sandstone	29	6
29. Sandstone with plants (E)	5	0
30. Sandstone, conglomerate, *coaly* shale	64	6
31. *Coal bed*	0	4
32. Fireclay, dark shales, plants (D)	7	6
33. Sandstone and conglomerate	58	0
34. Very dark shales with plants (C)	3	0
35. *Coal bed*	1	0
36. Conglomerate, sandstone, some shale	212	0
37. Dark sandy shales with plants (B)	0	4
38. Sandstone, shale, and conglomerate	195	0
39. Red shale with plants (A)	9	0

in all, somewhat more than 1,200 feet. The thickness is almost 150 feet less than is given by the Pennsylvania Survey reports, but the difference is due mostly to choice of plane for division from Lower Carboniferous. The lettered beds are those from which Mr White made collections of fossil plants. The coal beds in this section are wholly unimportant, but the horizons are at 43, 66, 214, 248, 398, 405, 458, 484, 686, 730, and 802 feet below the Buck Mountain coal bed, the lowest being at somewhat more than 400 feet above the assumed bottom of the formation.*

Returning now to the west portion of the field, one finds in the southern portion just east of the origin of the southern prong a full section obtained at the Kalmia and Lincoln collieries. Condensed, it is as follows, the topmost coal being at 48 feet below the Buck mountain.†

	Feet.	Inches
1. *Coal bed*	2	0
2. Mostly conglomerate	249	0
3. *Lykens Valley coal bed*, No. 1	10	0
4. Conglomerate, some sandstone and shale	287	0
5. *Coal* and shale	2	9
6. Sandstone and conglomerate	29	6

* David White, op. cit., pl. clxxxi.

† Atlas Southern Anthracite Field, AA, 4*b*, columnar section, sheet xi.

		Feet.	Inches
7.	*Coal* and shale	1	6
8.	Sandstone and conglomerate	38	6
9.	*Lykens Valley coal bed*, No. 2	3	0
10.	Slate	9	0
11.	*Lykens Valley coal bed*, No. 3	4	9
12.	Sandstone conglomerate and shale	85	6
13.	*Coal bed*	0	10
14.	Slate	4	6
15.	*Coal bed*	1	6
16.	Shale, sandstone, and some conglomerate	107	0
17.	*Coal bed*	1	6
18.	Sandstone conglomerate and shale	44	0
19.	*Lykens Valley coal bed*, No. 5	5	2
22.	Sandstone, shale, and conglomerate	70	0
23.	*Lykens Valley coal bed*, No. 6	2	11
24.	Sandstone	5	0
25.	*Coal bed*	0	6
26.	Shales and sandstones to 1,475 feet		

The coals in this section are at 48, 300, 597, 629, 669, 681, 771, 885, 930, 1,053, and 1,128 feet below the Buck Mountain coal bed. Mr White would draw the line for base of Pottsville at about 20 feet below number 25, thus giving somewhat more than 1,150 feet for the thickness. The numbered beds have been mined. Coals numbers 2 and 3 may be regarded as one bed, for at New Lincoln colliery they are separated by a mere parting. The division between Upper and Lower Pottsville may be made at a few feet below Lykens Valley number 3, for above that the rocks are more massive than below. Here, too, Mr White finds reason for a paleontological separation. He visited some of the old workings at the extreme western end of the southern prong, which were described by Mr Taylor. Though the slates on the dumps were much disintegrated, he was able to recognize the plant remains, and thereby to determine that the whole of the Pottsville is represented there.

The relations in the northern prong are quite similar. A series of borings near the western extremity showed eleven streaks of coal, 1 inch to 3 feet 2 inches, but two of these become 5 and 9 feet thick within a short distance. In the Lykens Valley region, farther east, the beds of the upper division above numbers 2 and 3 are wanting, those beds, united into about 5 feet of shale and coal, being separated by somewhat more than 600 feet of mostly conglomerate from the Buck Mountain horizon above. The Whites coal bed, regarded as number 4, is at 825 feet, and number 5 is at 1,056 feet, while number 6 and the little coal below are at 1,131 and 1,175 respectively. The anomalous interval is that of the Whites bed, which is more than 100 feet higher in the column than in

the southern section, while the other beds are almost exactly at the same horizons as in the Kalmia-Lincoln section. The lowest coal is about 200 feet above the bottom of the formation. The coal beds of the upper division have practically disappeared in this prong; number 1 is but a mere streak and numbers 2 and 3 are represented only by coaly shale. The thin beds belonging between 3 and 4 are present at about 100 and 140 feet below 3, so that all the beds of the lower division are present and several of them attain much greater thickness than in the Kalmia-Lincoln section. Farther east, however, number 1 is occasionally of workable thickness.

As one passes eastwardly beyond the union of the prongs, he finds the beds of the upper division increasing in importance, so that at Tremont the workable beds are at 554, 606, and 663 feet below the Buck Mountain horizon.* At Pottsville, Mr David White, after comparison of the fossil plants collected at the various localities, places his plant bed *L* at the horizon of Lykens Valley coal bed number 1; he regards the plant beds *H* and *I* as representing the Lykens 2 and 3, and plant beds *D* and *C* as approximately equivalent to numbers 4 and 5. Bed *C* is approximately 800 feet below the Buck Mountain horizon and 400 feet above the bottom of the Pottsville. The Upper Pottsville is about 550 feet thick, showing a decrease eastwardly; a similar decrease is apparent in the coal-bearing portion of the Lower Pottsville with an increase in the basal portion. It is worthy of notice that alike in the Upper and in the Lower, the conditions within the Pottsville area were unfavorable to accumulation of coal.

Toward the eastern end of the field, two beds are present in Locust gap, north from Tamaqua, at 240 and 385 feet below the Buck Mountain, at approximately the horizons of the fourth and fifth coal streaks near Pottsville. In the Panther Creek district the only coal is in the upper portion. But in the Broad Mountain, or most northerly division of this field, traces of coal have been found in the Altamont boring at approximately 26, 48, 160, 780, 940, 1,010 feet below the Buck Mountain; but the thickness is not more than 4 inches except in the highest, which is 2 feet 2 inches. It is possible that this bed is a split from the Buck Mountain. Another boring in the same district shows coals at 190, 250, 370, 410, 460 to 475 feet, of which all are mere streaks except the lowest, which is from 3 to 4 feet thick and is known as the "Lower Lykens coal." As the thickness of Pottsville here is given as approximately 1,200 feet, it would appear as though this coal should be taken as belonging to the Upper Pottsville and not lower than Lykens number 3.

*These figures are approximate, having been obtained by measurements on the diagrams of the columnar section sheets, and not by adding the detailed thicknesses. This remark applies to all the intervals given hereafter in these fields.

Passing into the western Middle field, one finds the Pottsville coal beds present and important at the western extremity of the Shamokin or northern basins, where three beds have been at 130, 288, and 419 feet below the Buck Mountain, with thicknesses of 5, 11, and 10 feet respectively. Farther east, at New Franklin, the succession is

	Feet.	Inches
Buck Mountain coal bed		
Interval	200	0
Coal bed III	5 to 10	0
Interval from *Buck Mountain*	320	0
Coal bed II	6 to 8	0
Interval from *Buck Mountain*	470	0
Coal bed I	10	0
Interval from *Buck Mountain*	570	0
Coal bed 0	5	8

The total thickness of Pottsville in this field is between 700 and 800 feet; so that the coal bed 0 is to be regarded as certainly in the Lower Pottsville, and possibly coal bed I should be placed there also. Near Shamokin, number II is 343 feet, and a new bed, IV, appears at 81 feet. The beds III and II are reported at many places in the central portions of the Shamokin, and occasionally they become of workable thickness. Near mount Carmel, in the eastern portion of the basin, a boring shows coals at approximately 38, 58, 219, 293, 674, and 708 feet, and the lowest is known as Lykens number 5, which is a not improbable reference. It is of workable thickness and is very near the bottom of the formation. Elsewhere, however, the coals appear to be almost wholly in the Upper Pottsville, those at Natalie being at 220 and 260; Potts tunnel, 240 and 325; those at Belmore colliery 146 and 232 feet below the Buck Mountain.

In the western portion of the Mahanoy basin, beds were found near Ashland at 240 and 325 feet. Farther east, between Shenandoah and Mahanoy City, traces of coal were found at 233 and 340 feet and a bed 3 feet 8 inches thick at 500 feet, while at the eastern end of the basin 3 feet of coal was found at 420 feet, with no other in the section. Evidently the coals of both divisions are represented in this southern basin.

In the eastern Middle the thickness of the Pottsville varies from 440 feet in the most southerly basin to 165 in the most northerly. Apparently the whole of the Lower Pottsville is wanting, and for the most part even the lower coals of the upper division seem to be absent. The records of borings are numerous, but the occurrence of the coal beds is irregular, as though petty areas alone received deposits, while the varying intervals suggest great irregularity in subsidence.

In the most southerly basins a bed known as the "Alpha," and sometimes of workable thickness, is present at 83 feet below the Buck Mountain. In the next basins north borings near Beaver meadow found coal at 27 to 38, 89, and 148 feet, while one at Beaver meadow found no coal in 235 feet. At Honey brook, 6 or 7 miles west, thin streaks were found at 16 and 56 feet; but at a little distance northwest another boring found only the Alpha, about 100 feet and 6 feet thick. In the Hazleton basin there seem to be no coals at both ends of the basin, though at Hazleton the Alpha is present at 157 feet, and near Stockton two thin streaks are present in the upper 50 feet. No coals appear in any of the Green Mountain sections, but Mr Smith states that the Alpha, too thin to be mined, has been found in several shafts.

At the eastern extremity of the Black Creek basin, where the Pottsville is about 300 feet thick, no coal is present in the upper half; but borings near Jeddo found streaks at 28 and 85 feet, while one at a little way south passed through the whole formation without finding a trace. Near Harleigh, at the western extremity of the basin, one boring shows streaks at 72 and 160. Another finds them at 24, 60, 77, and 120. Northward, near Tomhicken, in the next basin, coal is found in several borings at 53, 65, 72, 76, and 100 feet, but all are regarded as belonging to one bed. Such variations are much less than those in the intervals between the " splits " of the Mammoth bed within this area, which have been proved up by continuous workings. Westward beyond Tomhicken, in this as well as the little McCauley basins, the Pottsville coals are practically unrepresented, having been found only near Gowen, where are two streaks at 45 and 90 feet.

Northward, in the eastern portion of Little Black Creek basin, near Hollywood, the only coal is a thin bed at 84 feet; but 2 miles farther east streaks are reported at 68, 93, and 107 feet; 6 miles farther east one boring finds no coal in 190 feet, while another gives 1 and 3 feet at 24 and 75 feet. In the Upper Lehigh the most northerly basin, where the Pottsville is but 165 feet thick, two coals are reported, the upper at 17 to 35 feet, from 15 to 42 inches thick, and the other, the Alpha, at 98 feet and 52 inches thick. The persistent horizon in this field is that of the Alpha, varying from 60 to 150 feet below the Buck Mountain. Above it are two others, which in many places show thin streaks of coal, but the lower streak may be only a split from the Alpha.

In the Northern field one finds at some localities a bed known as coal bed "A," very near the middle of the Pottsville. Its distribution is uncertain. The bed is present in the southern district of this field, where its thickness is from 1 inch to 3 feet; but it appears to be absent from most of the other districts, though traces of it are shown near

Lackawanna about midway in the field. Its place is approximately that of the Alpha. Dr I. C. White discovered in Lackawanna county a black shale within 3 or 4 feet of the bottom of the Pottsville, which he named "Campbells Ledge black slate." It contains no coal at the typical locality, but near Nanticoke, in Luzerne county, he found it in part a coal shale.* There, according to Mr Smith, it contains 8 inches of impure coal. It has been recognized as far north as the middle of the Jermyn-Priceville division, where it is somewhat coaly. It has yielded immense numbers of fossil plants.

The thinning out of the Pottsville in this northwesterly direction is due to the loss of its lower members. The Lower Pottsville, so thick in the Southern field, is greatly diminished in the western Middle and wholly disappears in the eastern Middle, as evidently does also much of the Upper Pottsville. The stratigraphical evidence is in accord with Mr David White's conclusion, based on the study of the plant remains, that the Campbells Ledge coal bed can not be older than the Lykens Valley coal bed number 1.†

Broad Top field.—The insignificant area of Mississippian in Fulton county of Pennsylvania represents some portion of the Middle Anthracite field, while the Broad Top coal field of Fulton, Bedford, and Huntingdon counties is clearly equivalent to the extension of the Northern field.

Mr Ashburner found a thickness of 280 feet on the east side of Broad Top, which he divided as follows:

	Feet
Piedmont sandstone	160
Mount Savage group	40
Lower member	80

The Piedmont sandstone is very largely conglomerate, coarsest in the middle. The Mount Savage group shows above the middle a coal bed which was taken to be the same with that which in Maryland had been termed the "Mount Savage," but there is room for doubt respecting the identification. The lower member is described as a hard massive sandstone with some conglomerate midway. The coal bed is persistent on this side of the field.‡

Dr I. C. White studied the northerly and northwest side of the field, where he found only 160 feet, in which he recognizes the members of the western Pennsylvania section.

*I. C. White: Geology of the Susquehanna Region (G 7), 1883, pp. 39–42.

†David White: Op. cit., p. 819.

‡C. A. Ashburner: Aughwick Valley and East Broad Top District (F), 1878, p. 191.

	Feet
Homewood sandstone	80
Mercer shales and coal bed	20 to 30
Connoquenessing sandstone	50
Sharon shales and coal bed	5 to 15
Sharon sandstone	25

The Homewood is slightly pebbly, but the Connoquenessing is markedly so. Usually the pebbles are not larger than a pea, though occasionally one of egg-size occurs.*

Stevenson studied the southern portion of the field where the section is

	Feet.	Inches
Sandstone	121	
Coal bed		2 to 10
Shale	18	
Coal bed		2
Sandstone	125	

in all, 265 feet, corrected to 250 feet. The upper sandstone is not conglomerate, though portions are very coarse. It contains an irregular coaly streak in the upper portion, which may be equivalent to the Mercer, and so at the horizon of bed A of the Northern field. The shales between the sandstones with the thin coal streaks appear to represent the Campbells Ledge horizon of the Northern field, the Sharon of northwestern Pennsylvania. In the bottom sandstone of the section one must recognize the thickened sandstone of the Campbells Ledge region, which is evidently thickening southward or southeastward, being only 25 feet at Doctor White's locality. It is very coarse in the upper 20 feet, which contains much carbonized wood and at times rests on 5 feet of shale, containing some coaly matter; but this shale occurs only in pockets. These measurements indicate that the Pottsville is thicker on the east and south sides than on the northerly sides. The change is abrupt, for the field is barely 7 miles wide and 20 miles long.†

EASTERN EDGE OF ALLEGHENY PLATEAU

Returning now to the north to follow the edge of the Allegheny plateau, one finds some isolated coal areas—the Mehoopany in Wyoming and the Bernice in Sullivan county. The distance from the former to the nearest point in the Northern field is approximately 25 miles. In 1883 Doctor White called attention to the coal area in western Wyoming, which he identified with the Pottsville. The coal bed underlies a massive conglomerate and rests on dark shales containing abundance of plant

*I. C. White: Geology of Huntingdon County (T 3), 1885, p. 70.

†J. J. Stevenson: Geology of Bedford and Fulton Counties (T 2), 1882, pp. 65, 259.

forms similar to those in the Campbell Ledge shale of the Northern field. Serious objection to this identification was offered at the time because of the small interval to the Pocono; but this objection is without basis, for the westward thinning of Mauch Chunk and Pocono has been proved abundantly.* Somewhat later Mr Hill made a reconnaissance of this Mehoopany region and succeeded in securing sections which proved that the coal is at the bottom of the Pottsville, as Doctor White had asserted. The coal is 2 feet 10 inches to 3 feet 8 inches thick, impure at the bottom, and resting on fireclay. The Sharon sandstone is absent.† Samples of this coal had been procured in 1879 and were analyzed by Mr A. S. McCreath. It has a fuel ratio of 6.1 and 5.1 in the two benches, thus showing a composition very like that of the Lykens Valley coal.‡

The Bernice coal field of Sullivan, west from Wyoming, was studied by Mr Platt, who there found two coal beds, *A* and *B*, 60 feet apart. He evidently regarded both coal beds as belonging to the Allegheny, for he gives the Pottsville thickness as but 70 feet, that being the distance from the lower coal *A* to the Lower Carboniferous red shales at the west end of the basin. In one place he refers to a massive conglomerate above coal bed *A*, and in another describes a lower conglomerate, below the coal bed, as coarser than that above. His sections show that 52 feet of massive rock overlie coal bed *A*, while below it are 60 to 70 feet, making the total thickness not far from 120 feet. Mr Ashburner gives the thickness as from 100 to 110 feet.§

This little field was studied carefully by Mr Ashburner and also by Mr C. R. Claghorn, whose work is quoted by Mr Smith. They regard both beds as Pottsville, and Mr Claghorn estimates the thickness of the formation at 180 feet. Mr Smith, however, thinks that only the lower bed is Pottsville, looking on the upper bed as the equivalent of the anthracite Buck Mountain. The character of the rocks supports this conclusion, which is strengthened further by the relations of the plant remains, as determined by Mr David White. This is not the Campbells Ledge bed; it may be at the horizon of the upper bed of the Northern field, at the Mercer horizon.|| Clearly the Sharon sandstone is lacking in this area.

The composition of coal from this lower bed shows strange variations. Samples obtained from the western end of the petty area have a fuel ratio of 8.4 with less than 1.5 per cent of water, whereas two samples from

* I. C. White: Geology of the Susquehanna Region (G 7), 1883, p. 43.

† F. A. Hill: Ann. Rep. Geol. Survey for 1885, pp. 486 to 490.

‡ A. S. McCreath, quoted by F. Platt: Geology of Lycoming and Sullivan Counties (G 2), 1880, p. 226.

§ Franklin Platt: (G 2), pp. 173, 187, 199.
C. A. Ashburner: Ann. Rep. for 1885, p. 466.

|| A. DW. Smith: Final Report, 1895, p 2009.

a mine only a mile and a half farther east have a fuel ratio of 4.4 and 4.6, so that in the interval the coal has changed from anthracite to semi-bituminous, while it shows additional features which will be discussed in another connection. It is worthy of note that at the latter locality coal bed *B* is mined at 60 feet above bed *A*. Though the coal from the lower bed has a ratio of about 4.5, that from the upper bed is anthracite with the ratio of 10.3.*

No notes are available respecting the petty area in Lycoming county, but on the Allegheny crest in Clinton county Doctor Chance found 129 feet of Pottsville, with a coal bed 2 to 3 feet thick near the bottom of the upper third, showing that the Bernice conditions extend thus far. In Centre county, south of Clinton, Mr d'Invilliers finds about 255 feet of Pottsville on the Allegheny front south from Snowshoe and describes it as a massive sandstone with some layers of rounded white quartz pebbles, some as large as an egg. He makes no reference to coal.† The general section of Blair county on the face of the Alleghenies as made by Mr Sanders is

	Feet.	Inches
Sandstone	14	0
Coal bed	0	1
Fireclay	9	0
Sandstone	100	0
Concealed	100	0

to the first exposure of red shale. The bottom sandstone becomes coarser in the lower part.‡ Here one is perhaps 25 miles west from the Broad Top field.

Farther south in Bedford county one reaches the northern termination of the great syncline which deepens southwardly, so as to hold in Maryland and West Virginia the important coal field known as Mount Savage, Georges creek, as well as by other names in its more southern portions. On its easterly side, within Bedford county, Stevenson found

	Feet.	Inches
Conglomerate	75	0
Coal bed	4	0
Shale and fireclay	20	0
Coal bed	0	4
Shale	5	0
Sandstone with conglomerate	80	0

in all, 184 feet. The upper plate is coarse, with pebbles as large as peas;

* A. S. McCreath, quoted by F. Platt (G 2), p. 226.

† E. V. d'Invilliers: Geology of Centre County (T 4), 1884, p. 52.

‡ R. H. Sanders: Geology of Blair County (T) 1881, p. 12.

but the lower plate is less coarse.* Doctor White measured the formation on the westerly side of the basin in Somerset county, where the beds rise toward the Allegheny mountains, and obtained the following section:

	Feet.	Inches
1. Massive sandstone	75	0
2. *Mount Savage coal bed*	4	0
3. Mount Savage fireclay	7	6
4. Conglomerate sandstone	125	0
5. Sandstone and shale	11	0
6. *Coal* and shale	0	8
7. Impure fireclay	10	0
8. Shales	20	0
9. Massive sandstone	35	0

in all, 288 feet 2 inches. The same observer measured the formation on the Potomac river near Westernport, Maryland, and Piedmont, West Virginia; also on the western side of the basin, where the succession is †

	Feet.	Inches
1. Sandstone (Homewood)	20	0
2. *Coal bed*	2	0
3. Dark shale with fossil plants	45	0
4. Hard massive sandstone	40	0
5. Shales and sandstone	42	0
6. *Coal bed*	1	6
7. Fireclay, shale, and sandstone	42	0
8. *Coal bed*	1	6
9. Shale and flaggy sandstone	42	0
10. Pebbly sandstone	45	0
11. *Coaly* shale	0	5
12. Sandstone and shale	195	0
13. *Coal bed*	1	0
14. Sandstone and shale	11	0
Total	473	0

Mr O'Harra gives as an average section of the formation in the Potomac region in Maryland the following ‡ (condensed from the original):

	Feet.	Inches
1. Massive sandstone	20	0
2. *Coal bed, Westernport*	2	0
3. Shales and sandstones	127	0

*J. J. Stevenson (T 2), p. 100.

†I. C. White: Stratigraphy of the Bituminous coal field in Pennsylvania, Ohio, and West Virginia. Bull. U. S. Geol. Survey, no. 65, 1891, p. 186.

‡ C. C. O'Harra: Maryland Geological Survey, Allegany County, 1900, p. 114.

	Feet.	Inches
4. *Coal bed*	1	6
5. Fireclay and shale	22	0
6. *Coal bed, Bloomington*	1	6
7. Shale, sandstone, and conglomerate	82	0
8. *Coal* and *coaly* shale	3	0
9. Shales and sandstone	37	0
Total	296	0

A comparison of these sections shows noteworthy changes. On the east side of the basin, near the northern extremity, one finds only the two sandstones with intervening coal and shales, as in Broad Top; the upper sandstone there, as at Gladdens run, on the west side is very thick, but at the latter locality a great mass of sandstone is inserted between the coal beds, and the lower plate has become much reduced in thickness. Doctor White's section on the Potomac, as well as that of Mr O'Harra, shows the upper sandstone much reduced in thickness, the lower being represented by numbers 6 and 8 of the former and by numbers 4 and 6 of the latter; but below the bottom sandstone, number 9 of the Gladdens Run section, there are on the easterly side a coal bed and 37 feet of rock, while on the westerly side the section is increased by 200 feet at the bottom, including two coal streaks separated by 195 feet of rock. Further reference will be made to these conditions when the section has been traced southward from northwestern Pennsylvania.

EASTERN COUNTIES OF ALLEGHENY PLATEAU

Returning now to the north.

Bradford county, on the New York border, is north from Sullivan. The Barclay coal basin in the center of the county was studied many years ago by Professor J. P. Lesley and afterward by Mr Platt. Here are two coal beds, named *A* and *B*, as in the Bernice basin of Sullivan. The latter evidently belongs to the Allegheny; the section below it is

	Feet
Fireclay and sandstone	20
Conglomerate	60
Coal bed A	1
Sandstone to red shale	135

Another small area remains in Tioga county, west from Bradford, in which the Pottsville is 200 feet thick, with streaks of coal from half an inch to 2 feet thick. The rock is mostly sandstone, some of it conglomerate. The succession is*

*F. Platt: Report of progress in Bradford and Tioga Counties (G), 1878, pp. 120, 127, 167, 178.

	Feet.	Inches
1. Sandstone and shale	33	0
2. *Coal bed*	0	3
3. Sandstone and shale	17	0
4. *Kidney coal bed*	2 to	6
5. Sandstone and shale	10	0
6. *Coal bed*	0	½
7. Sandstone and shale	5	0
8. *Coal bed*	0	½
9. Sandstone and shale	88	0
10. *Coal bed*	0	2
11. Sandstone and shale	0	34

Here are clearly the Homewood, the Mercer, the Connoquenessing, and the Sharon of the western Pennsylvania section. Another area exists in southwestern Tioga, which continues into Potter county, where it is known as the Pine Creek basin, but no details are given respecting it further than that the upper plate of the Pottsville is very coarse. In Potter county is the small Coudersport basin which holds the middle and lower members of the Pottsville with a coal bed at 15 feet above the lower member, which is a massive sandstone between 60 and 70 feet thick and shows a good deal of conglomerate. This lower member, clearly the same with the bottom sandstone of the last section, has been proved to be the Olean conglomerate of Ashburner, the Sharon of I. C. White. The coal bed of this Coudersport basin is unimportant, though it has been mined for local use.*

Lycoming county is south from Tioga and west from Sullivan. Mr Hodge's section, near Astonville, showed a thickness of 116 feet, distributed as follows: †

	Feet.	Inches.	Feet
1. Coarse sandstone	30	0	
2. *Coal bed*	2 to 1	4	
3. Fireclay	5	0	
4. *Coal bed*	2	6 to	2
5. Fireclay and shale	5	0	
6. Pebbly sandstone	25	0	
7. *Coaly* shale	2	0	
8. Conglomerate	45	0	

giving still the triple structure, the sandstones separated by shale and coal.

Clinton county is west from Lycoming and south from Potter. In its western portion is a coal area within the same basin with the Bloss-

*Franklin Platt: Geology of Potter County (G3), 1880, pp. 73–78.

†James T. Hodge in Geology of Pennsylvania, 1858, vol. ii, p. 513.

burg region at the northeastward and the Cambria at the south. Mr Ashburner's section shows

	Feet.	Inches
1. Johnson's run sandstone	55	0
2. *Alton upper coal bed*	4	0
3. Alton shale and sandstone	36	0
4. *Alton lower coal bed*	3	2
5. Kinzua sandstone	33	0
6. *Upper Marshburg coal bed*	1	0
7. Olean conglomerate	Not measured.	

Very frequently another coal bed, the *Alton middle*, appears in sections of this and adjoining counties.*

The section is one within Tioga, Potter, Lycoming, and Clinton, only with variations in thickness or composition of the several members. It is characteristic also of Cameron and Elk, the counties west from Clinton, as well as of McKean, lying north from those counties along the New York border. Thus in Cameron county Mr Ashburner finds

	Feet.	Inches
1. Sandstone	27	0
2. *Coal* and shale	10	8
3. Fireclay and shale	8	0
4. *Coal* and shale	6	0
5. Shale	19	0
6. Sandstone	125	0
Total	195	0

The Connoquenessing (Kinzua) and Sharon (Olean) sandstones are not distinguished in the section, but Mr Ashburner states that a coal bed at times occurs almost midway in the lower sandstone. The section is similar in Elk county, where the Alton coals are frequently thick enough to be mined; so also farther west, in the same county, within Rogers fifth basin, where the total thickness is 182 feet. Sometimes a lower bed, the Lower Marshburg coal bed, is found. The coal beds are extremely irregular in their occurrence, and their variable thickness leads Mr Ashburner to speak of them as lenticular. It may be well to give Mr Ashburner's generalized section for McKean county:

	Feet
1. Johnson Run sandstone	30 to 75
2. *Alton coal group*	20 to 35
3. Kinzua sandstone	45 to 60
4. *Marshburg upper coal* and shale	5 to 15
5. Olean conglomerate	45

*C. A. Ashburner (G 4), p. 74.

The Johnson Run sandstone is massive and fine grained; it is the Homewood sandstone of Doctor White's type section. The Kinzua is less massive, but more or less pebbly. It is the representative of White's Connoquenessing sandstones and occasionally shows a trace of the Quakertown coal and shale. The Olean is the Sharon sandstone; it is often very coarsely conglomerate, but the coarser portions are lenticular. This is the rock forming the rock city at Olean, in Cattaraugus county of New York. The Alton group is the Mercer group of White, and the Alton coals are strictly equivalent to his Mercer and Tionesta coal beds, They are often three in number within McKean county, at times of workable thickness, but usually of little value, as much because of impurities as of abrupt variations in thickness.*

The dearth of information respecting Clearfield county, south from Cameron and Elk, is remarkable. The formation is above the streams at many localities, but apparently exposures admitting of measurement are exceedingly rare. Mr Franklin Platt estimates the thickness of Pottsville at not less than 200 feet in Boggs township of Clearfield, where the rock is a white quartzose sandstone with much massive fine conglomerate. Doctor Chance states that in Bell township of the same county the pebbles are at times large as a hen's egg. Coal is reported at several localities as occurring in the upper third, evidently some member of the Mercer group.†

In Jefferson county Mr Platt‡ was able to recognize the Homewood sandstone, the Mercer shales, and the Upper Connoquenessing sandstone. The Homewood is usually coarse and massive with, in many places, white quartz pebbles varying in size from pea to hen's egg. It makes "rock cities" and has an extreme thickness of 60 feet. The Mercer shales are 30 to 80 feet thick, with one to three coal beds, the upper never more than 8 feet below the Homewood. No limestones are here. The Connoquenessing sandstone is 125 feet thick at one locality; but evidently Mr Platt entertained some doubt respecting the exact relations of this great sandstone, as he discovered at one locality a red shale at about 100 feet below the top of the Homewood which bears much resemblance to Shenango.

Doctor White§ gives the record of a boring at Brookville which goes far to strengthen Mr Platt's evident doubt, for the thickness assigned to

*C. A. Ashburner: Geology of McKean County (R), 1880, pp. 49–59; Geology of Elk County (RR), 1885, pp. 69, 127.

A. W. Sheafer: Geology of Cameron County (RR), p. 48.

†H. M. Chance: Rev. of Bit. Coal Measures of Clearfield County (H 7), 1884, pp. 109, 115.

‡W. G. Platt: Jefferson County (H 7), 1881, pp. xxxiii, 84, 90, 125, 158, 165, 173–174, 186, 194–195, 196.

§I. C. White: U. S. Geological Survey Bulletin 65, p. 183.

the Pottsville is 372 feet, an extraordinary thickness in comparison with that in Elk and Cameron at the north and in counties at the south.

Cambria and Indiana counties are south from Clearfield and Jefferson. The former reaches to the crest of the Allegheny, where the Pottsville is exposed frequently. The thickness under the Viaduct axis is estimated by Mr Platt at not more than 250 feet, but he gives no measurements in detail.* In eastern Indiana, under the Chestnut Hill arch, he finds within Yellow Creek gap 70 feet of coarse sandstone, with 1 foot of coal very near the bottom; 4 or 5 miles farther south, in Black Lick gap, near Heshbon, the succession is

	Feet
Sandstone	20
Shale	25
Coarse massive sandstone	25

with the bottom not reached, the whole thickness being estimated as somewhat more than 75 feet. At the mouth of this gap exposures are very poor, and the thickness is given as not less than 60 nor more than 100 feet. †

Along the Conemaugh river, which separates Indiana from Westmoreland county, the Pottsville shows noteworthy variations. Near Nineveh, on the west side of Laurel hill, in Westmoreland county, the thickness of sandstone is approximately 150 feet, only moderately coarse, with layers of pea conglomerate. Some sandstone and iron ore underlie it, adding in all about 25 feet to the thickness. No coals were seen, but the exposure is not complete. On the easterly side of the gap made by the river through Chestnut hill, the thickness is not more than 70 feet, mostly fine sandstone and with a 1-foot coal bed at 7 feet from the bottom, almost exactly the same as Mr Platt's section at Yellow Creek gap; but on the west side of the mountain the sandstone has almost wholly disappeared and the mass shows little aside from shales. It is unfortunate that details respecting Clearfield county are wanting, for somewhere within that county the Sharon-Olean conglomerate disappears, though, as will be seen, the Sharon coals and shales persist, being apparently continuous with the Mauch Chunk shales below, so that they were placed in the Lower Carboniferous by Stevenson in his study of this region.‡

Somerset county, south from Cambria and extending eastward to the Allegheny crest, appears to offer few opportunities for measurement of the Pottsville, though that formation is exposed to a greater or less extent at many localities. The only estimate offered by Mr Platt is that

* William G. Platt: Cambria and Somerset Dist. I (H 2), 1877, p. 45.
† W. G. Platt: Indiana County (H 4), 1878, pp. 125, 101, 187.
‡ J. J. Stevenson (K 3), 1878, pp. 156, 172.

of about 200 feet on Haskins run, where coal is present in the upper portion.*

Westmoreland and Fayette counties are west from Somerset, the latter extending to the West Virginia-Maryland line. The great axes of Laurel hill and Chestnut hill increase southward, so that in the eastern portion of these counties the Pottsville is reached in numerous gaps, and one can trace the changes from the Conemaugh to the state line.

In Laurel hill, which separates these counties from Somerset, the sandstone mass, about 150 feet thick, seen on the Conemaugh, may represent the Homewood and Connoquenessing sandstones of White, the Johnsons run and Kinzua sandstones of Ashburner. The Sharon shales and coals underlying this are not shown on the Conemaugh, but within a few miles southward an exposure of 24 feet shows 2 to 4 inches of coal at 10 feet below the sandstone, associated with the iron ores, which, in these counties, are characteristic of this lower division. Farther south the sandstone mass is but 100 feet thick and not very coarse. In the Youghiogheny gap the sandstone is about 100 feet, but distinctly separated into the Homewood (Piedmont of Maryland) and the Connoquenessing sandstones, with a Mercer coal bed, the Mount Savage of Maryland, between them. The Homewood sandstone is about 30 feet thick and much of it is pebbly, in this respect differing little from the Connoquenessing. The coal bed rarely exceeds 15 inches and often is found distributed in fragments through the lower part of the overlying sandstone. The lower or Sharon division is shown in railway cuts below Ohiopyle on the Youghiogheny, where it consists of shales, sandstones, and thin coals. The thickness varies greatly, chiefly in the shales, but the extreme is approximately 140 feet. The sandstone beds are at 40 and 45 feet respectively, and show comparatively little variation. Three thin coal beds were seen here, the lowest at 140 feet below the Connoquenessing. A fourth evidently underlay the sandstone, as its fragments are distributed through the lower portion of that rock. There is nothing here that can be identified directly with the Sharon sandstone, but the great thickness below the Connoquenessing suggests that some portion may be contemporaneous with that deposit.†

Under Chestnut Hill the Pottsville quickly regains its character south from the Conemaugh, for in the Loyalhanna gap it shows 50 feet of sandstone resting on red shales, but without coal. The same thickness of sandstone was seen in the southern part of Westmoreland county, where the lower or Sharon division is about 90 feet thick. The Mount Savage coal bed is here, and at least two thin beds are in the Sharon

* W. G. Platt: Cambria and Somerset Dist. II (H 3), 1878, pp. 141, 146.
† J. J. Stevenson (K 3), pp. 82, 101, 134, 177.

shales, one of which, directly underlying the Connoquenessing, is shown on the east side of Chestnut Hill.

In the northern part of Fayette county, beyond the Youghiogheny river, the sandstone mass appears rarely to exceed 60 feet, and almost invariably it rests on a thin coal bed. The sandstone shows a thin coal bed below the middle which probably represents the Mount Savage. The Sharon shales are thin, for the lowest ore bed is but 25 feet below the sandstone—a decided contrast with the thickness at a few miles north and south. Beyond the Youghiogheny, in Dunbar, the sandstone mass is certainly more than 70 feet thick and rests on a coal bed, below which are clays, thin sandstones, and ores for 100 feet, with thin coal beds at 49, 62, and 83 feet. At a few miles farther south, on the west side of the mountain, the Sharon portion is but 70 feet, with much red shale and five thin streaks of coal, while near by it is 80 feet with three coal streaks 8 to 9 inches thick; but at ten miles farther south the thickness is only 45 feet, with apparently but two coals aside from the persistent bed underlying the sandstone mass.*

On the east side of Chestnut hill, along the national road in Fayette county, the Homewood (Piedmont) sandstone is apparently not more than 25 feet thick, and shows some layers of pebbles, rarely larger than a pea, while the lower sandstone appears to be not more than 50 or 60 feet and comparatively fine in grain. The Sharon division here and southward is not less than 120 feet thick and is more shaly than at the exposures along the Youghiogheny. The Mount Savage coal bed is present, with a thickness of at most 4 feet, but only one of the lower coals was seen in the ore pits. The opportunities for study of the lower division were very good twenty-five years ago, for at that time the iron ores were of much local importance, and were mined extensively to supply furnaces along the western slope of Chestnut hill, in Fayette and Westmoreland counties; but those ores are no longer esteemed, and all work was abandoned many years ago, so that during a restudy of the region it was found impossible to obtain any details or even to verify the measurements already reported. Southward the lower division becomes thinner and the sandstone mass thicker. At the most southerly measurement within Fayette county the shales below the Connoquenessing are little more than 50 feet.†

Thus far in the description of Laurel and Chestnut hills the whole section below the massive sandstones has been regarded as belonging to the Sharon portion of the section, for the reason that they were separated from the Pottsville by Stevenson in his reports on the region. But the

*J. J. Stevenson (KK), 1877, pp. 142, 174, 187, 195, 196, 210, 261.
†J. J. Stevenson (K 3), pp. 68, 71.

studies of I. C. White farther south under the same axes make clear that much of the great sandstone of the Youghiogheny section is rather to be regarded as Upper Connoquenessing, so that the persistent coal bed under the Connoquenessing of this description is most probably the equivalent of the Quakertown. The Cheat river, flowing northwestwardly, cuts the Viaduct, Laurel Hill, and Chestnut Hill anticlines in Preston county of West Virginia. Doctor I. C. White studied the section in the several gaps and his results may be given in reverse order (toward the southeast), that the western condition may be compared directly with that already given for the east side of the Allegheny mountains. The Cheat River gap through Chestnut hill is perhaps 15 miles from the National road. The succession on the westerly side of the mountain on Quarry run is

	Feet.	Inches
1. Sandstone	25	0
2. Concealed	40	0
3. Massive pebbly sandstone	75	0
4. *Coal bed*	1	4
5. Black slaty shale	10	0
6. Gray massive sandstone	20	0
7. Shales and *coal* streaks	1	0
8. Sandstone	15	0
9. Shales with iron ore	20	0
Total	197	0

Doctor White places number 9 in the Mauch Chunk; but in view of the presence of the iron ore, evidently representing the "Big Bottom" bed of Fayette and Westmoreland counties, it is included here with the Pottsville for the sake of uniformity with sections previously given. The Mount Savage coal bed should be in the concealed interval. Doctor White regards numbers 6 and 8 as representing the Lower Connoquenessing sandstone, so that the only representative of the Sharon would be in number 9. The little coal bed, number 4, is that which has been observed at so many localities toward the north, where it immediately underlies the second sandstone of those sections, and there is little reason to question the identification with the Quakertown. On the east side of this fold the section is

	Feet.	Inches
1. Sandstone, more or less pebbly	160	0
2. Dark shale, plants	10	0
3. *Coal bed, Quakertown*	1	6
4. Black fissile shale	15	0
5. Concealed	90	0

As at nearly all localities, the Quakertown coal is double The Mount Savage bed is wanting on this side of the axis.

The Pottsville is 245 feet thick on the west side of Laurel hill, including as before the ferriferous shales at the bottom. The mass above the shale is almost wholly sandstone, without any trace of coal; but on the side of Briery mountain (the Viaduct axis of Somerset and Cambria) the Homewood sandstone is distinct with the Mount Savage coal below it.*

Almost fifty years ago Professor W. B. Rogers reported on the iron ores of Chestnut ridge near Doctor White's Quarry Run section. He found at the bottom of the section, below the massive sandstone, 65 feet with five beds of iron ore which are described as evidently the same with those of Fayette and Westmoreland counties. Doctor White's incidental references show that the ores are persistent on Laurel hill.†

Doctor White succeeded in making a detailed section along the Baltimore and Ohio railroad under the Briery (Viaduct) axis within Preston county of West Virginia; it is so important that it is given here almost without condensation.

	Feet.	Inches
1. Sandstone	60	0
2. *Coal bed*	0	5
3. Shale	6	0
4. *Coal bed*	0	5
5. Shales, brown, sandy	45	0
6. *Coal* and coaly shale	2	0
7. Shale	3	0
8. Sandstone	68	0
9. Brown shale, traces of coal	4	0
10. Sandstone	20	0
11. Shale	3	6
12. *Coal bed*	0	5
13. Shale	4	0
14. *Coal bed*	0	4
15. Shales, some iron ore	13	6
16. *Coal bed*	1	0
17. Shales	10	0
18. *Coal bed*	0	4
19. Shales, brown, sandy	25	0
20. *Coal bed*	0	6
21. Brown shale	20	0
22. Sandstone	15	0
23. Buff sandy shale	20	0
24. Massive coarse conglomerate	20	0
Total	342	5

* I. C. White: Notes on the Geology of West Virginia. Proc. Amer. Phil. Soc., vol. xx, pp. 481, 486, 490, 492, 494.

† W. B. Rogers: Property of the Pridevale Iron Co. Mining Magazine, vol. iii, 1854, pp. 358-362.

This shows a notable increase southward, for under this axis in Somerset county, Mr Platt estimated only about 200 feet. The section can not be compared in detail with those already given, but the typical section can be recognized thus:

	Feet
Homewood sandstone	60
Mercer group, shales, and *coal bed*	57
Connoquenessing	92
Sharon shales and *coal beds*	78
Sharon sandstone with sandy shale	55

In any event, whether or not this grouping be exact in detail, the section shows clearly the presence of the Sharon sandstone at the bottom.

Mr Martin measured the section on the Youghiogheny river in Garrett county, Maryland, almost midway between the last section and that at Westernport. He gives

	Feet.	Inches
1. Massive sandstone, Homewood	50	0
2. Shale	6	0
3. Mount Savage fireclay	4	0
4. *Coal, Mount Savage*	3	0
5. Shale	5	0
6. Sandstone	5	0
7. *Coal, Lower Mercer*	0	10
8. Conglomeritic sandstone, Upper Connoquenessing	75	0
9. Black shale	2	0
10. *Coal, Quakertown*	1	6
11. Shale	0	6
12. Concealed	8	0
13. Massive conglomeritic sandstone, Lower Connoquenessing	75	0
14. Concealed	60	0
15. Shale	5	0
16. *Coal, Sharon*	1	4
17. Shale	0	6
18. Sandstone	25	0
Total	327	8

One recognizes here very clearly the typical section of northwestern Pennsylvania, both members of the Connoquenessing being present as massive more or less conglomerate beds, whereas farther west the lower sandstone, as at so many localities in the northwest, is represented

chiefly by sandy shales.* Comparison with the section at Westernport, in Maryland, shows that the Sharon is less important there.

WESTERN COUNTIES OF PENNSYLVANIA

Returning now to the northern line, Warren county is west from McKean, along the New York border. Only isolated patches of the Pottsville remain north and west from the Allegheny river, but some extensive areas are found in the southeastern part of the county. Mr Carll has shown that the lower member of the Pottsville, the Sharon-Olean conglomerate, disappears abruptly in the northeast corner of the county. At the "Pass," about 8 miles west from the McKean line and 7 miles south from the New York line, the section is

	Feet
Sandstone	60
Conglomerate	25
Shenango shales	30
Logan (Shenango) sandstone	

whereas at barely one mile northward the conglomerate has disappeared, and the sandstone rests directly on the Shenango shale. Eastward from the Pass the conglomerate is soon lost, and it is absent for about 2 miles, reappearing at the Quaker Hill mines, where it is very thin. It increases toward the south of east, becoming 8 feet within a mile, where it is but 5 feet above the Logan, and reaching 20 feet at a mile farther east. The overlying sandstone is regarded by Mr Carll as equivalent to the Kinzua (Connoquenessing) sandstone of McKean. The Sharon is persistent westwardly, for it is present in an outlier within Sugar Grove township, 16 miles west from the Pass and about 5 miles south from the New York boundary.

At the Pass the Connoquenessing and Sharon are in contact, but at the Quaker Hill mines, about 2 miles east, they are separated by

	Feet.	Inches
Shales	40	0
Coal	0	3
Shale	4	9
Coal	1	6 to 2 feet.
Shale	1	0

in all, about 47 feet. The shale between the coal layers is often replaced in part by conglomerate, in which the pebbles, like those of the Sharon conglomerate below, are coated with carbonaceous matter. This curious little basin, containing not more than 50 acres, shows a dip from all

*George C. Martin: Maryland Geological Survey. The Geology of Garrett County, 1902, p. 103.

directions toward the center. The dip is high, reaching even 45 degrees, and the coal is badly crushed; but the fuel ratio is 1.6. This is the Upper Marshburg coal bed of McKean and adjacent counties, the Sharon of counties along the Ohio line.

