

CARBONIFEROUS OF THE APPALACHIAN BASIN*

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(Presented by title before the Society December 29, 1905)

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INTRODUCTION

The Coal Measures above the Pottsville have been grouped in various ways by those who have studied the Appalachian basin.

* The earlier papers of this series are in this Bulletin, volume 14, pages 15-96; volume 15, pages 37-210. The writer desires to acknowledge his obligations to Dr I. C. White, Mr David White, and Mr E. V. d'Invilleers, who have given him information and valuable criticisms without reserve. It must be understood, however, that these observers are in no wise committed to the conclusions offered by the writer.

In the early reports on the geological survey of Pennsylvania Professor Henry D. Rogers used a numerical scale to designate the formations, the Pottsville being XII and the Coal Measures above being XIII; but in the fourth report he divided Formation XIII into the Allegheny and Monongahela series, drawing the line between them at the lowest rock bed seen at Pittsburg, or nearly at the place of the Ames limestone. In the next year he abandoned the geographical terms, using only XIII and designating the lower coals by letters.*

The numerical method was adopted in Virginia by Professor William B. Rogers, the Pottsville being designated by 12 in his second report. Two years later he divided the measures into the Lower and the Upper Coal series, separated by a considerable thickness of barren measures, and in his fifth report he gives

Lower Coal group, or Formation XIII;
Lower shale and sandstone group, or Formation XIV;
Upper Coal group, or Formation XV;

the Mahoning sandstone being included in the Lower group.†

In 1856 Professor J. P. Lesley offered this grouping:

Barren measures,
Upper series,
Barren measures,
Mahoning sandstone,
Lower series,

with the Pittsburg coal as the highest member of Number 3 and the upper limit of Number 2 indefinite.‡

Professor Rogers's final report of the geology of Pennsylvania appeared in 1858 and contained this arrangement:

| | | | |
|-----------------------|---|---|-------------------------|
| Upper Barren | Waynesburg group and Pittsburg coal and limestone | } | Greene County group. |
| Lower Barren measures | Mahoning sandstone | } | Middle or Barren group. |
| Freeport group | Freeport sandstone | } | Lower group. |
| Clarion group | | | |

The plane between the Allegheny and Monongahela of the previous

* H. D. Rogers: Second Ann. Rept. Geol. Explor. of Pennsylvania, p. 71; Third Rept., p. 62; Fourth Rept., p. 150.

† W. B. Rogers: Rept. Geol. Virginia for 1838, p. 84; Rept. for 1839, p. 98; Rept. for 1840, p. 76 et seq.

‡ J. P. Lesley: Manual of Coal and its Topography, pp. 94, 116.

arrangement had been placed almost midway in the Lower Barren measures.*

In 1870 Professor John S. Newberry divided the Ohio Coal Measures into Lower and Upper, including in the former all beds below the Pittsburg coal to practically the bottom of the Pottsville. Professor Edward Orton adopted this classification in his elaborate discussion of the Ohio coals, published in 1884.†

In the same year Stevenson employed the terms Lower and Upper for the Coal Measures of northern West Virginia, drawing the plane of separation just under the Pittsburg coal bed, but including only rocks above the Pottsville. In 1872 he grouped the deposits into

Upper Barren group,
Upper Coal group,
Lower Barren group,
Lower Coal group,

the last two being equivalent to XIII and XIV of W. B. Rogers and the first two equivalent to the higher groups of H. D. Rogers, as published in the final report.‡

Toward the end of 1875, in the first of the Pennsylvania reports, Mr Franklin Platt divided the Pennsylvania Coal Measures into

Upper Barren measures ;
Monongahela, from Washington coal bed to Pittsburg coal bed ;
Conemaugh, bottom of Pittsburg to bottom of Mahoning sand ;
Allegheny, bottom of Mahoning sandstone to top of Pottsville ;

using names originally employed by Professor Rogers, but not in the same sense.§

In 1876 Stevenson used the same grouping as in 1872, with a slight change in nomenclature, thus:

Upper Barren series { Greene County group.
Washington County group.
Upper Productive series.
Lower Barren series.
Lower Productive series.||

In the next year, Mr Platt modified his classification materially, his new grouping being

* H. D. Rogers : *Geology of Pennsylvania*, vol. ii, pp. 477, 500, 503.

† J. S. Newberry : *Rep. Prog. Ohio Survey for 1870*, p. 15.

‡ J. J. Stevenson : *Regents' Report of West Virginia University for 1870*, p. 47 ; *Trans. Am. Phil. Soc.*, vol. xv, p. 15 et seq.

§ F. Platt : *Second Geol. Survey of Pennsylvania*, Report H, p. 8.

|| J. J. Stevenson : *Report K*, pp. 34 et seq.

- I. Monongahela River system.
 - a. Greene County group of Upper Barren measures.
 - b. Washington County group of Upper Barren measures.
 - c. Upper Productive Coal Measures.
- II. Allegheny River system.
 - a. Lower Barren measures.
 - b. Mahoning sandstone.
 - c. Lower Productive Coal Measures.

the plane between the two systems being drawn at the bottom of the Pittsburg coal bed.* But the geographical terms were abandoned quickly, and in later volumes of the reports the terms Upper and Lower barrens, Upper and Lower Productive Coal Measures were used instead, the Mahoning sandstone in most of the reports being included in the Lower Productive Coal Measures.

In 1891 Doctor I. C. White introduced the term Dunkard to designate the Upper Barren measures, the Greene and Washington County groups of Pennsylvania, Report K, and at the same time limited the term Monongahela to the Upper Productive Coal Measures.†

The synonymy may be given as follows in ascending order:

Coal Measures, XIII of H. D. and W. B. Rogers

| | | |
|-------------------|--|--|
| Allegheny | Allegheny of H. D. Rogers in part; XIII, F. Platt, 1875. | Lower Coal group of W. B. Rogers less the Mahoning sandstone; Lower series of Lesley; Lower productive series of Stevenson less the Mahoning; Lower Coal Measures of Ohio in part; Lower group of H. D. Rogers. |
| Conemaugh | F. Platt, 1875. | Barren measures of Lesley plus the Mahoning sandstone; Lower shale and sandstone group of W. B. Rogers plus the Mahoning; Lower Barren series of Stevenson plus the Mahoning; Lower Coal Measures of Ohio, upper part; Middle group of H. D. Rogers. |
| Monongahela | I. C. White, 1891. | Middle portion of Monongahela of H. D. Rogers; Lower portion of Monongahela of F. Platt; Upper productive series of Stevenson; lower portion of Upper series of Lesley; in part XV, Upper Coal group of W. B. Rogers; lower portion of Upper Coal Measures of Newberry; lower division of Greene County group of H. D. Rogers. |

* F. Platt: Report H H, pp. xxiii, xxiv.

† I. C. White: U. S. Geol. Survey Bulletin no. 65, pp. 20, 43.

Dunkard Upper Barren series of Stevenson; upper part
 I. C. White, 1891. of Greene County group of H. D. Rogers;
 upper part of Upper Coal Measures of New-
 berry; upper part of XV of W. B. Rogers.

In the description of the several formations, the names here given will be employed as limited by Franklin Platt and I. C. White.

ALLEGHENY FORMATION

CORRELATION

The plane of separation between the Pottsville and the Allegheny in the bituminous area is marked on top of the Homewood sandstone, but only approximately, for, as will be seen, that sandstone is replaced more or less by shale in extensive spaces, while in others it is continuous with sandstone extending upward even into the Conemaugh. A more convenient base is the Brookville coal bed, belonging a few feet above the Homewood in its normal condition. The Allegheny is paleontologically as well as stratigraphically distinct from the underlying Pottsville; for, although the fauna exhibits comparatively little change, there is, as shown by Mr David White, for a great part of the field a very marked difference in the flora.

The Allegheny area is much smaller than that of the Pottsville. It becomes narrow in southern West Virginia and northeastern Kentucky. The present condition of our knowledge makes impossible any positive conclusions respecting its extent in southeastern Kentucky and southwestern Virginia, though reconnaissance work in the former state suffices to show that Allegheny coal beds are present there. It is possible that the formation reaches into the northeastern corner of the Tennessee coal field. Uncertainty prevails respecting the correlation of beds in the anthracite areas of Pennsylvania, which will be considered apart after the description of the Conemaugh.

Though comparatively thin, at most little more than 300 feet, the Allegheny contains a large number of elements, most of which are persistent for long distances on both sides of the basin, though practically all becomes unidentifiable in much of the broad interior, where throughout the Coal Measures the coal beds and limestones disappear or become indefinite and there remains only detrital matter of variable character. The important elements are:

- Upper Freeport coal bed.
- Upper Freeport limestone.
- Butler sandstone.
- Lower Freeport coal bed.

Lower Freeport limestone.
 Freeport sandstone.
 Upper Kittanning coal bed.
 Johnstown cement limestone.
 Middle Kittanning coal bed.
 Lower Kittanning coal bed.
 Vanport limestone.
 Clarion coal bed.
 Clarion sandstone.
 Putnam Hill limestone.
 Brookville coal bed.

The Upper Freeport coal bed... In Pennsylvania, Kelly of Broad Top, E of Rogers and Lesley, Upper Freeport of authors; in Ohio, 6 and Big vein of Columbiana, Cambridge of Guernsey, Alexander of Muskingum, Stallsmith, Norris, Bayleys run of Hocking valley, 7 of Tuscarawas; in West Virginia, Upper Freeport, Mason; in Maryland, Upper Freeport; in Kentucky, Coal 9.

This coal bed is present in nearly every county of Pennsylvania where its place is reached and it is important economically in extensive areas. It is traceable in most of the Ohio counties as well as along the eastern outcrop in West Virginia, where also it is frequently important. It is irregular in Kentucky and is wanting or very thin in much of the central region within West Virginia and Kentucky. Its irregularity along the outcrop is due in some measure to erosion during deposit of the Mahoning sandstone, but there are considerable areas in which the coal never existed. The bed is broken in many places by numerous partings, so as to be a thick mass of coal and shale. In some localities it is associated with a flint clay of good quality.

The Upper Freeport limestone.. In Pennsylvania, Upper Freeport; in Ohio, H. D. Rogers, Upper Freeport, "White" of Columbiana, Shawnee of Hocking valley; in Kentucky, First Fossiliferous.

This limestone is of somewhat uncertain occurrence in portions of Pennsylvania, but in a general way is one of the best marked strata in the section. In southern Ohio and in Kentucky it is so persistent as to be a notable stratigraphical guide, but in West Virginia it seems to disappear quickly south from the Pennsylvania line. Ordinarily it is non-fossiliferous, though occasionally showing some forms presumably of fresh-water types; but Professor Crandall describes it in Kentucky as carrying a characteristic Carboniferous fauna and terms it the First Fossiliferous limestone.

The Butler sandstone of I. C. White, Upper Freeport sandstone of authors, is, like most of the sandstones, somewhat indefinite; but one finds very frequently in the interval between the Freeport coal beds a sandstone, sometimes very thin, at others filling the whole interval. There is no regularity in the occurrence of these sandstones.

The Lower Freeport coal bed... In Pennsylvania, Lower Freeport, Middle Freeport, D. D'; in Ohio, Roger and Shaft of Jefferson, 6a of central counties, Black, Fowler, Juniper, Frank of Hocking valley, Hatcher, Waterloo of Lawrence; in Kentucky, Coal 8; in West Virginia, Lower Freeport.

This is almost as persistent in Pennsylvania, Ohio, and Kentucky as the Upper Freeport, but is less frequently of economic importance. It shows abrupt and extreme variations in thickness as well as quality and occasionally carries on top a thick deposit of impure cannel. It yields excellent coal in Jefferson county of Ohio, but in the greater part of that state it is worthless. Locally it is valuable in southern Ohio, but is insignificant in both Kentucky and West Virginia.

The Lower Freeport limestone.. In Pennsylvania, Lower and Middle Freeport; in Ohio, Norris and Snowfork of Hocking valley; apparently wanting in Kentucky and West Virginia.

In general features this resembles the Upper Freeport limestone. In the eastern basin of Pennsylvania it extends farther north than any other limestone, but its distribution throughout is very uncertain. Like the Upper Freeport, it varies in purity, yielding at times fine lime, but often is wholly worthless. Fossils are rare and those which do occur are thought to be of fresh-water types.

The Freeport sandstone of H. D. Rogers is as irregular and indefinite as the Butler sandstone, but in most localities a sandy shale or sandstone is present within the interval between the Lower Freeport and Upper Kittanning coal beds. This interval shows some interesting variations in Clarion and Armstrong counties and elsewhere in western Pennsylvania.

The Upper Kittanning coal bed. In Pennsylvania, Currie of north Butler, Darlington of south Butler; rarely present in Ohio and Kentucky; indefinite in West Virginia.

This is a widely persistent though very variable bed in Pennsylvania, but it disappears in the western part of that state to reappear somewhat rarely in Ohio. It quickly becomes indefinite in West Virginia and can not be recognized with certainty in the Kentucky sections.

The Johnstown cement limestone of W. G. Platt, Upper Kittanning of the Ligonier Valley report, is confined practically to the first and second bituminous basins of Pennsylvania, being found in only two or possibly three counties west from Chestnut hill in that state. It was confounded for a long time with the Vanport limestone, an error which led to confusion in those basins, where the lower limestone is wanting. It is non-fossiliferous.

The Middle Kittanning coal bed. In Pennsylvania, Middle Kittanning, Kittanning, Lower Kittanning of Ligonier valley, Darlington of Mercer and Lawrence; in southern Ohio, No. 6, "Great vein," Nelsonville, Hocking valley, Sheridan, etcetera; in Kentucky, Coal 7.

For the most part this is unimportant in Pennsylvania, though it is widespread and occasionally, like the Upper Kittanning and the Lower Freeport, carries a deposit of cannel which locally is of some importance; but in Ohio it attains vast importance within the Hocking Valley coal field. In much of Ohio it is roofed by a black shale carrying a rich marine fauna. The overlying shale has yielded an abundant flora in western Pennsylvania.

The Lower Kittanning coal bed. In Pennsylvania, Kittanning, Lower Kittanning, Barnett of Broad Top, Clarion of Ligonier valley, Dagus of McKean and Elk; in Ohio, Leetonia, "Clay vein." "Creek vein" No. 5 of Columbiana and Jefferson, Newcastle in southern Ohio; in Kentucky, Coal 6; in West Virginia, Kittanning; Kittanning of Lesley, 1856.

This coal bed is equally persistent with the Upper Freeport and shows similar variations in commercial importance. It is best on the eastern side of the basin, but occasionally it is good enough and thick enough in Ohio to be mined; it is unimportant for the most part in Kentucky. The interval between Middle and Lower Kittanning often disappears in Maryland and eastern West Virginia, so that both beds can be mined as one. The underlying clay is of great industrial importance in western Pennsylvania and in much of Ohio. The interval between Upper Freeport and Lower Kittanning shows no abrupt variations in most of Pennsylvania, though within the same area the intervals between intervening beds exhibit perplexing variations. The interval between the Lower Kittanning and the Vanport limestone below is one of the most variable in the whole section. When large, it often contains the Kittanning sandstone, whose changes in character are as marked as those of the Freeport and Butler.

The Vanport limestone..... In Pennsylvania, Ferriferous, Vanport; in Ohio, Ferriferous, Baird, Coshocton marble; in Kentucky, Ferriferous; in West Virginia, apparently wanting.
 I. C. White, 1878.