The whole section is present in Allegheny township south from the river, where Mr Randall measured

	Feet
1. Massive sandstone	30
2. Shales and thin *coal bed*	70
3. Concealed	20
4. Massive sandstone	65
5. Conglomerate	10
6. Shales and thin *coal bed*	45 to 50
7. Sandstone	45 to 70

with an average of about 300 feet for the whole column. It is easy to recognize the Johnson Run, Kinzua, and Olean sandstones with the Alton and Marshburg shales of counties already described. The rapid increase of the Sharon (Olean) sandstone is noteworthy, for the Quaker Hill mines are but 4 or 5 miles away.

Doctor Chance's section, obtained at a little distance farther east, where the exposures are incomplete, gives the sandstones as 30, 20, and 77 feet, the interval from Johnson run (Homewood) to Kinzua being 129 feet, with much of the lower portion concealed. Two Alton coal beds are present.*

Forest county south from Warren shows Pottsville on all of the uplands. Mr Ashburner's carefully measured sections make the relations very clear. In Jenks township he finds

	Feet
Johnson Run sandstone	70
Shales and *coal beds*	10 to 25
Kinzua sandstone	90
Shales	10
Sandstone	100

with an average of nearly 300 feet. The Kinzua sandstone is double, divided almost midway by 10 feet of shale apparently containing a coal bed at some localities; so that here are the two Connoquenessing sandstones and the included Quakertown shales of the Ohio line counties. The Sharon sandstone has increased greatly and some of the layers are conglomerate, but the pebbles are distributed irregularly. Four coal beds of the Alton (Mercer) group were seen, and the Marshburg (Sharon) bed is shown occasionally in the dark shales overlying the Olean. All

* J. F. Carll: Geology of Warren County (I 4), 1883, pp. 302, 304, 325–330, and 364.

of the coal beds are irregular, but are fairly persistent, having been observed at many places.*

Crawford county is west from Warren and extends to the Ohio line. The Pottsville remains only in the southern part, where Doctor White obtained the section, so often referred to in the foregoing pages. It is

	Feet
Homewood sandstone	50
Mercer group	30
Connoquenessing group	120
Sharon shales	50
Sharon conglomerate	45

with an extreme thickness of 300 feet. As in Forest, the Connoquenessing is double; the sandstones are each 35 feet, a little thinner than in Forest, but the intervening shale in crossing Venango county has thickened to 50 feet. The upper sandstone, white to grayish white, is more or less pebbly. The intervening shales, the Quakertown of White, show coal at only one locality. The lower sandstone is hard, coarse, and brown, often micaceous and sometimes pebbly. It is less persistent than the upper, being divided at times by 20 to 30 feet of shale.

The Sharon shales are from 25 to 50 feet thick, the variation being due to that in the Lower Connoquenessing sandstone. Where thick, they show a coal bed in the upper part; the Sharon bed, below the middle, is thin and poor, appearing only occasionally along the outcrop and rarely becoming thick enough to be worked.

The Sharon sandstone retains the character so frequently observed in the counties already crossed, in that the upper part is sandstone, while the lower part is a coarse conglomerate for about 10 feet. The pebbles are not so large in Crawford as at more eastern localities, being seldom larger than a hen's egg, whereas at Tidioute, in Warren, they are sometimes as large as a goose's egg. Everywhere the pebbles are ovoid, though Ashburner speaks of them in Forest county as occasionally rather angular. The thickness has diminished from 100 to less than 50 feet in crossing Venango county. The northern line of outcrop is from the Ohio line in southwest Crawford to northeast Warren.†

In Mercer county south from Crawford the Homewood sandstone is from 30 to 70 feet, being thickest at the north and varying from good building stone to coarse conglomerate. New members appear in the Mercer group, which here contains two coal beds and two limestones. The upper limestone is less persistent than the lower, which is present

* C. A. Ashburner: Report of Progress in Forest County (RR), 1885, pp. 307–316.
† I. C. White: Geology of Crawford and Erie Counties (Q 4), 1881, pp. 55, 56.

in by far the greater part of the county. These do not extend into Crawford, but disappear northwardly at about 3 miles south from the line of that county. Iron ore is associated with both limestones, sometimes even replaces them. Both beds contain familiar Coal Measure fossils. A coal bed underlies each limestone, and at one locality near the Venango line there is an intermediate bed at 6 feet above the Lower Mercer limestone. These are the Alton beds of Ashburner.

The Upper Connoquenessing sandstone is from 40 to 60 feet thick, light gray, and pebbly near the top. The Lower Connoquenessing is from 30 to 89 feet, varying abruptly and for the most part at the expense of the Sharon shales. The Quakertown shales show the coal bed in the upper portion and vary from 20 to 50 feet. The Sharon shales are usually less than 30 feet, but where the overlying sandstone is thin they become 70 feet and show thin coals at 65, 50 to 45, and 22 feet above the Sharon coal bed. The last attains its chief importance in this county, but its occurrence is very uncertain, as the coal is in pots or saucer-shaped deposits which are largest and carry the best coal on the Ohio side of the county, where the thickness is sometimes 5 feet.

The Sharon sandstone is diminishing southwardly, for it is only 20 feet thick at Sharon, and it disappears somewhere in the southern part of the county. Along the Ohio border it shows the usual features, but eastward it is for the most part only a massive sandstone, at times becoming flaggy.*

In Lawrence county, south from Mercer, the Homewood sandstone, about 40 feet thick, varies from sandstone to shale. It is a sandstone near the Mercer line, as also in the southern tier of townships bordering upon Beaver county, but in a great part of the county it is apparently shale. At never more than 5 feet below this sandstone is the Tionesta coal bed of I. C. White, which appears to be at the horizon of the Mount Savage coal bed. It extends northward almost to the Mercer line and appears to be persistent, since wherever its place is exposed one finds either a bed of impure coal or a deposit of very black bituminous shales.

The Mercer group shows in by far the greater part of the county the two limestones and coal beds. The Upper Mercer limestone, as in Mercer county, is much more variable than the Lower, and not infrequently is represented only by its ore bed. Both limestones are present in all of the townships along the Ohio line, and notable variation appears only as one approaches the Butler county line at the east; yet both are present in the extreme southeast corner of the county.

The Connoquenessing sandstones are as variable as the Homewood.

*I. C. White: Geology of Mercer County (Q 3), 1880, pp. 33–58.

Massive in the northern part of the county, they become shaly in other portions. At times they form a continuous mass of sandstone, and in southeastern Lawrence the Upper Connoquenessing is continuous with the Homewood sandstone, 130 feet thick. The Quakertown shales are sandy. Their coal is of workable thickness at Quakertown, on the Ohio line. Elsewhere it is thin, and in the southeastern part of the county it is represented only by carbonaceous shale.

The Sharon shales, with their iron, persist, and where exposed rest upon the Shenango shales; but in the southern part of the county two well records show a sandstone below them which may represent the Sharon. The Sharon coal bed disappears southward in the northern part of the county, but at many localities elsewhere its horizon is marked by black shales, occasionally containing coaly streaks.*

In Beaver county, south from Lawrence along the Ohio line, the Pottsville passes below cover at about 6 miles from the Lawrence border.

The notable feature is the extraordinary thickening of the Homewood sandstone at about 4 miles south from Lawrence county. At the northern line of Beaver the mass is of moderate thickness and is overlain by shales of the Allegheny formation, which include some thin coal beds; but near Homewood and thence southward for more than a mile it is from 150 to 160 feet thick, the increase being at the expense of the overlying beds, which it has replaced up to the Ferriferous limestone. Farther south the thickness diminishes, becoming only 60 feet within 2 miles, and the rock passes under cover along the Beaver river near New Brighton.

The Tionesta coal bed is present directly under the Homewood sandstone. The Upper Mercer coal bed and limestone are apparently absent throughout, but the Lower Mercer coal bed and limestone are present in the northern part of the county, though they evidently disappear within a short distance southward. The Connoquenessing sandstones appear to persist, being reported in the oil-well records as far as the southern border of the county, and the Quakertown shales are sandy. The Sharon coal bed, as well as the Sharon sandstone, is absent, but the plant-bearing shales marking the place of the coal persist.†

There remains a group of counties east from those along the Ohio line. Venango county, south from Warren and east from Crawford and Lawrence, evidently shows conditions similar to those of Crawford. The geological investigations in this county were made with especial reference to the petroleum interests, and few details respecting the Pottsville are given in the report, as it contains little of economic value; but

*I. C. White: Geology of Lawrence County (Q 2), 1879, pp. 52-70.

†I. C. White: Report of Progress in Beaver River District (Q), 1878, pp. 65-72.

Mr Carll shows that the three sandstones are distinct, with the intervening Mercer and Sharon shales. No reference is made to the Mercer limestones, but the several coals of the section are present, and evidently as uncertain in occurrence as in the western counties. The sandstones are named Homewood, Connoquenessing, and Garland, the last being the Sharon of White, the Olean of Ashburner.*

Clarion county, south from Venango, has Jefferson at the east. Doctor Chance's generalized section enables us to recognize here the series as on the Ohio line. It is

	Feet
Homewood	30 to 50
Mercer	35
Upper Connoquenessing	40
Quakertown	25
Lower Connoquenessing and Sharon	130

The Homewood is often shaly, and the change from a coarse, more or less pebbly, sandstone is often abrupt. It is equally variable in thickness, the extremes being 15 and 60 feet. The Mercer group is not shown in detail in the northern part of the county, but the Lower Mercer coal bed is present near Edinburg, and it may be the bed seen at one locality on the eastern side of the county. Both Mercer coals are shown on the Allegheny river in the southern part. The Mercer limestones are absent, but in the extreme southeast an ore bed was seen near the place of the lower bed. The Upper Connoquenessing sandstone is distinct throughout, separated by 4 to 35 feet of Quakertown shales from the lower sandstone, which in the central part of the county is continuous with the Sharon sandstone; but the Sharon shales, 45 feet thick, are present in the southeast corner of the county, where the sandstones are 50 and 40 feet respectively. The Quakertown and Sharon coal beds are unrepresented.†

Butler county is south from Venango and east from Mercer and Lawrence.

The Homewood sandstone is shown occasionally in the northern part of the county as a coarse, iron-stained sandstone at least 30 feet thick. It is thinner along the Mercer and Lawrence line, varying from 15 to 30 feet, but is thicker in the central portion, while on the eastern side, adjoining Armstrong county, it is from 15 to 80 feet, varying at the expense of the Mercer shales.

The "Tionesta coal bed" is present on the west side, adjoining Lawrence, where it underlies the Homewood and is 2 feet thick, but it was

*J. F. Carll: Geology of the Oil Regions (I 3), 1880, p. 14.

†H. M. Chance: Geology of Clarion County (V 2), 1880, pp. 73, 106, 116, 123, 134, 147, 162, 164, 177.

not observed elsewhere. The Mercer coals are shown in the eastern part wherever their place has not been taken by the sandstone. The extreme thickness of Mercer is 122 feet, and the limestones are wanting. The Connoquenessing sandstones are exposed on the Armstrong border, where they are each 20 feet, separated by 43 feet of Quakertown shales, showing no coal.*

Armstrong county is south from Clarion, between Butler at the west and Indiana at the east. On the northern border, along Red Bank creek, the section is

	Feet
Homewood †.	50 to 75
Mercer	40
Connoquenessing	150
Sharon shale	13
Sharon sandstone	50

The Mercer coal beds are represented by a 2-inch streak in the upper portion, but there is no trace of the Mercer limestones. The Connoquenessing is a continuous mass of sandstone along the boundary between Clarion and Armstrong for several miles, and, like the Sharon sandstone below, appears to be without pebbles. Farther northwest, on the Butler county border, the condition is the same, for 115 feet of Connoquenessing was seen above the river; but both of the Mercer coal beds are present there, as they are also at another locality 8 or 9 miles southwest.

In the northern half of the county, east from the Allegheny river, the Homewood sandstone is shown at several localities along that river, disappearing finally under the stream at about 5 miles above Kittanning. An interesting section is shown on Mahoning creek within 3 or 4 miles of the Indiana line. It is given here in detail:

	Feet.	Feet
Homewood sandstone	..	40
Concealed	..	12
Mercer group	..	96
Black shale	10	..
Sandstone	10	..
Shale	17	..
Limestone	6	..
Concealed	50	..
Shales and ore	13	..
Upper Connoquenessing	..	42
Quakertown shales, sandy, seen	..	10

* H. M. Chance: Northern Townships of Butler County (V), 1879, pp. 42, 70, 96, 102, 118, 122, 132.

† Here, as in several other sections, the writer has applied the now accepted names to parts of the section, though they were not used by the authors of reports from which the records are taken. For discussion of the relation, here accepted, see under "Correlation" in a later portion of this paper.

Here, apparently at the place of the Upper Mercer limestone, is a limestone bearing no resemblance to that bed either in structure or appearance, but, according to Mr Platt, almost exactly similar to the Tuscumbia limestone or Silicious limestone as shown in the Chestnut Hill gaps. Its appearance here, so far away from the nearest occurrence of any Mercer limestone, shows it to be a purely local feature, for whose occurrence no explanation is available. It disappears very quickly in all directions. The Black shale of the section is near the place of the Tionesta coal bed.

The Homewood sandstone is thicker toward the Indiana border, on Mahoning creek, where it is 70 feet, and both Mercer coal beds are present at about 2 miles above the last locality of the last section. The whole series is exposed on the Allegheny, at the mouth of Mahoning creek, about 12 miles from the Indiana border and 4 miles south from Clarion. The section is practically the same as on Red Bank creek, but the Mercer coal beds are not shown and only thin streaks of coaly matter occur in the Sharon shales, which there are 38 feet thick.

The most southerly exposure of any part of the Pottsville west from Chestnut hill is on Cowanshannock creek, say 40 miles northwest from the Conemaugh gap. There 63 feet are shown belonging to the Homewood sandstone in several massive layers, without pebbles and separated by shale.*

The Pottsville passes under cover in Armstrong, Butler, and Beaver counties at a few miles south from their northern boundaries. Thence southward in those counties, in Allegheny, Washington, and Greene, as well as in Westmoreland and Fayette, west from Chestnut hill, information can be obtained only from records of oil borings, which are not wholly consistent; but those records are so numerous that it is possible to trace the formations with close approximation.

The record at Petrolia, in Butler county, is

	Feet
Homewood sandstone	66
Shales and sandstones	145
Sandstone	148

Here one is almost due west from the Red Bank Creek region of Clarion and Armstrong. The succession is clearer on the western side of the county, where one finds

	Feet
Homewood	18
Mercer group	110
Upper Connoquenessing	65
Shale	3
Sandstone and shale	100

* W. G. Platt: Report of Progress in Armstrong County (H 5). 1880, pp. 88, 139, 143, 185, 194, 207, 215, 231.

In southern Butler a well on Thorn creek, about midway east and west in the county, shows 220 feet of sandstone at the bottom,* while a record in the extreme southeast part, near the Allegheny river, shows

	Feet
Homewood	65
Mercer	103
Upper Connoquenessing	75
Quakertown shale	40
Sandstone	200

A coal bed, the Tionesta, is here at 8 feet below the Homewood, and much black sand is present in the lower portion of the Mercer. The great mass of sandstone below the Quakertown represents the Lower Connoquenessing and the Sharon shales and sandstone, with, as in Butler, perhaps some beds of greater age.

At New Brighton, in Beaver county, the section is

	Feet
Homewood	53
Tionesta coal bed	1
Mercer group	112
Upper Connoquenessing	41
Quakertown shales	40
Lower Connoquenessing	50

The Mercer and Quakertown coals are not reported. A record in southeastern Beaver shows an extraordinary thickening of the Homewood sandstone similar to that already mentioned as observed near Homewood in this county. The thickness is 120 feet, the increase being at the expense of beds belonging to the Allegheny formation, as the Ferriferous limestone is but 17 feet above the Homewood. The lower sandstones at this locality have thickened greatly, but at the expense of the shales, as the total thickness is nearly the same.

Allegheny county is south from Butler, with southern Beaver at the west and Westmoreland at the east. In the northwestern part of the county, near the Beaver border, two records from wells barely a mile apart give

	Feet.	Feet
Homewood sandstone	17	12
Mercer group	31	32
Upper Connoquenessing	34	61
Quakertown shales	63	50
Sandstone	246	240

*J. F. Carll: Ann. Rep. 2d Geol. Surv. Penn. for 1886, pp. 648, 649, 650.

in which the bottom sandstone is mostly Logan, as appears from the succession somewhat farther south toward Allegheny, which shows

	Feet
Homewood sandstone	60
Not named	20
Coal bed, Tionesta [?]	2
Shale	63
Sandstone	35
Sandy shale	45
Sandstone	52
Shale	15
Sandstone	48

resting on the Tuscumbia (Silicious) limestone, which has made its appearance in the interval. The Mercer group is not less than 63 feet, the Connoquenessing is 132 feet, and the Sharon sandstone appears to be again in the section.*

A very notable change takes place at a little way south on the Monongahela, where one finds

	Feet
Homewood sandstone	45
Shales, sandstones, and a *coal bed*	73
Sandstone	42
Sandy shales and a *coal bed*	33
Sandstone and shale	7
Sandy shale with *coal*	7

resting on the Lower Carboniferous limestone. The Homewood, Mercer, and Upper Connoquenessing are distinct, but both Lower Connoquenessing and Sharon are absent, for the lower part of the section has the characteristics of the Quakertown. The Ferriferous limestone of the Allegheny formation is 55 feet above the Homewood.†

Eastward from the Allegheny and Monongahela rivers one finds important records in Westmoreland and Fayette. In the extreme northwest corner of Westmoreland, not far from the last locality in southeastern Butler, the record is

	Feet
Homewood, white sandstone	100
Shales	35
Sandstones—gray, red, white	120
Shales	50
Coal bed	7
Shales	40
Sandstone	178

*J. F. Carll: Seventh report on the oil and gas fields of Western Pennsylvania (I 5), 1890, pp. 152, 234, 239, 252, 253, 254, 255.

†J. F. Carll: 1886 report, p. 652.

Above the white Homewood are 65 feet of gray sandstone, extending to the Ferriferous limestone. The coal bed of the record is evidently the Sharon, and the bottom of the Pottsville is just below it, as the shales are Shenango and the sandstone Logan. The condition is similar at Murraysville, 10 miles farther south, where the succession is

	Feet
Homewood sandstone	55
Mercer shales	20
Upper Connoquenessing	75
Quakertown shales with sandstone and coal	20
Lower Connoquenessing	50
Sandy shales	30

to the Lower Carboniferous limestone which has made its appearance in the interval. The bottom shales are very black in the upper 10 feet, which may be taken as representing the Sharon coal bed, thus giving for the thickness of Pottsville 230 feet. No trace of the Tionesta or Mercer coals appears in the record. This record is of especial interest, as it is about one-third of the way eastward from Pittsburg to the Conemaugh gap, where only the upper part of the section is present.

Five or 6 miles farther south in Westmoreland county the record is

	Feet
Homewood	85
Mercer shales and "shells"	80
Upper Connoquenessing	40
Coal bed, Quakertown horizon	4
Sandstone and shale	55

resting on 85 feet of "Buttermilk sand," evidently the limestone. The Homewood has increased at expense of the overlying rocks, while the Connoquenessing sands are decreasing. The change continues southward for 6 or 7 miles farther. The record is

	Feet
Homewood	135
Mercer shale, black	30
Upper Connoquenessing, white	30
Quakertown shale, black	25
Lower Connoquenessing, white	20
Sharon shale, black	15

giving only 120 feet as total thickness of Pottsville below the Homewood. At barely a mile away the Homewood is but 48 feet, and the Connoquenessing sandstones have come together with a thickness of 80 feet.

A record in southern Fayette, within 8 miles of the West Virginia line, shows the same conditions, but exaggerated, for the Homewood is 160

feet thick and begins at only 848 feet below the Pittsburg coal bed, so that it includes some of the Allegheny beds as well as the Mercer and Upper Connoquenessing. A coal bed reported from this boring is evidently at the Quakertown horizon.*

The records in Washington and Greene counties, lying between the Monongahela river and the northern "Panhandle" of West Virginia, give much of interest. At Mount Pleasant, in northeast Washington, the succession is

	Feet
Sandstone	24
Shales	22
Sandstone	16
Shales	25
Sandstone	32
Dark shale	10

in all only 129 feet, and no trace of coals appears in the record. This is about 10 miles southwestward from the Monongahela locality, near Pittsburg. Compared with that, this shows a notable thinning in the upper part of the section. The Upper Connoquenessing is 72 feet thick at McDonald's station, 4 or 5 miles north from Mount Pleasant, where the other members of the section have very nearly the same thickness as given above. Here the Tionesta and Quakertown horizons are marked by black shale.†

The record at Washington, about 10 miles south from Mount Pleasant, is

	Feet.	Inches
Homewood	87	
Coal bed, Tionesta horizon	1	6
Upper Connoquenessing	81	6
Shales	93	

to the Lower Carboniferous limestone. Here the Homewood is at but 5 feet from the Ferriferous limestone, though the interval at Mount Pleasant is 111 feet, so that the increase is at the expense of the Allegheny beds; the Connoquenessing has increased at the expense of the Mercer shales, while the lower beds have lost their characteristics, and at best must be very thin, for much of the bottom shales must belong to the Shenango.

At Waynesburg, in Greene county, somewhat more than 20 miles south from Washington, the record is

	Feet
Homewood sandstone	65
Mercer shale	35

*J. F. Carll: Report (1 5), pp. 213, 219, 225, 322.

†I. C. White: West Virginia Geological Survey, vol. i, 1899, pp. 218, 219.

resting on 20 feet of red rock, separating the shale from the underlying limestone, and the Ferriferous limestone is but 75 feet above the Homewood. Here all the members below the Mercer shale have disappeared.*

The records show a strange condition east from Waynesburg, toward the Monongahela river, for at 2 miles northeast from Waynesburg one finds 175 feet of sandstone, beginning at 900 feet below the Pittsburg coal bed, whereas at 2 miles east from Waynesburg there is nothing but shale in that interval, the Lower Carboniferous limestone being reached at 1,107 feet below the Pittsburg; but at 5 miles east from Waynesburg the sandstone begins at 607 feet below that coal bed and continues to the limestone at 1,135 feet, giving a sandstone mass of 528 feet, while at Carmichaels, 4 miles southeast from the last and little more than a mile from the Monongahela, the sandstone begins at 691 feet below the coal, thus:

	Feet
Sandstone	165
Shale and "shells"	35
Sandstone	180

in all 380 feet, separated by 10 feet of red rock from the limestone below. The Pottsville is in the bottom sandstone. The same sandstone is found at Willow Tree, about 12 miles southeast from Waynesburg, where, beginning at 840 feet below the Pittsburg, the succession is

	Feet
Sandstone	50
Shale	35
Sandstone	90

with 145 feet of red rock below to the place of the limestone at 1,160 feet. The lower sandstone is the Pottsville. The record at the West Virginia line, about 8 miles south-southwest from the last, beginning at 892 feet below the Pittsburg, is

	Feet
Sandstone	55
Shale and sandstone	85

with 110 feet of "white sandstone, red rock, and limestone" underlying it.†

NORTHERN AND WESTERN OUTCROP IN OHIO

Mahoning county, of Ohio, adjoins Lawrence, of Pennsylvania. Professor J. S. Newberry studied it during the second geological survey

*J. F. Carll: 1886 Report, pp. 650, 658.

†J. F. Carll: Report (I 5), pp. 312, 313, 314, 315, 316, 317. Mr Carll must not be held responsible for the identifications presented in the records quoted from his reports, as the writer has made them on his own responsibility.

of the state, and, at a somewhat later date, Dr I. C. White followed the Pennsylvania section into the county, so that the relations are now sufficiently clear. The Homewood sandstone quickly becomes obscure west from the state line, but the Mercer group is characteristic throughout, both of the limestones as well as the coal beds being present at Lowellville, where the Tionesta coal bed is shown at from 2 to 10 feet above the Upper Mercer limestone. The Mercer group is about 70 feet thick. The Sharon coal bed appears about 2 miles farther up the Mahoning river, and thence in this as well as in the adjoining counties it occurs with its accustomed irregularity and uncertainty. The Ferriferous limestone, so important as a guide in Pennsylvania, disappears soon after crossing the state line, but its office is assumed by a new limestone, very near the bottom of the Allegheny formation, the Putnam Hill or gray limestone, which overlies a coal bed thought by Professor Orton to be the Brookville of the Pennsylvania column. This limestone first appears near Youngstown, a few miles west from the state line, where it is 2 feet 7 inches thick and 36 feet above the Upper Mercer limestone.

The Connoquenessing sandstones, termed by Newberry the Massillon (which name is retained in the later Ohio reports by Orton), appear in White's sections as well as in those by Newberry, and are persistent in this county, though, as in Pennsylvania, they are variable. Doctor Newberry's Youngstown section shows them distinct, yet in the Foster shaft there they are one, with a thickness of 146 feet. Evidently several valleys existed in this immediate neighborhood at one time during the Pottsville, for at a mile east from Youngstown there are barely 11 feet of sandstone in the whole Connoquenessing interval, while in another shaft, a mile farther southeast, the sandstone is 80 feet. A similar condition exists near Austintown, west from Youngstown, where one shaft shows the sandstone continuous and 120 feet thick, whereas in most of the others the sandstones are distinct and separated by the Quakertown shale. The Quakertown coal bed seems to be persistent at 50 to 80 feet above the Sharon, except where cut out by the overlying sandstone. The Connoquenessing sandstone often replaces the Sharon shales, and at times even the coal bed itself. There is little trace of the Sharon sandstone in this county. The peculiarities of the Sharon coal and of its occurrence have been described well by Doctor Newberry, and they will be discussed in another connection.*

The Pottsville extends northward into the southern part of Trumbull county, where the exposed section reaches to the blue or Lower Mercer

*J. S. Newberry: Report of the Geol. Survey of Ohio, vol. iii, 1873, pp. 784–795, 800, 803, 804, 805. I. C. White: (Q 2), pp. 219–224, 288.

limestone. The Lower Mercer coal bed (number 3 of the Ohio section) is wanting. The Connoquenessing sandstones are present, but the upper one tends to become shaly. The Quakertown and Sharon coal beds are present, and the Sharon sandstone makes its appearance with an extreme thickness of 15 feet;* but this rock must increase rapidly in the west and northwest, for in Portage county, west from Trumbull and Mahoning, Newberry finds it 175 feet thick in the northeast corner, barely 5 miles from the Trumbull line and not more than 15 miles northwest from Mr Read's locality; yet the thickness must be less in the westerly part of the county, for the general section gives it as only 100 feet. The rock is a coarse drab sandstone, with portions consisting of quartz pebbles varying in size from a pea to a hen's egg. The thickness decreases very quickly southward, for the rock is absent in the southeastern part of the county at not more than 8 miles from northwest Mahoning. Northward beyond Portage the Sharon sandstone extends into Lake and Geauga counties, reaching to within 10 miles of lake Erie, retaining its characteristic features and apparently losing neither thickness nor coarseness.

The general section of Portage county, as given by Doctor Newberry, shows that the Putnam Hill or gray limestone is a constant feature. It represents that limestone as from 28 to 54 feet above the blue or Lower Mercer limestone. As no reference is made anywhere to the Upper Mercer limestone, it is possible that it and the Putnam Hill have been confounded at some localities, the more so because the two beds are much alike in all respects at many localities. As in Mahoning county, the Homewood sandstone is no longer well marked, and it is represented ordinarily by shale. Whether or not the Tionesta horizon shows any coal in Portage county can not be said, as no detailed sections are given. The Lower Mercer coal bed is reported as occurring at from 150 to 200 feet above the Sharon coal bed. In the southern part of the county, within 3 miles of the northwest corner of Stark county, a thin coal bed, unaccompanied by limestone, was seen at 20 feet above the Lower Mercer. The conditions in Stark county lead one to believe that this is the Upper Mercer. The Upper Connoquenessing is sometimes conglomerate, but in many places it is shaly, and as a whole it is less persistent than the Lower Connoquenessing, which is apparently the original Massillon of Newberry, though afterwards that term was applied to both divisions. The Quakertown coal bed is thin, but persistent, though at times replaced by the overlying sandstone. The Sharon coal bed is as irregular as in the other counties, though the little basins in which it was deposited are larger than those in Mahoning county.†

* M. C. Read: Ohio Survey, vol. i, 1873, pp. 496, 498, 500, 502.

† J. S. Newberry: Vol. iii, pp. 137, 142, 143, 144, 145, 146.
M. C. Read: Vol. i, pp. 521, 522, for Geauga county.

In Summit county, west from Portage, the Sharon sandstone is said to be about 100 feet thick, becoming toward the bottom a mass of quartz pebbles, with just enough sand to hold them together; but these are coarser than in Portage, varying in size from that of a hickory nut to that of a man's fist. The ordinary irregularity of the Sharon coal bed is increased by inroads of the Connoquenessing sandstone, whereby it has been removed in many places. The Lower Mercer coal bed with its Blue limestone is from 130 to 160 feet above the Sharon, and the Putnam Hill limestone is from 25 to 40 feet higher. The report on this county deals almost wholly with economic descriptions of the several coal beds, and no local sections are given. The Homewood sandstone is as indefinite as in Portage.*

A small area of Pottsville remains in Medina county, northwest from Summit, and shows the Sharon sandstone about 130 feet thick, a coarse sandstone with some pebbles; but these, in contrast with the Summit County conditions, are for the most part very small. The Connoquenessing sandstone in the southwest corner of the county appears to be but 40 feet thick, separated by 48 feet of shale from the Sharon or Brier Hill coal bed, which at the locality described is 5 feet thick.†

Evidently the Sharon sandstone decreases rapidly toward southern Summit, for in Stark county, south from Summit and Portage, it is but 20 to 50 feet thick. The Sharon coal bed in this county is extremely irregular in occurrence, and has become variable in quality as well as in quantity, though in one portion its excellence is typical, and the bed is of great economical importance, so that it was named by Newberry the Massillon coal bed. The Connoquenessing (Massillon) sandstones are distinctly such in the Canton boring, as well as in many others; but the Upper is less persistent as a sandstone than is the Lower.

The Quakertown coal bed is commonly present and is known as the "fifteen-inch bed," though rarely exceeding 1 foot, and the interval to the Sharon is given as from 50 to 80 feet. A thin coal bed often underlies the Lower sandstone, almost always where the Sharon shale has not been cut out by the sandstone. One of Professor Orton's records shows that the cutting during or prior to the deposition of the sandstone must have been very deep. The Lower Mercer limestone and coal bed are persistent, though the coal is rarely of any value. The Upper limestone and coal bed are here but evidently very irregular in occurrence, for Newberry gives the interval from the Putnam Hill to the Lower limestone as 20 to 50 feet of shale and sandstone "sometimes containing a local coal and limestone." A boring at Alliance, in the northeast cor-

*J. S. Newberry: Vol. i, pp. 212, 213, 214, 217, 218.
†A. W. Wheat: Vol. iii, pp. 363, 378.

ner, adjoining Columbiana county, shows two coal beds, very thin, at 11 and 26 feet below the Gray limestone, which are evidently the Tionesta and the Upper Mercer, while at Magnolia, on the southern border of the county, a boring shows at 27 feet below the Gray limestone 2 feet 4 inches of limestone overlying 1 foot of coal, clearly the Upper Mercer. Professor Orton gives a section showing the Tionesta and the Mercer coal beds at 6, 15, and 57 feet below the Putnam Hill or Gray limestone coal bed, with both of the Mercer limestones present. The Homewood is not recognizable and its place is filled with shale or fireclay.*

In Medina county, according to Mr Wheat, the Sharon sandstone is 130 feet thick; but in Wayne, south from Medina and west from Stark, it has become so insignificant that Mr Read practically ignores it, considering the petty local accumulations as merely material from the Waverly hills which bounded the irregular valleys in which the Sharon coal bed was deposited. In Stark county the least interval between the Sharon coal bed and the Zoar or Lower Mercer limestone is given by Newberry as 130 feet, but Mr Read gives the extreme interval in Wayne county as only 60 feet—a statement confirmed by the observations of Professor Wright in Holmes county, as well as by Mr Read's measurements in Knox county. The interval diminishes, according to Mr Read, so rapidly that at a few miles west from the line of Stark county and almost on the Knox border it is only 32 feet. The Connoquenessing, though often sandstone, is replaced by shale in much of this county. Traces of the Quakertown coal bed were seen occasionally, but the Lower Mercer is persistent, while the Upper Mercer, at a few feet above the Lower Mercer limestone, becomes important locally as a 5-foot bed of very fair cannel.†

In the northwestern corner of Tuscarawas county, south from Stark, Professor Orton finds this succession:

	Feet.	Inches
1. Putnam Hill limestone and *coal bed*		
2. Shale	30	0
3. *Coal bed*	3	0
4. Shale	10	0
5. Limestone, gray or blue	2	6
6. Fireclay and shale	23	0
7. Blue limestone	6	0
8. *Coal* and shale	7	9
9. Fireclay and shale	30	0

Here are the Tionesta and Lower Mercer coals, with both of the Mercer limestones. This locality is about 10 miles from Magnolia, in Stark

*J. S. Newberry: Vol. iii, pp. 155, 159, 165, 166, 170, 172, 173.
E. Orton: Vol. v, 1884, pp. 231, 811.
†M. C. Read: Vol. iii, pp. 525, 531, 533, 537.

county. The three coals and both limestones are present in the southwest portion of Tuscarawas, as well as near Zoar, toward the center. The Tionesta alone becomes of workable thickness, yielding a coal remarkably high in volatile, with a ratio of almost 1, but with so much ash as to make it of little commercial value. The Lower Mercer limestone is persistent, being present in borings on both sides of the county, but the upper limestone is of uncertain occurrence. The Sharon coal bed is persistent, after its fashion, but the Sharon sandstone is conglomerate only on the western side, where its extreme thickness is about 9 feet.*

In Holmes county, south from Wayne and west from Tuscarawas, the typical section of western Pennsylvania reappears, for Professor Wright gives the following succession:

		Feet
1.	Putnam Hill limestone and *coal bed*	
2.	Sandstone and shale	20
3.	*Coal bed* [*Tionesta*]	
4.	Shaly sandstone	20
5.	Upper Mercer limestone	
6.	*Upper Mercer coal bed*	
7.	Shales	30
8.	Lower Mercer limestone, blue	
9.	*Lower Mercer coal bed*	
10.	Shales	22
11.	*Coal bed*	
12.	Massillon sandstone, upper	38
13.	*Quakertown coal bed*	
14.	Massillon sandstone, lower, and shale	38
15.	*Sharon coal bed*	

For the most part the Sharon coal bed rests directly on the Lower Carboniferous, the Sharon sandstone being absent; but Mr Read found that sandstone in the northern townships of this county, where it has an extreme thickness of 18 feet. In the northeastern portion it contains broken angular fragments of white and yellow chert, with a profusion of fossils, which Mr Meek recognized as Lower Carboniferous. Small fragments of precisely similar material, according to Mr Read, occur at the Nelson ledges, in northeastern Portage, and at Boston, in northern Summit, mingled at the latter place with large angular and flat rock fragments. In the northern localities these fragments are at the bottom of the great mass.

The Sharon coal bed is as irregular as in the more northern counties, sometimes reaching 4 feet, but often wanting. The interval to

*J. S. Newberry: Vol. iii, pp. 56, 58.
E. Orton: Vol. v, pp. 67, 76, 259.

the Lower Mercer coal bed varies from 80 to 100 feet, whereas in Stark and Mahoning it is from 130 to 160 feet. The coal bed resting on the Upper Connoquenessing (Massillon) sandstone is not present at all exposures, but the Quakertown, though always very thin, is rarely absent. The Connoquenessing (Massillon) sandstones are variable, and a thin coal bed was seen occasionally in the shales of the lower sandstone. The limestones and coals of the Mercer group appear in almost all of the sections, and the lower coal bed is almost as important commercially as is the Sharon. It yields a semi-cannel or block coal of good quality. The Upper Mercer is the Strawbridge cannel of Holmes county, with thickness of from 2 to 9 feet. The Tionesta coal bed is of workable thickness only near the Wayne county line, where it is from 3 to 4 feet thick. The Homewood, Tionesta of the later Ohio reports, is largely sandstone at many localities within this county. The whole thickness of Pottsville in the northern part of Holmes county is but 166 feet.*

A small area of Pottsville remains in Ashland county, west from Holmes, where the Sharon sandstone is represented by 20 feet of shale containing locally 10 feet of conglomerate. In the isolated patches crowning several hills in southeast Richland, just west from the Ashland line, Mr Read discovered the same kind of chert fragments as in the Sharon of Holmes county.†

Coshocton county is south from Holmes and west from Tuscarawas. Mr Hodge found the Sharon sandstone in the northern part of the county, where it is 2 to 3 feet thick and contains fragments of chert, from one of which he obtained a fine crystal of galenite. The Sharon coal bed is as in the counties already described. Professor Edward Orton, Jr., obtained the following section on the western edge of the county:

	Feet
1. Putnam Hill limestone and *coal bed*	
2. Interval	17
3. *Upper Mercer coal bed*	
4. Interval	15
5. Lower Mercer limestone	
6. *Lower Mercer coal bed*	
7. Shales and shaly sandstone	48
8. Sandstone	50

to the place of the Sharon coal bed, thus giving for the formation, with all of the members recognizable, only 130 feet. A section obtained in the same township by Mr Hodge gives the interval from the Sharon coal bed

*M. C. Read: Vol. iii, p. 546.
A. A. Wright: Vol. v, pp. 818, 823, 837, 838, 841.
†M. C. Read: Vol. iii, pp. 316, 317, 523.

to the Upper Mercer coal bed as 119 feet. The Connoquenessing sandstones can be recognized wherever their place is exposed, but they show much variation. At one locality Mr Hodge found the whole interval between the Sharon coal bed and the Upper Mercer limestone, 130 feet, occupied by an almost continuous sandstone, but in most places the Upper sandstone is rather shaly. The Lower Mercer limestone is the notably persistent member of the formation and occasionally it carries chert; the Upper limestone is absent at some places, but not often, and it is accompanied by chert; its coal bed is a valuable cannel in two townships. The Homewood is represented by shale almost everywhere.*

Small areas of Pottsville remain in Knox county, west from Coshocton. The extreme thickness of the Sharon sandstone does not exceed 15 feet. The general section in the eastern part of the county reaches to 235 feet above the Sharon coal bed as follows:

	Feet.	Inches
1. Concealed	115	
2. Sandstone, thin conglomerate near bottom	45	
3. *Coal bed*		2 to 1 6
4. Shale	45	
5. *Coal bed*		
6. Sandstone	30	
7. Shale	10	
9. *Coal bed*		

The Sharon, Quakertown, and Lower Mercer horizons are marked by coal; another bed exists at 60 feet above the Lower Mercer, which may be that associated with the Putnam Hill limestone, but the Mercer limestone as well as the Putnam Hill have disappeared. The cherty limestone occurring on some of the ridges at 100 feet above the highest coal bed represents the Allegheny limestone. The whole thickness of Pottsville does not exceed 140 feet.†

Muskingum county is south from Coshocton. Stevenson gives the following generalized section for the northern part of the county:

	Feet
1. Putnam Hill limestone and *coal bed*	
2. Sandstone and shale	21
3. Upper Mercer limestone	2 to 3
4. *Upper Mercer coal bed*	
5. Sandstone	10
6. Lower Mercer limestone	1
7. *Lower Mercer coal bed*	
8. Fireclay	

*J. T. Hodge: Vol. iii, pp. 571, 575, 576, 581.
E. Orton, Jr.: Vol. v, pp. 844, 853, 854, 859.
†M. C. Read: Vol. iii, pp. 335, 336.

	Feet
9. Sandstone	75
10. *Quakertown coal bed*	
11. Shale and sandstone	45 to 50
12. *Sharon coal bed*	
13. Shales	50
14. Conglomerate	28

The notable feature in the lower portion of the section is the great increase of rock below the Sharon coal bed—an increase which in one form or another becomes more and more noteworthy farther south along the western outcrop in Ohio and throughout the whole field in the states beyond. The Sharon conglomerate shows most of the features observed farther north by other students, but Stevenson makes no reference to fragments of chert. The Sharon coal bed occasionally reaches 2 feet 6 inches, but is broken by clay partings into benches of dissimilar coals; but the occurrence of this bed is very uncertain; it is wanting at many places. The Connoquenessing sandstones are persistent, and the Quakertown coal bed is present in the northwest part of the county, though very thin. The interval of 120 feet between the Sharon coal bed and the Lower Mercer is the extreme. The Mercer coal beds are present in every section where the horizon is exposed but, except in the southwest corner of the county, they are insignificant. No trace of the Tionesta coal bed was observed and the Homewood is never more than a shaly sandstone. The close resemblance of this section to that of Lawrence county, Pennsylvania, is important, for all members of the formation are here with much the same features as in the typical section. This Muskingum section was made in 1872.*

Before following the western outcrop farther toward the south, it may be well to refer briefly to counties lying eastward toward the Ohio river, where for the most part the Pottsville is under cover.

Columbiana county is south from Mahoning along the Pennsylvania border. Doctor White's sections in the northeastern part of the county show the Upper Mercer limestone represented by chert at many localities along the western outcrop. A thin coal bed, at one place, rests on the Upper Connoquenessing.

Professor Newberry reports two coal beds in a boring midway along the northern border which are at the proper places for the Mercer coals. Borings somewhat farther south reach the Lower Mercer and show both coals at 31 and 63 feet below the Putnam Hill limestone, but the Mercer limestones are wanting, as they are also at the more northern locality.†

*J. J. Stevenson: Vol. iii, pp. 239, 243.

†I. C. White: (Q 2), pp. 268-272. J. S. Newberry: Vol. iii, p. 110. E. Orton: Vol. v, p. 37.

An oil-well record in northern Jefferson, south from Columbiana, shows two coal beds at 111 and 150 feet below the Lower Kittanning coal bed, which evidently are the Mercer coals, but the Mercer limestones are missing.*

An oil-well record in West Virginia opposite Steubenville, Ohio, shows neither coal nor limestone in the Pottsville, unless the coaly matter at the bottom be taken as representing the Sharon coal bed. There, as at Steubenville, the Pottsville is a massive sandstone. Borings in Belmont county, south from Jefferson along the Ohio, show a somewhat similar condition, for in the 350 feet above the Lower Carboniferous there is only sandstone broken just above the middle by 30 feet of shale. It is clear that the coals and limestones are lacking in eastern Jefferson and Belmont counties as well as in a great part of Columbiana.†

Unfortunately there are no data available now for Harrison county, west from Jefferson and north from Belmont, but Stevenson reports some records of borings in Carroll county, north from Harrison, which show a limestone and coal bed at from 18 to 45 feet below the coal bed underlying the Putnam Hill limestone. The limestone is the Upper Mercer. The same observer states that the Upper Mercer limestone is reached in exposed sections within Guernsey county, between Belmont and Muskingum, and that the underlying coal is a cannel; but at Cambridge, in the central part of the county, a well record shows no trace of coal or limestone in 365 feet above the Lower Carboniferous, while in the eastern part of the county the first trace of coal is at 220 feet above the Lower Carboniferous. This underlies a fossiliferous black shale which may represent a limestone, perhaps the Putnam Hill.‡

Returning now to the west and passing southward from the Ohio Central railroad, one finds in the central part of Muskingum county a measurement by Professor Orton which shows the intervals between the Putnam Hill limestone, the Lower Mercer, and the Sharon coal beds to be 80 and 70 feet.

The Pottsville extends in isolated patches westward beyond Muskingum almost half way across Licking county. There Mr Read found the Sharon sandstone represented by conglomerate sometimes 15 feet

*J. S. Newberry: Vol. iii, p. 741.

†E. Orton: Vol. vi, pp. 338, 405.

‡J. J. Stevenson: Vol. iii, pp. 195, 221. The measurements by this observer were made in 1871 and 1872, but not published until 1878. The Pennsylvania terms were not used in his reports. They have been applied here, as also in the extracts from reports of other members of the survey during its earlier years.