This is in some respects the most remarkable member of the formation; it has not been observed in the first and second bituminous basins of Pennsylvania, but a limestone of similar character has been reported from the first basin southward in Maryland, which, however, may prove to be at the Putnam Hill horizon. This bed has been observed only at one locality in the area immediately west from Chestnut Hill, and there is much room for doubt respecting its existence in the counties south from the Ohio and Kiskiminetas except near the former river toward the West Virginia line; but north from those rivers it is persistent almost to the northern outcrop and to the Ohio line, becoming somewhat irregular toward the north, where it is replaced sometimes by cherty limestone or sandstone and seems to project, finger like, northward from the main mass. It practically disappears within a few miles west from the Ohio line, though it has been recognized by Professor Orton at several places beyond. In Pennsylvania it usually underlies an iron ore which in the earlier days was the source of supply for many furnaces. It reappears in central Ohio as the Black marble of Coshocton county, and thence southward it is followed easily as the Baird ore and limestone, to which E. B. Andrews applied the name Ferriferous limestone, but without any reference to the Pennsylvania bed. It is persistent southward in Kentucky into Elliott county and appears occasionally in Morgan county beyond; but eastwardly it disappears in Boyd and Lawrence counties before reaching the West Virginia line. It belongs chiefly to the western side of the basin. Within Pennsylvania and northern Ohio it carries a marine fauna, but in southern Ohio and Kentucky it seems to be non-fossiliferous.

The Clarion coal bed of H. D. Rogers is a double bed, as was demonstrated by Doctor H. M. Chance, but the splits are recognizable as such in a very small area, so that they have received distinct names. The upper split is:

The Scrubgrass coal bed..... Sulphur, Ferriferous, Upper Clarion, Canfield, at various localities in Pennsylvania and Ohio.
 I. C. White, 1879.

This bed occurs in western Pennsylvania and in much of Ohio directly below the Vanport limestone or separated from it by at most 10 feet. It is of uncertain occurrence and rarely is thick enough to be mined even for local supply.

The Clarion coal bed proper, 15 to 20 feet lower, is the limestone vein of Vinton county, Ohio, and is the more persistent bed, though not often of economic importance. In the first and second bituminous basins of Pennsylvania it is wanting south from the Conemaugh river and westward from the Chestnut Hill anticline; it disappears quickly in West Virginia; but it may be represented on the Kanawha river and south-westward by the coal seen occasionally above the Black flint. This bed becomes very indefinite in southern Ohio and occurs so rarely in Kentucky that it is not recognized in the generalized section. It is quite likely that at not a few localities the Brookville has been mistaken for this bed.

The Clarion sandstone, Hecla of southern Ohio, is present in many places between the Clarion and Brookville coal beds and is rather more persistent than the other sandstones; yet it is frequently replaced in part or in whole by shale, at times argillaceous. Along the southeasterly outcrop from Randolph county, West Virginia, to the Kentucky line the whole space from the Brookville coal bed to the Upper Freeport is filled with sandstone, interrupted only by coal beds and thin shales; but this, in part the Charleston sandstone of Mr M. R. Campbell, is for the most part coarse and evidently marks proximity to a shoreline, as it extends westwardly for only a few miles, changing gradually into shale and finer sandstone. A similar condition is revealed by oil-well records in Ohio, Marshall, Wetzell, and Tyler counties of West Virginia, along the central portion of the basin. Whether or not the sandstone areas of those counties are one can not be asserted, but the records are so numerous as to suggest continuity of the deposit. The irregularity in outline of the sandstone area is as irregular as that of open sand in the main oil-sands of Pennsylvania. The change from hard sandstone to fine shale and again to sandstone takes place at times within a few rods.

The Putnam Hill limestone. . . . Gray limestone of northern Ohio; apparently
 E. B. Andrews, 1870. absent in Pennsylvania and Kentucky;
 Kanawha black flint of West Virginia.

Within Pennsylvania and the greater part of West Virginia, as well as in Kentucky, the Brookville coal bed underlies coarse or fine detrital material from the land; but in northern Ohio, at a short distance west from the Pennsylvania line, a new element appears in the section, which is persistent thence almost to the Kentucky line and is as useful to the Ohio geologist as the Vanport limestone is to the student in Pennsylvania. It always carries a marine fauna and in southern Ohio bears the same relation to the Ferriferous of Andrews that it does in northern Ohio to the Vanport or Ferriferous of Pennsylvania. In Barbour county of West Virginia, on the eastern outcrop, a limestone appears at a few feet

above the Brookville coal bed, and at one locality it is pure enough to be used as a flux. It has not been reported southward along this outcrop, but in Nicholas county one finds at the same horizon the very fossiliferous Black flint which in Nicholas, Fayette, and Kanawha counties is at 1 to 15 feet above the Brookville coal bed. This is confined to a small area and disappears quickly south from the Kanawha river. The Putnam Hill limestone is often cherty in Ohio. It is possible that the Kanawha flint may be equivalent to the Vanport, but its relation to the Brookville and the presence of a coal bed at some places just above it render the reference to the Putnam Hill horizon much more probable. The occurrence of this marine fauna in a very restricted area within the Kanawha district is as curious as that of the Campbells Creek fauna in the Pottsville within a somewhat smaller area in the same district.

The Brookville coal bed..... In Pennsylvania, Cook of Broad Top, Brookville of authors, Clermont of McKean and Elk, Clarion of Ligonier valley, A; in Ohio, Brookville, No. 4; in Kentucky, Coal 5; in West Virginia, Upper Freeport, Lower Kittanning, Clarion, Arden, Roaring creek, Stockton.

This is by far the most persistent coal bed in the formation. It is rarely of economic importance in Pennsylvania, for though often very thick it is usually a mass of alternating coal and shale, its coal high in ash and sulphur. In West Virginia along the eastern outcrop it becomes very important south from the Baltimore and Ohio railroad and is the only coal bed of the Allegheny on which mining operations are carried on over any considerable area. It is almost as important in that state as the Pittsburg is in southwest Pennsylvania. In Pennsylvania and even in West Virginia it is very apt to break up into many layers of coal and slate or into benches somewhat widely separated. The relations of this bed have been much in doubt, and in the tentative correlation used by the writer in describing the Pottsville the bed was regarded as equivalent to the Lower Kittanning; but since that part of this work was published additional records of borings have been secured which make the matter wholly clear in the critical locality within northern West Virginia, as will be seen on a later page. The Brookville seems to be the only horizon at which coal was formed over any considerable area in the interior of the basin, its coal having been found in Tyler, Wood, Jackson, and Cabell counties of West Virginia as well as in Monroe and Washington counties of Ohio, where no trace of any higher Allegheny bed appears in the records of oil-well borings. At the same time it does not extend across the basin, being absent in several counties east from those named. It is

quite persistent in Kentucky, though almost always very thin in that part of the state where correlation is possible. The distribution of these coals seems to make clear, as suggested by the writer upward of thirty years ago, that the coal beds were formed as fringes around the basin, some extending farther toward the center than the others, but all ending at a comparatively short distance from the shores. Coal or carbonaceous shale is reported at various depths within the central part of the basin, but these deposits bear no definite relation to each other or to the recognized horizons of the section, and in all probability they are mere accumulations of vegetable matter drifted upon mud lumps.