E. Orton: Vol. vi, pp. 378, 381.

thick and containing angular fragments of chert such as those observed by him at more northerly localities. The Sharon coal bed is from 2 to 10 feet above it, and occasionally becomes 3 feet thick. At 2 miles northeast from Newark he found a bed of fireclay underlying a 4-foot bed of limestone and separated from the Sharon coal bed by 100 feet of sandstone, apparently the Lower Mercer limestone; but in the southeast corner of the county and extending into Muskingum he finds the "Flint Ridge cannel" under the same limestone, with occasionally a thin coal bed at from 25 to 35 feet below it.*

In the general description of formations exposed within the Second Geological district, Professor Andrews says that on the border of the Hocking Valley coal field, embracing parts of Perry, Hocking, and Athens counties, he finds at 80 feet above the Maxville limestone a limestone with a thin coal bed under it; at 20 to 35 feet higher another, often flinty and also overlying a thin coal bed, while at 40 feet above the last he finds the Putnam Hill limestone. These are the Mercer limestones and coal beds. The Sharon coal bed, very thin, is at a few feet above the Maxville limestone, while another is seen occasionally at 20 feet higher, and a third, the Quakertown, at 58 feet.†

The Pottsville was followed by Professor Orton around the Hocking Valley field, supplementing the observations of Professor Andrews. The Tionesta coal bed is present in Perry county at about 10 feet above the Upper Mercer limestone, and at one locality is commercially important. That limestone is not always present, but its ore bed is so well characterized as to mark the horizon. The Lower Mercer limestone is thoroughly persistent. Its extent is shown on the map of the Hocking Valley coal fields accompanying volume vi, from which it appears that the bed, where spared by erosion, reaches to the extreme western outcrops of the coal field in Perry, Vinton, and Hocking counties, attaining at times, even on the western line, a thickness of 10 feet. A thin coal bed is often shown at 45 to 50 feet below it, which may be at the Quakertown horizon. The Sharon coal bed, from 80 to 120 feet below the limestone, is represented usually by coal or coaly shale, and is separated by a thin shale deposit from the Maxville limestone, though occasionally one finds an attenuated representative of the Sharon conglomerate.‡

The Lower Mercer limestone was traced by Professor Andrews across Hocking county, where it is commonly accompanied by its iron ore, the "Little block" and the Lower Mercer coal bed. In Athens county,

*M. C. Read: Vol. iii, p. 358.
†E. B. Andrews: Vol. iii, pp. 823, 824.
‖E. Orton: Vol. v, pp. 886, 905, 919, 989.

east from Hocking, the limestone becomes very thin, being only 6 inches where last seen, and it evidently disappears within a short distance. The Sharon sandstone can not be recognized in Hocking or northern Vinton.*

Passing from Hocking into Vinton county, the next south, one finds the border of Upper Carboniferous extending farther westward than in the northern counties; so that in Vinton it is almost on the western edge of the county, while farther south it passes out of Jackson into Pike county, where some isolated areas remain, fully 20 miles farther west than the western limit in Licking county.

At numerous places in Swan and Jackson, the northwest townships of Vinton county, as well as in northern Richland, adjoining Jackson township on the south, a coal bed 4 inches to 2 feet 10 inches thick is shown resting on the Waverly or separated from it by at most a few feet of fireclay. This is 120 feet below the Lower Mercer limestone and is the Sharon coal bed. The Sharon sandstone makes its appearance in the middle of Richland township, where a section shows the Sharon coal bed at 60 feet above the Logan and 15 feet above a massive sandstone, of which the bottom 12 feet is a hard white sandstone containing "concretions of flint and lime and made up largely of organic remains, forms often comminuted." Professor Andrews thinks these probably represent the Maxville, and he states that he has seen similar forms near Newark, in Licking county. This is the same white sandstone so often referred to by Mr Read in his descriptions of the northern counties, and the concretions are evidently the same with Read's irregular broken fragments, accompanied by angular fragments of rock.

Other measurements by Professor Andrews in the southern part of Vinton county make the matter wholly clear and prepare the student to understand the conditions in Jackson county which caused so much perplexity in the past. In southern Richland, Professor Andrews reports a section which makes the interval from the Lower Mercer limestone to the Waverly 189 feet, with the Quakertown coal bed at 75 feet below the limestone, and another coal bed, 3 feet 6 inches thick, within 15 feet of the Waverly, or about 170 feet below the limestone. This was very perplexing to one who so zealously championed the doctrine of parallelism of coal beds, but he states that the measurement is open to no doubt, as it was made repeatedly by the aid of the Locke's level. It shows, he says, a thickening of the interval between the (Mercer) limestone and the Waverly of 60 feet in a southwest direction within three miles and a half. At an exposure within a mile he finds a coal bed, 13 inches thick

* E. B. Andrews: Report for 1870, pp. 80, 82, 87.

and of excellent quality, at 60 feet above the Logan or 110 to 120 feet below the limestone. This is the Sharon coal bed, and the lower bed is at a new horizon, unknown as coal bearing thus far in our tracing through Pennsylvania, outside of the Anthracite strip, and Ohio; southward it becomes important, though the coal is not always present, having been replaced by the sandstone at many places.*

According to Professor Orton, the Lower Mercer coal bed is more important in Vinton than elsewhere in Ohio except in Holmes county. Professor Andrews finds a variable coal bed at 4 feet above the Lower Mercer limestone in Elk and Richland townships which probably represents the Upper Mercer horizon. It does not appear in any others of his sections unless that at 18 in Clinton and that at 25 feet in Brown are the same bed. His sections show a fairly persistent bed at 34 to 37 feet above that limestone in Elk and Clinton, and Professor Orton refers to it as occurring in Madison. This is the Newland coal bed which Professor Orton is inclined to assign to the Tionesta horizon, where it certainly belongs, for the Brookville coal bed (of Orton) is present above it. The Lower Mercer limestone persists and at times is 10 feet thick even on the western outcrop.*

In western Vinton, one approaches once more the western margin of the Upper Carboniferous, for the coarse conglomerate reappears in Richland township, where Andrews found the Sharon coal bed at 60 feet above the Logan sandstone. Followed southwestwardly, the conglomerate increases rapidly, becoming 130 feet in the northwest corner of Jackson at a mile or two south from the Vinton line. Thence to the southern border of the county the outcrop trends southwardly and the thickness decreases, becoming only 80 feet in the other western townships. This conglomerate is often very coarse, with pebbles mostly of white quartz and as large as hens' eggs. The mass changes very quickly toward the east, being replaced in great part by sandstone and shale, and at the same time it becomes thinner.

The rapidity of this change is shown at one locality, where on one side of a narrow valley the conglomerate is 80 feet thick, whereas on the opposite side the upper 50 feet is replaced by shales and sandstones with a coal bed at the bottom or at 31 feet above the base of the conglomerate. Professor Orton has shown that in the northwest corner of the county this conglomerate contains coal beds.

The relation of this conglomerate to the other beds was a source of

* E. B. Andrews: Report for 1870, pp. 96, 97, 99, 100, 101, 102, 105.

† The reader, who may consult the reports of Professor Andrews for 1869 and 1870, should remember that in those reports the Blue limestone (Lower Mercer) is identified with the Putnam Hill limestone. This error was corrected by Professor Andrews in his later reports published in vol. i of the final volumes.

perplexity and the conclusions to which the several observers arrived were not wholly in accord. The condition beginning in southern Vinton and becoming so marked in Jackson is of such interest, in view of the further development of this portion of the section in more southern localities, that it is necessary to examine it with a degree of detail which may appear extreme.

Professor Andrews has shown that the Lower Mercer limestone is persistent, and Professor Orton has shown in addition that the Upper Mercer horizon may be followed easily by means of its ore bed (the Franklin or Dunkel Block) even where the limestone is absent.

Professor Andrews says that in the southwest portion of Washington township, within 2 miles of the Pike county line, a coal bed 3 feet 2 inches thick is present at 120 to 125 feet below the Blue or Lower Mercer limestone, with the intervening rocks concealed, but at a little way south a coal bed was seen at 70 feet below the limestone. These are the Sharon and Quakertown beds of Vinton. The lower bed, the Sharon, is known as the Wellston coal. At 3 miles from the last locality he finds a third bed at 36 feet below the Wellston, the three beds being exposed in the hillside. The interval between the Wellston (Sharon) and the lower coal bed is filled in great part by coarse sandstone and conglomerate. This lowest bed is composed of laminated coal like that obtained from the shaft bed at Jackson, and rests on the irregular surface of a heavy white pebbly sandstone at 97 feet below the highest coal bed, and therefore at about 167 feet below the Lower Mercer limestone. In this (Lick) township, the middle coal bed, Sharon-Wellston, is exposed at 125 feet below the Blue limestone, while near by an exposure shows coals at 45 to 80 feet below the nearest exposure of the limestone; and at a little way south the bottom coal bed is seen again, resting on a massive white sandstone at least 40 feet thick. The least interval between the Blue (Lower Mercer) limestone and the Wellston coal is in the northeast part of the county, where it is 113 feet.

At Jackson, 8 miles south from the Vinton line and at an equal distance east from the Pike line, the lowest coal bed is reached by a shaft and is known as the "Jackson Shaft coal bed." Its floor is very undulating; in one part of the mine it dips 30 feet within a few rods. Professor Orton finds this shaft bed at 142 feet below the Lower Mercer limestone in a boring about a mile east of Jackson.*

The facts observed in Vinton and Jackson counties leave no room for

* E. B. Andrews: Report for 1870, pp. 127, 132, 145, 148.
E. Orton: Vol. iii, p. 912; vol. v, pp. 1009, 1010, 1032.

doubt that the coal bed at 45 feet below the blue limestone is the same with that often seen just above the Upper Connoquenessing; that the bed at 70 to 80 feet is at the Quakertown horizon, and that the "Wellston coal bed" is the Sharon. The Jackson Shaft coal bed is within the Sharon conglomerate, and is the same with that discovered by Andrews in southern Vinton, representing a coal-making stage wholly without coal at any localities in the northern part of the basin, where the horizon is exposed frequently. The Wellston and Shaft coals are of excellent quality, and the former occasionally becomes cannel. As usual, the Sharon floor is irregular. The Mercer coals are unimportant, but the Tionesta is of workable thickness in the northeastern part of the county, where it is largely cannel, a characteristic which becomes more and more marked as the bed is followed southward.

In the report on Pike county, which is west from Jackson, Professor Orton joins the Jackson section to that of Pike. Three miles west from Jackson a 3-foot coal bed, identical in character with that of the Shaft coal bed, is worked. The same bed is mined at 2 miles northwest, as well as on the county line, which makes the junction with the mines of northeast Pike. There has been a great change in the Sharon sandstone within this interval. Professor Orton states that the Wellston coal bed is found at one place in northwest Jackson county at 125 feet above the lower coal bed. This shows a rapid increase in the upper Sharon, but he gives no measurements of the lower portion—that below the Shaft coal. The increase in this, however, is equally notable, for in northeastern Pike the Shaft coal bed is underlain by 180 feet of conglomerate and has overlying it 75 feet of sandstone and conglomerate to the top of the section. The Sharon (Wellston) coal bed is not reached in this county. It is evident that the western limit of the basin lay not far west from eastern Pike. The interval from the Sharon coal bed to the Waverly, in Lick township of Jackson, is not more than 60 feet; in eastern Jackson township it is 130 feet, while in the northeastern part of Pike it is not less than 310 feet, taking the interval above the Shaft coal as continuing unchanged into Pike; but the increase in the upper portion was the more notable in Jackson, so that the total in Pike may not have been less than 400 feet. The coal becomes uncertain in occurrence within Pike and runs out within 3 or 4 miles west from the Jackson line, for exposures of its place there show no trace of the coal.*

Professor Andrews states that the conglomerate reaches only into the northwest corner of Scioto county, south from Jackson. There it is 80 feet thick, but followed southward it loses coarseness, though its equiv-

* E. Orton: Vol. v, p. 1009; vol. vi, pp. 615, 631, 632, 635.

alent in shales and sandstones remains; for at 4 or 5 miles south from the southwest corner of Jackson he found the interval from Blue or Lower Mercer limestone to the Logan 194 feet, and a section near by shows the Quakertown and a sub-Sharon coal at 68 and 176 feet below the limestone, with much sandstone in the partially exposed interval above the lower coal. This lower portion is persistent westward to the outcrop, for the "Guinea Fowl" ore at 30 to 40 feet from the bottom persists to the western outcrop in this county, which, however, is much east from the western limit of the basin.

The Franklin, "Main," or "Big Red block" ore, marking the horizon of the Upper Mercer limestone, is present at 105 feet below the Ferriferous limestone, and at 24 feet lower is the "Little Red block" ore representing the Lower Mercer limestone. Professor Andrews reports the lower limestone in Vernon township with a thin coal below it. Professor Orton says that the Tionesta, lying above the Franklin ore, is fairly persistent, but is represented ordinarily only by streaks of coal distributed through 10 to 20 feet of shale, though occasionally it becomes concentrated so as to be of workable thickness.

Doctor White reports a section obtained by himself at Hanging Rock, in the southern part of the county, which must be given without change:

	Feet.	Inches
1. Massive sandstone	40	0
2. Fireclay	5	0
3. Limestone and ore, Upper Mercer	1	0
4. Shales	20	0
5. *Upper Mercer coal bed*	0	4
6. Sandy fireclay, shale, and sandstone	18	0
7. *Lower Mercer coal bed* and clay	3	1
8. Fireclay and shale	5	0
9. Upper Connoquenessing sandstone	30	0
10. Sandy shales and sandstones	15	0
11. *Quakertown coal bed*	2	1
12. Fireclay and sandy shale	20	0
13. Lower Connoquenessing sandstone, massive	25	0
14. Shales	40	0

to which must be added 40 feet to the bottom of the Pottsville, as shown in a well record at Hanging Rock. This is on the Ohio river, several miles below the mouth of the Little Sandy river, in Kentucky. The lower or Sharon sandstone portion of the column has disappeared.

The section exposed in Lawrence county, east from Scioto, extends downward only to the Tionesta, which is known here and in northern Kentucky as the "Hunnewell cannel." An oil-well record at Ironton, on the Ohio, a few miles below Hanging Rock, shows the Quakertown

coal bed, very thin, at 79 feet below the surface, which is very near the level of the Upper Mercer horizon. Below this coal there are only blue shales for 203 feet, with 8 feet of conglomerate at 112 feet and 10 feet of sandstone at 150 feet. Underlying the shales is a mass of sandstone and conglomerate, which Professor Orton was inclined to regard as representing both the Lower Pottsville and the Logan; but in view of the conditions at Hanging Rock and those soon to be mentioned in Kentucky, it is safer to regard the 8 feet of conglomerate as the Sharon sandstone and the bottom of the Pottsville.

Other counties along the Ohio river will be referred to in another connection.*

KENTUCKY

Passing over into Kentucky, one finds the Main or Franklin iron ore, which is at or very near the horizon of the Upper Mercer limestone, persisting in the northern part of the state, where it is from 85 to 100 feet below the Ferriferous limestone, which is traceable for more than half the distance to the Tennessee line. In studying the variations of the Pottsville within Kentucky, it is best to follow the western outcrop, where for the most part one finds the lower part of the section, and afterward to take up the counties eastward to the line of Virginia and West Virginia, in which the upper part of the section is shown, with occasional exposures of the lower part where that has been brought up by folds or faults.

Greenup county adjoins Scioto and Lawrence of Ohio and is north from Carter county. Professor Crandall's generalized section for these counties is as follows, the identifications with Ohio beds being inserted by the writer:

		Feet
1.	*Coal bed 5*	
2.	Homewood sandstone [Homewood]	37
3.	*Coal bed 4* [*Tionesta*]	
4.	Shales and Block ore [Main]	8
5.	Sandstone	29
6.	*Coal bed 3* [Mercer]	
7.	Sandstone [Upper Connoquenessing]	112
8.	*Coal bed 2* [Quakertown]	
9.	Sandstone [Lower Connoquenessing]	35
10.	Shale [Sharon]	40
11.	*Coal bed 1* [*Sharon, Wellston*]	
12.	Shales	33

* E. B. Andrews: On Scioto County, Report for 1870, pp. 163, 166, 167, 168, 173, 175, 176.
E. Orton: Scioto, vol. v, pp. 1040, 1042. Lawrence, vi, p. 305.
I. C. White: Bull. U. S. Geol. Survey, no. 65, p. 193.

	Feet
13. Conglomerate, coarse sandstone [Sharon]	100 to 0
14. Shale and non-plastic clay [Sciotoville]	19
15. *Coal bed* [*Jackson shaft*]	
16. Shale	8

to the Waverly or, where present, to the Lower Carboniferous limestone. The Upper Mercer coal bed appears to be unrepresented, "Coal bed number 3" being clearly the Lower Mercer. It will be referred to in succeeding pages as the Mercer coal bed.

The lowest coal bed, that at the horizon of the Jackson Shaft bed, is of somewhat uncertain occurrence, as the overlying sandstone frequently replaces it as well as a portion of the underlying beds. It is present along the Ohio river at some localities in western Greenup, and is seen occasionally in western Carter. Mr Lesley says that it is exposed frequently in the latter county along streams entering Little Sandy river from the west. Its thickness varies from 1 to 28 inches, and it is seldom of economic importance even locally, though its coal, like that at Jackson, Ohio, is usually of excellent quality. The Sciotoville clay overlying it was seen at many places along the Ohio, and it was observed at localities in western Carter, even to the southwest corner on the Rowan county line.

The interval to the Sharon coal bed above shows extreme variation. The Sharon conglomerate is practically absent in much of northern Greenup or is represented at most by a thin sandstone overlying the Sciotoville clay. Throughout western Greenup it is comparatively thin, seldom more than 30 feet, until toward the southern border, where an exposure shows it 90 feet thick. There is a narrow area in western Carter where this conglomerate seems to be wanting, but in central Carter, the space drained by Tygarts creek and the Little Sandy, it is thick—30 feet in the northern part of the county and increasing to 90 feet or more near the southern border. In like manner it increases westwardly from the area of vacancy, for Lesley found it 150 feet thick in Rowan county west from Carter. Crandall describes this Sharon as a very coarse ferruginous sandstone, with some layers of quartz-pebble conglomerate. It is much cross-bedded and the inclination of this bedding is very uniformly toward the southeast—a condition observed in all exposures across Lawrence county to the West Virginia line.

Beds overlying the Sharon are reached occasionally in the high hills of western Greenup and Carter, especially where that sandstone is very thin, but satisfactory sections for the most part were obtained only eastward from Tygarts creek. In northern Carter the Main Block ore is at

120 and 185 feet above the Quakertown and Sharon coals respectively and 330 feet above the Lower Carboniferous limestone; but in northern Greenup and southwestern Carter, where the Sharon sandstone is absent or very thin, the Sharon coal bed is but 44 to 60 feet above the limestone.

Near the mouth of the Little Sandy river, on the Ohio, the Quakertown coal bed is shown between the Connoquenessing sandstones at 76 feet above the Sharon coal, and at 44 feet below the latter is the Jackson Shaft coal underlying the Sciotoville clay. At a few miles south, on the west side of the river, the section exhibits the Main Block ore, with below it the Mercer coal bed at 35 feet, the Quakertown at 112 feet, and the Sharon at 189 feet, the Quakertown being double, with 8 feet of sandstone and shale between its "splits," so that the interval from the lower split to the Sharon coal is but 65 feet. As the Mercer coal is ordinarily double, Lesley called it the "Twin coal." The Lower Block ore of this region is not the same with that of Ohio, being in the Lower Connoquenessing sandstone. "Coal number 4," of the Kentucky survey, here identified with the Tionesta, is the Hunnewell cannel of Greenup, as was recognized long ago by Professor Orton. It is prominent on several streams entering from the east and is at somewhat less than 100 feet below the Ferriferous limestone and 38 feet above the Mercer coal bed. The Mercer limestones are not in the section, but a thin, blue, silicious limestone is shown in one section of western Greenup at 145 feet above what seems to be the Sharon coal bed, and apparently the same limestone is shown in northern Carter, where the interval is 160 feet.

The interval between the Sharon and Mercer coals in northern Greenup is from 150 to 160 feet, but it increases southwardly, so that in northern Carter it is 180 to 231 feet. In southern Carter the Sharon and Quakertown are 90 feet apart and the latter is cannel. The Mercer is still double and in southern Carter one of the benches is cannel. The Tionesta is easily traced across Carter into Elliott, but it varies greatly in thickness and quality.*

In Elliott county, south from Carter and east from Rowan, the bottom of the Pottsville is reached on some branches of Little Sandy, and beds overlying the Sharon sandstone are shown in the highlands. At localities examined by Professor Crandall, the conglomerate replaces the lower beds and rests on the Lower Carboniferous. Mr Lesley reports the Jack-

*Joseph Lesley: Fourth Report of the Geol. Survey of Kentucky, 1861, pp. 459, 460, 462, 463.

A. R. Crandall: Geol. Survey of Kentucky, Eastern Coal Field, vol. C, 1884, pp. 10, 29, 33, 36, 47, 48, 49, sections 1, 4, 5, 7, 8, 9, 19, 20. Vol. C is a reprint. Professor Crandall's report was published in Reports, new series, vol. ii. The intervals given in the text may not be altogether exact, as they were obtained by measurement of the diagrams. This remark applies to almost all measurements quoted from reports of the new series.

P. N. Moore: Geol. Survey of Kentucky, new series, vol. i, pl. 4, sec. 4.

son Shaft coal bed as present under the conglomerate on some large streams entering from the west. As in Carter, the Sharon is for the most part a coarse sandstone; it increases southward, for its cliffs on Little Sandy become 175 feet high, while above it is shaly sandstone passing into shale, in all 75 feet, on which rests the Sharon coal bed. How much of this upper rock should be regarded as Sharon is difficult to determine, but farther south it appears to be wholly separate and to have been deposited on an irregular surface of Sharon sandstone. The Sharon shale contains calcareous concretions already recognized at this horizon in Greenup and Carter, which characterize these shales in Lawrence county east from Carter, as well as in counties south from Elliott. The Quakertown coal bed, about 75 feet above the Sharon, retains its cannel in Elliott as it does southward and eastward in Morgan, Johnson, and other counties. The Mercer, at 163 feet above the Quakertown, or 240 feet above the Sharon, is an important bed and is mined at many places on the east side of the county, but on the westerly side it is broken by many partings and is less valuable. The Tionesta (Hunnewell) is very irregular, but is still the "upper cannel."*

Morgan county is south of Elliott and Rowan, with Menifee at the west. In its western portion the coal of the Jackson Shaft (?) horizon was mined by stripping many years ago and was highly prized for blacksmiths' use; it varied from 6 to 12 inches. Lesley found the Sharon sandstone 140 feet thick, with the Sharon coal bed above it. Professor Crandall says that the Sharon coal bed in northwestern Morgan is at about 50 feet above the Sharon sandstone, and the overlying shales contain calcareous bands and limestone concretions. Here, however, somewhat similar concretions, but much more sandy than those below, are associated with the Quakertown bed. The higher coal beds will be described in connection with the eastern counties. Professor Crandall gives the thickness of the sub-Sharon shales as from 10 to 50 feet and calls attention to cross-bedding of the sandstone.†

Menifee county is west from Morgan, southwest from Rowan. The section does not reach to the Sharon coal bed. In the southern portion, near the border of the basin, the Sharon sandstone becomes 200 feet thick and passes upward into a shaly sandstone as in Elliott. The underlying shale increases from 15 feet in the northern part of the county to 125 feet in the southern. The non-plastic Sciotoville clay is present, but its place was not ascertained, as only loose fragments were

*Jos. Lesley: Fourth Report, pp. 462, 463.
A. R. Crandall: Geology of Elliott County, 1887 (?), pp. 6, 13-16.
†Jos. Lesley: Fourth Report, pp. 463, 465-466.
A. R. Crandall: Vol. vi, new series, p. 11, sec. 2.

seen on the surface. Where the shales are thickest they hold coal beds at 5, 55, 85, and 110 feet above the Lower Carboniferous limestone, the second bed being cannel. This great thickness continues southward into Powell county, where 100 feet are exposed on Indian creek.*

The Sharon sandstone is 175 feet thick in Bath county, northwest from Menifee. It is a coarse sandstone with some conglomerate cemented by iron ore. At the localities examined by Mr Linney the sub-Sharon shales are wanting, replaced by the sandstone which rests on the Lower Carboniferous; but Mr Lesley in crossing the southeast portion of the county found the shales 85 feet thick and underlying 100 feet of sandstone. Two coal beds were seen by him at 15 and 27 feet above the limestone.† The shales are thinner in eastern Montgomery, which is west from Menifee, for there Lesley found but 40 feet, with a coal bed at 4 feet above the limestone. The shales are thicker in Powell, south from Montgomery, for there they are 75 feet, while the Sharon sandstone has increased to 196 feet. In Estill county, south from Powell, the Sharon is 235 feet thick near the old furnace in the northern part of the county, where it rests on sandy shales and thin bedded sandstones with a thick fireclay at the bottom, below which is a coal bed associated with the iron ore of the Lower Carboniferous limestone.‡

Wolfe county is between Morgan at the northeast and Powell and Estill at the west. Mr Hodge describes the Sharon as consisting of two benches of sandstone containing quartz pebbles in greater or less profusion, separated by a shale deposit, the thickness of the whole approximating 200 feet. Underlying this is a mass of shale, 100 feet thick in the northwest, but thinning rapidly southward and eastward to 50 feet. The upper bench of the Sharon sandstone contains a great abundance of quartz pebbles, whereas the lower bench contains comparatively few. The pebbles diminish in quantity eastwardly on the north fork of the Kentucky river, so that where the rock is shown in Breathitt, east from Wolfe, it is almost free from them. The upper surface is very irregular and the overlying shales and sandstones filling the irregularities are of correspondingly variable thickness, so that the Sharon coal bed at times rests almost directly on the sandstone, while at a comparatively short distance it is separated from it by an interval of almost 100 feet. A section in western Wolfe on the Powell border shows

	Feet.	Inches
1. Shale	150	0
2. Conglomerate	115	0

*A. R. Crandall: Vol. iv, new series, pp. 174, 177.

†Jos. Lesley: Fourth Report, p. 466.
W. M. Linney: Geology of Bath County (1886?), pp. 35, 36.

‡Jos. Lesley: Fourth Report, pp. 468, 469, 471, 530, 531.

	Feet.	Inches
3. Shale and clay with *coal* 5 inches	10	0
4. Conglomerate and shale	75	0
5. Shales	50	0
6. *Coal bed*	0	3
7. Shales	15	0
8. *Coal bed*	1	0
9. Shales	35	0
10. *Coal bed*		

to the Lower Carboniferous limestone. A coal bed is seen in the shales separating the plates of the conglomerate; another was found farther south in Clay county within 60 feet of the top of the conglomerate. These coals foreshadow the condition farther south, where coal beds within the Sharon sandstone become important. Mr Hodge finds two streaks of impure limestone here, one in Number 5 and another about 100 feet lower.*

Jackson and Rockcastle counties are in order southwest from Estill. The section evidently reaches only to the shaly sandstone overlying the Sharon sandstone. Mr Sullivan finds 8 coal beds in this lower portion of the Pottsville, which farther south has been designated the "Rockcastle group" by Professor Crandall; these are at 30, 45, 50–65, 75–95, 120–150, 185–200, and 225 feet above the Lower Carboniferous limestone, nearly all of which attain some importance locally. The main bed is that at about 60 feet as described by him and Mr Lesley. The whole thickness of this Rockcastle group is not far from 300 feet, the top portion being the coarse upper plate, evidently its upper portion, and the highest coal is very near the place of that observed by Mr Hodge in Clay county.

The increasing coarseness of the lower members of this Rockcastle group has become very distinct here. Mr Sullivan speaks of the coals as "interconglomerate," for in the intervals separating them are ledges of sandstone consisting largely of "hailstone grit." The important bed at about 60 feet above the limestone rests on a thick conglomerate ledge. The subconglomerate shales of more northern counties become replaced by sandstones near the border. The westward thinning of the measures observed in passing from Menifee into Montgomery is more sharply marked in Rockcastle, where the beds have spread apparently almost to the original border. Mr Sullivan says that in this county the thickness of the group varies from 45 to 250 feet. Mr Lesley gives the matter more in detail, for he says that the upper plate, 80 feet thick in southeast Rockcastle, is insignificant in the northwestern part of the county,

*G. M. Hodge: Preliminary Reports on the Southeast Kentucky Coal Field, 1887, pp. 95, 108, 109, sec. 92.

while the lower portion decreases with equal rapidity, so that the whole thickness, 300 feet at the southeast, becomes, in successive measurements, 240, 102, and finally only 40 feet on the western border. Southeastward from Rockcastle it shows increase in Pulaski, and thence until the maximum is reached in Pine mountain of Bell and Whitely counties.*

In Laurel county, south from Jackson, the Rockcastle group is shown with greatly increased thickness on a branch of the Cumberland river, but no information respecting this county is available beyond the statements that in northern Laurel, near Pittsburg, a boring found ten coal beds below the Laurel (Sharon) coal bed, and another near the Cumberland river found eight, all of them belonging to this group. In Pulaski, which is south from Rockcastle and west from Laurel, the rocks are shown at many places, especially in the eastern half of the county. In the western part Mr Lesley found the thickness, as in Rockcastle, not far from 300 feet and diminishing westwardly. The upper plate is about 80 feet, where thickest; in the lower portion, with an extreme thickness of 200 feet, he finds five beds of coal at 27, 80–93, 125, 150, and 175 feet, the last underlying the 80-foot ledge of conglomerate, a persistent coal-bearing horizon from its first appearance in Clay county for a long distance southward. He finds these five beds present in Wayne county southwest of Pulaski and extending to the Tennessee line. Clinton is west from Wayne along the Tennessee line and contains the most westerly fragments of the formation. Professor Loughridge's section gives the structure at a locality near the last western exposure:

	Feet
1. Conglomerate	30
2. Micaceous sandstone	42
3. *Coal bed* and fireclay	3 to 4
4. Shaly sandstone	140
5. Sandstone	60

an extreme thickness of about 275 feet and the rocks almost wholly sandstone. A thin coal bed was found resting on the lowest sandstone, so that here there remain the two persistent beds. The distinction between Sharon sandstones and sub-Sharon shales has disappeared. It is evident from the thickness of the mass that the shoreline must have been turned sharply westward as it passed beyond the area of Rockcastle county.†

*Jos. Lesley: Fourth Report, pp. 480, 482.
G. M. Sullivan: Geology of Parts of Jackson and Rockcastle Counties, 1891, pp. 7, 15, 18.
†Jos. Lesley: Fourth Report, pp. 484, 485, 486, 488, 490.
R. H. Loughridge: Geology of Clinton County, 1890, pp. 24, 25.
C. J. Norwood: Tenth Annual Report of Inspector of Mines, 1894, p. 129.

Mr Campbell's studies in Pulaski, Rockcastle, and Jackson counties add to the knowledge of the Kentucky conditions and make easy the carrying of the section into Tennessee.

His Lee formation as defined in this area is evidently coextensive with the Rockcastle group of Professor Crandall, and is from 250 to perhaps 1,000 feet thick, thickening southward from Jackson into Pulaski. It consists of sandstones and sandy shales, including two conglomerates, the Corbin above and the Rockcastle below.

The Corbin, evidently the coarse upper plate of Lesley and equivalent in part to the upper bench of Mr Hodge, varies from conglomerate to coarse sandstone. It is unimportant in Jackson county, but thickens southward so as to be 200 feet in Pulaski, beyond which it continues with lessening thickness into Tennessee, where it becomes unimportant at 40 or 50 miles from the state line. The Rockcastle is at the bottom of the formation and varies in thickness from 0 to 150 feet. It occupies a pre-Pottsville valley, eroded deeply in Lower Carboniferous beds, and becomes prominent midway in Rockcastle county, whence northward it was followed to the final outcrop in Jackson county. This valley is perhaps 4 miles wide and the deposit, usually a coarse conglomerate, thins out on each side. This lower conglomerate in some part is doubtless equivalent to the lower conglomerate bench reported by Mr Sullivan.

The shales and sandstones overlying this Lee formation are termed Breathitt by Mr Campbell, and, so far as preserved in this area, are about 500 feet thick. Near the bottom is the important bed in Laurel county already referred to, which is apparently the Sharon or at very near its horizon. Mr Campbell refers to a coal bed underlying the Rockcastle conglomerate.*

Returning to the north, Lee county is south from Wolfe and east from Estill. Here Lesley finds the sub-Sharon deposits 296 feet thick at Proctor, while farther north the thickness is 195, decreasing northwest to about 100 feet in southern Powell, and finally in northern Menifee to 15 feet. There are five beds of coal in Lee county, at 5, 106, 122, 157, and 301 feet above the limestone, the highest being directly under the great sandstone cliff. The rocks vary much, but sandstones prevail in sone of the sections. Mr Lesley calls attention to the fact that the sandstone diminishes southwardly from 200 feet in Menifee county to 82 feet in Clay, and evidently thinks that the lower portion is replaced by shale, thus explaining the thickening of the sub-Sharon. But Professor Crandall notes that in Menifee, where the sandstone mass is thickest, the underlying shales attain their greatest thickness for the region. Mr

*M. R. Campbell: U. S. Geol. Survey Folios. London, 1898; Richmond, 1898.

Hodge's section in Wolfe seems to make the matter clear, for from that county southward the sandstone is divided and new shales and new coals come into the section, which were unknown farther north. Mr Lesley's notes show also that even at a considerable distance eastward in the basin coarse materials prevail in the lower part of the section.*

The geology of eastern Pulaski is described by Professor Crandall in connection with that of Whitely, which is east from Pulaski and south from Laurel. The Sharon appears to be at very nearly the top of the section in eastern Pulaski. In eastern Pulaski the section reaches to but a little distance above the Sharon sandstone, which with the underlying beds is well shown in that county, as well as in western Whitely and along a branch of the Cumberland river in Laurel. Within this area the section assumes such importance that Professor Crandall terms it the Rockcastle group.

The upper plate of the Rockcastle group, the "Corbin lentil" of Mr Campbell, is from 100 to 200 feet thick, and the rocks between the coal beds are mostly coarse sandstones containing layers of quartz pebble conglomerate; but evidently the rock is less coarse in the bottom 150 feet. The lowest coal bed rests on the Lower Carboniferous limestone or is separated from it at most by only a few feet of shale. The other coal beds are approximately at 50–60, 90, 130, 240, and 310 feet above the limestone. The second, third, and sixth beds, known as the Bryvan, Main, and Barren Fork coals, are of great economic importance and mark horizons which show coal in nearly all of the sections for fully 100 miles northward. The other beds become locally valuable. The third bed is mined in Pulaski, Wayne, Whitely, and Laurel counties. It is the "Main" coal of the Cumberland and Rockcastle River region, and it was the important bed almost 50 years ago, when Mr Lesley made his study. The bed is usually double, with splint coal in one or the other bench and varies in thickness from 4 feet 4 inches to 4 feet 6 inches. The upper workable bed is usually in three benches with a total thickness of about 4 feet.†

The variations of the Rockcastle or lower portion of the Pottsville have been followed along the border from the Ohio river to the Tennessee line. On the Ohio river, where the most westerly exposure is considerably east from the line of Pike county, Ohio, the thickness is only a few feet; away from the river the Sharon sandstone reappears above the Sciotoville clay and thickens towards the south and southwest, while underneath these appears the shaly portion, which is prac-

*Jos. Lesley: Fourth Report, pp. 475-477.
A. R. Crandall: Menifee County, p. 11.
†A. R. Crandall: Geology of Whitely and part of Pulaski, pp. 15, 16, 18, 20, 21.

tically unrepresented north from Scioto county in Ohio. We have seen the Sharon sandstone dividing into a coarse upper plate and less coarse lower plate, separated by coal-bearing shale, while farther south the upper plate undergoes further subdivision; but we have seen, following the mass southward, that instead of thinning, as at the north, toward the central line of the basin, it thickens in that direction, meanwhile growing coarser, so that near the Tennessee line it is a mass of sandstones separated by coal bearing shales in all not less than 450 feet thick and possibly much more.

We have seen also the coal horizon of the Jackson Shaft bed remaining comparatively unimportant until Menifee county was reached; but there the sub-Sharon shales expand and new coal horizons are shown, while farther south coal beds make their appearance in the Sharon sandstone itself, occupying places such as do the coal blossoms spoken of as occurring within northwestern Jackson county of Ohio. One is led to suggest that these may represent periods when isolated marshes along the western shore of the basin were filling with coal deposits; so that while those deposits were not continuous they may have been practically synchronous. In southern Kentucky favorable conditions lasted long enough for the accumulation of important beds, as was the case also in Tennessee.

Before studying the section above the Sharon sandstone in southeastern Kentucky, where it has been described so well by Professor Crandall, it is well to return to the north, in order to take up counties east from those already examined, that the section may be carried southward with certainty, for variations occur in the Upper Pottsville very similar to those already observed in the Lower. At the same time the variations of the Lower Pottsville will be considered as they are shown by sections obtained where that portion of the series has been brought up by faults or folds.

The Sharon, Quakertown, Mercer, and Tionesta coal beds have been followed across Greenup, Carter, and Elliott counties into Morgan, where the succession is clear.

The whole of the Pottsville is below drainage in Boyd county, lying between Greenup and the West Virginia line, as well as in much of Lawrence south from Boyd; but in western Lawrence the succession is very clear over to Blaine creek, for an anticline rising in central Lawrence and passing southwest into Johnson county brings up the Sharon sandstone in deep valleys of both counties.

The Ferriferous limestone is the lowest bed exposed on Dry fork of Little Sandy, in the southeast corner of Carter county; but thence the

rocks rise toward the southeast, so that at the head of Dry fork that limestone is shown high up in the hills, with the Sharon coal bed at 280 feet below, while in a hill near by the Mercer is mined at 180 feet above the Sharon. Passing over to Big Blaine creek, which drains north Johnson and flows northwest across Lawrence to the Big Sandy river, one finds the Sharon sandstone along the forks in both counties. At the head of Blaine the Ferriferous limestone is 95 feet above the Mercer, which is 100 feet above the Quakertown. The intervals diminish in this direction, for in southern Carter that from the Ferriferous to the Sharon coal bed is 317 feet. In northwest Lawrence it is 280 feet, while on Irish creek of Blaine it is only 240 feet. The Mercer, Quakertown, and Sharon are all shown on Irish creek, where the intervals are 88 and 55 feet, and the Connoquenessing sandstones are well defined. In the southern part of the county the Mercer is 150 feet above the Sharon, which is separated from the Sharon sandstone by about 50 feet of shale.*

Passing into Morgan county, one finds in the northwest portion a section very similar to that of Elliott, but in the easterly and southern parts the section above the Sharon sandstone changes. In Greenup the Quakertown coal bed showed a tendency to divide, and at a number of localities a small bed was seen above Coal bed number 2, which Professor Crandall designated as "Number 2 A." This tendency is more marked in Carter and in the southern part of that county, where the interval between Mercer and Sharon has increased to 200 feet. The upper split of the Quakertown is at somewhat more than 75 feet below the Mercer. The section of western Carter prevails in Elliott and western Morgan, where the Quakertown is single; but in eastern Morgan the conditions observed in eastern Carter prevail, and the Quakertown splits are shown with increased interval. Not infrequently a thin coal bed appears underlying the Lower Connoquenessing sandstone, and several sections show a thin bed below the Sharon, resting directly on the Sharon sandstone.

In northwest Morgan the Sharon coal bed is from 40 to 60 feet above the Sharon sandstone, and the Quakertown at about 60 feet higher, while the little bed above the Sharon is 18 inches thick and 20 feet above the Sharon coal bed.

The Sharon coal bed is exposed in many places within western Morgan, where it appears to be thin, though occasionally reaching 3 feet. It is accompanied everywhere by the characteristic limestone bands and concretions, which are especially abundant in the underlying shales, though occasionally seen in those above; but the higher concretions in

*A. R. Crandall: Geology of Greenup, etcetera, pp. 51, 64, 65, secs. 47, 73, 76, 81.

the overlying shales, reaching in some cases even to the Quakertown coal bed, are arenaceous limestone and in contrast with those in the underlying shales. The coal bed is below drainage in most of eastern Morgan and in most of Magoffin (south and east of Morgan), but the reversal of dip brings it to the surface and eventually far above drainage; so that the Sharon sandstone and the underlying shales are shown in western Johnson, the former being 100 feet thick and overlying a 20-inch coal bed. The Sharon sandstone shows its characteristic cross-bedding. The Sharon coal bed in Johnson and Floyd (southeast from Johnson) is from 50 to 60 feet above the sandstone, from 2 to 5 feet thick, and yields at most mines a coal of remarkable excellence. At one locality on Levisa fork of Big Sandy in eastern Johnson a thin cannel was seen at 50 feet below the Sharon bed. Mr Lyon found the same bed in southwest Johnson at about 70 feet below the Sharon and resting on sandy shales. He noted there the limestone concretions below the Sharon coal bed, which he finds characteristic of the horizon all the way to the Big Sandy river at the West Virginia line.

The relation of the Sharon coal bed to the upper beds is shown in a section obtained by Professor Crandall in the southern part of Morgan, near the line of Wolfe county, which shows the Carter County conditions and prepares one for those seen in Wolfe and other counties at the south and east:

	Feet.	Inches
1. Sandstone, shale and shaly sandstone	30	0
2. Concealed	50	0
3. *Cannel, number 4* [*Tionesta*]	1 to 2	0
4. Sandstone and shale, imp. exp	42	0
5. *Coal bed number 3* [*Mercer*]		
5. Concealed	23	0
7. Sandstone	18	0
8. Concealed	20	0
9. Sandstone	20	0
10. Shale	5	0
11. *Coal bed 2A*, of which the *cannel* is 2 feet	4	7
12. Imperfectly exposed	50	0
13. *Coal bed number 2*, with *cannel* 2 feet	4	11
14. Sandstone and shale	68	0
15. *Coal bed number 1* [Sharon] in bed of creek		

The Ferriferous limestone, if present, should be in the hilltop, where fragments of iron ore are found, but apparently the limestone was not seen by Professor Crandall southward beyond the middle of the county, to which he had followed it from the Ohio river across Greenup, Carter, and Elliott counties. The Mercer coal bed is approximately 125 feet below it at this place. The interval between the Sharon and Mercer bed,

213 feet, is very nearly the same as in southern Carter, where the Quakertown beds are shown.

The shales overlying the Sharon sandstone, with their characteristic concretions, are shown along the branches of Licking river in southern Magoffin county, but Professor Crandall gives few detailed statements respecting the relations of the higher beds. The Sharon sandstone is exposed in Johnson county along Paint creek in the central portion, as well as along the forks of Blaine creek in the northern portion. The splits of the Quakertown persist in the sections of Johnson and Floyd counties, but the lower appears to be the more regular. In most of Carter, as well as Lawrence, the Quakertown is a bituminous coal, but in southern Carter it becomes cannel and continues as such into Morgan, and thence into several of the eastern and southern counties.

The Mercer coal bed in Johnson, Floyd, and Martin counties is broken by numerous partings and at times attains the thickness of 10 feet, including the partings. The Tionesta changes into splint toward the east, but the Quakertown remains cannel. The section on the border of Johnson, Floyd, and Martin counties, as compiled by Professor Crandall, is

	Feet.	Inches
1. Sandstone	30	0
2. Cannel		
3. Sandstone, etcetera	187	0
4. *Coal bed*	6	0
5. Clay, sandstone, and iron ore	46	0
6. *Coal bed*	1	6
7. Sandstone and shale	25	0
8. *Coal bed* with partings, *number 3*	10	0
9. Interval	88	0
10. *Cannel number 2A* (?)		
11. Shale and sandstone	50	0
12. *Coal bed number 2*	2	0
13. Interval	63	0
14. *Coal bed number 1*	3	8
15. Shale and sandstone	15	0

As this is a compiled section, the intervals are not exact for any one locality.

The Sharon is the Prestonburg bed of Floyd county, where a thin coal bed is present at 20 feet below it. This thin bed was seen at Paintsville at 35 feet, and the Sharon sandstone is above drainage at that place. The same bed is present elsewhere in Johnson county at varying distances below the Sharon bed.*

Mr Lyon ran a line of sections across Estill, Wolfe, Magoffin, Johnson,

*A. R. Crandall: Geology of Morgan, Johnson, Magoffin, and Floyd Counties, new series, vol. vi, pp. 323, 325, 326, 330, 334, secs. 2, 4, 6, 17, 18, 20.

and Martin counties to the Tug fork of Big Sandy river at the West Virginia line. He followed the Sharon sandstone, with its underlying coal bed, into Wolfe county, where he found a coal bed, the Sharon, at 80 feet above it, the interval being filled with shale. On Stillwater creek, in Wolfe, he gives a section showing the Sharon at 61 feet below the Quakertown, and there he first saw the concretions in the shale, which he describes as occurring sometimes in almost continuous beds, while at others they are separated masses weighing tons. These he found thoroughly characteristic of the horizon from this locality to the Tug fork of Sandy river. The Quakertown coal bed, though only 2 feet thick, is triple. Eastward its partings thicken, so that at 5 miles away the thickness is somewhat more than 11 feet. A similar structure was observed in southwest Magoffin, but farther east the bed becomes shaly and the interval to the Sharon coal bed diminishes, becoming 49 feet in central and 16 feet in east Magoffin, where the upper bed is represented by 17 feet of bituminous shale. On the border between Magoffin and Johnson the interval is but "a few feet." Eastwardly they diverge, and the Quakertown, which had been merely a mass of bituminous shale, again carries coal. The higher beds are not shown in Mr Lyon's Magoffin sections, but they are present farther north in the region studied by Professor Crandall. The shales underlying the Sharon coal bed and carrying the calcareous concretions are so well marked on Licking river of Magoffin that Mr Lyon terms them the "Licking shales," and he states that they are reached in all the deeper valleys for 13 miles eastward, where, though sometimes showing more or less of sandstone, they retain all their characteristics. At one locality on the river he found a thin coal bed in these shales at 71 feet below the Sharon.

In Johnson county the Quakertown is 61 feet above the Sharon and both are thin. The "Licking shales" increase in thickness and eventually become 150 feet, foreshadowing the still greater increase within the counties farther south along the Virginia line. For a few miles the Sharon coal bed is below drainage, though the Quakertown appears in all the sections; but it is reached again on Little Paint creek near the Levisa fork of Big Sandy river, where it is 34 feet below the lower split of the Quakertown and overlies 28 feet of shale carrying the characteristic calcareous bands and concretions. Higher beds are reached on Johns creek, east from Levisa fork, for there the section is

			Feet.	Inches
1. Sandstone and shales			34	0
2. *Coal bed*			6	6
Coal	2	4		
Clay	0	4		
Bituminous shale	1	10		
Coal	2	0		

	Feet.	Inches
3. Clay and sandy shale	19	0
4. *Coal bed*	0	8
5. Sandstone and shale, imperfect exposure	185	0
6. *Coal bed*		

Number 2, the Mercer coal bed, yields only bituminous coal. The interval to the Sharon, 204 feet, may be slightly too small, as the dip was ignored in the measurement. Lyon assigns certain coals in the neighborhood to 69 and 105 feet above the Sharon. The lower bed, approximately 140 feet below the Mercer, is reached in all the deeper valleys from Levisa fork to the state line, and the Mercer is frequently exposed.

Just east from the Levisa fork, Mr Lyon saw a quartz-pebble conglomerate at 540 feet above a coal which he took to be his "Adamsville" bed, the Sharon, but which better exposures eastward show to be the lowest bed, almost 100 feet below the Sharon. This conglomerate on Stonecoal branch of Rockcastle creek, in Martin county, is 100 feet thick and 244 feet above the Mercer coal bed, which is 10 feet 5 inches thick, with a 5 inch parting at 3 feet from the bottom. Near this locality coal beds were seen at 30 and 56 feet above the Mercer, which are present in Professor Crandall's section, and in addition a cannel underlies the conglomerate, according to both observers.

The section was followed to the Tug fork of Big Sandy river by Mr Lyon, the valleys being sometimes much deeper than enough to expose the Sharon coal bed, which Mr Lyon had followed for many miles under the names of the "Adamsville" or "A. J. Rice" coal. He finds this coal bed about 40 feet above the Tug fork at Warfield, with the underlying Licking shales carrying the characteristic concretions and bands so often referred to by him and Professor Crandall. On his return westward from the Tug fork, he followed the Licking shales to Paintsville in Johnson county, where the Sharon sandstone is above drainage.

Doctor White has given a section obtained at Warfield as follows:

	Feet.	Inches
1. Sandstone and shale	150	0
2. *Coal bed*	15	9
3. Concealed and sandstone	25	0
4. Silicious limestone	4	0
5. Shale and concealed	30	0
6. *Cannel*	2	0
7. Sandstone and concealed	30	0
8. Silicious limestone	1	0
9. Sandstone and concealed	20	0
10. *Coal bed*		
11. Concealed and sandstone	65	0

	Feet.	Inches
12. Silicious limestone	2	0
13. Massive sandstone	20	0
14. Shale and *coal*	0	7
15. Sandstone and shale	40	0
16. Massive sandstone	10	0
17. *Coal*	5	2
18. Concealed and sandstone	45	0
19. Silicious limestone	2	0
20. In boring	320	0

Number 17 is the Warfield coal bed. The interval to number 2 is 249 feet, about 40 feet more than at the west side of Martin county, showing that here is the increasing thickness of the section which becomes so marked in West Virginia. The Warfield coal bed, as will be seen, is the same with the Campbells Creek coal bed of the Kanawha valley, where one finds associated with it the limestone bands and lenticular masses such as characterize the horizon throughout a great part of Kentucky. A well record obtained in Mingo county of West Virginia, opposite Warfield, shows a coal bed, reported as 5 feet, at somewhat more than 100 feet below the Warfield coal bed, which is evidently the little bed observed in so many places by Lyon and Crandall. This record shows also a great change in the upper portion of the Rockcastle, for in 320 feet below this coal bed only two beds of sandstone appear, 18 and 20 feet thick. Below this for nearly 400 feet, sandstone predominates, but no trace of coal appears in the record.

Doctor White gives a section near Peach Orchard, in Lawrence county which is very similar to that at Warfield. The "Peach Orchard coal bed" is at 267 feet above the Warfield, the increase being very largely in the interval answering to numbers 3, 4, and 5 of the Warfield section. This Peach Orchard coal bed is regarded by Professor Crandall as the Coal 3 of the Kentucky section, and at Peach Orchard it is about 420 feet below the first Fossiliferous limestone. At Peach Orchard, as at Warfield, a sandstone overlies this coal bed which is very suggestive of that underlying Coal 4 in counties farther south.

The conglomerate at 250 feet above the Mercer coal bed is widespread through Johnson and Martin counties. It is somewhat more than 450 feet above the Sharon and immediately overlies a bed of cannel. Mr Lyon is inclined to identify it with the conglomerate which in so many places within Greenup and Carter counties overlies the Ferriferous limestone. The intervals have been increasing across the intervening counties, so that there is a probability that Mr Lyon's suggestion is a true one; but sections fail in Lawrence and much of Johnson, so the

junction can not be made. The conglomerate appears to follow the Ferriferous along the western edge of the basin.*

The effort now is to trace the section through the more southerly counties of Kentucky, where the section begins to show extreme variation—a fact of some interest in view of the other fact that along the western border in this region the Rockcastle group begins to assume the proportions so notable farther south.

The Kentucky river is formed in Lee county by the union of three forks; the South fork, rising in western Bell county, flows northward through Clay and Owsley to Lee, which is south from Wolfe and east from Estill; the Middle fork, rising in Leslie, east from Clay, flows northward through Leslie, Perry, and Breathitt into Lee, while the North fork, rising in Letcher, flows through Letcher, Perry, and Breathitt into Lee and receives tributaries also from Wolfe. This region was studied by Mr Hodge.

Mr Hodge remarks that a noteworthy change in composition of the rocks takes place beyond a line extending across northwest Breathitt, southeast Owsley, and northern Clay. Up to this line from the northwest, the rocks above the Sharon sandstone are largely shale, but thence southeastwardly the shales are replaced in great part by sandstone and the measures thicken rapidly.

In central Wolfe county, at some distance south from Mr Lyon's line, Mr Hodge finds this succession, the identifications being by the writer:

		Feet
1.	*Coal bed* [Tionesta]	
2.	Interval	37
3.	*Coal bed* [Mercer]	
4.	Interval	50
5.	*Coal bed* [2A, Upper Quakertown]	
6.	Interval	62
7.	*Coal* and black shale [Quakertown]	
8.	Interval	35
9.	*Cannel* [1A]	
10.	Calcareous shales	27
11.	*Coal bed* [Sharon]	

Mr Hodge regards numbers 3, 7, and 11 as coal beds 3, 2, and 1 of the Kentucky series. Number 9 is the little coal bed seen at so many places between the Quakertown and the Sharon, and number 5 is evidently the same with the upper split of the Quakertown, which has been followed

*S. S. Lyon: Vol. iv (old series), pp. 534, 535, 536, 538, 542, 543, 589, 591, 593.
I. C. White: Bull. U. S. Geol. Survey, no. 65, p. 146. West Virginia Geol. Survey, vol. i, 1899, p. 276.
A. R. Crandall: Geology of Greenup, etc., sec. 87.

from southern Carter county. On Frozen creek, in northwest Breathitt, the Ferriferous limestone is shown at 200 to 220 feet above the Mercer coal bed (3), while an impure limestone, very thin, appears at 15 feet above the Mercer coal bed, and the Tionesta coal bed is shown at 32 feet higher. A coal bed is shown here at 66 feet above the Tionesta, not belonging to the Pottsville, but useful in carrying the section. This locality is 12 miles southeast from that of the Wolfe County section, and all of the intervals between the coal beds show a marked increase.

In this upper Kentucky River region Mr Hodge recognizes four persistent beds within the interval taken in this paper to represent the Upper Pottsville. These are numbered by him 1, 2, 3, and 4. The intervals vary as follows:

I. Between 4 and 3:
   50 feet in Wolfe county; 65 feet in northwest Breathitt; 140 feet in central Breathitt; 110 feet in northern Perry and northern Leslie; 205 feet at the border of Leslie and Harlan near Pine mountain.
II. Between 3 and 2:
   112 feet in central Wolfe; 132 feet in northwest Breathitt and northern Leslie.

The interval between 1 and 3 varies from 130 feet in Wolfe to 360 feet in Clay county.

Coal bed number 4 is the Hunnewell cannel of the more northern counties, the Tionesta of Pennsylvania and Ohio. Though occasionally cannel, as in the counties previously studied, it is more commonly splint coal. It is the most characteristic and persistent bed of the series, and it has been identified in most of the sections; so that it was used by Mr Hodge as the key-bed throughout. Overlying it at many places along the Middle and North forks is another bed, sometimes in actual contact, but at others as much as 30 feet above it. Still another probable split was seen, which, being distinctly separate at one locality, was numbered 4 B. These three beds must be considered as one bed on the North and Middle forks, though they become sufficiently distinct and widely separated in Clay county. This coal bed is the notable bed of Breathitt county, where it shows from 3 to 8 feet of cannel on the North fork; but in Perry it is much broken by partings, though usually of workable thickness. It is variable in Leslie county, but remains important even to the Pine Mountain region, in the southern part of the county.

The Mercer coal bed 3, which has been followed across Knott county and identified with the "Elkhorn coal bed" of the Pike County region, is important in Wolfe county, though divided by clay partings 2 to 13

inches thick. It varies abruptly in Breathitt, being sometimes a solid bed, but within a short distance becoming badly broken by partings. At one locality the bed is solid, yet within a mile it is represented by three beds, 6, 24, and 21 inches thick, respectively, and separated by 20 and 10 feet of shale. On another stream in the vicinity the three splits are shown in a vertical space of 50 feet. The same peculiarities are exhibited in Perry county. The bed is broken badly by partings in Leslie county near the Perry line, but within 5 miles southward it shows 3 to 4 feet of coal with partings in all of not more than 2 inches. These abrupt variations are characteristic of the bed in the northern counties. The coal in the several benches varies from bituminous to splint and even to cannel. Associated with this bed is number 3 A, which in Breathitt is 30 feet above the Mercer; but the interval increases southward, becoming 50 feet in northern Leslie and 85 feet on the Harlan border. It is unimportant on the north and middle forks, but appears to be fairly persistent.

The Quakertown is of little importance and usually gives only bituminous coal; but it is opened at many places in northwest Breathitt, northern Leslie, and northwest Perry. The coal bed, number 2 A of the northern counties, is insignificant. It was seen in Wolfe and Breathitt wherever its horizon is exposed, but everywhere it is very thin. The Sharon coal bed is shown in Wolfe and Breathitt, very variable, but yielding good coal where thick enough to be worked. A thin cannel, not more than 4 inches thick, is present sometimes at 30 feet, more or less, above it.

The interval from the Sharon coal bed to the Conglomerate is given by Mr. Hodge as about 10 feet—very much less than is given by other observers; but he states distinctly that he uses the term "Conglomerate" as a formation name and without reference to constitution, so that the difference is apparent, not real. Mr Moore gives the interval as 50 feet, evidently, like Lesley and Crandall, taking the massive sandstone as the top of the Conglomerate; but the interval shows remarkable variation, for Mr Hodge says that within short distances it may vary from practically nothing to 100 feet. It should be noted here that in Mr Hodge's sections along the North and Middle forks there is an "Upper Splint bed," his number 5; the interval to the Tionesta or Lower Splint being from 90 to 125 feet, the latter being at the south near Pine mountain, though even there it is at times only 90 feet. This bed, however, belongs to the Allegheny formation.

The line of change from shale to sandstone in the Upper Pottsville crosses northern Clay county, and with that change the intervals increase rapidly. No sections are available for Owsley county, lying

between Lee and Clay, so that the sections in the last county appear to be in strange contrast with those of Wolfe and Breathitt. In northwest Clay the intervals are apparently not much greater than in northwest Breathitt, but as the beds are followed southeastwardly one soon finds the Sharon at 100 to 125 feet below the Quakertown and 250 feet below the Mercer. Coal bed 3A, which on the other forks of Kentucky river is simply a rider bed to the Mercer (3), becomes widely separated, until in southern Clay it is 125 feet above, while in the same neighborhood the Tionesta (4) is 425 feet above the Sharon (1). The thickening involves the higher measures also. In Wolfe county the ferriferous limestone is only 120 feet above the Tionesta, in Breathitt the interval is 130 to 150 feet, and in Clay it finally becomes 200 feet. In almost every section where the exposure is complete a coal bed, usually cannel, is shown at from 30 to 40 feet below the limestone. The splits from the Tionesta, 4A and 4B, become distinct beds in Clay, the interval to the latter being fully 100 feet in southern Clay.

Underneath the Tionesta, the Lower Splint, one finds a sandstone except in northwestern Clay and apparently in Wolfe. This thickens southward, becoming 80 and even 115 feet. In the northerly sections it is referred to as "mainly sandstone," but evidently it becomes more massive southward, so that on the border of Bell and Harlan counties it appears from the sections to be almost wholly sandstone. In sections within Clay, Bell, Perry, and Leslie counties, exposing the bottom of the sandstone, a thin coal is shown at never more than 5 or 10 feet below it.*

Professor Crandall made a preliminary study of Pike, Letcher, Harlan, and Bell counties, the eastern tier along the line of Virginia and West Virginia. Pine mountain is the state line to almost the southwest edge of Letcher, whence to the Tennessee line it is the northwesterly boundary of Harlan and Bell counties. The great fault of this mountain brings up the Pottsville with extraordinarily increased thickness, there being in the Pike County region, belonging to the lower portion, about 2,000 feet of rock, coarse ferruginous and more or less conglomerate sandstones alternating with shales so as to form five or six benches. Cross-bedding prevails throughout, and the pebbles are from mere grains to three-fourths of an inch in diameter. Thin coal beds exist in the shales, but they are unimportant.

The shales overlying the lower Pottsville have continued to increase. Crandall found them 50 feet in western Greenup and 150 feet in Law-

*A. M. Hodge: Preliminary Reports on Southeastern Kentucky Coal Field, 1887, pp. 59, 64, 67, 72, 73, 74, 75, 78, 80, 82, 98, sections 81, 84, 85, 86, 87, 88, 89, 90, 100, 102.

rence. Lesley found them increasing eastward from a few feet on the western outcrop to upward of 150 feet in Martin county, these being his "Licking shales." Across Floyd and Knott counties the increase is even more marked; so that in Pike and Letcher they reach an apparent maximum of 450 feet. The calcareous bands and concretions, first becoming abundant in Lawrence and characterizing the shales along the western border even to the Tennessee line, are even more prominent here and are distributed through about 300 feet of the section, while the number of coal beds belonging to their general horizon has increased to at least four. The increased number of coal beds throughout the section renders detailed comparison with more western localities impossible, as the work has not been connected fully, but the upper limit of the Pottsville appears to have been traced carefully. For more than 50 miles the tracing was checked above by the Ferriferous limestone, and beyond that the peculiar characteristics of the upper coal beds made identification easy.

The information at present available is not sufficient to justify a positive identification of any one bed as the Sharon, as it is represented apparently by several beds. The equivalent of the Quakertown is equally uncertain. Below the Mercer, which is identified positively, there are three beds, each occasionally of workable thickness, at 40, 140, and 165 feet, all of them above the great mass of shale and sandstone, which also contains several thin coal beds. The middle bed is thought by Professor Crandall to be the probable equivalent of his number 1 (Sharon), but this suggestion is merely tentative in the absence of detailed sections.

Kentucky coal bed number 3, taken as the Mercer in this paper, is readily identifiable with the Elkhorn coal bed of Pike county, which Professor Crandall thinks is the equivalent of the "Imboden coal bed" of southwestern Virginia. It is of great economic importance in the adjoining portions of Knott, Floyd, and Pike counties, as well as in Letcher. As usual, it is subject to extreme variations, often abrupt; but it is frequently of workable thickness under large areas and yields a superior coking coal. At 100 to 130 feet above it is number 4, the Tionesta, the Lower Splint bed, which is so characteristic throughout Breathitt, Leslie, and Perry and is so well known farther north as the Upper Cannel or the Hunnewell Cannel of Greenup and other counties. Underlying this coal bed is a great sandstone, to which reference has been made in the description of other counties, with at most localities a thin coal bed under the sandstone. At somewhat more than 100 feet above this bed is the Upper Splint, as in the counties at the west, with a cannel at about 150 feet higher, both belonging to the Allegheny for-

mation, while at somewhat more than 600 feet above the Elkhorn (Mercer) coal bed is a fossiliferous limestone, which appears to be persistent. These three deposits of the Allegheny formation will prove serviceable in the effort to make correlations along the eastern outcrop in southwestern Virginia.*

The area beyond Pine mountain will be considered in connection with southwestern Virginia.

Returning now to the southwestern area, the line may be taken in Laurel and Whitely counties, answering to northwestern Breathitt, where the intervals are not so great as in the eastern counties and the "Licking shales" are not so greatly developed. The intervals which had become so extreme in Clay persist southward into Knox, as appears from a section given by Professor Norwood;† but they decrease rapidly westward, so that in Laurel, west from Knox, one finds the intervals not very different from those in Wolfe and Breathitt. Nothing is available for this area except a mere reconnaissance, which suffices merely for recognition of the general horizons.

Professor Crandall places the first workable coal bed at 50 to 75 feet above the top of his Rockcastle group, the great upper conglomerate of that group being the "Corbin lentil" of Mr Campbell. This Laurel coal bed he identified with number 1, which is sufficiently consistent with the tracing along the western outcrop. It is shown in Laurel county practically to the Knox border in the deep valley of a fork of Cumberland river, so that a series of sections should be possible in Knox county by which to settle all questions relating to the equivalency of the higher beds.

The third workable bed is known as the "Jellico" and is at about 200 feet above the Laurel, while at about midway between the two is a cannel which attains much importance locally. These intervals suggest that the three beds may be at the Sharon, Quakertown, and Mercer horizons. At 75 to 100 feet above the Jellico is a splint coal bed, the interval being filled mostly by sandstone. This higher bed, the Cadell, is described as semi-cannel, free-burning. It underlies another bed, 72 feet higher. This section suggests that the higher beds are the two splints, numbers 4 and 5.

The calcareous concretions and bands, which in the central and northern counties belong to the horizon of coal beds 1 and 2, extend here through more than 200 feet vertically and are found even in the

*A. R. Crandall: Preliminary Reports on Southeastern Kentucky Coal Field, 1887, pp. 14, 15, 18, 28.

†C. J. Norwood: Report of Inspector of Mines for 1893, p. 112.

shale underlying the Jellico, as in Pike county, where they are found occasionally in shales underlying the Elkhorn.*

TENNESSEE

Passing over into Tennessee, along the western border, one has the following succession:

Corbin sandstone,
Shales,
Rockcastle sandstone,
Shales,

resting on the Lower Carboniferous. According to Mr Campbell, the Rockcastle rests on the Lower Carboniferous at a little way north from the Tennessee line, though eastward in Whitely county the underlying shales become important and contain at least two important coal beds, the "Main Cumberland" and the "Bryvan," as well as a third at the bottom, which is rarely important. Above the Corbin at 50 to 70 feet is the "Pittsburg or Laurel coal bed," which appears to be the equivalent of the Sharon of Pennsylvania. The Corbin and the Rockcastle in Tennessee are often conglomerate. Mr Campbell's work was carried into Tennessee, so that direct linking of Kentucky studies with those of the workers in Tennessee becomes comparatively simple. His notes concern the western border of the Cumberland plateau in Fentress and Cumberland counties, where the Rockcastle is practically the highest bed of the section, except near the Kentucky line, where the Corbin is seen at 100 feet higher. The Rockcastle, separated from the Lower Carboniferous by from 150 to 300 feet of shale, loses it coarseness southward so as to become merely a sandstone at somewhat more than 40 miles south from the Kentucky line. Meanwhile a sandstone makes its appearance in the lower part of the underlying shales, increasing in coarseness and importance, so that where the Rockcastle ceases to be a marked feature of the topography this lower conglomerate, the Bonair of Campbell, forms massive cliffs at approximately 125 feet below the Rockcastle along the western border. At first it rests almost directly on the Lower Carboniferous, but followed southward, the interval increases until, in White county at Bonair, it is 110 feet and contains mostly shales with a coal bed at the bottom. Mr Campbell notes the presence of some thin coal beds between the Rockcastle and the Bonair within the area studied by him, but hesitates to make identifications with the beds observed farther south. The Bonair or lowest conglomerate ceases to be an important member of the section north from Monterey in Cumberland county, where a 3-foot coal

*A. R. Crandall: Geology of Whitely County and part of Pulaski, pp. 24, 25, 28–37, 39, 42.

bed was seen directly under it and almost in contact with the Pennington shale.*

Professor Safford's detailed sections illustrate the formation as it occurs in Fentress, Overton, and Putnam counties, the last two being west and southwest from Fentress, which extends to the Kentucky border. In southwest Fentress he finds both the Rockcastle and the Bonair, the succession being as follows:

	Feet.
1. Conglomerate [Rockcastle]	40
2. Shale	51
3. Sandstone	6
4. Shale	21
5. Sandstone	46
6. Shale and sandy shale	50
7. Conglomerate [Bonair]	90
8. *Coal bed*	0 to 3
9. Fireclay, shale and sandstone	4
10. Shale and iron ore	25 to 30

He suggests that coal should occur in the shales, numbers 2, 4, and 6, but no exposure was found. The shales number 10 may belong to the Shenango (Pennington of Campbell). The lower conglomerate, "Main" of Safford, "Bonair" of Campbell, forms the cap-rock in much of the region, while the Upper conglomerate, Rockcastle of Campbell, is the cap-rock of much the greater part of Safford's northern division of the Cumberland Plateau in Tennessee.

In southeast Overton adjoining southwest Fentress, Professor Safford found on the east fork of Obey river a coal bed at 110 feet below the Rockcastle and 54 feet above the Bonair, underlying the sandstone, number 5 of the section just given. This, which is 4 feet thick and yields excellent coal, is evidently the "Sewanee coal bed," so important farther south. The interval between the conglomerates here is 168 feet; it is 174 at a few miles east within Fentress. Farther north in Overton county, say 6 or 8 miles, a coal bed was seen at 180 feet below the Rockcastle, and at a mile farther east coal beds were seen at 95 and 165 feet below the Rockcastle, 1 foot and 3 feet 6 inches thick; and Safford says respecting the lower bed "that this is followed not far below by the Main conglomerate." At both of the northern localities the great sandstone between the conglomerates shown in the southern Fentress section is wanting, so that it may not extend farther north than southern Fentress. No details are available for northern Overton, so that the northward extent of the Bonair can not be determined. The presence of this lower conglomerate in Overton county is interesting, for it is absent

* M. R. Campbell: U. S. Geol. Survey, Standing Stone folio, 1899.

from western Fentress except in the extreme southwest. Professor Safford's section at 4 miles west from Jamestown, near the Overton border, shows a very abrupt change to the conditions described by Mr Campbell in Fentress county, for the succession is

1. Conglomerate, very heavy	Not measured
2. Shale and sandstones	97 to 102
3. *Coal bed*	3 to 4
4. Concealed	4
5. Sandstone	20
6. Concealed to the Mountain Limestone	30

The coal bed is evidently the Sewanee, shown in southeast Overton at 54 feet above the Main (Bonair) conglomerate. The whole thickness below the Rockcastle is but 158 feet. At 6 miles east from Jamestown, in Fentress county, coal beds are shown at 40 and 61 feet below the Rockcastle, the lower bed being 4 to 5 feet thick.

Putnam county is south from Overton. Apparently there is little here above the Main (Bonair) conglomerate, which in the central part of the county is thin, with an unusual thickness of shale above and below it, so that Professor Safford thinks it largely replaced by shale. A thin coal bed, 2 feet, was seen above the conglomerate, and an important though variable bed is directly under it. The underlying shales vary greatly, for on Sinking Cane they are almost 100 feet, whereas on Calfkiller creek, barely a mile away, they are but 61 feet.*

Evidently Professor Safford regarded the conglomerate of western Fentress as his Main conglomerate, but in view of the studies made in Fentress and Cumberland by Mr Campbell and in eastern Fentress by Mr Keith, the deposit must be taken as the Rockcastle of Campbell. The Bonair, according to Mr Campbell, extends but little beyond Monterey in Cumberland county, for it changes northwest from that point and the shales underlying the Rockcastle are very much thicker there than elsewhere. Though present in Overton, as shown by Safford's sections, it is clearly wanting in much of Fentress. Its boundary is a line from southwest Fentress northeastward, and passing just west of Rugby, where oil borings prove its presence. Mr Campbell says that it is unknown farther north on the south fork of Cumberland river, so that it must be confined to southwestern Fentress.

Southward from Fentress, Putnam, and western Cumberland, along the western border, one has the work of Professor Safford and Mr Hayes to the Alabama line. It may be well to adopt, for convenience of description, Professor Safford's division of the area, considering first the region

* J. M. Safford: Geology of Tennessee, 1869, pp. 393, 396, 397, 398.

west from the Crab Orchard anticlinal followed by the Sequatchie valley, and afterward Walden ridge, forming the narrow strip east from that valley and extending to the eastern escarpment of the Cumberland plateau.

Mr Hayes divides the Upper Carboniferous rocks of southern Tennessee into Lookout sandstone, below, and Walden sandstone, above. The Lookout extends upward to the top of the Main (Bonair) conglomerate. "The Walden" is described as consisting of

1. A coarse, heavy sandstone, usually conglomerate.
2. Sandy shales.
3. Variable thickness of coarse, white, or yellow sandstone, containing pebbles; forms surface of much of Bledsoe and Cumberland counties.
4. Several hundred feet of shales, some approaching fireclay, others passing through micaceous, sandy shales into thin bedded sandstone; most important as containing chief coal bed of the region. This mass decreases westward and disappears near the western escarpment.

The full thickness of the beds as thus described is seen only near the Sequatchie valley, where it is 650 feet. As the Walden rests on the Bonair conglomerate, one must recognize in number 3 the Rockcastle, and in number 1 the Corbin of Campbell.

White county is south from Putnam. In the northeastern part of the county, on Calfkiller creek, Professor Safford found

	Feet.	Inches.	Feet
1. Conglomerate [Main, Bonair]	Not measured.		
2. Shales	80	0	
3. Sandstone [Etna, Cliff]	13	0	
4. *Coal* and fireclay	1	0 to 2	
5. Shale	12	0	
6. *Coal bed*	3	6	
7. Clay and concealed	32	0	

to the Lower Carboniferous. The important coal bed is at 106 feet below the Bonair. Here appears for the first time in the sections the sandstone, number 3, which farther south becomes "Safford's Cliff sandstone" or "Lower Etna conglomerate." At 4 miles north from Bonair the interval to the sandstone appears to be not more than 23 feet, and a coal bed 2 to 3 feet thick rests on the sandstone. At little more than 2 miles from Bonair, four coal beds are shown below the Bonair in about 100 feet of measures, and the Bonair is 90 feet thick. At Bonair, Professor Safford found the Bonair 90 feet thick, with 102 feet of measures below containing several thin seams of coal. Mr Campbell gives the thickness below as 110 feet, with an important coal bed very near the bottom. On Clifty

creek, near "Caney Fork gulf," Professor Safford obtained the following interesting section:

	Feet.	Inches
1. Sandstone and conglomerate [Corbin?]	65	
2. Shale	0 to 12	
3. *Coal bed*	2 to 6	
4. Fireclay and shale	62	
5. Sandstone [Rockcastle]	40	
6. Shale	20	
7. Fireclay	1	
8. Shale and sandstone	25	
9. Shale	52	
10. *Coal bed* [Sewanee]	3	
11. Shale	25	
12. Main Conglomerate [Bonair]	60	
13. Shale with *coal*	15	

to the Lower Carboniferous. There is a decided shortening of the section throughout, so that the sandstone, number 1, may well be taken as the Corbin; number 8 represents the important sandstone so frequently found between the Rockcastle and Bonair, which at this western locality has degenerated. The sub-Bonair beds have almost disappeared; a similar condition was observed by Mr Hayes on the border of Bledsoe and Cumberland counties, several miles southeast, where the Conglomerate rests directly on the Lower Carboniferous. But this preexisting ridge of Lower Carboniferous recognized by Mr Hayes must be very narrow, for Professor Safford, though giving the Clifty Creek section as characteristic of the formation in much of Van Buren south from White, says that the "Lower Coal Measures," those below the Bonair conglomerate, thicken eastwardly, and he shows that they thicken westwardly also, for they are 100 feet in White county westwardly from the section just given. Mr Hayes also shows that they thicken in each direction; for while on the border of Cumberland and Bledsoe east from White and Van Buren he finds Bonair and Lower Carboniferous in contact, he finds the lower beds in Van Buren. In Warren, west from Van Buren, on the extreme western outlying patch of the plateau, he finds at 6 and 7 miles southeast from McMinnville these sections:

	I		II
	Feet.	Inches.	Feet
1. Cross-bedded sandstone [Bonair]	50		25
2. Shales	30		25
3. *Coal bed*		8 to 10	3 to 4
4. Cross-bedded sandstone [Etna, Cliff]	50		
5. Shales	20		100
6. *Coal bed*	1	6 to 2 feet	
7. Shales	Thin		

to the Bangor limestone.

Mr Hayes gives two sections farther east in this division—the first in northern Cumberland county at probably 12 miles east from the Calfkiller Creek locality, in White, and the second in central Bledsoe near the Sequatchie valley. They are important as illustrating the eastward thickening of the measures, and must be given in full that the change from the western to the eastern conditions may be understood. The Cumberland section is

	Feet.	Inches
1. Coarse sandstone [Rockcastle]	60	
2. Interval	100	
3. *Coal bed* [Sewanee]	1	11
4. Shale and sandstone	80	
5. Conglomerate and sandstone [Bonair]	55	
6. *Coal bed*		
7. Interval	240	

to the Bangor limestone, showing a great increase in the sub-Bonair measures and a moderate increase in the beds above. The Pikeville section in Bledsoe, about 25 miles farther south, is

	Feet.	Inches
1. Sandstone with some shale [Corbin?]	75	
2. *Coal bed*		
3. Shales and sandstone	300	
4. Coarse sandstone [Rockcastle]	35	
5. *Coal bed*	2 to 4	
6. Sandstone and shales not fully exposed	140	
7. *Coal bed* [Sewanee]	3	
8. Shales and sandstones	90	
9. Conglomerate and sandstone [Bonair]	60	
10. *Coal bed*	1	6
11. Not fully exposed	340	
12. *Coal bed*	1	6 to 2
13. Thin shale to Bangor limestone		

It is altogether probable that the highest sandstone of this section is at the Corbin horizon or very near it, as the shales overlying the Rockcastle show a very great thickening in sections northeastward from the Pikeville region, to which reference will be made when studying the eastern escarpment. It is probable that here one finds the full presentation of the Rockcastle formation of Crandall, the Lee formation of Campbell's Kentucky folios. The Sewanee coal bed appears to be absent from a considerable portion of western Cumberland and a portion of White, but it is important in Bledsoe and most of Cumberland.

Farther southward the region under consideration includes Grundy and Franklin counties along the western border, with so much of Marion as lies west from Sequatchie valley, the last two extending to the Alabama

line. The Lookout sandstone of Hayes, having the Main (Bonair) conglomerate as its upper bed, forms the plateau, with detached areas of Walden sandstone in the several counties. The Lookout, inclusive of the Bonair, decreases from 510 feet at Sequatchie valley to 120 feet at the western outcrop. Mr Hayes finds the Walden 550 feet in eastern Grundy, 475 in eastern Marion; and only 300 feet in southern Grundy. These figures refer not to the full thickness, but only to that of the portion remaining. Professor Safford gives a detailed section near Tracy City, in southern Grundy and northern Marion, as follows:

	Feet.	Inches.	Feet.	Inches
1. Conglomerate [Rockcastle]	50	0		
2. *Coal bed*				
3. Shale	23	0		
4. *Coal bed*	0	6		
5. Shale	26	0		
6. Sandstone	86	0		
7. Sandy shale	45	0		
8. *Coal bed* [main Sewanee]	3	0	to 7	
9. Shale	33	0		
10. *Coal bed*	1	0		
11. Shale and sandstone	17	0		
12. Conglomerate [Bonair]	70	0		
13. *Coal bed*	1	0	to 0	6
14. Shale	10	0		
15. Cliff sandstone [Etna]	65	0		
16. *Coal bed* [Etna]	1	6	to 0	6
17. Shale	30	0		
18. Hard sandstone	78	0		
19. *Coal bed*	1	0	to 3	
20. Hard sandstone	20	0		
21. Shale to mountain limestone	20	0		

The average thickness of the Upper Measures is given as 240 feet, and that of the Lower Measures as 228 feet, not including the conglomerates. The sandstone of White county below the Rockcastle has doubled in thickness, and the Sewanee coal bed is at a greater distance above the Bonair, though less than in central Bledsoe, where it is possible some of the interval may be accounted for by uncertainty respecting the top of the Bonair. The average interval in these southern counties is not far from 50 feet. The Cliff sandstone, extending northward apparently no farther than White county, increases in importance southwardly and is a marked feature in much of Alabama; but the interval between it and the Bonair is variable; sometimes the two deposits are in contact, while at others they are separated by 150 feet. In northern Grundy they seem to be in contact, for there Professor Safford's section is

	Feet.	Inches
1. Conglomerate	130	
2. *Coal* and shale	25	
3. Sandy shale	50	
4. *Coal bed*	0	6

resting on the limestone. Evidently the Bonair and Cliff are one here, the thickness given being only 5 feet less than the combined thicknesses at Tracy City. A thin coal bed underlying the conglomerate mass becomes 3 feet thick within a short distance; it is the "Etna" of Safford, the "Cliff bed" of the Alabama reports. The sandy shale of number 3 is the hard sandstone, number 18, of the Tracy City section, which there also overlies a coal bed. The bottom members of the Tracy section have disappeared. Farther north there is a greater decrease below the Cliff, the whole thickness is 54 feet, while at the northern border of the county it is less than 20 feet and the coal beds are only one foot apart. Evidently a condition like that observed in White and on the border of Bledsoe and Cumberland must exist in southern or southeastern Van Buren.

The Sewanee coal bed is mined at many places around the petty areas of the Walden in the southern counties. At the Sewanee mines in southern Grundy it is from 2 feet 6 inches to 7 feet and yields a somewhat crushed coal; at most localities a small bed, the Jackson of Safford, appears between it and the Bonair, but it is rarely thick enough to be mined.

In Franklin county, west from Marion, the Lookout sandstone is present for two or three miles beyond the Marion line. Professor Safford gives two sections, one of which is within a half mile of the Alabama line, near Anderson, as follows:

	Feet.	Inches
1. [Bonair]	Not measured	
2. Shale with thin *coal bed*	40	
3. Cliff sandstone, estimated	120	
4. Coal bed [Etna], average	3	
5. Fireclay, shale, and sandstone	31	
6. Sandstone and sandy shale	55	
7. Shale	1	to 6
8. *Coal bed*	2	6 to 3
9. Shale	Not measured	

The shale at the bottom is 38 feet thick in the other section at a short distance farther north. The thickness of the Cliff sandstone may be excessive, for in the other section it measured but 74 feet.

The Sewanee coal bed is mined at several localities along the westerly

side of the Sequatchie valley. Mr Hayes obtained sections in northeast Marion 2 miles apart, which illustrate the structure, as follows:

	I		II	
	Feet.	Inches.	Feet.	Inches
1 Conglomerate and coarse sandstone	20		60	
2. Shale	50		25	
3. *Coal bed*	1		1	2
4. Shale and sandstone	150		125	
5. *Coal bed*	0	6	0	6
6. Shales and sandstone	200		200	
7. *Sewanee coal bed*	4 to 5	9	4	
8. Shale and sandstone	45		40	
9. *Coal bed* [*Jackson*]	1			
10. Shale	5		10	
11. Conglomerate and shale [Bonair]	70		65	
12. "*Cliff vein*" *coal bed*	0	8	0	8
13. Cross-bedded sandstone [Cliff, Etna]	100		95	
14. *Coal bed* [Etna]				
15. Sandstone and shale	210		200	
16. *Coal bed*	0	9	0	9
17. Shales	60		50	

to the Bangor limestone. In the second section a coarse sandstone, apparently almost 100 feet thick, begins at about 50 feet above the Sewanee coal bed; it is not so well shown in the other. This is the sandstone which it 86 feet at Tracy. The sandstone at 60 feet higher and about 70 feet thick is evidently the Rockcastle, the interval to the Bonair being somewhat less than 270 feet, only 30 feet more than at Tracy City, 14 miles toward the west. The "Cliff vein" of the section is not the bed known by that name in Alabama, which underlies the Cliff sandstone and is the Etna of Safford. The relations of the coarse sandstone at the top of the section are not clear; it is too near the Rockcastle to be the Corbin—at least such appears to be the condition by comparisons of the sections already given.

Farther south along the west side of the Sequatchie valley are two sections of the lower beds by Safford

	I		II	
	Feet.	Inches.	Feet.	Inches
1. Conglomerate [Bonair]				
2. Shale and *coal*	Thin		0 to 1	6
3. Sandstone and shale	60		68	
4. Cliff sandstone	90		105	
5. *Coal bed* [Etna]	2		Thin	
6. Shale	10		8	
7. Shale	0		6	
8. *Coal bed*	4		1 to 4	

	I	II
	Feet	Feet
9. Fireclay and shale	67	110
10. *Coal bed*		
11. Sandstone	12	

giving in the second, which reaches to the bottom, a thickness of about 350 feet—an increase of about 125 feet in comparison with Tracy City and of about 150 feet in comparison with Franklin county, but nearly 100 feet less than is shown by Mr Hayes's sections 8 or 10 miles farther northeast.*

Crossing now to the eastern portion of the Cumberland plateau, separated from the main area by the Sequatchie valley and known as "Waldens ridge," one finds little difficulty in following the section northward from the Alabama line, though the thickening of the measures causes perplexity at times. This area embraces portions of Marion, Hamilton, Sequatchie, Bledsoe, Rhea, and Cumberland; but the name is applied to the east portion of the plateau as far as the northern boundary of Tennessee, so that there may be included also portions of Roane, Morgan, Anderson, and Campbell counties. In its southern portion, Waldens ridge is sometimes spoken of as "Raccoon mountain," the name which it bears in Alabama.

The Etna mines are in southeast Marion at about 2 miles north from the Alabama line, about 10 miles west from Chattanooga, and somewhat farther east from the western side of the Sequatchie valley. The section extends from the Lower Carboniferous up to the great sandstone midway between the Bonair and the Rockcastle. It was studied nearly 50 years ago by Professor Safford and almost 30 years later by Professor Colton. The two sections are presented together, number 1 being that by Professor Safford:

	I	II	
	Feet. Inches.	Feet. Inches	
1. Sandstone	75	73	
2. Shale	48	32	Shaly sandstone
3. *Walker's coal bed*	4	4	
4. Shale with coal bed	30 to 40	46	
5. *Coal bed, Slate vein*	5 to 6	6	
6. Shale	44	44	
7. *Kelly coal bed*	2 to 3	2 to 5	
8. Fireclay	1 to 2	1 6	
9. Main conglomerate	75	82	Upper conglomerate
10. *Coal bed*	Thin	0 3	

*J. M. Safford: Geology of Tennessee, pp. 355, 369, 370, 372, 373, 374, 376, 379, 392, 393.
C. W. Hayes: U. S. Geol. Survey folios, Kingston, 1892; Chattanooga, 1892; Pikeville, 1895; McMinnville.

	I	II	
	Feet. Inches.	Feet. Inches	
11. Shale	30 to 40	45	Yellow sandy shale
12. *Coal bed*	0 10	Thin	
13. Sandy shale	100 to 130	45 2 to 1 45	Gray shales Coal bed Gray sandy shales
14. Lower Etna conglomerate, Cliff rock	70 to 100	96	
15. Shale	0 to 12	0	
16. *Coal bed, Main Etna*, or *Cliff vein*	3	2 to 5	
17. Fireclay and shale	6 to 23	22	
18. *Coal bed*	1 to 6	1	*Dade* or *Eureka coal bed*
19. Sandstone	80 to 120	95	Gray shale
20. Shale	0 to 5		
21. *Coal bed*	3 to 6	0 6	
22. Fireclay, shales, and sandstone	35 to 47	20	Black shale
23. *Coal bed*	3 to 6	3	
24. Fireclay, shales, and sandstones	80 to 150	74 2 102	Shale *Coal bed* Fireclay shales and sandstone

Professor Safford's section is not purely local, but it was intended to be representative of conditions within the space south from the Tennessee river. The close agreement of these sections, made at so great an interval of time and under very different conditions, is a welcome testimony to the skill and accuracy of Professor Safford, whose survey of Tennessee was made very largely at his own cost and without the many conveniences now regarded as essential by geologists.

The "Kelly coal" of the section is clearly the "Jackson coal bed," as Professor Safford recognizes, and he is inclined to regard the "Walker" and "Slate" beds as equivalent to the "Sewanee" of the western localities. Professor Colton identifies with the Sewanee his bed at 45 feet above the Cliff sandstone, but this identification, which has been accepted by Mr McCalley in the Alabama reports, is not consistent with the type section, where that coal bed is above the Bonair and at a varying interval below the sandstone which is at the top of both Etna sections. The thickness below the Bonair in Professor Colton's section is about 550 feet, coinciding with the average of the measurements given by Professor Safford.*

* J. M. Safford: Geol. of Tennessee, p. 383.
H. E. Colton: Cited by H. McCalley, Geol. Survey of Alabama, Coal Measures of Plateau Region, 1891, p. 18.

Mr Hayes gives a section obtained near the Etna mines, which differs somewhat from those by Safford and Colton. It is

		Feet.	Inches
1.	Sandstone	75	
2.	Shale and sandstone	120	
3.	*Coal bed, Etna*	4	
4.	Shales	50	
5.	Trace of *coal*		
6.	Shales and sandstones	120	
7.	*Sewanee (?) coal bed*	1	6
8.	Shale and some sandstone	70	
9.	*Soddy (?) coal bed*	1	2
10.	Sandstone and shale	25	
11.	Conglomerate and massive sandstone	80	
12.	*Castle Rock coal bed*	3	
13.	Shale	30	
14.	Trace of *coal*		
15.	Shale	65	
16.	*Dade coal bed*	3	
17.	Shale	20	
18.	Mostly concealed	250	

to the Lower Carboniferous.

The top of the Lookout here, number 11, is the Cliff sandstone of Safford and Colton, which will be referred to hereafter as the Etna conglomerate, for along the eastern escarpment in Tennessee, as well as in much of Alabama, it is as important as the Bonair or Main conglomerate of Safford. The "Castle Rock" coal bed of this section is the Main Etna coal bed of Safford, the Cliff vein of this region and Alabama, the Castle Rock of Georgia. The bottom of the sandstone at the top of the section is almost 400 feet above the Etna (Cliff) conglomerate, and it is evidently the same with that of the other sections, in which it is at about 360 feet. The Etna coal bed of this section is evidently the Slate bed of Safford, the number 5 of Colton, which should be at somewhat less than 50 feet above the Bonair. Where Mr Hayes's section was obtained, the Bonair seems to have been replaced by shale, as no trace of the conglomerate appears in his section. The coal bed, hesitatingly identified with the Sewanee, may be the coal bed, 30 to 45 feet below the Bonair in the other sections, and the "Soddy" (?) coal bed is evidently that seen by Professor Colton at 45 feet above the Etna (Cliff) conglomerate. The Walker coal belongs in the interval number 2. The thickness of measures below the Etna conglomerate is somewhat greater than that given in the other sections.*

*C. W. Hayes: U. S. Geol. Survey folios, Chattanooga, 1892.

Before proceeding further with the Waldens Ridge area in Tennessee, it is necessary to review summarily the conditions in Alabama.

ALABAMA

The Cumberland plateau of Mr McCalley lies north from the Tennessee river and west from Sequatchie or Browns valley, thus including parts of Jackson, Madison, and Marshall counties.

Mr McCalley takes as the basis of comparison the section obtained by Professor Colton at Etna and that by Professor Safford in southeastern Franklin county, both within 2 or 3 miles of the Alabama line. The Bonair conglomerate (Upper or Main of Safford) is the highest rock in most of this area and forms the "Second bluff," the "First" or "Lower bluff" being that of the Etna (Cliff) sandstone, commonly called the "Millstone grit." As in Tennessee, these conglomerates vary from coarse quartzose sandstones to pebbly rock and are separated by an interval of 25 to 150 or more feet. The Lower Measures, underlying the Etna sandstone, are rarely more than 50 feet thick in the plateau, though in other portions of the state they appear to be thicker than in any portion of Tennessee.