A matter of some interest which should not be overlooked is the occurrence of red shale in the upper part of the Allegheny within a little area in Ritchie, Wood, and Calhoun counties of West Virginia, and Washington of Ohio. No trace of red shale appears elsewhere within the Allegheny, so far as definite information is available, until one passes southwestward about 100 miles into Boyd county of Kentucky, where, near Cannonsburg, 18 feet of green and red shale appear between the Freeport coal beds. Green shales, however, seem to be characteristic of the Conemaugh in the southern areas and in the region beyond the Kanawha. Mr Campbell refers to his Braxton formation, including all deposits above his Charleston sandstone, as consisting chiefly of green and red shales and sandstones. In Boyd, Lawrence, and Carter counties of Kentucky green shales accompany the Freeport coal beds, while in southern Carter these green beds overlie the Lower Kittanning and in southern Lawrence they overlie the Middle Kittanning.

EAST FROM THE ALLEGHENIES

The insignificant area known as the Broad Top coal field, embracing parts of Bedford, Fulton, and Huntingdon counties of Pennsylvania, is of especial interest because of variations in the coal beds and in the intervals separating them. The following succession is a compilation of measurements made by Doctor White in Huntingdon and by Stevenson in Bedford and Fulton counties:

| | Feet. | Inches. | Feet |
|------------------------------|-------|---------|------|
| 1. Kelly coal bed..... | 0 | to | 14 |
| 2. Shales and sandstone..... | 65 | to | 120 |
| 3. Twin coal bed..... | 1 | 6 to | 6 |
| 4. Shale and sandstone..... | 2 | to | 30 |
| 5. Barnett coal bed..... | 1 | 9 to | 5 |
| 6. Shale and sandstone..... | 8 | to | 50 |
| 7. Cook coal bed..... | 2 | 6 to | 6 |
| 8. Clay and shale..... | 2 | to | 20 |

to the Pottsville.

The Kelly coal bed, clearly equivalent to the Upper Freeport, disappears in the northern part of the field, but increases southward and becomes of great commercial importance in Bedford county, though even there it varies in thickness from 4 inches to 16 feet in one mine. It is usually double, and the parting has been found 1 inch to 10 feet on a single property. The upper division is ordinarily single, but the lower is often divided into several benches. The interval to the Twin coal bed is occupied at times wholly by shale, but on the western side of the field it contains a coarse sandstone which may be taken as representing both the Butler and the Freeport sandstone, as the Lower Freeport coal bed is not here. The interval in Huntingdon county varies from 90 to 110 feet, but in Bedford from 65 to 118, being greatest on the westerly side, where the sandstones are most prominent. The Twin coal bed is persistent throughout the field and derives its name from the fact that at times it and the Barnett below are almost in contact, so that they may be mined as one bed. In Bedford county the coal varies from worthless to good and in thickness from 1 to 6 feet, so that it is unimportant; but in Huntingdon its coal is good, and when near enough to the Barnett is mined. The interval to the Barnett varies from 6 inches to 30 feet, though rarely less than 2 feet. Within 200 rods, on Sixmile creek, in Bedford, the thickness was measured, 37, 19, and 7 feet. The thinning is toward the east, but not regularly so. In Huntingdon, Doctor White found it 8 to 30 feet on one property, but on another, in the eastern part of the field, the variation is from 6 inches to 7 feet. The Barnett coal bed always carries bony coal, 3 to 10 inches thick on top, and in the main coal usually shows two benches separated by a variable parting. At one mine Doctor White made this measurement:

| | Feet. | Inches |
|--------------------------|-------|--------|
| 1. Twin coal bed..... | 2 | 0 |
| 2. Shale and rock..... | 4 | 0 |
| 3. Barnett coal bed..... | 17 | 9 |
| | Feet. | Inches |
| Bony coal | 0 | 9 |
| Coal | 2 | 6 |
| Shale | 3 | 0 |
| Sandstone | 11 | 0 |
| Coal | 0 | 6 |

This parting of 14 feet soon disappears, and in another part of the mine the bottom coal is in contact with the upper. The variability of this parting is a familiar phenomenon, as the mining operations on this bed are extensive within Huntingdon county. Doctor White correlates this bed with the Lower Kittanning of Blair county, to which it bears close resem-

blance in structure. The interval from the Barnett to the Cook coal bed is commonly about 50 feet; on the east side, in Huntingdon, it decreases to 35 feet, but midway in the field within Bedford a shaft shows it but 8 feet. A thick bed of fireclay underlies the Barnett and another overlies the Cook. In Bedford county the Cook coal bed varies from mere black shale to 7 feet of coal within a few rods; the quality of coal is inferior and the bed is not worked; but in Huntingdon county it has been worked, for the coal is thicker and better. It usually shows three or four benches separated by ordinarily thin partings, but one of these varies from 2 to 25 feet. On the east side of the field in this county the bed has its coals distributed through a vertical section of almost 48 feet.*

The Georges Creek, or Potomac, basin, originating in Bedford and Somerset counties of Pennsylvania, extends southward across Allegheny and Garrett counties of Maryland into Mineral and Tucker counties of West Virginia. Many measurements have been made by Messrs White, Martin, and O'Harra, from which five may be selected, which are as follows, arranged from north to south:

| | I | | II | | III | | IV | | V |
|-----------------------------------|-------|---------|-------|---------|-------|---------|-------|---------|------|
| | Feet. | Inches. | Feet. | Inches. | Feet. | Inches. | Feet. | Inches. | Feet |
| Upper Freeport | 5 | 0 | 4 | 2 | 5 | 4 | 5 | 2 | 8 |
| Interval | 20 | 0 | 60 | 0 | 137 | 0 | 135 | 0 | 95 |
| Lower Freeport | 2 | 0 | 1 | 2 | | | | | |
| Interval | 74 | 0 | 55 | 0 | | | | | |
| Upper Kittanning | 7 | 0 | 1 | 0 | 3 | 0 | 0 | 2 | 0 |
| Interval | 65 | 0 | 45 | 0 | 42 | 0 | 61 | 0 | 40 |
| Middle and Lower Kittanning | 5 | 6 | 6 | 5 | 6 | 4 | 8 | 5 | 11 |
| Interval | 129 | 0 | 85 | 0 | 80 | 0 | 121 | 0 | 65 |
| Clarion | | | 2 | 6 | 2 | 4 | 1 | 6 | 3 |
| Interval | | | 45 | 0 | 35 | 0 | 18 | 0 | 40 |

to the Pottsville.

- I. Piedmont, West Virginia (I. C. White).
- II. Above Harrison, Mineral county (I. C. White).
- III. Harrison, Garrett county, Maryland (G. C. Martin).
- IV. Henry, Garrett county, Maryland (G. C. Martin).
- V. Thomas, Tucker county, West Virginia (I. C. White).

A full series of records published in 1906 shows that the Allegheny in this area varies from 260 to 350 feet, the thickness being greatest in the southern and eastern portions. The Upper Freeport coal bed, known locally as the Thomas, is persistent throughout, but increases in thickness

* J. J. Stevenson: Bedford and Fulton counties (T 2), pp. 62, 64.

I. C. White: Huntingdon county (T 3), pp. 52, 54, 55, 58, 59, 61, 66, 68.

and importance southward. At the north it is variable, usually in several benches or broken by numerous partings and often containing much bony coal. Southward, in the Potomac region, it is mined extensively, yielding at times 4 or 5 feet of good coal. The Lower Freeport is unimportant, yielding less than 2 feet of coal at the north and apparently disappearing southwardly, as at Henry there is only bone coal and at Thomas a mere trace. Between the Freeport coal beds, one finds occasionally a representative of the Upper Freeport limestone resting on the Butler sandstone, which is very massive and at times conglomerate. A limestone is reported in a borehole at Henry 16 feet thick and at a little way below the Lower Freeport, but no trace of it was observed elsewhere.