The outliers in Madison county are farther west than those of Franklin in Tennessee. The Etna, the highest bed in most of Madison, is a massive sandstone without pebbles and not more than 75 feet thick; at the western exposures it rests directly on the Etna coal bed and the interval to the Lower Carboniferous limestone varies from 2 to 20 feet. In northwest Jackson, the Etna sandstone, 50 to 80 feet thick, overlies the Etna (Cliff) coal bed, which is 2 to 10 feet above the limestone, but on Poor House mountain the interval is 60 feet; on Keel mountain, farther east, both Bonair and Etna are shown with the Etna coal bed represented by several layers distributed through 20 feet of section. At Limerock, in the southern part of the county, the Lower Measures are much thicker; thus

	Feet
1. Cliff rock [Etna]	70
2. *Cliff coal seam* [*Etna*]	4
3. Fireclay	4
4. Shale and sandstone	200
5. *Coal* and fireclay	1 to 3
6. Heavy bedded sandstone	25
7. Concretionary sandstone	12

giving 247 feet below the Etna sandstone. No details are available for Marshall county.*

* H. McCalley: Geol. Survey of Alabama, Coal Measures of Plateau region, 1891, pp. 25, 30, 31, 32, 38, 59.

Waldens ridge as it crosses northwest Georgia becomes Raccoon mountain, and the name is retained in Alabama. Sequatchie becomes Browns valley and continues practically to the south line of Blount county, about 50 miles from the Tennessee line. On the east, Raccoon mountain is cut off by Wills valley, continuous with the Great valley of Tennessee and separating Raccoon from Lookout mountain, which begins just north from the Tennessee line.

In Dade county, the most northwesterly in Georgia, Mr McCalley's section at the Dade mines is

	Feet.	Inches.	Feet.	Inches
1. Cliff sandstone [Etna]	75	0		
2. *Cliff coal* [*Etna*]	2	0 to		6
3. Shale	50	0		
4. *Dade coal*	17	0 to	1	
5. Shale and clay	45	0		
6. *Red Ash coal bed*	3	0 to		6
7. Fireclay and sandstone	81	0		
8. *Coal bed*	1	2 to		10
9. Shale to the Limestone	40	0		

about 225 feet between the Etna sandstone and the Lower Carboniferous limestone. Farther west, near the Alabama line, at the Castle Rock mines, the place of the "Red ash" coal bed is concealed, but the other beds are exposed. The interval from the lowest coal to the limestone appears to be 250 feet, and the thickness of the Lower measures is about 500 feet.

The Etna sandstone forms the main bluff on the west side of Raccoon mountain in Jackson county of Alabama. It is 60 feet thick at 4 miles from the Georgia line, but increases to 100 feet on Long Island creek, 4 miles farther southward. The immediately underlying Etna coal bed persists in the sections and rarely exceeds 2 feet. A coal bed at about 50 feet above the Etna sandstone is shown in many sections, varying from 6 inches to 3 feet. It is evidently the same with the Sewanee of Colton's section and seems to be very near the place of the Cashie coal bed in Gibson's Blount Mountain section. That name will be used in the descriptions. Mr McCalley's section at 18 miles from the Georgia line is

	Feet.	Inches.	Feet.	Inches
1. Conglomerate [Bonair]				
2. Sandstone debris	30	0		
3. *Coal* and sandstone	0	4		
4. Clayey shale	2	0		
5. *Coal bed*	1	0 to		8
6. Ill exposed	20	0		
7. *Coal* in shaly sandstone	1	6		
8. *Coal bed* [*Cashie*]	0	10 to		4
9. Interval	40	0 to	30	
10. Cliff rock, Millstone grit [Etna]	80	0 to	100	

with the Etna coal bed, thin and worthless, underlying the sandstone. Farther south 20 feet of the Bonair remain in place at only 30 feet above the Etna. The latter rock decreases in thickness locally, for at a little more than 20 miles from the state line it is but 30 feet, with the "Cashie" coal bed at 22 feet above it. Respecting the rock at this place, Mr McCalley says: "For several feet up in this Lower Conglomerate, from its base, there run streaks of hard cubical coal, filling cracks in the conglomerate; the thicker of these coal seams sometimes divide up into many coal streaks." In the extreme southern part of Jackson county, near the Marshall line, both conglomerates are shown, each 50 to 60 feet thick, separated by an interval of only 10 feet, including the Cashie coal bed.

Mr McCalley gives a number of sections in Marshall county south from Jackson. The interval between the conglomerates increases, so that at the Blount county line it is 70 feet, with the Cashie coal bed persistent. The Etna coal bed is triple, and the interval from the top of the Etna sandstone to the Lower Carboniferous limestone has decreased to 140 feet—little more than one-fourth of the thickness at the Georgia line.

On the easterly side of Raccoon mountain the Bonair is 75 to 80 feet at Browns gap, 2 miles from the Georgia line, where it is massive and almost wholly pebbles. The interval to the Lower Carboniferous is approximately 300 feet, showing a rapid decrease within a few miles southeast. In this region the Etna is a mass of pebbles, but farther south it is less pebbly, and in places is merely a cross-bedded sandstone. The interval between the conglomerates increases southward until it becomes 90 feet in northern Etowah county, south from Marshall. The Cashie and Etna coal beds persist in the sections, but they are usually thin, rarely reaching workable thickness.*

Raccoon mountain is divided in Blount and Etowah counties by Murphrees valley, originating near the north line of Etowah and passing southwest through Blount until it unites with the Coosa or Birmingham valley, which topographically is a continuation of Wills valley. The portion lying between these valleys is known as Blounts mountain, while that west from Murphrees to Browns (Sequatchie) valley retains the name of Raccoon mountain. The conditions in Blount mountain, as described by Mr Gibson, contrast strangely with those in the area farther north. It is evident that the thicknesses assigned by him to some of the beds are merely estimates and in excess, but it is equally evident that there is an abrupt thickening of the whole column.

* H. McCalley: Op. cit., pp. 44, 45, 47, 48, 49, 50, 52, 57, 75, 81, 82, 107.

The Lower Measures, including the Etna conglomerate, nowhere exceed 300 feet along the east side of Raccoon in De Kalb county, and the interval between Bonair and Etna is only 90 feet. In Marshall, on the west side of Raccoon, the interval between the conglomerates is 70 feet, and the Lower Measures at most 140 feet; but within 10 miles southwestwardly Mr Gibson estimates the Lower Measures at 800 feet and the interval between the conglomerates at 500 feet. As will be seen, these estimates approximate the thicknesses in Waldens ridge of Tennessee.

The Etna or first conglomerate of Blount mountain is 50 to 100 feet thick, and varies from a mass of rounded pebbles to a coarse grained sandstone. The second conglomerate, unhesitatingly identified by Mr Gibson with McCalley's upper conglomerate, the Bonair, is easily distinguished from the Etna, as its pebbles are less firmly cemented, and where pebbles are absent the rock is light gray. Its thickness increases southwestwardly, being 100 feet on Lime creek in Etowah county, while midway in Blount mountain it is estimated at between 400 and 500 feet—estimated because no measurements can be obtained. A third conglomerate, at approximately 1,000 feet above the Bonair, is composed of "good sized, but not well rounded pebbles, firmly cemented together with carbonate of iron." A fourth conglomerate occurs very near the top of the formation, about 1,250 feet above the third. Its upper portion is "light colored, loosely cemented, and weathers badly, and is hence seldom seen on the surface," but its place is shown by the abundance of large rounded pebbles. The lower part is harder and better preserved. The total thickness is not more than 55 feet, and the underlying rocks for 100 feet are "quartzites."

The interval between the Etna and Bonair is 110 feet in Etowah county at a little distance from Lime creek. Two miles southwest, as calculated from the dip, it is somewhat less than 250 feet. At 5 miles farther it was thought to exceed 500 feet; thence southwestwardly it decreases, becoming 100 feet or even less in the southwestern part of the area. It is unfortunate that no detailed measurements of the higher portions of the section are given for the northeastern part of the area. Mr Gibson's map shows that measures to a considerable distance above the third conglomerate are present at not more than 5 miles southwest from Lime creek. It has been seen that the interval between Bonair and Etna increases southwest from 90 feet in Etowah to possibly 500 feet on headwaters of Blackburns fork; that the Bonair increases in the same distance from 110 to 400 feet or more, while the Lower Measures increase from 300 to 800 feet. As all portions from the Bonair downward show this extreme increase, one is led to surmise that the upper portion increases in like manner. The temptation to suggest that the

third and fourth conglomerates are equivalent to the Rockcastle and Corbin is very great, the more so because midway between the Bonair and the third there is a great and persistent sandstone holding a relative place very like that of the persistent sandstone above the Sewanee coal bed in the Tennessee sections. But in the absence of beds above the Bonair conglomerate almost everywhere south from the Etna mines, in Tennessee, to Blount county stratigraphy is helpless, and the final determination must be made by means of palæobotany. Happily the material is within easy reach, for plant-bearing beds are present at several horizons up to within 200 feet of the fourth conglomerate. More than twenty-five years ago Leo Lesquereux, after studying the plant remains, referred the formation to the Pottsville.* Mr Gibson's section shows twenty-six coal beds above the Etna conglomerate, most of which attain workable thickness in some portion of the area. Three beds are persistent between the Bonair and Etna, the middle one being the Cashie. The coal beds in the Lower Measures are insignificant.†

The Raccoon Mountain area may be regarded as extending only to the southern line of Blount county, where Sequatchie-Browns valley terminates and Raccoon becomes continuous with the Great Warrior coal field, covering a large area west from Browns valley and tapering southward to Tuscaloosa. At the west and south the Coal Measures pass under the cretaceous beds. Messrs Gibson and McCalley have studied the formation in Blount county. The work of the latter was merely reconnaissance, but he traced the Bonair on both sides of Raccoon and found the Etna coal bed at a few localities, nowhere more than 1 foot thick. Whether or not more than one coal bed are present between the conglomerates was not ascertained.‡

Mr Gibson's section of Berry mountain, a high fragment remaining in the southern part of Blount county, contrasts strangely with the section on Blount mountain on Blackburns fork, about 6 miles toward the southeast. The measures below the Etna are but 30 to 40 feet thick. The Bonair and Etna conglomerates are each 50 to 60 feet and are separated by 25 to 30 feet of flaggy sandstone with clay. Seven hundred feet of measures remain above the Bonair, with coal beds at 150–200, 250–300, 375–425, 455–500, 475–520, and 495–535 feet above that conglomerate. One can not determine the equivalents of these beds in the general section of Blount mountain. Plant-bearing shales are present near the top of the section.§

* E. A. Smith in letter to writer.

† A. M. Gibson: Geol. Survey of Alabama, Coal Measures of Blount Mountain, 1893, pp. 17, 18, 21 22, 23, 32, 33, 36, 38, 42, 47, 49.

‡ H. McCalley: Op. cit., pp. 132–134.

§ A. M. Gibson: Coal Measures of Plateau Region, pp. 192, 193.

Before taking up consideration of the Warrior coal field, one must record the features of isolated fields lying toward the east in position comparable with that of the Southern and Middle anthracite fields of Pennsylvania. These are Lookout mountain, occupying a synclinal extending from the Tennessee line across northwest Georgia into Alabama and terminating near Gadsden; the Cahaba field, beginning 20 miles southwest from Gadsden and extending about 40 miles in almost direct continuation of the Lookout strike, and finally the Coosa coal field, southeast from the Cahaba field and about 37 miles long.

The Lookout Mountain coal field, beginning in Hamilton county of Tennessee, passes southwest across Dade and Walker of Georgia, De Kalb, Cherokee, and Etowah of Alabama, and terminates near the Coosa river. As the coal beds are of comparatively little importance, detailed information is scanty.

Professor Safford's section at the north end shows

	Feet
1. Upper conglomerate, very heavy, pebbly, estimated.	250
2. Trace of *coal*	
3. Fireclay and sandy shale	1 to 39
4. Conglomerate	37
5. Shale	23
6. Trace of *coal*	
7. Sandy shale and some sandstone	305 to 320

Professor Spencer's section at the same locality differs very little. His measurement gives 225 feet as the thickness of number 1, the bottom 50 feet being a massive conglomerate and the upper portion chiefly cross-bedded sandstone. This mass evidently includes both Bonair and Etna, and the underlying coal bed, mined at a few miles farther south, is recognized by Spencer as equivalent to the Etna (Castle Rock) of Raccoon mountain.

The basin deepens southward, so that within 6 miles from the Tennessee line Professor Spencer obtained a long section, thus:

	Feet.	Inches.	Feet.	Inches
1. Shales and concealed	274	0		
2. *Coal* and shale	14	0		
3. Shale and concealed	43	0		
4. Sandstone	35	0		
5. *Coal bed*	3	6	to 4	6
6. Sandstone	35			
7. Shales, red, black, blue, variegated, with thin limestone	32	0		
8. *Coal bed*	1	10		
9. Red and blue shales	105	0		

		Feet.	Inches.	Feet
10.	*Coal bed*	0	2	
11.	Shales and sandstones, variable	150	0	
12.	*Coal bed*	1	8	
13.	Massive sandstone, some shale	27	0	
14.	*Coal bed*	0	2	to 9
15.	Upper Conglomerate and sandstone	150	0	
16.	Shales	120	0	
17.	Lower Conglomerate and sandstone	40	0	
18.	Shales and concealed, estimated	250	0	

The feature of especial interest is the presence of red, blue, and variegated shales so far down in the section. Number 6 is certainly not higher than the Rockcastle sandstone; yet below it is a mass of shales suggesting the Conemaugh conditions. The interval from the top of the Upper to the bottom of the Lower conglomerate is practically the same as in the other section. The Etna and "Dade" coal beds are mined within 2 miles of this locality. The beds numbers 2 and 5 were seen by Mr Hayes, who gives about 60 feet as the interval. The lower bed is of importance. Number 13 is at the horizon of the Sewanee, while the two thick beds are at the horizon of important beds in southern Kentucky.*

Passing over into Alabama, one finds Mr McCalley's general section of the measures,

		Feet.	Inches.	Feet.	Inches
1.	Sandstone	75	0	to 0	
2.	*Coal bed*	2	0	to 0	4
3.	Shales	10	0	to 4	
4.	*Coal bed*	0	10	to 0	0
5.	Shale	30	0	to 25	
6.	*Coal bed*	1	8	to 0	3
7.	Upper Conglomerate [Bonair]	60	0	to 50	
8.	*Coal bed*	1	0	to 0	
9.	Shales	9	0	to 0	
10.	*Coal bed* [Cashie]	3	6	to 2	
11.	Shales and sandstone	40	0	to 35	
12.	Lower Conglomerate [Etna]	100	0	to 25	
13.	*Coal bed* [Etna, Cliff, Castle Rock]	2	0	to 0	
14.	Sandstone and shale	50	0	to 40	
15.	*Coal bed, Dade, Eureka*	2	8	to 2	8
16.	Fireclay with fossil stems	20	0	to 3	
17.	*Coal bed*	1	6	to 0	6
18.	Sandstone and shale, estimated	250			

* J. M. Safford: Geol. of Tennessee, p. 385.
J. W. Spencer: Geol. Survey of Georgia, the Paleozoic Group, 1893, pp. 135, 139, 254–257.
C. W. Hayes: U. S. Geol. Survey folio, Ringgold, 1894.

The variable bed, represented by numbers 2, 3, and 4, is at the Sewanee horizon, and number 6 is at the Jackson horizon of southern Tennessee; both beds seem to be persistent to the southern end of the field, and the Sewanee is mined to some extent for use in Gadsden. The Cashie coal bed is important near Fort Payne of De Kalb county, but in Cherokee and Etowah it rarely exceeds 1 foot. It often underlies the Bonair directly and sometimes it is distributed irregularly through the bottom layers of that deposit. In like manner the Etna coal bed often occurs as strings or pockets in the Etna sandstone and it is rarely of any value. The Dade coal varies greatly, but sometimes, as at the Eureka mines in De Kalb, is thick enough to be mined, but all of the beds tend to become thinner toward the southern end of the field.

The Bonair is very coarse near the Georgia line; it becomes less coarse southward, and within 8 or 10 miles is merely a coarse sandstone, about 60 feet thick. The Etna is not conglomerate; usually is a more or less cross-bedded sandstone, much of it massive. In De Kalb it is about 60 feet; in Cherokee, from 75 to 100 feet, and in Etowah about 75 feet. The interval between Bonair and Etna varies from 15 to 60 feet, and the total thickness from the top of the former to the bottom of the latter is somewhat more than 200 feet, approximately the thickness assigned by Professor Spencer to his Upper Conglomerate at the north end of the field.*

The Cahaba coal field, embracing portions of Saint Clair, Jefferson, Shelby, and Tuscaloosa counties, was studied by Mr Squire wholly with a view to determine economic values, so that the details of beds, aside from coals, are scanty. The diagrammatic sections on the map reveal the presence of very little shale, the rocks being sandstone, gritty slate, and conglomerate. The topmost 500 feet are almost wholly conglomerate. The aggregate thickness assigned by Mr Squire is 5,525 feet. The conditions observed in Blount mountain are clearly only a transition from those in Raccoon to those in Cahaba, as well as to those in Coosa. The Millstone Grit group is about 1,700 feet thick, and consists mostly of pebbly rocks and gritty slates. There are evidently three great beds of conglomerate separated by gritty slates, with several thin coal beds, only two of which appear to be persistent. One of these underlies what may be taken as the Etna conglomerate, and is at about 250 feet above the Lower Carboniferous limestone, the interval being filled with rocks less coarse than the overlying conglomerate. On top of the massive Etna, about 300 feet thick, one finds gritty slates extending to the second great conglomerate, which with the slates is about 650 feet. The upper divis-

* H. McCalley: Coal Measures of Plateau Region, pp. 84, 87, 88, 89, 91, 94-97, 105.

ion is about 500 feet thick—conglomerate, sandstone, and gritty slates. The middle conglomerate is identified by Mr Gibson with his second conglomerate of Blount mountain, the Bonair. If this identification be correct, the important coal bed above is at the Sewanee horizon. The immense mass of conglomerate at the top is thought by Mr Gibson to be the same with his fourth conglomerate of Blount mountain, but this conclusion awaits confirmation.*

The Coosa coal field, embracing parts of Saint Clair and Shelby counties, is only 3 or 4 miles east from the last, being separated from it by the Cahaba valley. Mr Gibson gives 5,750 feet as the thickness of Coal Measures in the deepest portion of the basin. He has traced his First and Second conglomerates (Etna and Bonair) through a great part of the field, but they are greatly increased in thickness and are separated by about 200 feet of shale, the total being nowhere less than 1,200 feet, while in one part it may be 1,500. He recognizes his Fourth conglomerate in 500 feet of conglomerate and quartzitic rocks near the top of the section, evidently the top conglomerate of the Cahaba field. Mr Gibson especially emphasizes the thickening of the coarser beds; the First (Etna) conglomerate, only 80 to 100 feet in Blount mountain, is 400 to 500 feet here, and the Fourth conglomerate shows an almost equal increase. The coal beds, almost twenty in number, are persistent, and half of them are workable, while one of them attains a thickness of 13 feet of solid coal.†

The thickness assigned to the sandstones in the Cahaba and Coosa fields may be excessive, but numerous opportunities for direct measurement were found, and such measurements prove sufficiently that Mr Gibson is correct in asserting so firmly that the coarser deposits thicken rapidly toward the east.

The western part of the Warrior coal field is properly the southern termination of the great Indiana-Illinois coal field, from which, however, it is separated by an interval of more than 200 miles. The general conditions were the same throughout this southern part of both basins, as appears from the close resemblance of the sections obtained in the several counties. The work in this field was performed by Mr McCalley.

The elevated ridge, forming the eastern edge of the field along Browns valley and the northern edge across Marshall, Morgan, Lawrence, and Franklin almost to the Mississippi border, is known as Sand mountain.

The continuation of the Raccoon area lies east from the Warrior river, in Jefferson and Tuscaloosa counties, and passes under the Cretaceous

* J. Squire: Geol. Survey of Alabama, Cahaba Coal Field, 1890, pp. 4, 5, 14. Diagrams of sections on the map.

† A. M. Gibson: Geol. Survey of Alabama, the Coosa Coal Field, 1895, pp. 26, 55, 79, 81, 125.

near the latitude of Tuscaloosa, a few miles north from the similar termination of the Cahaba field in Bibb county. The section in Jefferson and Tuscaloosa is very long, showing somewhat more than 3,000 feet of Coal Measures, fully 2,800 feet being above the Bonair sandstone. The Etna sandstone, at about 40 feet above the Lower Carboniferous, is light colored, massive, coarse, but without pebbles, and from 40 to 75 feet thick, with the thin Etna coal bed immediately below it, and the Dade, or perhaps a lower bench of the Etna, at from 3 to 10 feet lower. The Bonair, 30 to 50 feet thick, is somewhat pebbly, is about 50 feet above the Etna, and rests on the Cashie coal bed. The Jackson and Sewanee horizons are represented by coals at 5 and 41 feet above the Bonair.

The detrital deposits above the Sewanee horizon show extreme variability, intervals being given as 50 to 300 feet, 25 to 125 feet, 60 to 225 feet in the generalized section. Fossiliferous limestones, associated with sandstones also containing marine fossils, are at about 1,000, 1,300, 1,950, and 3,000 feet above the base of the formation, but these limestones are local in distribution. Two persistent conglomerates, both thin, are shown, one at about 1,500 feet above the base and the other toward the top of the series. Several non-persistent conglomerates appear in the upper 600 feet of the section, but they are all thin and mere lentils. One may recognize the third conglomerate of Blount mountain, and in the coarser beds at the top of the section there appears to be the representative of the conglomerates of the Coosa and Cahaba fields. Mr McCalley reports 50 coal beds above the Bonair, but for the most part they are very thin, though several of them become economically important under large areas. It is difficult, in the absence of detailed sections, to make proper comparisons with the Coosa and Cahaba fields, but the thickness of the coal beds in the Coosa field and the diminished number there seems to suggest that the many beds reported by McCalley in the Warrior may represent separated benches of thicker beds at the east.

Variegated shales make their appearance at about 1,000 feet above the base, and thence upward are of frequent occurrence. In Walker county, west from Jefferson, a red sandstone, 25 feet thick, is shown at a little way below the Third conglomerate. The rocks generally are soft, and the sandstones tend to be shaly; but the section in this county, as well as in Fayette and Lamar westward to the Mississippi border, does not reach downward to the Bonair.

Northward from this tier of counties the section becomes shorter, so that in Cullman there remain only about 1,000 feet above the Bonair. Here, as in Jefferson, no determination can be made of relations above the Sewanee coal bed, which underlies about 500 feet of shales and sandstones. Both Bonair and Etna are here, massive and more or less

pebbly; but they are thin, about 30 feet, and averaging 40 feet apart. The Cashie and Etna coal beds are insignificant, and the interval to the Lower Carboniferous is from 30 to 40 feet. In Winston, west from Cullman, the detrital beds are coarser, and sandstone seems to prevail above the Bonair. In counties along the northern outcrop the section remaining extends to but a short distance above the Bonair. Both sandstones are present to the last exposure at the west, within two or three miles of the Mississippi line. They retain a thickness of approximately 60 feet, but toward the west become less massive and are divided by beds of shale. The interval below the Etna, 30 to 40 feet in Marshall, increases westwardly to 60 feet in Morgan and almost 100 feet in Franklin.*

TENNESSEE

Returning now to Tennessee, at the Daisy mines, about 20 miles north from Chattanooga, on the eastern escarpment, Mr Hayes obtained a section as follows:

	Feet.	Inches
1. Sandstone	50	0
2. Shale	10	0
3. *Coal bed* [Sewanee]	3	6
4. Shale and sandstone	25	0
5. Sandstone [Bonair]	65	0
6. Shales and concealed	85	0
7. Sandstone	20	0
8. Concealed	60	0
9. *Soddy coal bed*		
10. Clay and shale	5	0
11. Conglomerate and massive sandstone [Etna]	80	0
12. *Coal bed* [Etna]	3	0
13. Shales, some sandstone	100	0
14. *Coal bed*	1	6
15. Shales, some sandstone	155	0
16. Trace of *coal*		
17. Shales and sandstone	115	0
18. Concealed	70	0
19. Shales and sandstone	30	0

The succession is sufficiently clear. The coal bed number 3, at 260 feet above the Etna conglomerate, which here also is the top of the Lookout, is the Slate vein of the Safford Etna section, the Sewanee coal bed of the Tracy City section. The Bonair is present at the Daisy mines

* H. McCalley: Geol. Survey of Alabama, Warrior coal field, 1886. For Jefferson and Tuscaloosa, pp. 273, 416, 417; Walker, Fayette, and Lamar, pp. 99, 110, 131-134; Cullman, pp. 89, 90, 93: Marion and Winston, pp. 30, 31, 64, 65.

The Plateau region. For Blount, pp. 208-215; for Marshall, Morgan, and Franklin, pp. 59, 64, 65, 69, 70, 71, 73.

as a massive sandstone at 25 feet below the Sewanee. The Soddy coal bed rests almost directly on the Etna (Cliff) conglomerate. The Etna (Cliff-Castle Rock) coal bed is 3 feet thick and is mined. The Dade coal bed of Mr Hayes' Etna section is here at 100 feet below the Etna coal, approximately the same distance as in that section; but here it is not of workable thickness.

Mr Hayes' section at Rathbun, a few miles northeast from the Daisy mines, is important; it is as follows, the identifications in brackets being by the writer:

	Feet.	Inches
1. Sandstone	65	0
2. *Coal bed* [*Walker*]	2	0
3. Sandstone and shale	65	0
4. *Coal bed* [*Slate, Sewanee*]	3	2
5. Shale and sandstone	50	0
6. Sandstone [Bonair]	75	0
7. Shale	20	0
8. *Coal bed*	3	0
9. Sandstone and shale	50	0
10. *Coal bed*	5	0
11. Shale	30	0
12. *Coal bed*	1	3
13. Shale	40	0
14. *Soddy coal bed*	4	6
15. Interval	5	0
16. Conglomerate and massive sandstone [Etna]	70	0
17. Shale	10	0
18. *Coal bed* [Etna]	1	6
19. Shale	30	0
20. *Coal bed* [*Dade* of Colton]	1	0
21. Shale, a little sandstone	185	0
22. *Coal bed*	1	6
23. Shale	55	0
24. *Coal bed*	2	4
25. Shale	15	0
26. Sandstone	50	0
27. Shale	10	0
28. *Coal bed*	1	8
29. Shale and sandstone	25	0
30. *Coal bed*	1	3
31. Mostly shale	85	0

The interval between Bonair and Etna is 158 feet; at Daisy, it is 170, and at Etna, 140. The Sewanee is 283 feet above the Etna conglomerate, and underlying the sandstone is the Walker, which may be, as Safford suggested, merely a split from the Sewanee. Four coal beds are present in the interval between the conglomerates and three of them are of work-

able thickness. The Soddy, workable here and at the Daisy, does not appear in the other sections. The Bonair is evidently only a sandstone, but the Etna (Cliff) is conglomerate. Below the latter the measures are 475 feet, a notable thickening in the northeasterly direction, and this thickening is at the bottom of the column. The lowest coal bed at Etna is about 200 feet below the Etna conglomerate or at the place of number 22 of the Rathbun section; but in the latter are three lower beds, the lowest at nearly 400 feet.

At Graysville, in southern Rhea county, about 12 miles northeast from Rathbun, another section was obtained by Mr Hayes, as follows:

	Feet.	Inches.	Feet
1. Sandstones, shales, and concealed	550	0	
2. *Bony coal*	5	0	
3. Shales and sandstone	90	0	
4. *Nelson coal bed* [Sewanee]	3	0	
5. Shales	35	0	
6. Conglomerate and massive sandstone [Bonair]	115	0	
7. Shale	40	0	
8. *Bony coal*	0	8	
9. Shale and sandstone	40	0	
10. Sandstone	60	0	
11. Shale	50	0	
12. *Coal bed*	0	0	to 3
13. Shale and sandstone	110	0	

The lower rocks concealed or not measured.

Number 6 is the top of the Lookout; it here includes some of the underlying shale, replaced by sandstone, as well as some of the overlying sandstone. The " Nelson " bed is at the horizon of the Sewanee and is 190 feet above number 10, which is in the place of the number 10 at Rathbun, while number 10 is at 150 feet above number 14, which holds the place of the Etna coal bed in the Rathbun section. At Dayton, also in Rhea county and about 5 miles northeast from Graysville, Mr Hayes obtained a very important section, which is as follows, the identifications in brackets being, as in other sections, by the writer:

	Feet.	Inches
1. Sandstone [Corbin]	75	0
2. Shale	20	0
3. Sandstone	15	0
4. Shale	25	0
5. *Richland coal bed*	4	0
6. Shale and sandstone	35	0
7. Sandstone	65	0
8. Shale	20	0
9. Sandstone and shale	75	0

	Feet.	Inches.	Feet
10. Shale	75	0	
11. Sandstone [Rockcastle]	70	0	
12. Shales	50	0	
13. *Coal bed*	1	0	
14. Shale	70	0	
15. Sandstone	25	0	
16. *Coal bed*	0	4	
17. Shale and some sandstone	75	0	
18. *Nelson coal bed* [Sewanee]	5	0	
19. Shale and some sandstone	55	0	
20. Conglomerate and massive sandstone [Bonair]	70	0	
21. *Coal bed*	0	2	
22. Shale and sandstone	90	0	
23. *Coal bed*	0	10	
24. Shale and sandstone	165	0	
25. *Coal bed*	3	0	to 4

Here one reaches the higher measures again. The succession above the Nelson (Sewanee) coal bed appears to be clear; the sandstone, number 15, is that so persistent between the Bonair and Rockcastle; number 11 is the Rockcastle, about 280 feet above the Bonair, and number 1, at about 330 feet above the Rockcastle, is in place of the Corbin, that being very nearly the interval at Pikeville, almost due west from Dayton. If these identifications be correct, the Richland coal of Hayes is at the horizon of the Barren Fork coal bed in Pulaski county of Kentucky.

No section or note is available for the region northeast from Dayton until Rockwood, 30 miles distant, in Roane county, is reached. There Mr Hayes' section is

	Feet.	Inches
1. Sandstone	150	0
2. Shale	25	0
3. *Richland coal bed*		
4. Shale and sandstone	85	0
5. Massive sandstone	140	0
6. Shale	25	0
7. Trace of *coal*		
8. Shale	15	0
9. Sandstone	310	0
10. *Rockwood coal bed* [Sewanee]		
11. Shale	50	0
12. Conglomerate and sandstone [Bonair]	70	0
13. *Coal bed*		
14. Sandstone and concealed	300	0
15. *Coal bed*	0	2
16. Shale and concealed	175	0

to the Lower Carboniferous limestone, giving for the Lookout formation

a total of about 550 feet, inclusive of some part of the Pennington shales of Campbell and Keith (Shenango). Surmise is dangerous where the gaps are so wide, but the sections seem to suggest that the Bonair and Etna conglomerates come together between Rathbun and Graysville, as they do in the region west from Sequatchie valley, not far from the latitude of Graysville, and that the combined mass is thinner. This is the more probable, since northward from Rathbun the escarpment is cut back and all members of the formation thin very rapidly toward the west for several miles from the escarpment. Mr Hayes says that the Lookout diminishes from 510 feet on the escarpment to 260 feet in the Crab Orchard range, only 4 or 5 miles toward the west.*

Professor Safford's section in the gap through Crab Orchard, about 8 miles west from Rockwood, reinforces the suggestion. This locality is midway between Rockwood and Crossville. He finds the "Conglomerate" 100 to 150 feet thick, with the Sewanee ("Haley's") coal bed at 30 to 40 feet above it, while below the conglomerate there are but 228 feet of measures.†

But, however the conditions may be at Rockwood and southwestward, the Bonair and Etna (Cliff) conglomerates are distinct at Harriman, 12 miles northeastward from Rockwood, where the escarpment extends farther toward the east. Mr Hayes gives a short section at Harriman showing an interval of 155 feet between the "Rockwood-Harriman" coal bed and the little bed below the Bonair. About thirty years ago Professor Bradley compiled a general section north from Harriman, which is of great importance, as it was measured carefully.‡ It is

	Feet.	Inches.	Feet
1. Shales	140	0	
2. *Coal bed*	1	6	
3. Shale and sandstone	179	0	
4. *Coal bed*			
5. Shale and sandstone	90	0	
6. *Coal bed*	1	0	to 3
7. Shale and sandstone	110	0	
8. *Coal bed*, reported to be	1	0	
9. Interval	50	0	
10. *Coal bed*, said to be	1	6	
11. Interval	193	0	
12. Heavy bedded sandstone [Corbin]	153	0	
13. Mostly shale	320	0	
14. Irregularly bedded sandstone [Rockcastle]	50	0	to 70
15. Shale and concealed	180	0	to 200

*C. W. Hayes, U. S. Geological Survey folios, Kingston, 1892.

†J. M. Safford: Geology of Tennessee, p. 389.

‡F. H. Bradley, quoted by Killebrew and Safford: Resources of Tennessee, 1874, pp. 200, 201.

	Feet.	Inches.		Feet
16. Heavy bedded sandstone	40	0	to	45
17. Mostly shale	117	0		
18. *Rockwood coal bed* [Sewanee]	3	0	to	4
19. Fireclay, shale, and shaly sandstone	18	0	to	27
20. Coarse to fine and pebbly sandstone, heavy bedded, with 3 beds of shale; in all, 18 feet	154	0		
21. Ferny shale	40	0		
22. *Coal bed* [Soddy]	3	0	to	4
23. Heavy bedded sandstone, mostly conglomerate [Etna, Cliff]	140	0	to	150
24. Clay and sandy shale	180	0		
25. Sandstone	25	0		
26. Gray ferriferous shale	170	0		
27. Sandstone	85	0	to	100
28. Shales	150	0	to	200

The whole of this section belongs to the Pottsville. With the Corbin, which is the Sharon sandstone, one reaches once more the beds equivalent to the northwest Pennsylvania section, of which it is the bottom. No attempt at identification of the higher beds is attempted here, but, as Harriman is on the border of the area showing greatest thickness, one should find at a short distance northwest not less than 1,000 feet of Pottsville above the Corbin (Sharon) sandstone. The thickness of Corbin here is practically the same as in Mr Hayes' Rockwood section. The Bonair in number 20 can not be separated sharply from the overlying and underlying sandstone beds, which replace much of the shales. The coal bed number 22 can hardly be the coal bed of Mr Hayes' Rockwood section at 155 feet below the Sewanee; it is more nearly in the place of the Soddy, which rests on the Etna conglomerate. The identification of number 23 with the Etna conglomerate agrees with that of Professor Bradley, who says that the Etna coal bed is at 15 feet below it. A 2-foot coal bed has been opened in number 24, but its exact position is not given in the extract from which the section was copied. The thickness of measures below the Etna (Cliff) conglomerate is 643 feet, and the whole thickness of the Lookout, including what may be taken as the Bonair proper, is about 925 feet. From this should be taken probably 100 feet at the bottom belonging to Campbell's Pennington (Shenango) shales, so that the thickness may be taken approximately at 800 feet.

The coal at Rockwood and Harriman is badly contorted. Messrs Killebrew and Safford say that the bed at Rockwood dips 35 degrees northwest, and "is remarkable for the immense curled masses of coal

rolled up between the 'horsebacks' and attaining a thickness of from 60 to 110 feet."* Mr Hayes reports that at Harriman the dip is about 45 degrees northwest, and that the coal is crushed into rhomboidal blocks with polished surfaces.

At Harriman one is on the border of Safford's northeastern district, where the greatest thickness of Coal Measures is found. He made practically no systematic study here, his volume containing only an incomplete section in northern Anderson county. Much of the region was examined by Mr Keith, who has published only a brief synopsis of his work. Professor Bradley made a preliminary section in Anderson county. It is unfortunate that so little of detail is available for this area, in which, as proved by Mr Campbell's work in southwest Virginia and by the work of Professor Crandall in Kentucky, so great changes take place in the Pottsville. Enough, however, is available to enable one to follow out the main horizons and to recognize the more important conditions.

Mr Keith's work, beginning in eastern Fentress county, where it is in contact with that of Mr Campbell, extends across to the eastern escarpment, where it is continuous with that of Mr Hayes at the south. His division of the section within his area is

	Feet
1. Anderson sandstone remaining	550
2. Scott shales. Largely shale, but containing some sandstone, several coal beds, of which one near the bottom is especially important and sometimes 6 feet thick.	500 to 600
3. Wartburg sandstone. A bold sandstone at top and bottom with other sandstone beds, some of them 60 feet thick. Fully one-half of the mass is sandstone. It contains certainly five coal beds.	500 to 600
4. Briceville shales. Bluish gray to black, argillaceous to sandy shale, with thin sandstones and several coal beds.	200 to 650
5. Lee conglomerate	400 to 1,200

It is sufficiently clear that in Fentress and in western Morgan the Rockcastle is taken as the top of the Lee, which is represented on the general chart of the Briceville folio as embracing the Lookout and the lower part of the Walden. The Lookout closes with the Bonair, which is well marked in eastern Fentress, having been reached in borings near Rugby. The Briceville shales overlie the Rockcastle and decrease westwardly, being only 200 feet thick in Fentress, where they underlie the Corbin sandstone, the top of the Lower Pottsville. Mr Campbell finds

*J. B. Killebrew and J. M. Safford: Resources of Tennessee, p. 197.

them only 125 feet thick in western and northern Fentress. The Corbin sandstone, then, is the bottom prominent sandstone of the Wartburg, above which should come the Sharon and Mercer, or Upper Pottsville. The upper or great sandstone of the Wartburg holds the place of the great sandstone underlying the Hunnewell or Tionesta coal bed of Kentucky and Ohio, and that coal bed is to be looked for in the important bed reported by Mr Keith at the bottom of the Scott shales. In Fentress, except at the extreme east, in the western third of Morgan, and in northwest Scott, rocks higher than the Rockcastle are practically wanting; in eastern Morgan and Scott the surface rocks are mostly Briceville, though, especially in Morgan, considerable areas of Wartburg and insignificant areas of Scott remain. In Anderson and Campbell, reaching to the eastern escarpment, those higher groups remain in considerable patches, but at 2 or 3 miles back from the escarpment.

The Lee conglomerate thickens very rapidly toward the east. At Rugby, in the extreme north of Morgan, where the Bonair is 80 feet, a boring showed for the whole a thickness of about 500 feet, while at Rugby road, 7 miles south-southeast, it is 700 feet, the increase being chiefly in the Bonair and underlying beds, which are represented by 250 feet of sandstone and conglomerate, suggesting that the Etna (Cliff) conglomerate has been reached in this direction. The interval between Rockcastle and Bonair in this boring is about 350 feet. The Rockcastle is a sandstone, not showing the conglomerate features characterizing it farther toward the west and northwest.

Professor Bradley's section on Coal creek, in Anderson county, is the only one embracing the whole column as found in the area; it was merely preliminary, having been made during a rapid examination for economic purposes, so that it is lacking in detail. A partial section at Coal creek is given by Mr Keith, and another was made by Professor Safford at 3 to 5 miles west from Coal creek. This last, though measured under serious disadvantage, gives important details which are wanting in the others and enables one to reconcile the apparent discrepancies. The section by Professor Bradley is given here with very little condensation.

	Feet.	Inches.		Feet.	Inches
1. Shale and sandstone	200	0			
2. *Coal bed U*	0	6			
3. Shale, Cliff sandstone	80	0			
4. *Coal bed T*	1	8	to	0	1
5. Interval	20	0			
6. *Coal bed S*	3	3			
7. Shales	10	0			
8. *Coal bed R*	1	0			

	Feet.	Inches.		Feet.	Inches
9. Shale and sandstone	10	0			
10. *Coal bed Q*	1	6			
11. Shale, Cliff sandstone	20	0			
12. *Coal bed P*	2	6			
13. Shale, some sandstone	300	0			
14. *Coal bed O*	5	0	to	7	
15. Shale, thin sandstone	350	0			
16. *Coal bed N*					
17. Shales and sandstone	110	0			
18. *Coal bed M*					
19. Shale, sandstone	100	0			
20. *Coal bed L*	2	10			
21. Shale	10	0			
22. *Coal bed K*	2	2			
23. Shale, Cliff sandstone	180	0			
24. *Coal bed J*	3	6			
25. Shale, sandstone	320	0			
26. *Coal bed I*					
27. Shale, sandstone	160	0			
28. *Coal bed H*	2	0			
29. Sandstone and shale	142	0			
30. *Coal bed G*	2	0	to	3	
31. Sandstone	40	0			
32. "Shells"	130	0	to	150	0
33. Laminated sandstone	12	0	to	15	0
34. *Coal bed F*	1	6	to	2	2
35. Shale and *coal*	1	0			
36. Clay	9	0	to	15	
37. *Coal bed E, Coal creek*	4	0	to	5	0
38. Clay	1	0	to	2	0
39. Shale, sandstone	30	0	to	40	0
40. Clay shale	30	0	to	35	0
41. Sandstone	20	0	to	35	0
42. Shale	10	0			
43. *Coal bed D*	1	6	to	2	4
44. Clay and shale	17	0	to	24	0
45. Shale, sandstone	40	0	to	50	0
46. *Coal bed C*	3	0	to	4	0
47. Shaly sandstone	52	0			
48. Heavy sandstone	33	0			
49. Clay shale	57	0			
50. *Coal bed B*	1	6	to	2	0
51. Shale, sandstone	150	0			
52. Heavy sandstone	50	0	to	60	0
53. Sandstones and shales with *Coal bed A*	250	0			

As the area in which the lower portion of the section, that below number 40, was obtained is much disturbed, the measurements are largely

estimates and the thickness below number 41 is approximately 675 feet. Professor Safford's section does not extend below the "Wheeler" or "Coal Creek" bed, number 37 of Professor Bradley's section. Mr Keith's measurements below that coal bed, made during his work for the United States Survey, differ materially from that of Professor Bradley. His section is

		Feet.	Inches.	Feet.	Inches
1.	*Coal Creek seam*				
2.	Shale	40	0		
3.	Trace of *coal*				
4.	Shale	30	0		
5.	*Coal bed*	0	10		
6.	Shale	25	0		
7.	Trace of *coal*				
8.	Shaly sandstone	90	0		
10.	Shale	25	0		
11.	Sandstone	40	0		
12.	Shale	20	0		
13.	*Coal bed*	1	8	to 2	6
14.	Shale	15	0		
15.	Sandstone and conglomerate	110	0		
16.	Shale	15	0		
17.	Sandstone	50	0		
18.	Shale	10	0		
19.	*Coal bed*	2	6		
20.	Shale	20	0		
21.	Sandstone	50	0		

or about 550 feet below the Coal Creek seam. This section is far from reaching the bottom of the Lee, to which Mr Keith is inclined to assign a thickness of 1,100 to 1,200 feet, with number 11 of this section as the top member. It seems preferable to take number 8 as the top and to regard it as the Bonair, with number 15 as the Etna (Cliff) conglomerate. This interpretation would make the Coal Creek coal bed the Sewanee, and a comparison of the sections above that bed confirms the correlation. In all of the sections there is practical agreement as far up as Bradley's "Coal bed I," above which for 320 feet (Bradley) or 350 feet (Safford) no coal beds were seen. Mr Keith's section shows four coal beds in the interval.

The sections by Professor Bradley and Mr Keith were made in the same locality, the lines passing through the Coal Creek mines; but Professor Safford's section was made at 3 or 4 miles westward, though the top of the section was within a mile of the highest point reached by Professor Bradley.

In Professor Safford's section a massive sandstone, 50 to 60 feet thick,

is shown at about 190 feet above the Coal Creek (Sewanee) coal bed, or 20 feet above Bradley's "Coal G," while at 235 feet higher, about 480 feet above the Coal Creek, is a great sandstone, 75 to 100 feet thick. This is about 50 feet above Bradley's "Coal I" and 560 feet above the Bonair conglomerate, a decided increase of thickness of measures toward the east, for at Rugby road, 12 or 15 miles west, the interval between Bonair and Rockcastle is about 350 feet. The lower sandstone is evidently that between the Sewanee coal bed and the Rockcastle, which is persistent in all the sections. At 370 feet above this great sandstone, taken to be the Rockcastle, is another, 60 to 90 feet, which is in the place of the Corbin, the top of the Rockcastle formation of Crandall, the Lee formation of Campbell's Kentucky folios, while at approximately 800 feet higher is a massive sandstone, 100 feet thick, capping the peaks in Safford's area and evidently almost immediately underlying "Coal P" of Bradley's section. At about 250 feet below it in Safford's section is a bed of fine coking coal, 6 feet thick and divided by a 6-inch clay parting. This is Bradley's "Coal O," which in his section is 300 feet below "Coal P."

The intervals observed at Coal creek, Harriman, and Dayton may be compared.

	I	II	III
	Feet.	Feet. Inches. Feet.	Feet
Coal bed	4	1 6	
Interval	230	193 0	
Corbin	60 to 90	193 0	75
Interval	370	320 0	334
Rockcastle	75 to 100	50 0 to 70	70
Interval	235	180 0 to 200	121
Sandstone	50 to 80	40 0 to 45	25
Interval	190	117 0	75
Sewanee coal bed			

The interval from Sewanee to Rockcastle shows constant increase in northeastward direction, but that from the Rockcastle to the Corbin is practically uniform throughout, and that between the Rockcastle and the coal bed at the top shows no change between Harriman and Coal creek. The section below the Sewanee coal bed shows a similar increase northeastwardly. The Bonair and lower rocks are not more than 800 feet at Harriman. The thickness at Oliver springs, according to Mr Keith, is about 900 feet, but at Coal creek it is 1,100 to 1,200 feet.

This grouping of the measures is of interest not only as showing the relation to the Kentucky coal field, but also as binding the Tennessee work to the detailed studies of Mr Campbell in southwest Virginia. The great sandstone crowning Professor Safford's section is that which under-

lies the Kentucky "Coal 4." It is Mr Campbell's "Gladeville sandstone" of southwest Virginia. The coal bed above it is the Tionesta of Pennsylvania and Ohio, the Hunnewell and Lower Splint of Kentucky, while that at 300 feet, more or less, below this coal is apparently the number 3 of Kentucky, the Mercer or Elkhorn, and perhaps the Imboden of southwest Virginia; so that in this section by Professor Bradley the whole of the Pottsville and a small portion of the Allegheny are included.*

VIRGINIA

No detailed observations are recorded between Coal creek and northeastern Lee county of Virginia, a distance of 40 miles. At the latter locality one finds the section closely allied to the Elkhorn section of Kentucky.

In the Big Stone Gap area, embracing parts of Lee, Wise, and Scott counties, Virginia, and of Harlan county, Kentucky, Mr Campbell divides the measures into

	Feet
Wise formation	1,276
Gladeville sandstone	120
Norton formation	1,280
Lee formation	1,530

with a still higher formation, which does not concern the present paper.

In Lee county, at a few miles southwest from the limits of Mr Campbell's area, Stevenson obtained a section of the Lee formation along Penningtons gap, where the rocks are almost vertical and, except in one very tortuous portion of the gorge, well exposed. The intervals were determined by pacing during a very hasty examination, so that while the succession is given correctly, some of the thicknesses assigned are certainly incorrect. The rocks are almost wholly sandstone and conglomerate, with a reported thickness of somewhat more than 1,000 feet, evidently too little, for here one has higher measures than in Mr Keith's Coal Creek section, where the thickness from Bonair downward is given as 1,100 to 1,200 feet. The error is most probably in the estimate of a sandstone mass at about 255 feet below the "Bee rock" or top conglomerate of the formation. Mr Campbell's section in Big Stone gap, somewhat more than 15 miles northeast from Penningtons gap, is in marked contrast with that offered by Stevenson not only in thickness but in composition. It is

* F. H. Bradley: Report to Coal Creek Mining and Manufacturing Company, 1872, pp. 5–10. This report is quoted in Resources of Tennessee, pp. 207–210.
J. M. Safford: Geology of Tennessee, pp. 401–403.
A. Keith: United States Geol. Survey folios. Briceville, 1896; Wartburg, 1897.

	Feet.	Inches
1. Massive sandstone, "Bee rock"	95	0
2. Black carbonaceous shale	31	0
3. Dark sandy shale	14	0
4. Brown and green shale	6	0
5. Concealed	85	0
6. Dark shale	210	0
7. Sandstone, with a few bands of shale	566	0
8. *Coal bed*	4	10
9. Shale, with a few bands of sandstone	112	0
10. *Coal bed*	3	0
11. Shale	150	0
12. Conglomerate	250	0

The conglomerate at the bottom, also present in Penningtons gap, where it is certainly much thinner, is a new member or at least it can not be recognized in descriptions of sections farther south. It may be the lowest sandstone of Bradley's Harriman section, which rests on shales, of which much belongs to the Pennington (Shenango) of Campbell, and it may be the lowest conglomerate referred to by Mr Keith. A coal bed at 20 to 30 feet below this conglomerate is described by Campbell as a very fair cannel. Accepting the reference of the conglomerate as given above, this coal bed would be at the place of Bradley's Coal A, and some of the shales assigned by Campbell and Stevenson to the Lower Carboniferous should be placed in Pottsville.

The Norton formation extends upward to a bold sandstone, the Gladeville, which was traced through Lee and Wise counties of Virginia and Harlan of Kentucky. The thickness of Norton, as given by Campbell, is fully 500 feet greater than Stevenson's estimate, obtained by tying together two sections which evidently were not continuous. Mr Campbell gives two measured sections in the western part of Wise county, which together show the upper part of the Norton, and Stevenson gives one in Lee county for the lower portion, the thicknesses being largely estimates. Though not continuous, these enable one to get such understanding of the succession as is necessary for comparison with adjacent areas in Tennessee and Kentucky. The section by Mr Campbell includes the Gladeville sandstone and some higher beds which are important in this connection. It is

	Feet.	Inches
1. Sandstone	45	6
2. "*Cannel bed*"	6	6
3. Thin bedded sandstone	29	0
4. *Upper Splint bed*	1	6
5. Concealed	58	6
6. Shale	16	6
7. Sandy shale	13	6

		Feet.	Inches.	Feet.	Inch
8.	*Lower Splint bed*	2	0		
9.	Gladeville sandstone	122	0		
10.	*Coal bed*	2	0		
11.	Shale and concealed	11	0		
12.	*Kelly coal bed*	1	6		
13.	Interval	75	0		
14.	*Imboden coal bed*	6	7	to 13	1
15.	Concealed	70	0		
16.	Sandstone	20	0		
17.	*Coal* and clay	4	8		
18.	Shale	10	0		
19.	Sandstone	105	0		
20.	Shale	110	0		
21.	*Coal bed*	0	8		
22.	Sandstone	10	0		

showing in all about 530 feet of the Norton. In Stevenson's section at Penningtons gap traces of coal were seen at 25 and 150 feet above the "Bee rock," while at 235, 318, 380, and 417 feet are beds which sometimes attain workable thickness. A massive sandstone is present at about 325 feet above the "Bee rock."

In Harlan county of Kentucky, along the foot of Pine mountain and southward, the Norton appears to hold no important bed of coal, aside from that immediately underlying the Gladeville sandstone. Shales 375 feet thick overlie the Lee formation, with a 1-foot coal bed at the top, immediately underlying a massive sandstone, which is a notable feature in the topography, and clearly the same with at 325 feet above the Lee in Penningtons gap. The Gladeville sandstone is a marked feature in valleys on the southeast side of the county, and the coal bed underneath it becomes at times 5 feet thick. The Lower Splint coal bed resting on the Gladeville varies greatly, but is persistent and of great commercial importance. The Upper Splint is from 65 to 100 feet above the Lower, and the "Cannel" is 21 to 60 feet higher. On Little Black mountain the Cannel is 150 to 160 feet above the Lower Splint. The "Imboden" coal bed, though attaining great thickness in western Wise county, becomes insignificant in Lee, where it was not identified positively by Mr Campbell. Eastward it was followed to very near the line of Dickenson and Russell counties. The Cannel and Splints overlying the Gladeville sandstone were traced by Mr Campbell to the Dickenson line, about 20 miles from Pound gap, in the Elkhorn region of Kentucky.

Mr Hodge found a persistent fossiliferous limestone, 1 to 3 feet thick, at about 725 feet above the Imboden coal bed in Little Black mountain of Wise county.

In the extreme eastern part of Wise county Mr Campbell measured a section which shows the relations of the chief horizons of the Norton.

		Feet.	Inches.		Feet.	Inches
1.	Gladeville sandstone					
2.	Interval	150	0			
3.	*Imboden coal bed*	4	5			
4.	Interval	250	0			
5.	*Upper Banner coal bed*	3	0	to	7	
6.	Interval	100	0			
7.	*Lower Banner coal bed*	1	6	to	4	4
8.	Interval	225	0	to	285	
9.	*Kennedy coal bed*	1	0	to	9	
10.	Interval	340	0			
11.	*Tacoma coal bed*	3	4	to	4	4
12.	Interval	90	0			
13.	*Jawbone coal bed*	4	4	to	8	8
14.	Interval to Lee formation	150	0			

giving in all somewhat more than 1,200 feet for the Norton. The coal beds numbers 11 and 13 correspond to beds seen by Stevenson in Penningtons gap, where the latter is sometimes of workable thickness. The other beds below the Imboden are usually thin in Lee and western Wise. Careful and detailed observations were made in this area by Messrs McCreath and d'Invilliers, whose results will be utilized in another connection.*

In attempting to correlate these Virginia deposits with those already described in Tennessee, one is at some disadvantage because no available information exists for the region along the easterly border from Coal creek northeastward; the more so because only two imperfect sections of the Lee formation have been obtained within the Stone Gap area. It is possible only to recognize the chief members of the column, and detailed correlations must be left in great part for others.

Mr Campbell's Lee formation is strictly equivalent to Mr Keith's Lee conglomerate of the Wartburg quadrangle in Tennessee, the top member of which is the Rockcastle of Mr Campbell's section on the west side of

*J. J. Stevenson: Geological reconnaissance of parts of Lee, Wise, Scott, and Washington counties, Virginia. Proc. Amer. Phil. Soc., vol. 19, 1881, pp. 229, 230, 238, 239, 249, 250. The names *Cannel, Upper Splint, Lower Splint, Kelly,* and *Imboden,* applied to the coal beds in this paper, have been retained by Mr Campbell, though the upper three beds do not retain throughout the area the characteristics upon which the names were based. Stevenson's work in this region was a mere reconnaissance and in no sense "a careful study," as some have supposed. The whole time spent in the coal area within three counties was less than three days.

M. R. Campbell: Geology of Big Stone Gap coal field of Virginia and Kentucky. Bulletin U. S. Geol. Survey no. 111, 1893, pp. 39, 41–46, 63, 69; U. S. Geol. Survey folios, Estillville, 1894; Bristol, 1899.

J. M. Hodge: The Big Stone Gap coal field. 1893, p. 3 (author's edition, Trans. Amer. Inst. Mining Eng'rs).

the Cumberland plateau in that state and in Kentucky. This is the "Bee rock" of the sections in Penningtons and Big Stone gaps. The sandstone of Penningtons gap and of Harlan county, which belongs in the interval above the "Tacoma" coal bed of eastern Wise and western Russell, from 325 to 375 feet above the Rockcastle ("Bee rock"), is the Corbin of Campbell and the Sharon sandstone of Pennsylvania and Ohio. It is of interest to note that this interval has shown little change for more than 100 miles along the eastern outcrop. The Bonair and Etna (Cliff) are distinct in Penningtons gap, but they are not separate in the Big Stone Gap section. The Gladeville sandstone, 800 to 900 feet above the Sharon (Corbin), is the great sandstone underlying the Kentucky Coal 4, the Hunnewell cannel, and the Tionesta of Ohio and Pennsylvania. The Imboden coal bed is evidently at the horizon of Bradley's Coal bed O; the Lower Splint is his Coal bed P, and the interval in western Wise is practically the same as on Coal creek, the Gladeville sandstone in each locality being about 800 feet above the Sharon (Corbin). There are some additional details which confirm these identifications. It will be remembered that Professor Crandall, in his description of the Pound Gap region, showed a succession very similar to that of the Big Stone Gap area. His provisional section for the Elkhorn region may be compared with that at Big Stone gap:

	Feet.	Feet	
1. Fossiliferous limestone.....			
2. Interval.....	210	265	
3. *Cannel*.....			
4. Interval.....	150 to 175	21 to 60	
5. *Upper Splint*.....			
6. Interval.....	100 to 130	65 to 100	
7. *Lower Splint*.....			
8. Sandstone.....	120 to 150	120	Gladeville
9. *Coal bed*.....			
10. Interval.....	15 to 40	111	
11. *Elkhorn coal bed*.....	....	....	*Kelly*
12. Interval.....	20 to 40	75	
13. *Wright coal bed*.....	....	....	*Imboden*

with in Kentucky 400 feet and in Virginia 600 feet of shales and sandstones to the Sharon (Corbin) sandstone, these lower beds containing coal beds, some of which become of workable thickness at various localities.

Although Professor Crandall is careful to state that his Elkhorn general section is purely provisional, it suffices to show that the general succession is the same in both localities. Measured sections in neigh-

boring counties of Kentucky show that the intervals above the Gladeville sandstone to the Cannel are larger there than in the Stone Gap region. This decrease southwardly in the Allegheny is a foreshadowing of conditions which will be observed farther north. Below the Gladeville sandstone the increase is very marked, the interval to Sharon increasing from less than 500 to about 800 feet. The succession below the Gladeville sandstone would make the first coal bed equivalent to the "Kentucky 3*a*," and the "Elkhorn" equivalent to the "Kelly;" but the interval from Gladeville to Elkhorn in the Pound Gap region is much less than farther south in Kentucky. The structure of the bed, its peculiar variations in thickness, the remarkable excellence of the coal—all tend to ally it more closely with the Imboden. At present, however, the sections have not been made across the area, and one can go no farther than to recognize in the Kelly-Imboden horizon the representative of the Mercer beds of Pennsylvania and Ohio, represented in Kentucky by coal 3 and in some portions of the state by coals 3, 3*a*, and 3*b*.

No study of the region immediately northeast or northwest from Wise county has been published; but at about 25 miles from the Wise county line one reaches the extensive area studied by Mr Campbell, beginning with Tazewell and Buchanan counties of Virginia and continuing thence through Mercer, McDowell, Raleigh, and Fayette counties of West Virginia to the New river, and thence along that and the Kanawha river almost to the Ohio. In much of this area, as well as between it and the Kentucky line in West Virginia, one has Dr I. C. White's careful observations, as well as notes by Mr McCreath, some measurements by Mr d'Invilliers in Wyoming and Boone counties of West Virginia, and Mr Lyman's report on the Coal River region of the same state.

The eastern edge of the coal area beyond Wise county swings abruptly toward the east, the direction being but little north of east, whereas in Tennessee as well as in Lee county it is somewhat north of northeast. This change carries one quickly into a region where the sedimentation is different in type, and the tracing of minor horizons, in the absence of sections in Russell and western Tazewell of Virginia, must be somewhat hypothetical. The section for Tazewell, eastern Buchanan of Virginia, and western McDowell of West Virginia, as compiled from Mr Campbell's text, is as follows:

	Feet.	Inches
Tellowa formation:		
1. Sandstone and shale	350	0
2. *Coal bed*	5	8
3. Sandstone and shale	150	0

	Feet.	Inches.	Feet. Inches
Sequoyah formation:			
4. Sandstone and shale	200	0	
5. *Coal bed*	3	5	
6. Sandstone and shale	75	0	
7. *Coal bed*	2	5	
8. Sandstone and shale	175	0	
Dotson formation:			
9. Coarse sandstone	120	0	
10. Shales, thin *coal bed*	60	0	
Bearwallow formation:			
11. Conglomerate	60	0	
Dismal formation:			
12. Sandstone and shale	145	0	
With *coal*	4	8	
13. Sandstone or conglomerate	100	0	
14. Sandstone and shale	140	0	
15. *Coal bed*	4	0	to 8
Raleigh formation:			
16. Sandstone	100	0	
Welch formation:			
17. Sandstone, shale, and two *coal beds.*	250	0	
18. *Coal bed*	1	0	to 2
19. Sandstone and shale	100	0	
20. *Upper Horsepen coal*	2	0	to 8
21. Sandstone and shale	60	0	
22. *Middle Horsepen coal*	1	0	to 4
23. Sandstone and shale	110	0	
24. *War Creek coal*	4	0	to 5
25. Sandstone and shale	120	0	
26. *Lower Horsepen coal*	4	9	
27. Sandstone and shale	150	0	
Pocahontas formation:			
28. *Pocahontas coal*	3	8	to 10
29. Sandstone and shale	60	0	
30. *Coal bed*	2	6	to 3 8
31. Sandstone and shale	150	0	
32. *Coal bed*	2	8	
33. Sandstone and shale	150	0	

The Tellowa and Sequoyah are the Gladeville sandstone and the upper Norton, with perhaps the lower beds of the Wise. The Dotson sandstone is the Sharon (Corbin), and the Raleigh is the Bonair. The conditions in the lower half of the column are much in contrast with those farther southwest. Here are no conglomerates, and even the sand-

stones are not coarse. The contrast is even more noteworthy below the Pottsville, for in Wise county the Shenango (Pennington) shales are at most 1,300 feet, whereas in eastern Russell and in Tazewell they are represented by more than 3,000 feet of fine sediment.

Mr Campbell offers a somewhat different grouping farther east, which should be noted here, that comparisons may be made the more easily:

Sewell formation.
Raleigh sandstone.
Quinnimont formation.
Clark formation.
Pocahontas formation.

The Sewell formation includes the Dotson, Bearwallow, and Dismal; the Quinnimont and Clark are subdivisions of the Welch, the line being drawn under the "Upper Horsepen" coal bed, which on New river has long been known as the "Quinnimont" coal bed. The "Clark" is bounded by two well marked sandstones, numbers 21 and 27. The higher formations, Sequoyah and Tellowa, belong to the Kanawha formation of counties farther north.

The Tellowa and Sequoyah extend eastward only into northern Buchanan and western McDowell, and the important coal bed of the former is mined in northwestern McDowell. It is at somewhat more than 600 feet above the Dotson (Sharon) sandstone, and evidently represents the Kelly-Imboden horizon. Only the Dismal or lower part of the Sewell extends eastward beyond the central line of McDowell; the formation covers the higher areas in eastern Buchanan, western McDowell, northern Russell, and western Tazewell. Its lower coal bed, the Sewell of more northern localities, the Sewanee of Tennessee, has been opened at many places. The Raleigh sandstone varies from 80 to 100 feet; though retaining its thickness and identity, it becomes shaly sandstone west from the line of central McDowell and Tazewell, but eastwardly it becomes coarser and occasionally conglomerate. It forms the escarpment of the high hills in eastern McDowell and Wyoming counties known as Flat Top, where it is about 80 feet thick, massive, and coarse.

The Horsepen group of coals, numbers 20, 22, 24, and 26, belong, with the exception of the Upper, to the Clark formation, and attain their maximum near the line between Tazewell of Virginia and McDowell of West Virginia. The "Pocahontas" coal bed has been traced along the easterly outcrop in Tazewell and Mercer counties by means of openings for the Flat Top Land Association. It is from 4 to 12 feet thick and everywhere yields a coal of remarkable purity.

The relations of the lower beds are shown in two sections. One reported by Mr McCreath from northeastern Tazewell is

		Feet.	Inches
1.	Concealed measures	40	0
2.	*Coal 7*	2	0
3.	Concealed	20	0
4.	*Coal 6*	1	6
5.	Concealed	80	0
6.	*Coal 5* and dirt	4	6
7.	Concealed	91	0
8.	*Coal 4*	2	0
9.	Concealed	90	0
10.	Sandy fireclay	6	0
11.	*Coal 3, Pocahontas*	11	3
12.	Fireclay	6	0
13.	Shales and sandstone	61	0
14.	*Coal 2* and shale	4	0
15.	Concealed	12	2
16.	Gray sandstone	15	4
17.	*Coal 1*	1	0
18.	Sandstone, some shale	67	10
19.	Sandstone, *coal* streaks	8	8
20.	Shale and sandstone	294	9

to red shale. The section does not reach to the top of the Clark formation. The thickness of the Pocahontas formation is about 120 feet greater than that assigned by Mr Campbell, but the difference is due probably to choice of strata for the bottom. Doctor White gives a section supplemented by a boring at Welch, in north central McDowell, of West Virginia, much longer than that by Mr McCreath:

		Feet.	Inches.	Feet.	Inches
1.	Concealed	150	0		
2.	*Coal*	2	6		
3.	Shales, sandstone, and concealed	40	0		
4.	*Coal*	2	0		
5.	Shales and concealed	60	0		
6.	*Coal bed, "Welch"*	3	1		
7.	Shales and concealed	10	0		
8.	Raleigh sandstone	190	0		
9.	Shales and concealed	160	0		
10.	*Coal, Quinnimont*	1	6	to 2	.6
11.	Sandstone and concealed	180	0		
12.	Sandstone and slate	38	0		
13.	*Coal* and bone	0	11		
14.	Sandstone and shale	117	7½		
15.	*Coal bed*	0	9		
16.	Sandstone and slate	142	6½		

	Feet.	Inches
17. *Coal 4*	3	5
18. Sandstone and shale	64	4
19. *Coal 3, Pocahontas*	5	2
20. Sandstone and slate	27	5½
21. *Coal*, slate, and bone	1	9
22. Slate and sandstone	10	10½
23. *Coal bed 2*	0	7
24. Slate and sandstone	47	0
25. *Coal bed 1*	0	9
26. Sandstone and slate	202	2

to red beds of the Mauch Chunk, giving 295 feet for thickness of the Pocahontas and 707 for the Clark and Quinnimont. If the tentative identification of the Quinnimont coal bed be correct, the Quinnimont formation shows a notable decrease and the Clark formation an equally notable increase. As the total of both is very nearly that assigned by Mr Campbell, it may be better for the present to look on the coal bed number 10 as one of the smaller beds of the formation, with the Quinnimont to be sought for in the largely concealed interval, number 11. Doctor White suggests that numbers 2 and 4 may represent the "Sewell" coal bed, a wholly probable suggestion, as here one is on the border of the area in which subdivision of coal beds is as much the rule as in other regions it is the exception. The section below number 12 was obtained in a boring. As Welch is at least several miles from any outcrop of the Pocahontas, the record connects the southern area of that bed with the Guyandotte area at the north, where it again comes to the surface and is commercially important.*

WEST VIRGINIA

McDowell and Mercer counties, to which reference has been made already, are in West Virginia. Farther north in this state, in Wyoming, Raleigh, and Fayette, higher rocks are reached, so that one finds at the top the Charleston sandstone of Campbell, about 300 feet of thick sandstones broken by important coal beds; the Kanawha formation, a mass of shales, sandstones, and strangely varying coal beds, in all more than 1,000 feet thick, with the Sewell, now 600 to 800 feet. The Raleigh, Quinnimont, Clark, and Pocahontas are still present, but all showing changes.

Mr Campbell points out that these lower formations, generally speaking, retain their thickness and characteristics as far north as southern

* A. S. McCreath: Mineral Wealth of Virginia, 1884, p. 107.
M. R. Campbell: U. S. Geol. Survey folios, Pocahontas, 1896; Tazewell, 1897.
I. C. White: West Virginia Geol. Survey, vol. ii, 1903, p. 620.

Raleigh. The plane of separation between the Pocahontas and Clark was drawn on top of the Pocahontas coal bed, and this division is clear on Flat Top, in Mercer, as well as along the Guyandotte river in southern Raleigh and Wyoming; but that coal bed becomes insignificant northward, and the two formations near New river are united by Mr Campbell into the Thurmond, which there is but 450 or 500 feet as against about 750 in southern Raleigh. Along the Guyandotte river the Pocahontas coal bed is important, and Mr d'Invilliers has described it in detail. Other beds of some importance are present there in both the Clark and the Pocahontas, but near New river, in Fayette county, the Thurmond appears to contain no coal bed of any value whatever.

The Quinnimont, equivalent to the upper Welch of the Tazewell-McDowell area where it is more than 300 feet thick, decreases northward, as does the Thurmond, and is only 180 feet on New river. The Quinnimont coal bed rests on the heavy sandstone at the top of the Thurmond, and the "Beckley" coal bed is directly under the Raleigh sandstone. Two other beds are in the interval, but they have not been exploited. The Quinnimont bed, named by Fontaine many years ago, is the same with the Fire Creek bed of lower New river; it is extremely variable. In southern Raleigh it is unimportant, but in southern Wyoming, near the Raleigh line, as well as in the central part of the county, it is valuable. On New river it is important from Quinnimont to Sewell, 10 or 12 miles, but below Sewell Mr Campbell did not recognize it, though several miles farther on it was found by Doctor White. The "Beckley" coal bed is workable only in northern Raleigh, but either thin coal or black shale is present at almost every exposure of its horizon. These persistent beds below the Raleigh (Bonair) sandstone bear much resemblance in their position and in their persistency to the beds between the Bonair and Etna sandstones in Tennessee, and it is possible, one might almost say probable, that the persistent sandstone at the top of the Clark or Thurmond, which has been seen in all the sections from eastern Russell to New river, may prove to be the Etna (Cliff) sandstone.

The Raleigh (Bonair) sandstone is less thick in southern Raleigh than at Welch, in McDowell county, but it thickens northward until it becomes 150 feet or more near New river. Eastward and southeastward from that river, in Fayette county, it decreases and becomes unimportant within a few miles; but it maintains itself northward along New river, and westward it is easily recognized in Raleigh and Wyoming wherever its place is exposed.

The Sewell formation, 600 to 700 feet thick, has as its highest member the Nuttall (Sharon, Corbin, Dotson) sandstone, which along New river

is a massive conglomerate, 150 to 200 feet thick, forming cliffs from Nuttallburg to Gauley bridge, at 375 feet above the Raleigh. West from New river, in Fayette county, the upper portion of this sandstone loses its massiveness and coarseness within a few miles, but the lower portion remains conglomerate for 12 miles. In western Fayette, in Boone, and northern Raleigh the whole deposit becomes more or less a shaly sandstone and soon loses its distinctive features. The coal beds of the Sewell formation are at least four, but only one, that at from 40 to 90 feet above the Raleigh, is of commercial importance. This, the Sewell of New river, the Sewanee of Tennessee and Alabama, is about 4 feet thick at Sewell, on New river, and increases somewhat toward the west, but it diminishes eastward and northward in Fayette county, becoming only 2 feet thick at the Hawksnest, 15 miles northwest from Sewell.

The plane of separation between Sewell and Kanawha is sufficiently sharp along New river, where the Nuttall (Sharon, Corbin, Dotson) sandstone is characteristic; but westwardly, where that rock becomes indefinite, the two formations are continuous. Many of the coal beds familiar to those living along the Kanawha river have been recognized here; but reference to them must be deferred until after the section along the Kanawha river has been studied, and the relations of the Charleston sandstone will be reviewed at the same time.*

More than sixty years ago Professor William B. Rogers determined that the coal rocks of New river, in Fayette county, belong to his formation XII, the Seral conglomerate of the Pennsylvania column; but his published notes are very brief. The first detailed descriptions known to the writer were given by Professor Fontaine, who applied the name "New River series" to the rocks in question. His section near Quinnimont extends from the Raleigh sandstone to the Lower Carboniferous and shows

	Feet
Raleigh sandstone	150 to 200
Quinnimont formation	198
Clark formation	326
Pocahontas formation	543

The Beckley and Quinnimont coal beds are shown in his section. The top and bottom sandstones of the Clark are defined sharply, the lower being a massive bed, and the thickness of the formation is 326 feet, or almost 50 feet less than that given by Mr Campbell for southern Raleigh. The excessive thickness assigned to the Pocahontas is due to including beds at the bottom which later observers have referred to the

* M. R. Campbell: U. S. Geol. Survey folios, Raleigh, 1902.
E. V. d'Invilliers: Geological Report on the West Virginia and Ohio Railroad Line, 1886, pp. 8, 12, 13, 14.

Lower Carboniferous, and the thickness thus corrected is about 250 feet. The four coal beds of the Clark are all thin, and the Pocahontas coal bed, immediately underlying the bottom sandstone of the Clark, is 2 feet 6 inches thick. A section at Sewell reaches to the Nuttall sandstone. It shows the Sewell (Sewanee) coal bed at 50 feet above the Raleigh sandstone, and another bed at 190 feet higher. Two coal beds are shown in the Quinnimont, the upper one at 100 feet above the Quinnimont coal bed and 78 feet below the Raleigh. Four coal beds are present in the Clark portion of the column at 100, 112, 152, and 208 feet below the Quinnimont bed. The Sewell (Sewanee) coal bed is irregular and known to the miners as the "conglomerate seam." Its floor is not the usual fireclay, but is "a curious conglomerate, consisting of fragments of fine-grained gray sandstone and very fine gray shale, cemented together by shaly matter colored with coaly matter." The roof shales contain an abundant flora. Doctor White's section at Sewell gives 982 feet as the thickness below the Sewell coal bed.*

The first complete section of the Lower Pottsville was made by Doctor White at Nuttallburg on New river at 10 or 12 miles below Sewell. This was measured in 1884, but revised afterward and republished in 1903. It is

		Feet.	Inches
1.	Sandstone, massive, pebbly	110	0
2.	Shales	60	0
3.	*Coal*	1	0
4.	Sandy shales and sandstone	75	0
5.	Sandstone	25	0
6.	Black slate	2	0
7.	*Coal*	1	0
8.	Shales and sandstone	75	0
9.	*Coal*	0	10
10.	Shales and sandstone	50	0
11.	*Coal*, Sewell, Nuttall	3	6
12.	Shales and slates	75	0
13.	Massive sandstone, Raleigh	155	0
14.	Slates, dark	10	0
15.	Concealed and shales	120	0
16.	*Coal*	3	5
17.	Shale and sandstone	130	0
18.	*Coal*, Quinnimont	4	5
19.	Shale and sandstone	35	0
20.	*Coal*, slaty	2	4
21.	Shales	40	0

* W. M. Fontaine: Great Conglomerate on New river, West Virginia. Amer. Jour. Sci., 1874, pp. 465, 573, 574. Conglomerate Series of West Virginia. Amer. Jour. Sci., 1876, vol. xii, pp. 279 et seq.

I. C. White: Catalogue West Virginia University, 1884, p. 89.

	Feet.	Inches
22. *Coal*	1	5
23. Shales	10	0
24. Concealed	30	0
25. Massive sandstone	125	0
26. Concealed and sandstone	60	0
27. Massive sandstone	140	0
28. Conglomerate and sandstone	55	0

or 1,400 feet to the top of the Mauch Chunk red shales. Grouping the beds for comparison with localities at the south, one has

	Feet
Sewell formation	478
Raleigh sandstone	155
Quinnimont formation	268
Clark and Pocahontas (Thurmond)	499

The only decrease is in the Sewell; the Quinnimont shows a decided increase. A great change has taken place in the lower part of the column. Fontaine's section near Quinnimont shows much shale and flaggy sandstone in the lower Clark and in the Pocahontas, where massive sandstones predominate in the Nuttallburg section. The four coal beds of the Sewell formation persist, though the Sewell (Sewanee) bed is the only one of value. Three beds are exposed in the Quinnimont and the upper two beds of the Clark still persist. The place of the Pocahontas is in the concealed interval, number 26, but no trace of it or of the other low coals is reported by Doctor White.*

The Nuttall (Sharon, Corbin) sandstone forms cliffs along New River canyon to Kanawha falls, about 12 miles northwest from Nuttallburg. There, according to J. B. Rogers, it is still more or less conglomerate. It finally passes under the Kanawha river (formed by union of New and Gauley rivers) at 3 miles below the falls, not far above the mouth of Armstrong creek, where Doctor White obtained a section which will be referred to further on. From the falls westward and northwestward along the river one has to do with the Kanawha formation almost to Charleston, beyond which the Charleston sandstone and higher beds are the surface rocks. To prepare a generalized section of the Kanawha formation as it occurs along the river is very difficult, owing to the extreme variability of the coal beds and of the intervals separating them, conditions to which Professor W. B. Rogers first called attention 63 years ago and which were emphasized by Professor Fontaine 30 years ago. The general succession may be given as follows:

*I. C. White: U. S. Geol. Survey Bulletin, no. 65, p. 197; West Virginia Geol. Survey, vol. ii, 1903, p. 617.

	Feet.	Inches.	Feet
1. Black Flint	7	0	to 12
2. Shales	1	0	to 25
3. *Cannelton* or *Stockton coal bed*			
4. Shales and sandstone	75	0	to 100
5. *Coalburg coal bed*			
6. Shales, massive sandstone	75		
7. *Winnifrede coal bed*			
8. Shales, sandstone with thin coal beds	200	0	to 250
9. *Cedar Grove coal bed*			
10. Shales	50	0	to 75
11. Campbells Creek limestone	1		
12. Shale, sandstone	40	0	to 50
13. *Campbells Creek coal bed*			
14. Shales, sandstone with *Brownstown coal bed*	75	0	to 100
15. Stockton cement	2	6	
16. Shales	45	0	to 50
17. *Eagle coal bed*			
18. Shales	20		
19. *Little Eagle coal bed*			
20. Shale, sandstone	55		
21. Eagle limestone	1		
22. Shale, sandstone	120		
23. Siliceous limestone	1		
27. Interval	100		

to the Nuttall sandstone. As will be seen, the extent of variation in the intervals exceeds greatly the figures given in the table.

There is little of interest below the Eagle limestone of I. C. White. Several thin coal beds are in the interval, but they are not present in some of the sections, though some of them may be represented by black shales at several horizons. The Eagle limestone, commonly known as the "black marble," is black, more or less carbonaceous, blocky, impure, with cone-in-cone structure, and is richly fossiliferous, as are the shales inclosing it.

The "Eagle" coal bed of I. C. White, mined just east from the Fayette-Kanawha line, passes under the Kanawha at a short distance west from that line, but is brought up again by a gentle anticline. It is evidently the bed on Smithers creek referred to by Rogers as 90 feet below the "Thick?" coal bed and separated by yellow shales from a richly fossiliferous limestone. Like the "Little Eagle" below, it is a soft, coking coal, with no trace of splint.

The Stockton or Cannelton cement bed, at most 50 feet above the Eagle coal bed, and 2 feet 6 inches thick, is not always a continuous bed, but sometimes occurs in lenticular masses, separated by 1 to 10 feet. It has cone-in-cone structure and is apparently non-fossiliferous.

Rogers refers to it as occurring in separated masses farther down the river, on Rider and Hughes creeks, where it underlies yellow shales with nodular iron ore.

The variability of the interval between the "Campbells Creek" and Eagle coal beds is shown by the following measurements by Doctor White at Cannelton and Brownstown, 16 miles apart:

	Feet.	Inches.	Feet.	Inches
1. *Campbells Creek coal bed*				
2. Sandstone and shales	40	0	74	0
3. *Brownstown coal bed* and partings	20	6	2	0
4. Shales and sandstone	40	0	70	0
5. Limestone	1	0	1	0
6. Shales	10	0	45	6
7. *Eagle coal bed* and partings	26	2	3	0
Total	137	8	195	6

At Brownstown the Eagle coal bed is 98 feet above the Nuttall sandstone, but at Armstrong creek the vertical distance is 290 feet. Three miles below Brownstown, 6 miles above Charleston, the whole interval from Campbells Creek coal bed to the Nuttall is but 132 feet, a decrease of 34 feet per mile. The contrast between conditions above and below the Eagle at Armstrong and Brownstown is worthy of notice; for while the interval to the Nuttall decreases almost two-thirds in 16 miles, that above to the Campbells creek increases almost one-half. The Brownstown coal bed is unimportant and disappears at a little way below the Brownstown locality.

The Campbells Creek coal bed is one of the most persistent as well as most variable beds in the formation. Like the coals below, it is a soft coking coal, showing no splint, except a thin streak in one of its divisions. On Gauley mountain, in Fayette county, near the eastern outcrop, it is 11 feet thick, with thin partings. On Armstrong creek, in Fayette, it is in six benches, distributed through 22 feet 4 inches, and the top of the bed is 568 feet below the Black Flint. Near Cannelton, 3 or 4 miles lower down the river, Doctor White's section shows the lower portion of the bed 5 feet thick at 541 feet below the Flint, with the overlying 500 feet concealed. The bed here was described by Professor Rogers as Stockton's 7-foot seam. Mr Ridgway's section at the same place, made upward of sixty years ago, when exposures were almost complete, shows the bed in seven benches, distributed in 85 feet of vertical section, the thick coal at the bottom being at about 550 feet below the Flint. At Coal valley, a short distance lower down the river, the interval to the thick coal at the bottom is 640 feet. Professor Ansted's

section on Paint creek does not extend down to this coal, but Mr Maury's on the same stream shows a very complex structure. In this part of the Kanawha valley the main upper and lower divisions of the Campbells Creek bed are so widely separated that they have received different names, the upper being known as the "Peerless" and the lower as the "Blacksburg," or number 2 gas coal. At Winnifrede junction the two beds are 26 feet apart and at 9 miles above Charleston 20 feet. From this locality northwestward the partings become thinner, until on Campbells creek the Peerless and Blacksburg are mined as one bed, with 1-inch partings. The identity of the section is proved by the persistent Campbells Creek limestone above and the Cannelton cement below, which appear in most of the measured sections. The splint layer of the Campbells Creek coal is in the upper bench of the Blacksburg, or lower division. The variations in this bed have been given in detail because they suffice to exhibit the changes shown to a greater or less extent by all the principal coal beds of the Kanawha formation in this region. These variations have been studied by Doctor White during almost twenty years, and his conclusions are shown by a great number of vertical sections to be beyond question.

The Campbells Creek limestone of I. C. White is persistent in the shales overlying the Campbells Creek coal bed, the interval to the coal bed varying from 10 to almost 50 feet. On Campbells creek, according to Professor Rogers, the shales overlying the coal bed are 40 feet thick, bluish drab in color, and contain what he terms "madreporite," which occurs "in large spheroidal masses, resembling the nodules or septaria of formation VIII. These masses are highly calcareous, constituting in fact a tolerably pure limestone, and generally found within a width of about 10 feet of the slate." He notes the usefulness of this deposit as an aid in tracing the coal bed below.

At from 50 to 165 feet above the Campbells Creek coal bed is the Cedar Grove, Arno, or Trimble coal bed, not a true splint as are the higher beds in great part, not soft "gas" coal, as are the lower beds of the Kanawha formation. The bed is thin, but it appears to be present in a large area, and its coal is always of admirable quality. The shales associated with it are rich in fossil plants. Two hundred to 300 feet of sandy measures intervene between the Cedar Grove and the Winnifrede. No coal beds of any importance are seen in this interval, and such as do appear are usually insignificant. The Winnifrede coal bed overlying the sandstone mass rises from the Kanawha river at 2½ miles above Charleston, where it is 18 to 20 inches thick and 150 feet below the Flint; farther up the river this interval increases to 225 feet. The bed is important toward the west and southwest from the river, having been mined

continuously from Kanawha county into Boone, the next west, where Mr Lyman shows its variations. At Winnifrede it is approximately 5 feet thick and consists of alternating layers of splint and gas coal. It is of little value in the upper Kanawha region, but it is present in Ansted's Paint Creek section, and Doctor White recognizes it on the border of Fayette county.

Above the Winnifrede at a variable distance—100 feet near the Fayette line, 75 near Lock number 3, 86 opposite Coalburg, and 50 at 12 miles above Charleston—one reaches the Coalburg coal bed, which is at an average distance of 80 or 90 feet below the Flint; but at times the interval is less than half that distance, while in others it approaches 150 feet. The bed varies greatly, though not to the same extent as the Campbells Creek bed. At 3½ miles above Charleston it is mined as one bed, there being three benches with partings of 2 inches and 2 feet respectively; but nearer Charleston the benches are separated by 25 to 30 feet of shale and sandstone. The partings thicken up the river; then disappear; once more thicken, but again diminish, so that at Coalburg the bed is important. It is the "Thick bed" of Ansted's Paint Creek section, and Maury, in the same area, assigns to it a thickness of 11 feet. In the three benches at Coalburg, Stevenson thought he saw the three thin beds near the Kanawha salines, but this was a mere hazard which chanced to be true. The bed is characterized by a peculiar bony slate known as "niggerhead." The coal is comparatively good at one locality near the Kanawha-Fayette line, though above that, while retaining its thickness, the bed becomes worthless. The "Stockton," or highest coal bed of the Kanawha, is at 5 to 130 feet above the Coalburg. On the Cannelton Coal Company's property the interval varies from 5 to 10, 26, 30, and 75 feet, while 5 miles farther down the Kanawha the interval is from 90 to 130 feet. The Stockton is from 1 to 25 feet below the Black flint. Like the other beds, it shows great variation in structure. It rises from the river bed at a little way above Charleston, whence it has been traced by Doctor White to the eastern outcrop in Gauley mountain within Fayette county. It frequently divides into two beds, known as Stockton and "Lewiston," the latter, the lower, being the splint or cannel bed.

The "Kanawha Black flint" is the highest bed of the Kanawha formation. Long ago its peculiarities aroused the interest of Professor Rogers. It is from 4 to 12 feet thick and is a marked horizon from its eastern outcrop in Fayette county to where it passes under the river above Charleston. At many localities it, as well as the associated shale, contains an abundance of the familiar Coal Measures invertebrates. It disappears quickly southward and almost as quickly northward, along

the easterly outcrop, but it is present all along the Elk river into Clay county, where the writer recognized it twenty years ago, and it has been followed by Doctor White along the Elk river and northeastward into Nicholas county, not less than 80 miles by the roads from the Kanawha at Charleston.

Overlying the Black flint is a great sandstone 200 or more feet thick, which contains two important coal beds, the "Number 5 block" and the "Mason," which will be considered in another connection.

The decrease in thickness of the Kanawha and Lower Pottsville in northwesterly direction should be noted. At Armstrong creek, in Fayette county, Doctor White's section gives 1,006 feet for the Kanawha; at 9 miles above Charleston, 801; at 6 miles above Charleston, 641; at Charleston, 573; at 1 mile below Charleston, 450. For the Lower Pottsville, Doctor White's Nuttallburg section gives 1,400; a boring at Winnifrede, reported by Mr Campbell, 960; one at Burning spring, reported by Doctor White, 839; at Charleston, 580.*

Before considering further the relations of the Kanawha formation, one must carry the section westward across West Virginia from Raleigh county to the Kentucky line and northward to the Chesapeake and Ohio railroad between Charleston and the Ohio river. The exposed column in much of this region extends downward barely to the Nuttall sandstone, but records of borings are available with which to complete the sections. The typical section for the upper Kanawha is that obtained on Armstrong creek by Doctor White. This was made originally in 1884, and published in 1891, but it has been revised and recast recently, without change in the measurements; it is given here in the completed form with very slight condensation.

	Feet.	Inches
1. Black flint		
2. Interval	12	0
3. *Coal bed*	3	0
4. Sandstone and concealed	345	0
5. Silicious limestone	1	0
6. Sandstone	25	0

*References for the Kanawha valley are:

W. B. Rogers: Report Geol. Survey of Virginia for 1839, pp. 127, 128, 129, 132, 133, 135.

D. F. Ansted: Report on the "Wilson Survey" near Great Kanawha river, Virginia, 1855.

T. S. Ridgway: Geological report on Chesapeake and Ohio railroad, 1872.

J. J. Stevenson: Ann. N. Y. Lyc. Nat. Hist., vol. x, 1873, pp. 273, 276.

W. M. Fontaine: The Great Conglomerate on New river, p. 462. The Conglomerate Series of West Virginia, p. 279.

I. C. White: Catalogue of West Virginia University, 1885, pp. 69, 70, 71, 73, 74, 76, 77, 78. U. S. Geol. Survey, Bull. no. 65, 1891, pp. 135, 138, 139, 140, 141, 162, 167, 170, 172, 195, 196, 197. West Virginia Geol. Survey, vol. ii, 1903, pp. 372, 509, 565, 567, 586, 593.

M. R. Campbell: U. S. Geol. Survey folio, Charleston, 1901.

		Feet.	Inches
7.	*Cedar Grove coal bed*	2	5
8.	Shale, sandstone, concealed	165	0
9.	*Coal bed*	1	8
10.	Sandy shales	12	0
11.	*Peerless coal bed*	2	0
12.	Bluish shale	15	0
13.	*Blacksburg coal bed*	5	4
14.	Fireclay, shale, sandstone	40	0
15.	*Coal bed* and shale	4	4
16.	Shale, sandstone	15	0
17.	*Coal bed*	1	2
18.	Concealed and sandy shale	40	0
19.	Silicious limestone	1	0
20.	Shale	10	0
21.	*Coal bed*	2	6
22.	Sandy shale	20	0
23.	*Eagle coal bed*	3	8
24.	Shale, sandstone	20	0
25.	*Little Eagle coal bed*	1	6
26.	Shale, sandstone	55	0
27.	Eagle limestone	1	0
28.	Fossiliferous shale	5	0
29.	Sandstone	75	0
30.	Bituminous shale	2	0
31.	Shale	30	0
32.	Silicious limestone	1	0
33.	Shale, sandstone, and concealed	100	0

The interval from the top of the Stockton coal bed, number 2, to the Cedar Grove is 375 feet, but at 3 miles farther down the river it is 421 feet, where the Coalburg and Winnifrede coal beds are shown. The intervals there are

		Feet
1.	*Stockton coal bed*	
2.	Interval	90
3.	*Coalburg coal bed*	
4.	Interval	100
5.	*Winnifrede coal bed*	
6.	Interval	210
7.	*Cedar Grove coal bed*	
8.	Interval	145
9.	*Blacksburg coal bed*	
10.	Interval	115
11.	*Eagle coal bed*	

The Campbells Creek limestone is not exposed at either locality, but there are many exposures of it between them.*

*I. C. White: West Virginia Survey, vol. ii, pp. 371, 372, 529.