The Upper Kittanning is of very uncertain distribution, but at some localities in the Potomac region it has 3 to 4 feet of good coal. It is absent or insignificant in a great part of the area. The Middle and Lower Kittanning coal beds are separated in extensive areas by a mere parting, so that they are mined as one bed; but at Stoyer, in southern Garrett, this parting is 8 feet and elsewhere it increases to as much as 30 feet. The united bed is the Davis coal of the Potomac area and the Six-foot of the Georges Creek area. This bed has suffered much from "squeezes," the coal having been removed for considerable spaces both above and below the middle shale; but on each side of the disturbance the coal reappears and offers a large area free from the irregularity. It has suffered in this respect far more than any of the succeeding beds. At times the shale and bone partings so thicken as to render the bed unimportant commercially. The interval from Upper Freeport to Lower Kittanning varies from 170 to 210 feet. The Freeport sandstone is generally present, but varies greatly in thickness and structure. An irregular coal bed, known as the "Split-six," 30 to 46 feet below the Lower Kittanning, is present in the Georges Creek area. The available information does not justify an attempt to correlate it with any bed known farther west. A limestone appears occasionally below the Lower Kittanning in southern Garrett of Maryland and in Tucker of West Virginia, underlying iron ore in the latter. Doctor White and Doctor Martin see in this a representative of the Vanport (Ferriferous) limestone. It is non-fossiliferous here, but in the next basin westward a fossiliferous limestone has been found which is supposed to be very near this horizon.

A massive sandstone, in many respects closely resembling the Homewood of this region and at times 70 feet thick, is between the Lower Kittanning and the next coal bed below. This has been correlated with the Clarion sandstone by the Maryland geologists. Two coal beds are below the sandstone, the upper or Parker and the lower or Bluebaugh, separated

by an interval of 12 to 30 feet; the lower bed is the less persistent and is very close to the Homewood sandstone. If the overlying sandstone be the Clarion, it becomes necessary to regard these beds as representing the Brookville, which in much of the bituminous area is a complex bed, while farther southwest it occasionally divides in this manner; but the distance of this region from any other where the relations are distinct makes positive correlation impossible.*

FIRST BITUMINOUS COAL BASIN OF PENNSYLVANIA

This, extending from the Allegheny mountains westward to Laurel Hill, is traceable readily from Bradford county at the northeast across Lycoming, Clinton, Center, Clearfield, Cambria, and Somerset counties of Pennsylvania into Garrett of Maryland and Preston of West Virginia. It is divided in Pennsylvania by two anticlines, that at the west originating at the northern extremity and the other in southeast Cambria, so that the basin, double at the north, becomes triple in Somerset. The axes increase southwardly in Pennsylvania, Laurel becoming a bold mountain, the westerly fold growing into the great Viaduct axis and the Cambria fold developing into Negro mountain. The interior folds approach each other toward the Maryland line, so that the synclinal is too shallow to hold the Coal Measures in Maryland. The easterly, or Salisbury, sub-basin of Somerset becomes shallow in Maryland and the Allegheny beds shoot out within 15 miles; but the western, or Johnstown, subbasin continues across Garrett into Preston of West Virginia, where, owing to the lessening strength of the Laurel anticlinal, the Allegheny beds become continuous with those of the Second Pennsylvania basin.

The somewhat widely separated patches of coal-bearing rocks within Bradford and Lycoming counties are confined to the western side of the basin. The Barclay area of Bradford county shows four coal beds in a vertical section of about 150 feet, which have been described by Mr Platt. How much of the section belongs to the Allegheny can not be determined.†

The Lycoming areas known as McIntyre and Pine creek are larger, and Mr Platt has measured the section there in detail as follows:

* I. C. White: U. S. Geol. Survey Bull. no. 65, pp. 126-127; Geol. W. Va., vol. 11, p. 354.

C. C. O'Harra: Maryland Survey, Allegany county, p. 117.

G. C. Martin: The same, Garrett county, pp. 112, 115.

W. B. Clark et al.: The same, vol. v, pp. 298-299, 300, 333, 335-341. Advantage has been taken of delay in publication to insert here, as well as in the proper place under Conemaugh, additional material contained in volume v of the Maryland Survey, which has appeared since this manuscript was offered to the Society.

† F. Platt: Bradford and Tioga (G), pp. 125-127.

| | Feet. | Inches |
|-------------------------------------|-------|--------|
| 1. Sandstone and conglomerate..... | 27 | 0 |
| 2. Black shale | 1 | 3 |
| 3. Sandstone | 21 | 0 |
| 4. Blue shale with plants..... | 2 | 0 |
| 5. Coal and shale E..... | 5 | 7 |
| 6. Fireclay | 3 | 0 |
| 7. Sandstone and conglomerate..... | 76 | 0 |
| 8. Coal bed, D..... | 8 | 0 |
| | Feet. | Inches |
| Coal | 0 | 9 |
| Clay and shale..... | 5 | 0 |
| Coal and shale..... | 2 | 3 |
| 9. Fireclay | 1 | 0 |
| 10. Sandstone and conglomerate..... | 47 | 0 |
| 11. Coal and shale, C..... | 7 | 4 |
| 12. Sandstone | 19 | 0 |
| 13. Black shale, plants..... | 2 | 0 |
| 14. Coal and shale, B..... | 7 | 1 |
| 15. Clay, sandstone and shale..... | 13 | 0 |
| 16. Coal and slate, A..... | 9 | 10 |
| 17. Sandstone | | |

The same beds are present on Pine creek where the intervals are variable, that from A to B being 15 to 40 and that between D and E being 75 to 88 feet. The sandstone above E was taken by Mr Rogers, and afterward by Mr Platt, to be the Mahoning, thus identifying the bed E with the Upper Freeport. Bed B is the only one economically important. Mr David White's studies of the plant remains have made more than probable that the correlation made by the older geologists is incorrect, for he finds that the evidence would place bed B at the Mercer horizon of the Pottsville, so that bed E is probably in the Kittanning group.*

Two areas, no longer important, are in Clinton county, each showing the beds lettered A, B, D by Mr Platt. No information is given respecting the interval rocks. The Snowshoe field of northern Center county was studied by Mr Platt, whose section, revised by Mr d'Inwilliers, is as follows:

| | Feet. | Inches |
|--|-------|--------|
| 1. Upper Freeport coal bed, E..... | 5 | 0 |
| 2. Fireclay, concealed, sandstone..... | 53 | 9 |
| 3. Lower Freeport coal bed, D..... | 2 | 0 |
| 4. Ore and coal | 2 | 0 |
| 5. Limestone [L. Freeport]..... | 2 | 6 |

* F. Platt: Lycoming and Sullivan (G 2), pp. 93, 99, 125.

David White: Northern Appalachian coal field; 22d Ann. Rept. U. S. Geol. Survey, p. 136.

| | Feet. | Inches. |
|--|-------|---------|
| 6. Fireclay and black shale..... | 39 | 4 |
| 7. Upper Kittanning coal bed, C'..... | 7 | 8 |
| 8. Fireclay and shale..... | 19 | 6 |
| 9. Sandstone | 13 | 0 |
| 10. Middle Kittanning coal bed, C..... | 4 | 0 |
| 11. Black shale, gray sandstone..... | 28 | 6 |
| 12. Lower Kittanning coal bed, B..... | 5 | 0 |
| 13. Concealed | 45 | 0 |
| 14. Ore and sandy shale..... | 18 | 0 |
| 15. Brookville coal bed, A..... | 3 | 0 |

resting on fireclay, not measured, to the Pottsville. The Clarion was not seen in this shaft, but Mr d'Inwilliers saw it at other localities 15 to 25 feet above the Brookville. The Gorman coal bed of the southern counties appears occasionally. The Upper Freeport consists of Bony coal 4 to 8 inches and 5 feet of good coal, with midway a slate 2 to 3 inches thick; but the Upper Kittanning, roofed by 2 feet of slaty cannel, is the more important bed, being available in a larger area. A long narrow strip of Allegheny occupies the easterly division of the basin in the southeast part of the county, where the Lower Freeport, worthless in Snowshoe, is worked and has this structure:

| | Feet. | Inches |
|-----------------|--------|---------|
| Bony coal | 0 | 2 to 4 |
| Coal | 0 | 6 to 12 |
| Cannel | 0 | 2 to 3 |
| Coal | 4 to 5 | 0 |

and sometimes a thin streak of cannel in the main coal. No limestone was seen in any portion of this area.*

In Clearfield county one has Doctor Chance's partial section at Morrisdale, about 12 miles southwest from Snowshoe and on the westerly side of the basin. The Lower Freeport and Johnstown Cement limestones are here. The coal bed identified with the Upper Freeport is insignificant, but that taken to be the Lower Freeport is important and has the exact structure of the Upper Freeport at Snowshoe, thus:

| | Feet. | Inches |
|-------------|--------|--------|
| Bony | 0 | 2 to 8 |
| Coal | 3 to 2 | 6 |
| Slate | 0 | 1 to 2 |
| Coal | 1 | 3 to 2 |

* F. Platt: Clearfield and Jefferson (H), pp. 24, 41, 69.