Doctor White gives two sections, one in central Raleigh, on the authority of Mr Miller, the other made by himself near Oceana, in central Wyoming, almost directly west from the former. These are

Raleigh

	Feet.	Inches
1. Sandstone, shale	98	0
2. *Coal bed* and partings	4	8
3. Shale	43	0
4. *Coal bed* and partings	18	5
5. Sandstone and shale	247	0
6. *Coal bed*	4	0
7. Sandstone	19	0
8. *Coal bed*	0	1
9. Fireclay and shale	37	2
10. *Coal bed*	3	2
11. Fireclay, sandstone, shale	115	6
12. *Coal bed*	0	2
13. Fireclay, shale, and sandstone	91	4
14. *Coal bed* and partings	9	8
15. Sandstone	46	0
16. *Coal bed*	0	3
17. Sandstone and shale	208	0

Wyoming

1. Sandstone and concealed	100	0
2. *Coal bed*	3	8
3. Sandstone and concealed	155	0
4. *Cannel* shale and *coal*	3	0
5. Massive sandstone and concealed	72	0
6. *Coal bed* and partings	27	2
7. Concealed and sandstone	20	0
8. *Coal bed*	0	9
9. Fireclay, sandstone, shale	65	0
10. *Coal bed* and partings	24	9
11. Massive sandstone	100	0
12. Concealed and shale	60	0
13. *Coal bed*	7	7
14. Sandstone and concealed	70	0
15. *Coal bed*	5	8
16. Concealed and shales	65	0
17. *Coal bed*	2	3
18. Shale, sandstone, and two thin *coal beds*	212	0

In each case the section rests on the Nuttall sandstone, and the top is taken to underlie the Charleston sandstone. The Eagle coal bed is easily recognized in numbers 14 and 15 of the respective sections at 254 and 279 feet above the Nuttall (Sharon) sandstone, but the limestones

belonging in this interval are apparently absent. In the Raleigh, number 6 is 266, and number 4, 517 feet above the Eagle, not far from the intervals for Cedar Grove and Winnifrede in the upper Kanawha region. Number 10 is 207 feet, only 15 feet more than the interval between the Eagle and Campbells Creek near Brownstown. The condition in Wyoming county leads to the belief that this interval is greatly increased southward, with a corresponding decrease in the interval between the Campbells Creek and the Cedar Grove. Number 10 of the Wyoming section appears to be, almost without doubt, the equivalent of the Campbells Creek, and it is almost 240 feet above the Eagle. The " Cook " or " Big bed " of northern Wyoming has been identified with the Campbells Creek by Doctor White and Mr d'Invilliers, both of whom have given many sections. The bed has been traced for the Guyandotte Coal Land Association around a large area, openings having been made at short intervals, so that there seems to be no room for doubt of its identity with the Campbells Creek. The bed, number 13, has its great thickness only locally, and elsewhere in Wyoming county is very thin. It is not far from the place of the Brownstown, and is evidently at the same horizon with number 12 of the Raleigh section. The Cedar Grove near Oceana is but 86 feet above the Campbells Creek, which is double, triple, or even quadruple, and shows the same tendency to variation as on the Kanawha. The highest beds in both sections are taken to be at the same horizon, and probably represent the Coalburg.

Doctor White gives a section in southern Logan county, almost due west from Oceana, as follows:

	Feet
1. Shales and sandstone	100
2. *Coal bed*	
3. Shales, massive sandstone	300
4. *Coal bed*, large blossom	6
5. Massive sandstone	40
6. Shale, sandstone, and concealed	180
7. *Coal bed, Eagle*, large blossom	5
8. Shale, sandstone	55
9. *Coal bed, Little Eagle*	2
10. Shale, sandstone, and concealed	140
11. Limestone, blue, impure	1
12. Shales, sandstone, and concealed	75
13. *Coal bed*	1
14. Shale, sandstone, and concealed	85

to massive sandstone. The succession is made sufficiently clear by comparison with the Wyoming section. The interval from the Sharon sandstone to the Eagle coal bed has increased, being 70 feet more than at

Armstrong creek and 80 feet more than near Oceana. Number 4, at 220 feet above the Eagle, is very near the place of the Campbells Creek, and number 2 is very near that of the Winnifrede, the intervals, 220 and 526, showing a small decrease westward. Number 11 is one of the impure limestones below the Campbells Creek coal bed.*

In southern Mingo county, about 20 miles west from the Logan locality, an exposure shows †

	Feet.	Inches
1. *Stockton coal bed*, splint	2	0
2. Interval	100	0
3. *Coal*	Blossom	
4. Interval	150	0
5. *Winnifrede coal*, mostly splint	4	0
6. Interval	160	0
7. *Coal*	2	6

This shows an increased interval between Stockton and Winnifrede, the intervals on the upper Kanawha being 90 and 100 feet there, 100 and 150 feet here.

At Warfield, Kentucky, about 10 miles west of north from the last locality, one has Doctor White's section, already given, but which must be repeated: ‡

	Feet.	Inches
1. Massive sandstone	150	0
2. *Coal* and partings	15	9
3. Concealed, sandstone	25	0
4. Limestone, silicious	1	0
5. Shale, sandstone, and concealed	30	0
6. *Coal, cannel*	2	0
7. Sandstone, concealed	30	0
8. Limestone, silicious	1	0
9. Sandstone, concealed	20	0
10. *Coal*, blossom		
11. Sandstone, concealed	65	0
12. Limestone, silicious	2	0
13. Massive sandstone	20	0
14. *Coal* and shale	0	7
15. Sandstone, shale	40	0
16. Massive sandstone	10	0
17. *Warfield coal*	5	2
18. Sandstone, concealed	45	0
19. Silicious limestone	2	0
20. Shales, sandstones	320	0

* I. C. White: Bulletin no. 65, p. 147.
† I. C. White: Vol. ii, p. 378.
‡ I. C. White: Bulletin no. 65, p. 146; vol. i, p. 277.

The measurement number 20 was obtained in a boring. Number 2 is identified by Doctor White with the Winnifrede. It is in 4 thin benches separated by shale, and the coal is mostly splint. The Warfield bed is clearly taken by him to be the Campbells Creek, and the suggestion is made that the limestone number 12 may represent the Campbells Creek limestone. The interval here between the Campbells Creek and Winnifrede is 246 feet; in Logan it is 300. These are coals 1 and 3 of the Kentucky column, which in an earlier part of this paper have been identified with the Sharon and Mercer horizons of Ohio and Pennsylvania. A well record on the West Virginia side of the river shows the Eagle coal bed at about 100 feet below the Campbells Creek (Warfield) coal bed and 320 feet above the Nuttall (Sharon) sandstone, evidencing a remarkable uniformity of conditions over a great area. The Lower Pottsville is but 378 feet to the first red beds, about one-fourth of the thickness in Fayette county, 60 miles eastward.

Dingess, in Mingo county, of West Virginia, is about 10 miles south of east from Warfield. There Doctor White combined the exposed section with a well record as follows:*

		Feet.	Inches
1.	*Coal bed, Stockton*	8	1
2.	Sandstone, concealed	140	0
3.	*Coal, Winnifrede (?)*, seen	1	0
4.	Concealed, sandstone	195	0
5.	*Coal bed, Cedar Grove (?)*	3	1
6.	Massive sandstone	40	0
7.	*Coal bed*	0	10
8.	Shale, sandstone	100	0
9.	*Coal bed, Dingess, Campbells Creek*	4	8
10.	Sandstone, 10 feet of shale	71	0
11.	*Coal bed*	1	0
12.	Shales, 10 feet of sandstone	233	0
13.	Sandstone [Sharon]	130	0
14.	Shale, blue and white	89	0
15.	White sandstone	473	0
16.	Black shale	11	0
17.	*Coal bed*	6	0
18.	Black shale	4	0
19.	White sandstone	308	0
20.	Black shale	22	0

to the lower carboniferous limestone. The lower Pottsville is 1,043 feet thick, and its section may be compared with that obtained opposite Warfield

*I. C. White: West Virginia Geol. Survey, vol. i, pp. 277, 280; vol. ii, p. 378.

	Feet
1. Sandstone	130
2. Shale, light and white	81
3. White sandstone	112
4. Shelly slate	55

in all, 378 feet. It is clear that the loss westward is wholly in the lower portion, for this section coincides with the upper portion at Dingess; but there is no trace here of the Dingess section below the upper third of number 15. Doctor White identifies the "Dingess" coal bed with that at Warfield, so that number 11 is the Eagle. The interval below it to the Sharon sandstone decreases almost 100 feet, while that between Campbells Creek and Winnifrede increases almost 100 feet, the interval from Sharon sandstone to Winnifrede remaining practically the same—622 feet at Warfield, 648 feet at Dingess.

The record of a boring in southern Lincoln county about 10 miles northeast from Dingess shows a section of the Lower Pottsville differing in composition though resembling in succession that at Dingess.*

	Feet
1. Sandstone	175
2. Blue shale	107
3. Sandstone	403
4. Shale, sandstone	131
5. Sandstone	182
6. Blue shale	18

in all, 1,016 feet. A trace of the coal bed, number 17 at Dingess, is found in 4 feet of black shale underlying the sandstone number 3. The shales have increased at the expense of the sandstones. The decrease in total thickness from Fayette county to this Lincoln locality, 40 miles westward, is barely 400 feet, less than half as much as in the same distance northwestward along the Kanawha river. The line of abrupt change lies very little west from the line passing through this locality and Dingess, which should extend into Floyd county of Kentucky. This is shown by the record of a boring reported by Mr Campbell from southern Wayne county, about 10 miles northwest from Dingess and 15 miles west from the Lincoln County well:†

	Feet
1. Slate	41
2. *Coal bed*	4
3. Slate and rock	327
4. *Coal bed*	6
5. Slate and sandstone	264

*I. C. White: West Virginia Geol. Survey, vol. i, p. 280.

†M. R. Campbell: U. S. Geol. Survey folios, Huntingdon, 1900.

	Feet
6. Sandstone	280
7. Slate	86
8. Sandstone	87
9. Slate	5

giving 458 for the Lower Pottsville or Crandall's Rockcastle group. As compared with both Lincoln and Dingess, one finds here the lower portion of the section gone and the succession the same as that at Warfield. The coal bed number 4 may be the Campbells Creek and number 2 the Winnifrede, the intervals being very nearly those required by Doctor White's identifications at Dingess.

At 25 miles west of north from the Wayne locality is the record of a boring near Catlettsburg, Kentucky, reported by Mr. Campbell, which though giving little of detail, is extremely important as affording the means of comparison with other sections in all directions. It is

	Feet
1. Clay	40
2. Sandstone and shale	100
3. Slate and shells	100
4. Sandstone	30
5. Blue slate	150
6. Sandstone [Sharon]	60
7. Shale	40
8. Sandstone	80
9. Shale	35
10. Sandstone	60

to the Lower Carboniferous limestone, giving 275 feet for the Lower Pottsville and 420 feet for the overlying rocks. The especial value of the record is that it shows the whole interval from the Kentucky coal 6 to the Lower Carboniferous limestone to be barely 650 feet, so that in less than half of the thickness of the Lower Pottsville at Nuttallburg, 70 miles south of east, one has here the whole Pottsville and a part of the Allegheny.

Mr Crandall's section at this locality shows Kentucky coal 6 at low-water level, consequently just above number 2 of the record. This, the first coal bed above the Ferriferous limestone, a Kittanning bed, evidently the "Lower Kittanning," is 120 feet above Coal 4, the *Tionesta*, and 50 feet below Coal 7. The interval from Coal 6 to the Sharon sandstone is somewhat more than 380 feet in the record. It is interesting to observe that the Lower Pottsville is still thick, 275 feet at Catlettsburg, whereas at Hanging Rock, only 10 miles farther down the Ohio river, it is not more, possibly less, than 80 feet. At Ashland, Kentucky,

a little more than 4 miles northwest from Catlettsburg, Coal 6 distinctly overlies the Ferriferous limestone. The dip to Catlettsburg is about 26 feet per mile. Two miles east from Catlettsburg, at Kenova, West Virginia, Doctor White found a thin bed in the river bank, which, judging from the dip, must be Kentucky coal 7.*

Central City, in Cabell county of West Virginia, is 6 miles eastward from Catlettsburg. The record of a deep well bored there is given by Doctor White

	Feet
1. Clay, etc.	26
2. Shale, sand, lime	94
3. Limestone	7
4. Slate, fireclay veins	98
5. Sand, fine	25
6. Slate	50
7. Sand with gas	30
8. Black slate	10
9. Sand, gray	60
10. Black slate	10
11. Sand, gray	85
12. Slate, white, blue	25
13. Sand, limestone	20
14. Slate	20
15. Black slate	175
16. Gray sand [Sharon]	25
17. Slates with *coal 2 feet*, black, blue	105
18. Sand, gray, black	40
19. Black slate	30

to the first limestone and 35 feet above the great mass of limestone 150 feet thick.†

The limestone, number 3, at 203 feet above the black slate, number 8, shows that the latter is in the place of Kentucky coal 6, for the Kentucky sections along the Ohio and Sandy rivers show that limestone at about 200 feet above the coal. The interval to the Sharon sandstone, number 16, is 395 feet, or practically the same as at Catlettsburg. The Lower Pottsville is 200 feet, or 235 feet thick, if the whole of the black shale to the great limestone is to be included. The double sandstone, numbers 5 and 7, represents the Charleston sandstone. Doctor White states that the "Pittsburg" coal bed is about 340 feet above the mouth of the well, or 670 feet above the black shale, number 8. If this shale

*M. R. Campbell: Huntingdon folio.
A. R. Crandall: Report on Greenup, etc., sec. 81.
I. C. White: Bull. no. 65, p. 158.

†I. C. White: West Virginia Geol. Survey, vol. i, p. 275; Bull. no. 65, p. 135.

represent the Lower Kittanning of Pennsylvania, the estimated altitude of the Pittsburg is very nearly correct, for in southeastern Ohio the Lower Kittanning is from 134 to 150 feet below the top of the Allegheny, and the Conemaugh is about 500 feet thick, so that bed ought to be about 650 feet below the Pittsburg.

Mr Campbell reports the record of a boring made at Huntingdon, 2 miles northeastward from Central City, which shows

		Feet
1.	Clay	20
2.	Red shales	330
3.	Sandstone	125
4.	Black shale	3
5.	*Coal bed*	10
6.	Shale	30
7.	*Coal bed*	4
8.	Shale	40
9.	*Coal bed*	6
10.	Shale	332
11.	White sandstone	100
12.	Shale	172

The thick sandstone, number 3, is the same with the double sandstone at Central City, as recognized by Doctor White and Mr Campbell, the latter seeing in it his Charleston sandstone, which overlies the Black flint of the Kanawha valley. Numbers 4 to 10, inclusive, are the Kanawha formation, and numbers 11 and 12 are the Lower Pottsville. Number 5 is Kentucky coal 6, the Stockton of the Kanawha valley, or possibly that bed may be represented by numbers 5 and 7, as the Stockton and Lewiston. Number 9 is very nearly in the place of the black shale, number 10, of the Central City well. Doctor White gives a measured section at Huntingdon from the Pittsburg coal bed to the bottom of the sandstone, number 3, showing the interval to be 660 feet, or 10 feet less than the estimated interval at Central City. Sandstone seems to be wholly wanting in the Kanawha at Huntingdon.*

Mr Campbell, in the same folio, gives also the records of two borings in eastern Cabell county, at about 14 miles south-southeast from Huntingdon. The Lower Pottsville in both appears to be a continuous mass of sandstone, 410 to 420 feet thick, showing rapid increase from Huntingdon, with disappearance of the bottom shales. The shale at the bottom of the Kanawha is 275 feet in one well and 339 in the other, above which, in each, is sandstone to a coal bed, 5 to 6 feet thick, at 355

* M. R. Campbell: Huntingdon folio.
I. C. White: Bulletin no. 65, p. 84.

to 360 feet above the Sharon sandstone. A sandstone 160 feet thick overlies the coal bed.

The record of a boring at Charleston, on the Kanawha, suffices to link the tracing. It is*

	Feet.	Inches
1. *Coal bed*	3	0
2. Shales and slates	55	0
3. *Coal bed*	1	6
4. Sandstones and shales	116	0
5. Slaty *coal*	5	0
6. Shale and sandstone	203	0
7. Coarse sandstone	70	0
8. *Coal bed*		
9. Shales and sandstone	90	0
10. Shales	30	0
11. Sandstone	580	0

Number 1 is the Stockton, number 5 the Winnifrede, and number 8 the Campbells creek. Number 3 may be the Lewiston. The great mass of shales observed in so many sections toward the west has become unimportant and the Lower Pottsville shows no shales or coal in the record. The Stockton coal bed is about 800 feet below the Pittsburg coal bed, the increased interval being due chiefly to thickening of the Charleston sandstone and the Upper Conemaugh.

The identity of the Campbell Creek coal bed with that at Warfield, Kentucky, seems to have been placed practically beyond doubt by Doctor White's studies, thus fixing it at the Sharon horizon. A matter of very curious interest is the presence of the lenticular limestones along the Kanawha valley and in a so great area within Kentucky, while they are absent or at least not reported from the intervening space in West Virginia, except in one of Doctor White's sections. The Winnifrede coal bed is evidently equivalent to Kentucky coal 3, the Splint of Warfield, the Peach Orchard and McHenry coals of Kentucky, representing the Mercer horizon of Pennsylvania and Ohio. The Stockton is distinctly equivalent to Kentucky coal 6, which is at a little distance above the Ferriferous limestone, and therefore the Lower Kittanning of Pennsylvania; but the Stockton may embrace a higher bed and represent the whole Kittanning horizon. This reference bears out the suggestion made by Doctor White that the Stockton might prove to be Lower Kittanning and not Upper Freeport, as has been the belief for almost one-third of a century. The relation of the Coalburg is not wholly clear. To the writer it appears to be most nearly at the horizon of Kentucky coal 4,

*I. C. White: Bulletin no. 65, pp. 58, 136, 195.

the Tionesta of Ohio and Pennsylvania, and so the highest bed of the Pottsville.

WEST VIRGINIA, NORTH FROM THE KANAWHA RIVER AND CHESAPEAKE AND OHIO RAILROAD

The effort now will be to trace the section through the northern part of West Virginia. In this extensive area the sole reliance must be the work of I. C. White, who has published the records of oil borings in the central portions of the region and has supplemented them by many carefully measured sections along the outcrops. His studies make available also the scattered observations by other students, which will be acknowledged in the proper places. To trace the section is comparatively simple in the eastern part of the area, where the well records have been checked by measured sections, but in the central part of the area, where one is dependent solely on well records, the work becomes excessively difficult. The absence of limestones, the almost total disappearance of the coal beds, and the abrupt variations in sandstones, elsewhere persistent, render wholly impossible the tracing of minor horizons, and at times even the boundaries of the formations become obscure. The section will be followed northward and northeastward from the Kanawha river to Pennsylvania through the easterly counties of the area; afterward, by means of oil-well records, southwardly through the western counties to the Kanawha, there to connect with the work already reviewed. The complexity of the problem is the excuse for the detail in which it is considered.

Major W. N. Page's carefully measured section at Ansted, 5 miles north from the Kanawha river, in Fayette county, gives 1,051 feet as the thickness of the Kanawha formation and 490 feet as the thickness of the Sewell formation, resting on 60 feet of the Raleigh. The intervals between the coal beds, as named by Doctor White, are

	Feet.	Feet
Stockton		
Interval	50	
Lewiston (?)		50
Interval	137	
Coalburg		190
Interval with thin coal	79	
Winnifrede		218
Interval	229	
Cedar Grove (?)		512
Interval	108	
Campbells Creek		620
Interval	93	
Eagle		724
Interval	305	
Nuttall sandstone		

The numbers opposite the coal beds indicate the distance below the Stockton coal bed. The Black flint is present in the section, but it disappears very quickly northward. The Charleston sandstone with its two coal beds, the number 5 Block and the Mason, is persistent, and its massive cliffs make simple the carrying of the Stockton horizon. Sandstones, many of them massive, appear in the section above the Campbells Creek coal bed, and farther north are as interesting as the coal beds themselves.

At Gilboa, in southern Nicholas county, 10 miles northeast from Ansted, Doctor White's section shows the massive Charleston sandstone, with the blossom of the Stockton coal under it; the Black flint has disappeared already along this line, but it is present under the sandstone at only 2 miles toward the west. The thickness of the Kanawha has decreased within 10 miles from 1,051 to 688 feet; evidence of coal was seen at 70, 130, 160, 250, 340, and 545 feet below the Stockton. The lowest bed is the Campbells Creek; no other is exposed except that at 340 feet, which is evidently at the horizon of one of the thin beds occasionally seen on the Kanawha in the interval between the Cedar Grove and Winnifrede. The exposures throughout are poor, but massive sandstones are present under the Stockton as well as under the beds at 160 and 340 feet. The decrease in the thickness is due almost wholly to loss of the lower members, for here the Campbells Creek coal bed is only 120 feet above the Nuttall, whereas at Ansted the interval is 400 feet.

On Powell mountain, about 15 miles due north from Gilboa, the section extends from the top of the Charleston sandstone to about 330 feet below the Stockton. The Mason and number 5 Block coals of the Charleston sandstone, as well as the Stockton, are well exposed, and coal beds were seen at 50, 140, 193, 223, 254, and 271 feet below the Stockton, all of them thin. There is much sandstone below the Stockton, but the exposures are imperfect. The Campbells Creek coal bed is not reached here, but it is shown in Muddlety creek, 4 or 5 miles away, at somewhat more than 550 feet below the Stockton.

Cottle knob, about 11 miles east from Powell mountain, in southwest Webster county, is capped by the Charleston sandstone. The Stockton is not exposed, but coal beds were seen at 255, 588, and 604 feet below the lowest exposure of sandstone. The Kanawha is probably 700 feet thick here. The second and third beds are splits of the Campbells creek. Three miles farther east, at Camden-on-Gauley, 30 miles northeast from Ansted, a well record, beginning about 250 feet below the bottom of the Kanawha, shows that the Lower Pottsville is not more than 950 feet thick. The Raleigh sandstone is 92 feet; the Sewell (Sewanee), Quinnemont, and some others of the southern coal horizons are recog-

nizable, but of the section below the Raleigh sandstone only 416 feet remain. The decrease as compared with Nuttallburg is due largely to loss of the lower part of the section.

Near Weeses station, about 10 miles east of north from Cottle knob, the section shows coals at 100, 385, 455–482, and 585 feet below the Stockton. The extremely thin coal at 100 feet is between massive sandstone, 90 and 110 feet, beginning at 10 feet below the Stockton. The bed at 455–482 feet is the divided Campbells Creek, and that at 585 feet is the Eagle, at 25 feet above the Nuttall sandstone, which forms cliffs along the Laurel fork of Elk river 75 to 100 feet high. Respecting the identification of the Campbells coal bed no doubt exists, as it can be followed continuously along the Gauley river from the Kanawha to within 4 or 5 miles of this locality, where the Kanawha is but 617 feet thick. The upper part of the section is followed easily down Laurel fork to the mouth, and thence up the Middle fork on which, at about 4 miles east from Weeses station, Doctor White's section shows the massive sandstone beginning at 30 feet below the Stockton and exposed for 150 feet, below which exposures are poor to the Campbells Creek coal bed, at 460 feet below the Stockton; the Eagle is at 560 feet, or 40 feet above the Nuttall. The exposure is imperfect, and whether or not the Campbell's Creek is double as at the last two localities can not be determined. The thickness of the Kanawha is 607 feet, a decrease of not more than 75 feet in 35 miles, from Gilboa on the Fayette-Nicholas border. At this place the Lower Pottsville is 700 feet thick, mostly conglomerates, with several thin coal beds. It has lost 250 feet in 14 miles from Camden-on-Gauley.

On the north fork of Elk river the Charleston sandstone is conspicuous from the mouth of Middle fork. At 2 miles below Hacker, about 10 miles north-northeast from Weeses station, coal beds are shown at 120, 230, 415, and 520 feet below the Stockton, the last at 30 feet above the Sharon sandstone, the thickness of Kanawha being 561 feet. The third bed is the Campbells Creek and the fourth the Eagle. The decrease in thickness is above the Campbells Creek. There is much sandstone in the 120 feet interval below the Stockton, and the 6-inch coal bed may be the same with that at 100 feet near Weeses station.

In southern Randolph county, near Pickens, on the Buckhannon river, 10 miles east from Hackers and 16 miles northeast from the section on Middle fork of Elk river, the Kanawha is 582 feet thick. The massive sandstone is present under the Stockton, with a double coal in it at 150 feet down. The coal beds in the section are at 150, 452–479, and 569 feet below the Stockton; the double bed at 452–479 represents the Campbells Creek, and the lower division, 3 feet thick, is known locally

as the Pickens coal bed. That at 569, known locally as the "Gimmel," is most probably the Eagle coal bed.

No measurements have been published for localities between Pickens and the northern border of Randolph county, almost 20 miles. Some borings at about 15 miles north from Pickens indicate a thickness of not far from 500 feet for the Lower Pottsville. At the bottom, for nearly 200 feet, the rocks are almost wholly conglomerates or coarse sandstones. Some coal beds are present higher up, but they are very thin and apparently do not occur at the same levels in the different borings, which are separated by short distances.

Borings were drilled with diamond drill in northern Randolph county at two places on the Valley river. These are reported by Doctor White in connection with the exposed section to the Stockton coal bed. The first north from Beaver Creek is

	Feet.	Inches
1. [*Stockton*] *coal bed* and partings	14	0
2. Fireclay and sandy shales	10	0
3. Sandstone, conglomerate with five layers of shale or clay; in all, 9 feet 1 inch	282	0
4. *Coal bed*	0	4
5. Shale	13	0
6. Sandstone and sandy shale	48	5
7. Shale and black shale	6	4
8. Sandstone and sandy shale	36	1
9. *Coal bed*, including 12 feet of sandy slate	15	1
10. Fireclay and sandstone	5	8

to bottom of boring, 431 feet 3 inches. The exposure below the Stockton coal is complete, and the sandstone shows no break for 187 feet. It contains streaks as well as three beds of conglomerate, 15, 26, and 10 feet thick. The upper portion of the mass, 50 to 75 feet thick, is the Roaring Creek sandstone of I. C. White, so named from Roaring creek, in Randolph county, where it forms a fall of 50 feet or more. The mass can be followed up the Valley river to Pickens, in the southern part of the county, where it forms cliffs on the hillsides. The coals in this section are at 292 and 396 to 411 feet below the Stockton. The other boring was opposite the mouth of Laurel run, near the Randolph-Barbour line. It differs somewhat:

	Feet.	Inches
1. [*Stockton*] *coal bed* and partings	10	0
2. Interval	293	10
3. *Coal bed*	1	2
4. Sandstone and sandy shale	54	5
5. Black shale	8	9
6. Sandstone and sandy shale	31	9
7. Sandstone	141	11
8. *Coal bed*, divided by 7 feet 11 inches of shale	10	9
9. Fireclay and sandstone	62	9

in all, 615 feet; but before discussing further the relations of these beds it will be wise to take up another line, beginning at Charleston, in the Kanawha, and meeting at Philippi, in central Barbour, the one followed thus far.*

Doctor White has given a practically complete section at Charleston, extending from the Pittsburg coal bed to the Lower Carboniferous. The portion below the Stockton coal has been quoted already; it is necessary only to give the portion above, and then to summarize the whole. Condensed, it is

		Feet
1.	*Pittsburg coal bed*	
2.	Interval	350
3.	Red shales with Ames limestone	50
4.	Interval	176
5.	Massive and pebbly sandstone	75
6.	*Mason coal bed*	2
7.	Shale	10
8.	Sandstone	120
9.	Shales	10
10.	Black flint	5
11.	Shales	2
12.	*Stockton coal bed*	

The interval from the Pittsburg to the sandstone, number 5, is 566 feet, and to the Mason coal bed 651 feet. Numbers 5 to 8 are the Charleston sandstone of Campbell, here very much thicker than at Huntingdon, The interval between the Mason and Stockton is 147 feet in this section. but at a little way farther up the Kanawha it is somewhat greater. The number 5 Block coal bed is from 40 to 65 feet above the Stockton, and usually a thin coal bed rests on the Flint. If Doctor White's suggestion be accepted and the Mason be taken as the Upper Freeport of Pennsylvania, the division of the column would be

	Feet
Pittsburg coal bed	
Conemaugh	651
Allegheny	200
Pottsville	1,100

The subdivision is only approximate for Allegheny and Pottsville, but it may be taken tentatively for the study. In tracing the section the Stockton will be used as the key-bed. At Charleston the thickness from Stockton to Lower Carboniferous is about 1,150 feet, almost equally divided between Kanawha and Lower Pottsville. The Campbells Creek

* I. C. White: West Virginia, vol. ii, pp. 360-362, 363, 364-365, 365-366, 366-367, 368, 369, 459-460, 534-535, 616, 623.

coal bed is 450 feet below the Stockton and 120 feet above the Nuttall (Sharon) sandstone.

The Black flint comes up from the bed of Elk river at Queens shoals, 20 miles northeast from Charleston, and on the border of Kanawha and Clay counties, with the Upper Freeport (Mason) coal bed at 175 feet and the number 5 Block (Mahoning) coal bed at 80 feet above it. Doctor White's section at Clay court-house, 12 miles farther northeast, shows*

	Feet
Stockton coal bed	3
Massive sandstone and concealed	100
Coalburg coal bed	6
Sandstone and concealed	15

The Coalburg bed, between two massive sandstones, is mined at Clay, where it is largely splint, as on the Kanawha, and contains the characteristic "niggerhead" slate. The Stockton is thin and slaty here, but in most of this region it is very thick and broken into numerous benches by variable partings.

Ten miles northeast, at one and a half miles below Sutton, in Braxton county, a well record is*

	Feet
1. Conductor	50
2. Blue slate	30
3. Sandstone	80
4. *Coal bed*	6
5. White sandstone	230
6. Black slate	50
7. Gray sandstone	100
8. Black slate	20
9. Brown limestone	75
10. Black slate	30
11. Gray sandstone	50
12. Black slate	75
13. Gray sandstone	20
14. White limestone	50
15. Black slate	40
16. Sandstone	50
17. Blue slate	60
18. Gray limestone	55
19. Blue slate	54
20. Yellow sandstone	25
21. Shale	40
22. Sandstone	210
23. Slate	30

*I. C. White: West Virginia, vol. ii, pp. 239, 456.

The coal bed, number 4, is the Stockton, as the boring begins in the Charleston sandstone, which here is 250 feet thick. The great mass of sandstone underlying the coal is the same with that observed in Webster, Nicholas, and Randolph counties. The underlying coal beds of other sections have disappeared or are represented by carbonaceous matter distributed through black shale at 230, 380, 475, 555, and 700 feet below the Stockton, no one of which, except that at 475, can be correlated with any bed at Charleston. In view of the thickening of the measures, it is quite possible that that shale may represent the Campbells Creek horizon. It is very near the place of that coal bed, on the middle fork of Elk, 15 miles southeast, in Webster county. The distance from Stockton to Lower Carboniferous is 1,264 feet, about 200 feet greater than at Charleston, more nearly that to be expected on the Kanawha, at 7 or 8 miles above Charleston.

Where the Stockton coal bed comes today at 2½ miles above Sutton, the interval to the first coal is 152 feet 6 inches, very largely concealed, but containing some massive sandstone. A second coal bed, also a double bed, is at 15 feet lower, the intervals being 155 and 175 feet. At 3 miles east-northeast from Sutton these beds are shown again and somewhat thinner. Massive sandstone is present below the Stockton, as well as below the lowest bed, the lower division of the sandstone being exposed for 40 feet or to 240 feet below the Stockton. The Upper Freeport (Mason) coal bed is present at the latter locality, 135 feet above the Stockton.*

Near Wildcat, in the southern panhandle of Lewis county and 10 miles northeast from the last, Doctor White obtained a measurement of the Kanawha. Here one is about 8 miles north from the Hacker locality in northern Webster. The section is†

		Feet.	Inches.	Feet
1.	[*Stockton*] *coal bed*	12	9	
2.	Sandstone and concealed	125	0	
3.	*Coal bed*	Blossom		
4.	Concealed	80	0	
5.	*Coal bed*	Blossom		
6.	Concealed and sandstone	175	0	
7.	*Coal bed*	Blossom		
8.	Sandstone	20	0	
9.	Shale and concealed	25	0	
10.	Interval	30	0	
11.	*Coal bed*	7	0	to 10
12.	Interval	25	0	

*I. C. White: West Virginia, vol. i, p. 270; vol. ii, pp. 453, 454.
†I. C. White: Vol. ii, p. 364.

making a thickness of 502 feet 9 inches. The coal beds are at 125, 205, 380, and 470 feet below the Stockton.

At Hackers, on Holly, 8 miles south, the coals are at 120, 230, 415, and 520 feet, and the thickness of the Kanawha is 561 feet. At Pickens, in Randolph county, 12 miles east from the Holly River locality, the coals are at 150, 451 to 478, and 568 feet, and the thickness is 581 feet.

It is apparent that the variations in thickness are largely above the Campbells Creek bed, which is at 380, 415, and 451 to 478 feet below the Stockton at the several localities. . The lowest coal of the Wildcat section is equivalent to the Gimmel of Randolph, which is very clearly at the Eagle horizon. The total thickness from Stockton to the Lower Carboniferous is not far from 1,000 feet, so that the section is almost as thick as at Charleston, but a change appears abruptly at a little distance west and northwest from this line.

A section obtained near Ireland,* 4 miles north from Wildcat, affords means for checking up the tracing; for there the interval from the Pittsburg to the Stockton is 721 feet, with coal beds at 21 and 105 feet above the latter. The upper bed, the Upper Freeport, is 613 feet below the Pittsburg and rests on 84 feet of massive sandstone.

Passing over into Upshur county to the Buckhannon river, one comes to Alexander, 10 miles north from Pickens. The Stockton coal bed is mined at many places along the river below Pickens, while the Charleston and Roaring Creek sandstones are in cliffs. The section is clear up the little Kanawha river from Wildcat to within 2 miles of the Buckhannon, and it is repeated on the other side of the divide. At Alexander the section is †

	Feet.	Inches
1. Massive pebbly sandstone	60	0
2. Concealed	5	0
3. [*Stockton*] *coal bed* and partings	13	4
4. Concealed	10	0
5. Massive pebbly sandstone	60	0
6. Shale	5	0
7. *Coal bed*, seen	2	0
8. Concealed and sandstone to river	200	0

Here is the great sandstone underlying the Stockton, with a coal bed in it at 75 feet, the upper portion or Roaring Creek sandstone being separated from the lower. The Stockton coal bed passes under the river at Sago, 5 miles south from the village of Buckhannon, but comes up again at the Upshur-Barbour line, where one is at 12 miles west-northwest from the borings already recorded on the Randolph-Barbour border.

*Op. cit., p. 239.

† I. C. White: Vol. ii, p. 445.

But before returning to consideration of those records, a record should be given which was obtained on the Upshur-Lewis border, about 6 miles west from Buckhannon and about 15 miles north from Wildcat, for this illustrates the great change which has taken place between southern Upshur and the line of Buckhannon. The measurements are reported by Doctor White upon the authority of Mr F. H. Oliphant.*

		Feet
1.	*Pittsburg coal bed*	
2.	Interval	225
3.	Red rock, soft	125
4.	Shales	325
5.	Sandstone	30
	Slate and shell	20 — 80
	Sandstone	30
6.	[*Stockton*] *coal bed*	12
7.	Sandstone	20
	Slate	13
	Sandstone	30 — 73
	Slate	5
	Sandstone	5
8.	*Coal bed*	5
9.	Sandstone	95
10.	Shales	68
11.	Sandstone	15
12.	Limestone, pale brown	17
13.	Pebbly sandstone	20
14.	Black slate	10
15.	Sandstone, gray, hard	45
16.	Black slate and blue "limestone"	75
17.	Sandstone, gray, hard	50
18.	Limestone	10
19.	Sandstone, white, yellow, hard	150

to the Lower Carboniferous red shale. The interval from Pittsburg to Stockton is 755 feet, if the distance of the Pittsburg above the well curb was given accurately; this is about 30 feet more than in southern Lewis. The interval from the Stockton coal bed to Lower Carboniferous is 630 feet. On the Upshur-Randolph border, 10 miles southeast from Buckhannon, the Lower Pottsville is approximately 500 feet thick, while here, only 15 miles away toward the northwest, the total thickness of Kanawha and Lower Pottsville is less than 650 feet. The coal bed within the great sandstone mass is evidently the same with that seen at Alexander. No trace remains of lower beds except the black slate at about 300 feet below the Stockton, which may represent the Campbells Creek. The coal bed, number 8, has been seen in other sections farther south, and it is shown

* I. C. White: West Virginia, vol. i, p. 255; vol. ii, p. 443.

on the Buckhannon river 3½ miles below Sago, where it is double and 5 feet thick. The Roaring Creek sandstone above it is shown for 50 feet, beginning at 10 feet below the Stockton.

Returning now to northern Randolph, near the Barbour line, 12 miles southeast from the reappearance of the Stockton on the Buckhannon river and a little more than 20 miles east from the well in Lewis county, one finds the Roaring Creek sandstone beginning at 10 feet below the Stockton coal bed and continuing for 282 feet, the coals in the respective borings being at

292 and 395 to 408 feet, with black shale at 354 feet.
292 and 538 feet, with black shale at 350 feet.

The coal at 395 to 408 feet in the southerly boring is absent in the other, as the great sandstone, 141 feet, begins at 400 feet. It is unfortunate that no boring in this immediate region has been carried down to the Lower Carboniferous, as the great change in thickness and type of the Pottsville rocks takes place here. Only 8 or 9 miles southwest the Lower Pottsville is between 400 and 500 feet. On Rich mountain it has been called the Pickens sandstone by Taft and Brooks, who give the thickness as from 400 to 500 feet, increasing southwardly. It is

Light gray or white sandstone.
Brown sandstone shales and coal beds.
Massive gray to white sandstone to conglomerate.*

The lowest division is about 100 feet. The principal coal bed is 3 to 5 feet thick, and at only a little way above the third or lowest portion.

Stevenson describes the Lower Pottsville of Rich mountain along the Staunton pike as a coarse sandstone, with pebbles at times 2 inches in diameter, with micaceous sandstone. In the lower portion quartz crystals occur in great numbers, some of them three-fourths of an inch long and doubly terminated. A coal bed about 3 feet was seen at several localities. The thickness of the mass on the Staunton pike, by barometer, was found to be about 600 feet.†

Passing northward into Barbour county, one finds the great sandstone underlying the Stockton coal bed distinct along the Valley river to within 3 or 4 miles of Philippi, as well as along Buckhannon river to its junction with the Valley river, 4 miles south from that village. The sandstone has been in view all the way down the Valley river from Pickens. At Philippi, 12 or 13 miles north from the Randolph line, a well was bored, the record of which is reported by Doctor White. The

*J. A. Taft and A. H. Brooks: U. S. Geol. Survey folios, Buckhannon, 1896.

†J. J. Stevenson: Notes on Geology of West Virginia, vol. ii. Proc. Amer. Phil. Soc., vol. xiv, 1875, p. 388.

Upper Freeport (Mason) and number 5 Block coal beds are present at 40 and 115 feet above the Stockton, below which the succession is*

	Feet
1. [*Stockton*] *coal bed*	
2. Shale	20
3. Hard sandstone	45
4. *Coal bed*	7
5. Very hard sandstone	30
6. Shales	40
7. Hard sandstone	60
8. Shale, limestone (?)	30
9. Hard sandstone	25
10. Shales, limestone (?), 8 feet	113
11. Hard sandstone	50
12. Slate and shells	40
13. Hard sandstone	20
14. Shales, limestone (?)	28
15. Hard sandstone	14
Total	522

to the Mauch Chunk red rock. Here one finds the coal bed under the Roaring Creek sandstone number 3, as at Wildcat, in the Lewis County well and near Sago. The great mass, 280 feet thick in southern Barbour and northern Randolph, is here 237 feet, though no longer continuous, and rests on 113 feet of shales—in all, 370 feet—to number 11, the top of the Lower Pottsville. The coal bed at 395 feet in the Randolph boring is at the place of the Campbell Creek coal bed, and that bed should be in number 10, below the middle. The relations are made thoroughly clear in another boring at about 4 miles northwest from Philippi, where the measurement from the Pittsburg coal bed downward is complete. The interval from the Pittsburg to the Stockton coal bed is 717 feet, with the Ames limestone at 305 feet and the Upper Freeport (Mason) coal bed at 607 feet. The section is important.*

	Feet
1. [*Stockton*] *coal bed*	
2. Sandstone, limestone	15
3. White slate	30
4. Black slate	5
5. White slate	30
6. White sandstone	52
7. White shale	25
8. Limestone	10
9. *Coal bed*	5
10. Sandstone	15

* I. C. White: West Virginia, vol. ii, pp. 34, 238, 357, 358, 359.

	Feet
11. *Coal bed*	5
12. Sandstone, pebbly below	56
13. Brown shale	24
14. *Coal bed*	2
15. White shale	18
16. *Coal bed*	2
17. White shale	13
18. Sandstone	40
19. Black shale	35
20. *Coal bed*	3
21. Shale, brown, black	43
22. Sandstone	25
23. Black shale	10
24. Sandstone	55
25. Shale, mostly black	45

in all, 538 feet to the Lower Carboniferous. The Roaring Creek sandstone seems to have disappeared, and the black slate at 45 feet below the Stockton is apparently the coal bed number 4 of the last section. The mass of sandstone below that coal bed is no longer continuous, and coal beds are present at 142, 162, 247, 267, and 357 feet below the Stockton. The Campbells Creek bed is that at 357 feet. It is very clear that the great Lower Pottsville of the Kanawha region and southward has almost disappeared. In this record there remain only 135, in the other only 152 feet, to represent the 1,400 feet at Nuttallburg. Numbers 6 to the bottom are the Pottsville of western Pennsylvania, which may be divided thus:

Number 6 is the Homewood sandstone.
Numbers 9 and 11 are in the *Mercer* coal group.
Number 12 is the Upper Connoquenessing sandstone.
Numbers 14 and 16 are in the Quakertown shales.
Number 18 is the Lower Connoquenessing sandstone.
Number 20, the *Campbells Creek coal bed*, is the *Sharon coal bed.*
Number 22 is the Sharon sandstone.

Descending the Valley river, one comes to Moatsville, on the border of Taylor county, where the Stockton coal bed is at 10 feet above a massive pebbly sandstone; and at Webster, in Taylor county, about 5 miles west from Moatsville, the section is*

	Feet.	Inches
1. *Pittsburg coal bed*		
2. Interval	308	0
3. Ames limestone	1	0
4. Shales	193	0

* I. C. White: Vol. ii, pp. 232, 297, 356.

		Feet.	Inches
5.	*Coal bed*	0	9
6	Interval	120	0
7.	[*Upper Freeport*] *coal bed*	3	0
8.	Clay, shale, limestone, sandstone	52	0
9.	*Coal bed*	4	9
10.	Shale, limestone	44	0
11.	[*Stockton*] *coal bed*	5	10
12.	Clay, limestone, shale	10	0
13.	Sandstone and conglomerate	172	0
14.	Very hard conglomerate	47	0

Here the Stockton coal bed is 728 feet below the Pittsburg coal bed. Traces of coal were found at 75 and 180 feet below the Stockton; that at 180 feet answers to the bed at 142 in the boring northwest from Philippi, for the interval to the first coal below has increased 35 feet. The horizon of the Campbells Creek coal is not reached, as it lies beneath the great sandstone.

Not far from the line of Webster the section changes, and a new series of coal beds comes in between the sandstone overlying the Stockton and the Pottsville, for at Valley Falls, 6 or 8 miles north from Webster, several coal beds are shown, which are practically continuous thence to the Pennsylvania line. A complete section at Morgantown, about 8 miles from the state line, is given by Doctor White. From the Pittsburg coal bed to the Upper Freeport coal is exposed; from that below to the Pottsville sandstone was obtained by measuring a diamond-drill core; the Pottsville is exposed.* The Conemaugh is much thinner here.

		Feet.	Inches
1.	*Pittsburg coal bed*		
2.	Interval	285	0
3.	Ames limestone	1	6
4.	Interval	164	0
5.	Mahoning sandstone	100	0
6.	Shales	40	0
7.	*Upper Freeport coal bed*	5	7
8.	Fireclay	7	7
9.	Sandstone	53	2
10.	*Coal bed*		
11.	Shales and fireclay	22	8
12.	Sandstone and fireclay	7	7
13.	Black shale and sandstone streaks	15	4
14.	*Upper Kittanning coal bed*	2	10½
15.	Shale and fireclay	32	6½
16.	*Middle* and *Lower Kittanning coal bed* with black shale.	8	0½
17.	Fireclay and sandstone streaks	14	11½

*I. C. White: Vol. ii, pp. 230, 346.