E. V. d'Inwilliers: Center (T 4), pp. 57, 64, 66-68, 70, 74, 81, 91, 106-107, 109, 113, 115.

A structure which bears no resemblance to that of the Lower Freeport is southwest Center. Doctor White's section at Houtzdale, 7 or 8 miles southwest from Morrisdale, is:

| | Feet. | Inches |
|---|-------|--------|
| 1. Mahoning sandstone, about..... | 100 | 0 |
| 2. Upper Freeport coal bed..... | 5 | 4 |
| 3. Interval | 42 | 0 |
| 4. Lower Freeport coal bed and thick partings.. | 13 | 0 |
| 5. Freeport sandstone and shale..... | 36 | 0 |
| 6. Dark shale | 14 | 0 |
| 7. Upper Kittanning coal bed..... | 3 | 0 |
| 8. Fireclay and dark shale..... | 33 | 0 |
| 9. Middle Kittanning coal bed..... | 1 | 0 |
| 10. Slate, sandstone, shale..... | 19 | 0 |
| 11. Lower Kittanning coal bed..... | 4 | 0 |
| 12. Fireclay and shale..... | 10 | 0 |
| 13. Hard sandstone [Kittanning]..... | 32 | 0 |
| 14. Shales | 21 | 0 |
| 15. Clarion coal bed [Brookville]..... | 3 | 6 |
| 16. Hard fireclay | | |

The Upper Freeport has the same structure as in Snowshoe. No observer notes the occurrence of limestone until 8 miles west-southwest from Houtzdale, where Mr Platt found a 6-foot bed at 14 feet below a thin coal which he is inclined to take as Lower Freeport; but it may be the Upper Freeport limestone, as that is evidently present in the southern part of the county.*

The section is followed readily into Cambria, and at Bennington, on the Blair County border, Mr Fulton's long section shows all the coal beds present except the Gorman, with in addition a thin bed just above the Upper Freeport limestone. That is the only limestone in the section and is broken into many layers, which with the intervening shales occupy most of the interval to the Lower Freeport coal bed. Of the important sandstones, only the Freeport is noteworthy, the others being represented mostly or altogether by shale. At a few miles southwestwardly, in this easterly, or Wilmore, subbasin, many sections have been obtained, several of which have been grouped by Mr d'Inwilliers. Condensed, these are:

* F. Platt: (H), pp. 34, 85, 105.
 H. M. Chance: (H 7), pp. 38, 41-42, 53, 55, 61, 64.
 I. C. White: Bulletin no. 65, u. 124.

| | I | | II | | III | | IV | | V | |
|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. |
| Upper Freeport | 5 | 4 | 4 | 0 | 4 | 1 | 4 | 2 | 5 | 0 |
| Interval | 44 | 2 | 60 | 0 | 69 | 0 | 53 | 6 | 50 | 0 |
| Lower Freeport | 5 | 0 | 3 | 1 | 2 | 0 | 3 | 2 | 3 | 7 |
| Interval | 43 | 10 | 27 | 6 | 38 | 0 | 45 | 4 | 45 | 0 |
| Upper Kittanning | 2 | 10 | 2 | 6 | 4 | 0 | 5 | 4 | 2 | 7 |
| Interval | 54 | 9 | 80 | 0 | 68 | 0 | 94 | 4 | 97 | 11 |
| Middle Kittanning | 3 | 8 | 3 | 0 | 1 | 8 | | | | |
| Interval | 38 | 0 | 23 | 0 | 22 | 0 | | | | |
| Lower Kittanning | 3 | 6 | 4 | 0 | 4 | 0 | 3 | 3 | 4 | 6 |
| Interval | 35 | 8 | 22 | 6 | 20 | 0 | 33 | 10 | | |
| Clarion | 1 | 8 | 2 | 0 | 5 | 0 | 0 | 2 | 68 | 11 |
| Interval | 30 | 0 | 28 | 3 | 29 | 8 | .. | .. | | |
| Brookville | 5 | 0 | 4 | 9 | 1 | 8 | .. | .. | 3 | 6 |

I. Bennington (d'Inwilliers).

II. Bens Creek (Prosser and Hardin).

III. Sonman shaft (Prosser and Hardin).

IV. Sonman borehole (Prosser and Hardin).

V. Wilmore borehole (d'Inwilliers).

The Gorman coal bed is in the second, at 46 feet below the Upper Kittanning, and in the last a thin coal at 35 feet above the Lower Kittanning represents the Middle Kittanning. The Upper Freeport limestone is in the first three, while in the third, which is very near the east side of the basin, one finds for the first time the Johnstown limestone. The Lower Freeport limestone is shown on the southern border of the county. On the western side of Cambria, in the Johnstown subbasin, the Johnstown is the only limestone shown in Mr Fulton's section. It underlies the Upper Kittanning coal directly. The whole series of coal beds is present, but the only prominent sandstone is the Freeport—massive, micaceous, and 21 feet thick.*

Comparatively few details respecting the Allegheny are available in Somerset south from Cambria. The beds are reached for the most part only in gorges of Laurel hill or the Allegheny where the region is still largely forest. The Brookville and Lower Kittanning were recognized on the Allegheny, 50 to 60 feet apart, with another at 100 feet higher. The Upper Kittanning and both Freeports appear to be persistent in Negro mountain where the Lower Freeport and Johnstown Cement limestones are present. In the center of the county, near Somerset, the Freeport sandstone is massive and 30 feet thick; but there only the Johnstown

* F. Platt: Blair county (T), p. 95.

J. and W. G. Platt: Cambria (H 2), pp. 3, 4, 40, 41, 61-64, 100, 115.

J. Fulton in (H 2), pp. 97-98; Appendix to H 3, p. 367.

A. G. Prosser and O. B. Hardin: The same, 374, 377, 379.

E. V. d'Inwilliers: Final Rept., 1895, plate 414, opposite p. 2220.

cement was seen. The Gorman coal bed is in some of the sections at 15 feet above the Middle Kittanning. A notable section was obtained by Mr W. G. Platt on Castlemans river, in the southern part of the county. It is as follows, the identifications being by the writer:

| | Feet. | Inches |
|--------------------------------------|---------|--------|
| 1. Upper Freeport coal bed..... | 2 | 0 |
| 2. Shales and concealed..... | 75 | 0 |
| 3. Lower Freeport coal bed..... | 10 | 2 |
| | Feet. | Inches |
| Coal | 2 | 10 |
| Bone and clay..... | 4 | 0 |
| Coal | 3 | 4 |
| 4. Fireclay | 2 | 0 |
| 5. Lower Freeport limestone | 2 | 0 |
| 6. Fireclay and ore | 3 | 9 |
| 7. Concealed | 25 | 0 |
| 8. Upper Kittanning coal bed..... | Blossom | |
| 9. Interval | 3 | 0 |
| 10. Johnstown cement limestone | 3 | 0 |
| 11. Concealed | 5 | 0 |
| 12. Sandstone | 18 | 0 |
| 13. Middle Kittanning coal bed..... | 2 | 0 |
| 14. Fireclay and concealed..... | 16 | 0 |
| 15. Sandstone | 35 | 0 |
| 16. Lower Kittanning coal bed..... | 17 | 6 |
| | Feet. | Inches |
| Coal | 1 | 0 |
| Clay, sandstone | 8 | 0 |
| Black shale | 8 | 0 |
| Coal | 0 | 6 |
| 17. Concealed, shale, fireclay..... | 33 | 0 |
| 18. Clarion sandstone | 10 | 0 |
| 19. Brookville coal bed | 14 | 4 |
| | Feet. | Inches |
| Coal | 1 | 2 |
| Clay | 3 | 0 |
| Shale | 7 | 0 |
| Coal | 1 | 6 |
| Shale | 2 | 0 |
| Coal | 1 | 6 |
| 20. Concealed to Pottsville | 10 | 0 |