	Feet.	Inches
18. Sandstone, shale streaks in upper part	54	2
19. Shale	2	4
20. *Clarion coal bed*	1	6½
21. Fireclay	11	6½
22. Interval, about	10	0
23. Pottsville sandstone, about	250	0

The interval between the Upper Freeport coal bed and the Stockton horizon is practically the same as at Webster, but here the Stockton is represented by numbers 14 to 16, in all occupying a space of 43 feet 6 inches, while from the bottom of 16 to the Clarion coal bed is 71 feet 6 inches, the Roaring Creek sandstone being number 18. Below the Clarion coal bed is the great sandstone mass overlying the Campbells Creek or Sharon coal bed. No detailed measurement is given of this mass for the gorge through Chestnut hill east from Morgantown, but the section in Cheat River gorge, 6 or 7 miles farther north, shows a coal bed within the sandstone and the Campbells Creek underlying, while the Sharon sandstone and the rest of the Lower Pottsville of the southern localities have disappeared, permitting the shales below the Connoquenessing sandstone to be continuous with the Shenango shales of the Lower Carboniferous.

A brief reference only can be made to the region lying east from the area already studied, as the information at present available is very small.

Some insignificant areas of Pottsville have escaped erosion on the mountains forming the boundary between Tucker and Randolph counties at the west and Grant and Pendleton at the east. Mr Darton states that his Blackwater formation, which is equivalent to the Pottsville, consists of*

	Feet
1. White conglomerate	100
2. Sandstone, shales, *coal* beds	200
3. Gray sandstones	100

These outlying patches are almost on the strike with the most southeasterly extension in Mercer and Tazewell counties, south from the Kanawha-New river.

Messrs Darton and Taft state that in the Potomac field of Tucker, Grant, and Mineral counties the thickness of the Blackwater varies from 645 feet in Tucker to 290 feet on the Potomac.†

*N. H. Darton: U. S. Geol. Survey folios, Franklin, 1896.

†N. H. Darton and J. A. Taft: U. S. Geol. Survey folios, Piedmont, 1896.

Mr David White obtained in Blackwater gorge, Tucker county, an important section, which, reduced from the diagram, is as follows:

	Feet.	Inches
1. Sandstone	15	0
2. Massive conglomerate	40	0
3. Soft sandstone, with lenses of shale containing fossil plants	25	0
4. Massive conglomerate	40	0
5. Soft sandstone, lenses of *coal* and shale with fossil plants, Mercer forms	20	0
6. Soft sandstone	63	0
7. Shale	10	0
8. Dark shale	5	0
9. Shale with nodular iron ore	5	0
10. Sandstone	10	0
11. *Coal* and fireclay	Thin.	
12. Clay shales, with plants and nodular ore	25	0
13. *Coal bed*	Thin.	
14. Green shale and blue clay	20	0
15. Sandstone	40	0
16. Shaly sandstone	10	0
17. Sandstone and conglomerate	45	0
18. Shaly sandstone	28	0
19. *Coal*, clay, carbonaceous shale	10	0
20. Shales, lower portion *coaly*	20	0
21. *Coal bed*	1	6
22. Shale	15	0
23. Sandstone	25	0

to the Lower Carboniferous red shale. Number 1 is at 10 feet below a thin coal bed associated with shales containing plant remains of Allegheny type.

Numbers 6 to 10 appear to represent the Connoquenessing sandstones, with the Quakertown shales, and number 15 is evidently the Sharon sandstone, the Lower Pottsville being represented by numbers 15 to 23, inclusive, thus giving for the Upper Pottsville a thickness of 278 feet and for the Lower Pottsville of about 195 feet.

WEST VIRGINIA—CENTRAL AND WESTERN COUNTIES

Passing now to the western counties of West Virginia, the effort will be to follow the section westward to the Ohio river and southward to the Kanawha. At Morgantown the intervals from the Pittsburg coal bed are

	Feet
Upper Freeport coal bed	560
Kittanning coal bed	670
Roaring Creek sandstone	713
Top of Pottsville	800

The intervals are smaller than at the south or north, owing to thinning of the Conemaugh and, to a less extent, of the Allegheny.

At the Brown well, 10 miles northwest from Morgantown, on the Pennsylvania line, the intervals are 570, 670, 745, 820 feet, with 35 feet between the Roaring Creek and the Pottsville. This formation shows

	Feet
1. Sandstone	20
2. *Coal bed*	2
3. Slate	8
4. Sandstone	180
5. "Slate and shells"	20

in all, 230 feet, separated by 140 feet of mostly red rock from the Lower Carboniferous limestone; but in a neighboring well the top sandstone is 43 feet and the overlying shale but 7 feet. Number 1 is evidently the "Homewood" and number 4 the "Connoquenessing." At about 10 miles southwest from the Brown well and 2 miles northeast from Fairview, in Marion county, the Pottsville is reached at 826 feet below the "Pittsburg," and consists of two sandstone plates, 50 and 136 feet respectively, separated by 69 feet of "slate and shells," so that the upper part of the Connoquenessing has been replaced by shale. The lower plate rests on red rock, and is 165 feet above the limestone. At about 8 miles west from Fairview the change is more marked. There the Upper Freeport is at 578, but below it only "slate and shells" is recorded to 918 feet, where a sandstone 80 feet thick is reached. This rock, 240 feet above the limestone, represents the middle portion of the Connoquenessing mass at Browns. The same condition exists at Metz, 5 miles southwest from the last, where the sandstone, 75 feet thick at 918 feet, rests on 245 feet of unrecorded material. In northeastern Wetzel, at Hundred, 9 miles northwest from Metz, 100 feet of sandstone appear at 930 feet, with apparently only shales up to the Roaring Creek sandstone. Near Cogley, 10 or 12 miles farther north in Marshall county, the change is complete, for the Roaring Creek sandstone is at 705 feet, and the next sandstone, the Logan, is at 1,095 feet. At 10 miles north from Cogley, in the same county, the normal condition begins to reappear, for beginning at 770 feet below the Pittsburg, one has

	Feet
1. Sandstone	10
2. Slate	60
3. Sandstone	20
4. Slate	50
5. White sandstone	85
6. Black sand and slate	110

to the limestone, which here is but 1,065 feet below the Pittsburg coal bed. The shale is still present in abnormal proportion. It is not possible to determine how much of number 6 belongs to the Pottsville, as no details are given in the record. Five miles farther west, in the same county, at Moundsville, on the Ohio river, one finds, beginning at 780 feet

	Feet
1. Sand	10
2. *Coal bed*	3
3. Sand	10
4. Black slate and shells	31
5. Sand	67
6. Slate and shells	82

to the limestone, which is only 983 feet below the Pittsburg, as against 1,170 feet in the Brown well. At Wheeling, on the Ohio river, and about 12 miles north from Moundsville, one finds a condition similar to that already observed at several localities in southwestern Pennsylvania, for a sandstone begins in one well at 564 feet below the Pittsburg, in another at 534, which is continuous with the Logan sandstone. In one of the wells it is broken by the Stockton (Kittanning) coal bed at 96 feet below the Upper Freeport. Doctor White finds no difficulty in differentiating the Pottsville in this well, for at 112 feet below the Kittanning the section is

	Feet
1. White sandstone	70
2. Yellowish gray sandstone	50
3. Yellowish gray coarse sandstone	170

resting on the brown coarse sandstone of the Logan. The contrasts are sharp in this well, yet in the other well, 3 miles south, where the sandstone is 706 feet thick, the portion assigned to the Pottsville is wholly fine grained and white, as indeed is most of the Logan—an excellent illustration of the variability of the deposits.

At Wellsburg, in Brooke county, 15 miles north from Wheeling, the Pottsville, beginning at 738 feet below the Pittsburg, shows

	Feet
1. Sandstone	15
2. Slate	75
3. Sandstone	145
4. *Coal bed*	6
5. Slate	31

or 272 feet to the Logan sandstone, which is 1,035 feet. The coal bed is at the Sharon horizon, number 3 being clearly the Connoquenessing. At 15 or 16 miles farther north, near New Cumberland, the section is

	Feet
1. Sandstone	15
2. Slate	30
3. Sandstone	110
4. Slate	45
5. Sandstone	25
6. Slate	35

to the Logan sandstone. Here one is at the extreme point of the "Panhandle," 2 miles west from line of Beaver county, Pennsylvania, and at about the same distance from the northern part of Jefferson county, Ohio. It is very possible that number 5 represents the Sharon sandstone, for the southern limit of that bed is not far north from this latitude in western Pennsylvania. The well at McDonalds, in Washington county, Pennsylvania, is about 15 miles east-northeast from Wellsburg. Its record shows little aside from shale for 886 feet below the Pittsburg coal bed. The Pottsville is 256 feet thick, including 58 feet of black shale resting on the Logan, which is 1,142 feet below the Pittsburg, an increase of 107 feet in 15 miles, due wholly to increase in the Conemaugh and Allegheny, the Pottsville having decreased 16 feet in the interval. In the same way one explains the small intervals in West Virginia near the Pennsylvania line. At McDonalds and Morgantown the intervals are, to the

	Feet.	Feet
Upper Freeport coal bed	613	560
Upper Kittanning coal bed	749	670
Top of Pottsville	886	800

showing a decrease southward of 53 feet in the Conemaugh and of 45 feet in the Allegheny. The loss is regained farther south.*

Returning to the southeasterly side, one finds at Fairview, in Marion county, about 20 miles south of west from Morgantown, the top of the Pottsville at 808 feet below the Pittsburg. The section is

	Feet
1. Sandstone	60
2. Slate and shells	60
3. Limestone (?)	20
4. Sandstone	100
5. Slate	30

in all, 270 feet, separated by 165 feet of mostly red rock from the limestone, thus differing little from the section at 2 miles northeast, except in thickening of the shales, numbers 2 and 3, at the expense of number

*I. C. White: West Virginia Geological Survey, vol. i, pp. 218, 234, 238, 239, 247, 348, 349, 350, 363, 365, 366, 369. Doctor White must not be held responsible for the limits assigned to the formations. The writer has taken the records as reported by Doctor White and has drawn the lines himself.

4. At Mannington, also in Marion county and 8 miles southwest from Fairview, one has A. J. Montgomery's record of the well drilled by him for Doctor White, which gives the succession in detail and shows the increasing thickness of Conemaugh, the intervals being 607 to the Upper Freeport, 807 to the Clarion, and 845 to the Pottsville, which shows

	Feet
1. Sandy shales, very hard	55
2. Pebbly sandstone	117
3. Dark slate	31
4. Pebbly sandstone	15
5. Sandy shale	37
6. Light shale, show of *coal*	30

285 feet, with 111 feet of mostly red shale to the limestone below. Here one finds the beginning of a change, which is complete in the next section, the record of a well at Joetown, 9 miles southwest from Mannington, which shows

	Feet
1. Sandstone	42
2. Black slate and limestone	38
3. Sandstone	185
4. *Coal bed*	2
5. Sandstone	18
6. Black shale	38
7. Sandstone	105

428 feet and resting on the limestone. At Fairview a thin coal bed is shown at 11 feet above the Pottsville; at Mannington it is in shale at 21 feet, while here it is represented by 5 feet of black shale. Number 3 is divided by 3 feet of black shale at 32 feet from the top. The upper part of the section, numbers 1 to 4, is that which is familiar in Monongalia, Wetzel, and northern Marion, equivalent evidently to the Homewood, Mercer, and Connoquenessing, with the Sharon coal bed (Campbells Creek) underlying the last. The interval from the Pittsburg coal bed to the Great Limestone is 1,243 feet at Fairview, 1,241 feet at Mannington, and 1,240 feet at Joetown. The section below number 4 is clearly equivalent to the red rock and other materials between the Sharon coal and the Limestone, of which one finds at Fairview 165 feet, at Mannington 111 feet, and here 0 feet, while the interval from number 4 to the limestone is 161 feet.

At about 15 miles west from Joetown, a well in Wetzel county shows the Roaring Creek and Pottsville in contact, the top of the latter being at 809 feet below the Pittsburg coal bed, the succession being

	Feet
1. Sandstone	62
2. Slate	63
3. Sandstone	10
4. Slate, shells, limestone	35
5. Sandstone	50
6. Black slate	63
7. Red rock	10
8. Sandstone	56

in all, 349 feet, and separated by 15 feet of shale from the Limestone. The section is shorter, as is to be expected. The presence of the red rock is important as showing the equivalence of the lower part of the section. At probably 20 miles west from Joetown, in Tyler county, and about 12 miles southwest from the last locality, a record shows the Roaring Creek in contact with the Pottsville.*

At 3 or 4 miles southeast from Joetown, a well on Laurel run, in Harrison county, shows, beginning at 702 feet below the Pittsburg,

	Feet
1. Sandstone	270
2. Limestone (?)	35
3. Sandstone	95
4. Black slate	48
5. Sandstone	20

separated by 93 feet of "limestone and slate" from the Limestone. At Joetown the top of the Roaring Creek sandstone is at 696 feet below the Pittsburg; if the conditions remain as at that place, only about 150 feet of the top sandstone belong to the Pottsville. There is a replacement of the bottom sandstone by shale, so that instead of 108 feet, only 20 remain. The Connoquenessing ends with number 3, and the Sharon coal bed, if present, should be in the upper part of number 4. The interval from number 3 to the Limestone is 161 feet. Here, as at the preceding two localities, one finds in the union of the Roaring Creek and Homewood sandstones the condition observed 20 miles southeast in the Webster boring, a notable condition along much of the eastern border.

The variability of the section is shown by the record of a well at Browns Mills, in Harrison county, only 8 miles south from Joetown, which is in notable contrast with the records at Joetown and Laurel run. The place of the Upper Freeport coal bed is at 592 feet below the Pittsburg; thence for 300 feet there are only "black slate and shells;" so that, beginning at 892 feet, one finds

*I. C. White: Op. cit., vol. i, pp. 239–240, 241–242, 341–342, 346; vol. ii, pp. 390–391.

	Feet
1. Sandstone	30
2. Black slate	30
3. Black sand	10
4. White sand	5
5. Black slate	10
6. Black sand	55
7. White sand	102
8. Slate and shells	8

with perhaps 100 feet of shales and limestone to the limestone. It may be that here there is a local thickening of the Allegheny, but the section is again that which is familiar in the northern counties, with the 157 feet of Connoquenessing as practically the lowest member. At Clarksburg, in Harrison county, about 10 miles southeast from Browns Mills and 11 miles east of south from Joetown, a record shows

	Feet
1. *Upper Freeport coal bed* (?)	
2. Sandstone and sandy shale	114
3. *Coal bed*	1
4. Black slate	21
5. Sandstone	28
6. *Coal bed* and slate	4
7. Sandstone	40
8. Slate	14
9. Sandstone	174
10. Black slate	72
11. Sandstone	10

to red beds. Here one finds the sandstone beginning directly under the coal bed, and almost continuous for 396 feet, there being in the interval only 40 feet of clay and coal beds. This condition recalls that at Webster, and it is found measurably at Long Run, in Doddridge county, 15 miles southwest from Browns Mills and 22 miles west from Clarksburg, for the sandstone is almost continuous from the Freeport to the upper portion of the Pottsville, which there is a sandstone 143 feet thick. The lower part must be shaly, for the driller reports only "slate, shells, and limestone" 230 feet to the limestone. In northern Doddridge, 10 miles west of north from Long Run and about 20 miles south of west from Joetown, the record, beginning at 864 feet below the Pittsburg, shows seven alternations of shale and sandstone, in all 240 feet, with underlying beds

	Feet
1. Blue slate	30
2. Red slate	75
3. Black slate	25
4. Limestone	22
5. Sandstone	40

in all, 192 feet to the limestone. Doctor White would place all of this in the Lower Carboniferous. It certainly is equivalent in great part to the red rock and associated beds of the more northerly sections, as has been observed already at several localities. The blue slate of this section most probably belongs to the Pottsville. Whether or not the red slate is Shenango will be referred to in another place. At Oxford, in Doddridge county, 15 miles southwest from Long Run, the section is in contrast with those already given, for, underlying 277 feet of shale, one has

	Feet
1. Sandstone	55
2. *Coal bed*	3
3. Black slate	43
4. Sandstone	53
5. Black slate	10
6. *Coal bed*	3
7. Black slate	11
8. Sandstone	40
9. Dark slate and sandstone	19

giving a total of 272 feet to the limestone. A coal bed is shown at 15 feet above number 1. At Long Run the interval from the Pittsburg to the Lower Carboniferous limestone is about 1,200 feet. Here it is 1,168 feet, or 32 feet less, though in the interval the Allegheny is 45 feet thicker. It is evident that the lower part of the section north from Long Run has disappeared in this direction, and that the whole of this Oxford section is Pottsville, the Shenango shales being certainly absent. The coal beds are in the places for Mercer and Quakertown, and number 9 represents the Sharon shale. At Harrisville, 15 miles west, in Ritchie county, one finds, beginning at 1,236 feet below the Washington coal bed, or about 825 feet below the Pittsburg, a series 442 feet thick and separated by 8 feet from the limestone below; and at Cairo, 3 miles west, the series is 431 to 460 feet thick, with a heavy sandstone at the bottom. These sections look much like a thickening of the Oxford section, and so to be Pottsville throughout. A section in the western edge of Ritchie county shows

	Feet
1. Sandstone	57
2. Shale	99
3. Sandstone	137

a notable decrease, but the loss has been mostly in the shales dividing number 3. Here those three beds are but 19 feet thick. In a well near Cairo the shales are 164 feet.

Wood county extends westward from Ritchie to the Ohio river. It is difficult here to determine the Pottsville. A record in northwestern part of the county shows two plates of sandstone, 120 and 100 feet respectively, separated by 90 feet of blue and black shale. The lower plate rests on the limestone. In much of the county the Mauch Chunk is wanting, and the Pottsville is continuous with the Logan or separated from it by a shale mass so thin that drillers seldom note it. At Parkersburg, on the Ohio, the two sandstone plates are present, each 50 feet and separated by 25 feet of black shale. The Logan is at a few feet below.*

Returning now to the easterly side, one finds at Vadis, on the Lewis-Gilmer line and 15 miles southeast from Oxford, the Pottsville, beginning at 868 feet below the Pittsburg, as follows:

	Feet
1. Sandstone	20
2. Shale	7
3. Sandstone	18
4. Shale	45
5. Sandstone	80
6. Shale	67
7. Sandstone	53

One is now approaching the region where the Pottsville begins to thicken, and at Glenville, in Gilmer county, 12 miles west of south from Vadis, the top of the Pottsville is at 875 feet below the Pittsburg coal bed. The section is

	Feet
1. White sandstone, with gas	18
2. *Coal bed*	3
3. Black slate	45
4. Gray sandstone	11
5. Black slate	235
6. White sandstone, with gas	164
7. Blue and black slate	32
8. White sandstone	24
9. Black slate	50

with 135 feet of blue and red shale to the limestone. Taking the shales as Shenango, the thickness of Pottsville is 545 feet. The "Clarion" (?) coal bed is at 8 feet above number 1. The coal bed, number 2, belongs to the Mercer group. The incomplete record of a well at Stumptown, on the Gilmer-Calhoun border and 12 miles southwest from Glenville, shows the same condition; for, beginning at 895 feet below the Pittsburg, the section is

* I. C. White: Op. cit., vol. i, pp. 248, 250, 285, 302-303, 304, 318, 321, 325, 333. Bull. no. 65, pp. 129, 189.

	Feet
1. Sandstone	113
2. Limestone, shale, and slate	287
3. Coal bed	9
4. Limestone (shale)	26

or 435 feet, and the bottom not reached. The shale, number 2, the same with number 5 of the Glenville record, is a notable feature under several counties; but the beds vary much, for in a Calhoun County well, probably 10 or 12 miles northwest from Stumptown, the shale is broken up and the thickest body is but 145 feet. At Burning Springs, in Wirt county, 12 or 15 miles northwest from the last and at the same distance southward from Cairo, in Ritchie county, the record, beginning at 890 feet below the Pittsburg, is

	Feet
1. Sandstone	60
2. Shale	118
3. Sandstone	58
4. Shale	14
5. Sandstone	110

Returning to the south and passing into Roane county, southwest from Gilmer, one finds at Spencer, about 15 miles south from Burning Springs and 20 miles west from Stumptown, a record which, beginning at 1,282 feet below the "Washington" coal bed, shows

	Feet
1. Sandstone	29
2. *Coal bed* and slate	10
3. Sandstone	41
4. Shales	228
5. Sandstone	45
6. Slate	3
7. Sandstone	277
8. Slate	8
9. Sandstone	12

in all, 653 feet to the limestone. This is very like the Glenville section, except in increased thickness. The Roaring Creek sandstone, 85 feet thick, is at 5 feet, and the Mahoning at 208 feet above number 1. The coal bed at 8 feet above the top of the Pottsville in the Glenville section is represented here by 5 feet of black slate. Another record at 10 miles southeast in this county shows a somewhat similar succession, with the shale 200 feet thick and resting on 197 feet of sandstone. The total thickness is 647 feet. The great increase has been distributed throughout the section, and the distinction between Upper and Lower Pottsville is clear.

With these one comes to the end of tracing, for records are few toward the west and south. At Ravenswood, in Jackson county, 25 miles west from Spencer, the Pottsville appears to consist of two sandstone plates, 47 and 85 feet, separated by 33 feet of black slate; but at Letart, in Mason county, 10 miles farther west, the section is

	Feet
1. Sandstone	35
2. Shale	115
3. Sandstone	20
4. Shale	165
5. Sandstone	60

in all, 395 feet, resting on the limestone. A well opposite Gallipolis, Ohio, and about 12 miles southwest from Letart shows the interval from the Pittsburg coal bed to the limestone to be only 1,125 feet, almost 400 feet less than at Spencer. The decrease is due very largely to loss in the Pottsville, but in part to decrease in the Conemaugh, for there the bottom of the Mahoning sandstone is at 597 and the Kittanning (Stockton) coal bed is at 660 feet below the Pittsburg. The Kittanning rests directly on

	Feet
1. Sandstone	213
2. Shale	33
3. Sandstone	170

with 45 feet of slate below to the limestone. The upper part of number 1 is the Roaring Creek sandstone of the Allegheny. Number 3 is the Sharon sandstone.*

Winfield, in Putnam county, is about 28 miles southeast from Gallipolis and 40 miles southwest from Spencer. A complete section from the Pittsburg coal bed to the bottom of the Pottsville is obtained here by uniting the measurements reported by Doctor White and Mr Campbell. It is as follows:

		Feet
1. *Pittsburg coal bed*		
2. Interval	Conemaugh	539
3. Mahoning sandstone	Conemaugh	70
4. Coal and shale, *Upper Freeport*	Allegheny	20
5. Sandstone	Allegheny	108
6. Place of *Stockton coal bed*	Allegheny	
7. Shale	Allegheny	52
8. Sandstone	Allegheny	20
9. Shale	Allegheny	37

* I. C. White: Op. cit., vol. i, pp. 257-258, 260, 262, 264, 274, 282; vol. ii, pp. 397, 398-402.

		Feet
10. Sandstone	Upper Pottsville	21
11. Shale		15
12. Sandstone		19
13. Shells		45
14. Shale		10
15. Sandstone		20
16. Shale		15
17. *Coal* and shale		25
18. Sandstone		45
19. Slate		45
20. Sandstone		15
21. Shale	Lower Pottsville	20
22. Sandstone		275

At Lock number 6, 20 miles southeast from Winfield, 35 miles south-southwest from Spencer, and 5 miles northwest from Charleston, the succession, according to Doctor White, is

		Feet
1. *Pittsburg coal bed*		
2. Interval	Conemaugh and Allegheny	750
3. Shales and *coal*		45
4. Sandstone		35
5. Shales and shells	Upper Pottsville	220
6. Sandstone		10
7. Shales and shells		40
8. Sandstone		50
9. Shale		10
10. Limestone		35
11. Sandstone		45
12. *Coal bed*		3
13. Sandstone		7
14. Slate		35
15. Sandstone	Lower Pottsville	480

The rapid decrease of the lower members northwestwardly is shown by these comparisons:

	Charleston.	Lock 6.	Winfield
	Feet.	Feet.	Feet
Pittsburg to Stockton	800	750	737
Stockton to Lower Carboniferous	1,155	975	692*

CORRELATION

The reader who has followed this tracing of the Pottsville section is ready, doubtless, to unite with the writer in a pious expression of relief. It remains, however, to give a general summary of the relations, and to

*I. C. White: Op. cit., vol. ii, pp. 400, 401.
M. R. Campbell: U. S. Geol. Survey folios, Charleston.

tabulate, as far as possible, the synonymy of such beds as are of stratigraphical importance.

In the preceding description, the plane between Upper and Lower Pottsville was drawn on top of the Sharon sandstone.

Crossing the Anthracite fields northwardly, one sees that the Pottsville column decreases rapidly, for the most part owing to successive disappearance of the lower members, so that in much of the northern field even the Sharon sandstone has but an insignificant representative. The loss in the lower portion continues westwardly, so that in Wyoming and Sullivan counties even the Sharon and some overlying beds have disappeared. Only the upper members of the section are present along the Allegheny front in Pennsylvania, but the whole of the Upper Pottsville, as well as the Sharon and some sub-Sharon beds, make their appearance along this line in Maryland, as shown by the Potomac sections. Thence southward, along the eastern border of the basin, the Lower Pottsville increases by successive additions of new members below—sandstone, conglomerates, shales, and coal beds—as well as by thickening of the upper beds, until on New river, of West Virginia, it is the great New River series of Fontaine, which is 1,400 feet thick in Doctor White's Nuttallburg section. Southwestwardly the increase continues until the maximum is reached in southwest Virginia and northern Tennessee. Thence southward, along the general line of outcrop, in Tennessee, into Alabama, the section shortens through loss of some lower members, as well as by thinning of the higher beds. Meanwhile, in the same direction, the Upper Pottsville expands in a similar way—by addition to the lower part of the section—while the upper members for the most part expand less rapidly; but as the Kanawha river is approached the expansion becomes notable throughout, and the great thickness observed in central West Virginia is maintained into northern Tennessee, where one reaches the last exposure of the Upper Pottsville.

Along the northern border the Sharon sandstone and immediately overlying beds reappear in the area studied by Mr Ashburner and Doctor Chance, and thence along the northern border of Pennsylvania one has the grouping offered by Doctor White:

Homewood sandstone.
Mercer group, shales, coals, and limestones.
Connoquenessing sandstones, with Quakertown shales and coal.
Sharon group, shales and coals.
Sharon sandstone.

This is the succession in Ohio along the northern and much of the western border, though at the extreme northwest there is a great thick-

ening of the Lower Pottsville, which attains fully 175 feet in some places and clearly has a new member in the lower portion; but in Ohio the western border lies for the most part far east from the old shore line, so that for some distance there is simply the northwest Pennsylvania section, with the Sharon sandstone somewhat irregular in occurrence.

As one approaches Jackson county, in southern Ohio, where the beds extend westward farther than in the northern part of the state, lower members of the Pottsville reappear, and one recognizes there the two members of the Sharon, with the Jackson Shaft coal bed between them. No further change appears until one has passed, in Kentucky, to 40 or 50 miles south from the Ohio river, where there is a mass of shales underlying the lowest Ohio bed. Thence southward the change is very marked, so that in Tennessee one finds appearing below these shales the Bonair and Etna sandstones, which persist to the last exposures in Alabama, with a varying thickness of beds below them, to the Lower Carboniferous. Meanwhile a change takes place in the Upper Pottsville. Until one has gone southward 40 or 50 miles into Kentucky, the section shows little variation except in the loss of its limestones, but there the column quickly expands throughout, so that in southern Kentucky and northern Tennessee the conditions are as on the eastern border. In much of Tennessee, as well as in northern Alabama, the Upper Pottsville has been removed by erosion, but it reappears in the Warrior, Coosa, and Cahaba fields of Alabama, evidently greatly expanded and bearing little resemblance to any sections obtained in northern Tennessee.

Within the basin, beginning at the north, one finds the Lower Pottsville, represented by the Sharon sandstone, disappearing quickly toward the south, not to reappear until one has gone some distance into West Virginia. The great thickness assigned to the Pottsville in Clearfield county is to be explained by the absence of the Shenango shales and lower beds, so that the Pottsville and Logan are continuous. There is good reason for believing that there one has only the upper members of the section. In the preceding pages Mr W. G. Platt's Red Bank section in Armstrong county has been referred to the Pottsville in deference to the opinion of one for whose acumen the writer has great respect; but the conditions observed farther south and southeast in Indiana and Westmoreland counties seem to forbid this reference, and to support Mr Platt's contention that the limestone is not Mercer, but rather the Silicious (Tuscumbia) of the Lower Carboniferous, and that the great underlying sandstone is Pocono (Logan). The writer is convinced that there the Pottsville is represented only by its highest members, the Homewood and upper Mercer, the lower members of the Pottsville having thinned out eastwardly and southeastwardly.

It seems probable also that Stevenson erred in his determination within Westmoreland county, and that he referred too much to the Sharon horizon, his conclusions being at variance with the results of borings in the Monongahela valley, within both Westmoreland and Fayette counties. This matter will be examined carefully on the ground prior to preparation of the discussion of the geographical conditions.

In West Virginia the Lower Pottsville reappears at some distance south from the line of the Baltimore and Ohio railroad, and, as has been seen in the study of oil well records, new members are added below toward the south, though with irregularities, which possess much interest in another connection. Southward from the Kanawha the section approximates more closely to that along the eastern border, until in Kentucky and northern Tennessee it is practically the same. The Upper Pottsville varies in much the same way, increasing slowly throughout, until beyond the Kanawha one finds the great increase in the lower part of the column with less notable increase in the upper.

Further reference to these conditions is unnecessary in this connection. In a later portion of this work the detailed discussion will be given.

The distinction between Upper and Lower Pottsville is very marked in the greater part of West Virginia, Virginia, and northern Tennessee, on the eastern side of the basin, as well as in much of Ohio; in Kentucky and northern Tennessee along the western side. It is necessary to designate them by special terms. The only name which has been applied to the Upper Pottsville, as defined in this paper, is that of Beaver series, used by J. P. Lesley in 1878; but several correspondents in referring to the formation have spoken of it as the Mercer, a good term. Kanawha of Campbell can not be employed, as it embraces important horizons of the Allegheny and its use would lead to confusion. Several terms have been applied to the Lower Pottsville, in whole or in part. Lee of Campbell, in southwest Virginia, does not include the highest members in the locality where the name was first applied. The earlier name, Rockcastle of Crandall, was given in southern Kentucky, where the lowest members are wanting; but in the same report it was applied to the Pine Mountain region, where the section is practically complete.

Synonymy

The synonyms and distribution of the more important horizons are

Beaver.	
Homewood sandstone..... (I. C. White.)	Homewood of I. C. White, Johnson Run of Ashburner, Piedmont of Ashburner and Stevenson in Pennsylvania; Piedmont and Homewood of I. C. White and

	Martin in Maryland; Homewood and Tionesta of Orton in Ohio; not named in Kentucky, where it is frequently shale; not reached in most of the Tennessee field; Homewood of I. C. White, "salt sand" of drillers, in part, in West Virginia.
Mount Savage coal bed..... (J. P. Lesley.)	Tionesta of I. C. White, Alton Upper of Ashburner, Mount Savage of Stevenson in Pennsylvania; Mount Savage of Lesley and others in Maryland; Tionesta, Wartman, and Newland of Orton, Bolivar of Newberry in Ohio; number 4 and Hunnewell of Crandall, Lower Splint of Hodge in Kentucky; coal P of Bradley in northeastern Tennessee; Lower Splint of Campbell and Stevenson in southwestern Virginia; Coalburg (?) in southern West Virginia.
Mercer shales..... (I. C. White.)	Upper portion becomes sandstone in central part of Kentucky, persists as such in Kentucky, northern Tennessee, and southwestern Virginia, where it is the Gladeville sandstone of Campbell.
Mercer limestones..... ..... (I. C. White.)	Present in only a small part of northwestern Pennsylvania; present, but irregularly, in Ohio almost to the Ohio river; the Lower is the Blue or Zoar of Newberry; absent in other parts of the basin.
Upper Mercer coal bed..... (I. C. White.)	Upper Mercer of I. C. White, Middle Alton of Ashburner in Pennsylvania; Bruce of Newberry, Strawbridge of Read, Bedford of J. T. Hodge, Upper Mercer of Orton in Ohio; not definitely recognized in Kentucky, but may be coal 3b of that state and unnamed bed under Gladeville sandstone in southwestern Virginia; not recognized in Tennessee and southern West Virginia.
Lower Mercer coal bed..... (I. C. White.)	Apparently the persistent bed. Lower Mercer of I. C. White, Lower Alton of Ashburner, probably Alpha of northern Anthracite field, coal A of Bernice in Pennsylvania; coal 3 of Newberry, blue limestone coal, Flint Ridge, Lower Mercer of Orton in Ohio; Elkhorn, Jellico, Peach Orchard, McHenry of Crandall, Twin bed of Lesley in Kentucky; Bradley's coal O in northern Tennessee; represented in southwestern Virginia by either the Kelley or Imboden of Campbell and Stevenson, or perhaps by both of those beds; Winnifrede of Kanawha and southern West Virginia; eroded from most of Tennessee and northern Alabama.
Connoquenessing sandstone. (I. C. White.)	Upper and Lower of I. C. White, separated by Quakertown shales and coal bed, Kinzua of Ashburner in Pennsylvania; Massillon of Newberry and others

	in Ohio; frequently present as sandstone in Kentucky, as well as in many sections within West Virginia, but not named in either state except in northern part of the latter; Connoquenessing of the Maryland reports.
Quakertown coal bed..... (I. C. White.)	In Quakertown shale of I. C. White in Pennsylvania and northern West Virginia; Quakertown of Orton in Ohio; coals 2 and 2a of Crandall and Hodge in Kentucky; not identified in southwestern Virginia; Cedar Grove (?) of Kanawha river.
Sharon coal bed..... (H. D. Rogers.)	Sharon and Campbell's Ledge of I. C. White, Marshburg of Ashburner in Pennsylvania; Block, Brier Hill, Massillon, and Wadsworth of Newberry, Sharon and Wellston of Orton in Ohio; number 1 of Crandall and Hodge, Laurel of Norwood, Pittsburg of Crandall and Campbell, Adamsville of Lesley, Warfield of Lesley and I. C. White in Kentucky; not named in Tennessee; not identified in southwestern Virginia; Campbells Creek, Sharon, and Cook of authors in the Kanawha region.
ROCKCASTLE.	
Sharon sandstone..... (H. D. Rogers.)	Sharon of I. C. White, Olean of Ashburner, Garland of Carll in Pennsylvania; Sharon conglomerate in Ohio; conglomerate in northern and central Kentucky, Corbin of Campbell in southern Kentucky; Corbin in northern Tennessee; Dotson of Campbell in southwestern Virginia; Nuttall of the Kanawha region, "salt sand" in part of drillers in West Virginia.
Jackson Shaft coal bed ..... (E. B. Andrews.)	Jackson Shaft of Andrews and Orton in Ohio; Barren Fork of Crandall in southern Kentucky, not named in northern part of the state; represented probably by several beds in southeastern Kentucky; present in Harlan county, Kentucky, but not named by Campbell; persistent in West Virginia, Virginia, and northern Tennessee, but not named by observers; probably bed underlying Sharon sandstone on the Potomac; disappears northward in central Ohio and West Virginia; removed by erosion from southern Tennessee and northern Alabama.
Rockcastle sandstone..... (M. R. Campbell.)	The hornstone bearing part of the conglomerate in Ohio underlying Jackson Shaft coal bed; Rockcastle of Campbell in Tennessee and southern Kentucky; "Bee rock" of Campbell and Stevenson, Bearwallow (?) of Campbell in southwestern Virginia; removed from northern Alabama and most of southern Tennessee; may be Gibson's Third conglomerate in Alabama; present in middle and

	southern Anthracite fields of Pennsylvania, but does not extend into other parts of that state or into northern West Virginia.
Sewanee coal bed..... (J. M. Safford.)	Wanting in Ohio, in Pennsylvania, except southern and middle Anthracite fields, and in most of West Virginia north from the Kanawha; wanting in northern Kentucky, but present in southern Kentucky, where it is probably the Main of Lesley; Main Sewanee of Safford, Coal Creek, Harriman, Rockwood, etcetera, of authors in Tennessee; present but not mined or named in northern Alabama; Sewell in Kanawha region of West Virginia.
Bonair sandstone..... (M. R. Campbell.)	Wanting in Pennsylvania bituminous areas, in northern West Virginia, in Ohio, in most of Kentucky; Bonair of Campbell, Main of Safford in Tennessee; Upper Conglomerate of McCalley, Second Conglomerate of Gibson in Alabama; Raleigh of Campbell in West Virginia.
Cashie coal bed..... (A. M. Gibson.)	Wanting in Pennsylvania bituminous, in most of northern West Virginia, in Ohio, in Kentucky; not named in most of Tennessee; Sewanee of Colton in southern Tennessee and of McCalley in Alabama; is very near place of Campbell's Beckley coal in southern West Virginia; a still lower bed in Tennessee and Alabama is at the place of Fontaine's Quinnimont.
Etna sandstone ..... (J. M. Safford.)	On west side of basin extends northward only to middle of Tennessee, on east side to probably 50 miles north from New river in West Virginia; Cliff sandstone and Lower Etna conglomerate of Safford in Tennessee; Cliff sandstone and Millstone grit of McCalley in Alabama; probably the sandstone underlying Quinnimont coal bed in southern West Virginia.
Etna coal bed..... (J. M. Safford.)	On west side extends northward only to middle of Tennessee; represented in West Virginia south from New river by one of the Clark formation beds; Cliff, Main Etna of Safford in Tennessee; Castlerock of Georgia; Cliff of Alabama.

Lower horizons of much importance are present along the eastern line of outcrop in Tennessee and the Virginias northward to New river, but one may not attempt to make correlations, as the sections in most of Tennessee and Virginia are somewhat indefinite and details are practically wanting until one reaches West Virginia. Here belongs the "Pocahontas" coal bed, which is followed without difficulty for more than 75 miles in Virginia and West Virginia.

While the greater part of the Rockcastle has disappeared northward, so as to bring the Sharon sandstone and even higher beds into contact with the Lower Carboniferous within the bituminous areas, it seems wholly probable that the whole or a very great part of the Rockcastle is present in the southern Anthracite field, where the "Lykens Valley" coals are likely to prove equivalents of beds seen in the southern part of the Appalachian basin.

Some matters connected with these correlations need especial consideration.

The Kanawha Valley

In the Virginia report for 1839 Professor William B. Rogers described the beds along the Kanawha, and drew the plane of separation between the Upper and the Lower Coal Series at the top of a calcareous sandstone, fossiliferous, and 140 feet above the Black flint. No very definite explanation of the terms was given in this report, but in that for 1840 the Kanawha deposits above Charleston are placed in the "Lower Coal Group," which is succeeded by the "Lower Shale and Sandstone Group," extending upward to the Pittsburg coal bed.* The Kanawha formation of Campbell is almost accurately the equivalent of the "Lower Coal Group," which Rogers thought to be the same as the lower productive Coal Measures of Professor H. D. Rogers in Pennsylvania, now the Allegheny formation.

In 1871 Mr Ridgway regarded several of the Kanawha coal beds as equivalent to certain beds of the Pennsylvania Lower Coal Measures (Allegheny); and in the next year Stevenson, after a cursory examination, went somewhat further in determination of equivalents. In 1874 Professor Fontaine came to the same general conclusion, laying stress on the fossils of the Black flint, which appeared to correlate it with a black shale underlying the Mahoning sandstone near the Pennsylvania line. In 1876 Mr Maury recognized the Kanawha beds as equivalent to the Pennsylvania Lower coals, but he went no further in detailed determination than to assert that the sandstone overlying the Black flint is the same with the Mahoning of Pennsylvania, now taken in Doctor White's grouping as the lowest bed of the Conemaugh.†

In 1874 Stevenson, during a reconnaissance across West Virginia, examined the greatly expanded coal bed in Randolph and Upshur counties known as the Roaring Creek coal bed. Finding there a massive

* W. B. Rogers: Report of progress of the Geol. Survey of Virginia for 1839, p. 135; for 1840, p. 73.
† W. M. Fontaine: Great Conglomerate of New river, pp. 461-463.
M. F. Maury, Jr.: Resources of West Virginia, p. 196.

sandstone of great thickness, he identified it with the Mahoning sandstone, and the underlying coal bed with the Upper Freeport of Pennsylvania. A gap of at least 60 miles intervened between the Upshur locality and the Pennsylvania line, near which, in 1870, he had made correct correlations with the Pennsylvania beds; but this evidently was not a matter worth considering. For many years no detailed study of the intervening space was made, and Stevenson's identifications were accepted as accurate. Ten years later Doctor White followed the Roaring Creek coal bed from Upshur county to the Kanawha river, and found it to be the equivalent of the Stockton coal bed, which, by common consent of all previous observers, had been regarded as practically at the horizon of the Upper Freeport coal bed. The careful tracing of the section by Doctor White evidently confirmed the conclusions of all who had gone before him.*

Several years after the publication of Doctor White's results Mr David White collected plants at several horizons along the Kanawha river. The testimony of these plants contradicted absolutely the conclusion that the Stockton is Upper Freeport, and required that a great part of the Kanawha formation be placed in the Pottsville. Still later, Doctor White, after a study of the region northward from Upshur county, suspected the accuracy of the identification of the Roaring Creek coal bed with the Upper Freeport, and suggested that the bed might be correlated with the Lower Kittanning of Pennsylvania, and that the Upper Freeport might prove to be represented on the Kanawha by the Mason coal bed. This suggestion proved to be correct in the main, for, as has been seen, the Stockton coal bed is at the horizon of Kentucky coal 6, which is the Lower Kittanning, being at only a few feet above the Ferriferous limestone. Doctor White's sections, north from the Kanawha, show conclusively that the Stockton can not be higher than the Kittanning horizon, so that it is in the lower portion of the Allegheny formation. The matter is now sufficiently clear. There is no conflict between stratigraphy and paleobotany respecting the main horizons. The conflict was but apparent, and was due solely to hasty correlations by the earlier observers.†

Of the coal beds found along the eastern outcrop north from the Kanawha none except the Campbells creek can be correlated closely with Pottsville coal beds elsewhere. Evidently the tendency to divide, shown by beds along the Kanawha, prevails for many miles northward, and

*I. C. White: Catalogue West Virginia University for 1884–1885, p. 59.

†D. White: Pottsville series along New river, West Virginia. Bull. Geol. Soc. of Amer., vol. vi, pp. 305 et seq.

I. C. White: W. Va. Geol. Survey, vol. ii, p. 603.

Doctor White's sections are too far apart to make close identification more than conjectural.*

The Anthracite Fields of Pennsylvania

The stratigraphical study shows that the Rockcastle or Lower Pottsville is thickest in the Southern field, that much of the lower portion is wanting in the Middle field, and that practically the whole of the section is absent from the Northern field. The study of plant remains tells the same story; for twenty years ago Doctor White, making use of Mr Lacoe's studies, found in them the proof for his conclusion that the Campbells Ledge coal bed of the Northern field belongs near the base of his Pottsville. Mr David White's study of plants from many horizons in the Southern field leaves no room for doubting the general statement. In this work Mr White offered tentative correlations with horizons at localities in the Virginias and farther southward, tentative because they were based upon limited collections from the southern localities. These do not coincide in all cases with the conclusions reached in this paper from study of the stratigraphy; but in several instances the study of extensive collections has enabled Mr White to reach final conclusions, which, in so far as the localities studied are concerned, are in practical agreement with those suggested by the stratigraphy.†

The Anthracite fields are separated by hundreds of miles from the nearest localities at which the Lower Pottsville is shown in great thickness. The conditions in the Anthracite area were very different from those of any southern area except eastern Alabama, so that any attempt at correlation on the basis of stratigraphy would be deserving only of ridicule. The question as to whether the whole of the Rockcastle section and Lower Pottsville section is to be looked for in the Anthracite area or in the southern areas must remain without answer until study of the fossil plants has been completed.

A similar condition exists with respect to the Alabama coal fields, where a great mass of measures is found, separated by at least 100 miles from the nearest locality in Tennessee, where the upper beds have escaped erosion. The probabilities seem to be that the Pottsville, above the Bonair sandstone, is enormously expanded; but the determination of this matter also must be left for the paleobotanist, as there is nothing on which the stratigrapher may build securely.

* That this remark be not construed as a reflection on Doctor White, it is well to state that the material published in the bulky volume ii of the West Virginia Survey is a gift from the author to his state, the work having been performed prior to his appointment as state geologist.

† I. C. White: Geology of the Susquehanna Region (G 7), pp. 41-43.

D. White: Fossil floras of the Pottsville formation; Twentieth Ann. Rept. U. S. Geol. Survey, pp. 755 et seq.