Irregularity of deposit frequently characterizes all beds of the series, but it is especially characteristic of the Kittannings and lower coal beds. The Upper Freeport limestone is not in this section, but it is present elsewhere, being almost as persistent as the other limestones in the southern and western portions of the county. The Gorman and Clarion beds have not been recognized in Somerset.*

* F. and W. G. Platt: Somerset (H 3), pp. 122-123, 127, 129, 130, 194-195, 282-283.

Before following the section into Maryland it may be well to summarize the conditions in Pennsylvania. The thoroughly persistent coal beds are the Upper Freeport and Lower Kittanning, both of which attain great commercial importance in several parts of the basin. The others are of irregular occurrence and vary so in the quality of their coal that they are seldom of any importance. The intervals between the beds show great variation in almost contiguous sections, but it is worthy of note that the interval between the two important coal beds, Upper Freeport and Lower Kittanning, shows little variation in any given area. It exhibits great regularity as appears from this table:

| | Feet |
|--|--------|
| Snowshoe, Center county (F. Platt)..... | 172 E. |
| Morrisdale, Clearfield county (Chance)..... | 156 W. |
| Houtzdale, Clearfield county (I. C. White)..... | 161 W. |
| Bennington, Blair county (Fulton)..... | 179 E. |
| The same (d'Invilliers)..... | 193 E. |
| Sonman, Cambria county..... | 204 E. |
| Wilmore, Cambria county (d'Invilliers)..... | 195 E. |
| Johnstown, Cambria county (Fulton)..... | 181 W. |
| Hooversville, Somerset county (W. G. Platt)..... | 195 W. |
| Castlemans, Somerset county (W. G. Platt)..... | 200 W. |

The letters refer to the east and west sides of the basin. From Clearfield southward there is evidently an increase in thickness of the measures.

No limestone is reported on the easterly side of this basin north from Cambria county, where one finds the Upper Freeport and at 3 or 4 miles farther south the Johnstown cement; but the Lower Freeport occurs on the westerly side as far north as Snowshoe, in Center, and the Johnstown cement is said to be in northern Clearfield. In central and in most of southern Clearfield all limestone is wanting practically, the limestone border evidently skirting the eastern edge. The distribution of the limestones geographically is capricious in the extreme, only the Johnstown being reasonably persistent; it is generally found wherever its horizon is exposed. The composition of the limestones is equally variable; each of them at times is pure enough to yield very fair lime, but they are frequently so siliceous or so argillaceous as to be worthless for any purpose, and such changes occur within short distances. None of them is markedly fossiliferous; several contain minute univalve shells, but distinctly marine forms were not seen in any. The Butler, Freeport, Kittanning, and Clarion sandstones are unimportant. The Freeport interval usually contains some sandstone, at times massive, even pebbly, but the other intervals are filled for the most part with shale except in Somerset and southern Cambria, where the Clarion is frequently a massive rock.

Passing over into Garrett county of Maryland, one has Mr Martin's measurements in the Salisbury subbasin at 7 or 8 miles from the Pennsylvania line. There the thickness of the Allegheny is given as 257 feet 6 inches. The Upper Freeport is in all 13 feet 5 inches thick, but contains a parting of almost 11 feet of black slate and a thin layer of bony coal. It is 136 feet above the bed designated Middle and Lower Kittanning, a mass of shale and coal 14 feet thick, with three thin benches of coal and two partings, each somewhat more than 5 feet thick. Midway between these beds is another consisting of two streaks of coal, 2 and 14 inches respectively, separated by 12 feet of shale. A sandstone 51 feet is below the Kittanning, and at 79 feet below that coal bed is another double bed, the benches 8 and 12 inches, with 14 feet of shale parting them. The relations are somewhat obscure, as the thickness of the Conemaugh is very much greater than at any other locality in this or any other basin, being given as 718 feet, while at a few miles west and north it is not far from 600 feet.

At a few miles west, near Oakland, another section is given, being the record of a boring; it is:

| | Feet. | Feet |
|---|--------------|------|
| 1. Mahoning sandstone | | |
| 2. Concealed, about | 40 | 0 |
| 3. Lower Freeport coal bed | 2 | 8 |
| Consists of 8 layers of coal, bone and shale. | | |
| 4. Concealed, about | 80 | 0 |
| 5. Sandstone, coarse to shaly | 49 | 9 |
| 6. Shales | 12 | 9 |
| 7. Middle and Lower Kittanning coal bed..... | 3 | 9 |
| | Feet. Inches | |
| Coal | 1 | 4 |
| Bone | 0 | 7 |
| Shale | 0 | 6 |
| Coal | 1 | 4 |
| 8. Gray shale | 13 | 4 |
| 9. Calcareous rock | 1 | 2 |
| 10. Black shale | 3 | 11 |
| 11. Split-six coal bed | 1 | 7 |
| | Feet. Inches | |
| Shale and bone | 0 | 8 |
| Coal | 0 | 11 |
| 12. Shales, gray, green, red, black..... | 73 | 6 |
| 13. Shales and sandstones | 18 | 3 |
| 14. Fossiliferous limestone, ferriferous..... | 1 | 2 |
| 15. Alternating shale and sandstone..... | 17 | 0 |
| 16. Clarion coal bed | 0 | 5 |
| 17. Fireclay. flat and plastic, shale..... | 7 | 4 |

Here the interval from Lower Freeport to Middle Kittanning is about 143 feet; at the other measurement it is about 10 feet less from Upper Freeport to the Kittanning. The Split-six may be part of the Lower Kittanning. The fossiliferous limestone, Number 15, correlated with the Vanport of western Pennsylvania, is rich in marine forms, mostly brachiopods, at this locality. A limestone at varying distances below the Lower Kittanning has been observed in Garrett and Allegany counties of Maryland, but elsewhere in this region it contains only forms of doubtful affinity. Whether this be the same with the fossiliferous limestone of the boring can hardly be asserted positively. This Herrington-Manor limestone is at a very great distance below the Kittanning as compared with that of the Vanport farther west. The flint clay under the Clarion (Brookville) coal is a common feature farther west.

Doctor White gives a section in Preston county of West Virginia, within the Johnstown subbasin, which shows the Upper Freeport at about 56 feet above the Lower Freeport and about 141 feet above the Middle Kittanning, which is 90 feet above 1 foot of coal separated by 18 feet from a mass of coal and clay 8 feet thick. It is not impossible that the Lower Freeport of the Herrington-Manor section is the Upper, as the bed shows the same general structure throughout, but improves westwardly, being of much economic importance in this portion of Preston county.*

SECOND BITUMINOUS COAL BASIN OF PENNSYLVANIA

The Second bituminous basin of H. D. Rogers, lying west from Laurel Hill, is narrow and well defined, having in most of its extent the great anticline of Chestnut hill as its western boundary. The most northeasterly patches of Allegheny are in Tioga county, not far from the line of New York, whence the formation can be followed across Clinton, Center, Clearfield, Cambria, Indiana, Westmoreland, and Fayette counties of Pennsylvania into Preston county of West Virginia.

Mr Platt gives measurements at six localities in the Blossburg and other areas of Tioga county, showing six coal beds varying greatly in thickness, as do also the intervals between them. Only one of them is of economic importance, the Bloss, which is the fourth in descending order. Mr David White regards this as equivalent to the bed B of Lycoming county, which he refers to the Mercer horizon of the Pottsville. Only

* G. C. Martin: *Maryland Geol. Survey, Garrett county, 1902*, pp. 116-117, 119, 129.
I. C. White: *Bulletin no. 65, p. 76. W. Va. Geol., vol. II, pp. 349, 409, 411.*

the upper two beds can be placed in the Allegheny, and their relations to beds farther south can not be determined on stratigraphical grounds. The nearest measurement is that at Renovo, in Clinton county, 32 miles southwest, and the next, by Doctor Chance, is about 13 miles farther. These are not sufficiently complete to make comparison with the Tioga section or even with the detailed sections obtained in Center county and beyond.*

Mr d'Inwilliers's section in Center county has a familiar look; this is about 15 miles northwest from Snowshoe, in the First basin. At a few miles southwest in Clearfield is Mr James's section at Karthaus, recorded by the First Pennsylvania Survey, and at Clearfield, nearly 15 miles farther, is a section by Doctor White. These in the order given are as follows:

| | Feet. | Inches. | Feet. | Inches. | Feet. | Inches |
|-------------------------|-------|---------|-------|---------|-------|--------|
| Upper Freeport | 3 | 6 | 6 | 0 | 4 | 4 |
| Interval | 50 | 0 | 47 | 0 | 50 | 0 |
| Lower Freeport | Thin | 0 | 0 | 10 | 2 | 6 |
| Interval | 42 | 0 | 32 | 6 | 70 | 0 |
| Upper Kittanning | 2 | 8 | 3 | 0 | | |
| Interval | 34 | 0 | 38 | 6 | | |
| Middle Kittanning | 3 | 0 | 3 | 2 | 1 | 6 |
| Interval | 45 | 0 | 33 | 0 | 35 | 0 |
| Lower Kittanning | 2 | 6 | 3 | 9 | 2 | 0 |
| Interval | 32 | 0 | 37 | 6 | 45 | 0 |
| Clarion and shale | 1 | 6 | 1 | 6 | 10 | 6 |
| Interval | 22 | 0 | 36 | 9 | 10 | 0 |
| Brookville | 2 | 6 | 1 | 0 | 2 | 0 |

The interval from Upper Freeport to Lower Kittanning varies from 158 feet 6 inches to 176 feet, but another measurement by Mr d'Inwilliers in Center county gives only 163 feet 6 inches; so that the variation in this distance of about 30 miles is insignificant. Clearfield is 10 or 12 miles northwest from Houtzdale, in the First basin, where the interval is 161 feet. The "Big bed" of the Karthaus section is clearly the Upper Freeport, which is the important bed in this region, as it is in Snowshoe. The Lower Freeport is worthless, as in Snowshoe and in the First basin within Clearfield. The Gorman coal bed is reported in several sections, but as in the other basin is always unimportant. Doctor Chance's sections show that the Lower Freeport limestone is persistent as far north as Karthaus, beyond which it soon disappears. The Upper Freeport limestone is of

* F. Platt: (G), pp. 166, 174, 176, 186, 189.

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

M. M. Chance: (G 4), p. 69.

uncertain occurrence and the Johnstown cement extends northward to but a little way beyond Clearfield.*

Mr d'Invilliers reports several sections in northwestern Cambria showing the varying intervals within an area of 8 or 9 square miles, thus:

| | Feet. | Inches. | Feet. | Inches |
|-------------------------|-------|---------|-------|--------|
| Upper Freeport | 3 | 6 to 4 | 4 | 0 |
| Interval | 33 | 0 to 50 | 50 | 0 |
| Lower Freeport | 3 | 0 to 4 | 4 | 6 |
| Interval | 35 | 0 to 46 | 46 | 0 |
| Upper Kittanning | 3 | 0 to 7 | 7 | 0 |
| Interval | 34 | 0 to 49 | 49 | 0 |
| Middle Kittanning | 2 | 0 to 2 | 2 | 0 |
| Interval | 35 | 0 to 45 | 45 | 0 |
| Lower Kittanning | 4 | 0 to 7 | 7 | 5 |
| Interval | 15 | 0 to 22 | 22 | 0 |
| Clarion | 1 | 8 to 1 | 1 | 10 |
| Interval | 30 | 0 to 30 | 30 | 0 |
| Brookville | 2 | 0 to 3 | 3 | 0 |

But while the intermediate intervals show such variation, that between the Upper Freeport and Lower Kittanning varies only from 163 to 168 feet, the increase being southwestwardly, which continues, for on Black lick the interval is 183 feet. The increase here is in the upper part of the section between the Freeport coal beds. Shales predominate in all of the sections, but the Freeport sandstone is present in two of them. The Upper Freeport and Johnstown cement limestones are present in several of the sections, especially on Black lick, where the Lower Kittanning is the important coal bed.†

In Indiana county the Second basin is known as the Ligonier valley, and this name is retained southward into West Virginia. Most of the area is covered by the Conemaugh, and the Allegheny is reached near the mountains. Near the Clearfield line the Upper Freeport is 8 feet 4 inches thick, carries on top 8 inches of bony coal, and is divided by a 4-inch parting, thus resembling the structure observed at many places in the First basin as well as farther north in this. A section on the west side not far from the Clearfield line is:

* Geology of Pennsylvania: Vol. 11, p. 525.

E. V. d'Invilliers: (T 4), p. 124.

H. M. Chance: (H. 7), pp. 38, 41-42, 46, 53, 55, 61, 93, 96, 99, 103, 116, 129.

I. C. White: Bulletin no. 65, p. 123.

† E. V. d'Invilliers: Final Report, plates 415, 418, opposite pp. 2222, 2230.

| | Feet. | Inches |
|--|---------|--------|
| 1. Mahoning sandstone | | |
| 2. Upper Freeport coal bed | 4 | 0 |
| 3. Fireclay, sandy shale | 15 | 0 |
| 4. Black shale and thin coal | 2 | 0 |
| 5. Upper Freeport limestone and clay | 11 | 0 |
| 6. Fireclay | 5 | 0 |
| 7. Interval | 30 | 0 |
| 8. Lower Freeport coal bed | Thin | |
| 9. Lower Freeport limestone, about..... | 7 | 0 |
| 10. Interval | 43 | 0 |
| 11. Upper Kittanning coal bed | Blossom | |
| 12. Interval | 50 | 0 |
| 13. Middle Kittanning coal bed | 4 | 0 |
| 14. Mostly sandstone | 40 | 0 |
| 15. Lower Kittanning coal bed | 4 | 0 |
| 16. Black shale | 20 | 0 |
| 17. Coal bed [Clarion] | 0 | 6 |
| 18. Black shale | 25 | 0 |
| 19. Clay shale | 5 | 0 |

to the Pottsville. This is the most northerly exposure of the little coal on the Upper Freeport limestone, already seen at Bennington, in Blair county. The principal sandstones of the formation are wanting and the Brookville coal bed does not appear in the section. At 8 miles southeast, where an anticline brings up the Allegheny, the interval between the Freeport coals has increased to 76 feet, but that from Upper Freeport to Lower Kittanning is unchanged. At 6 miles southeast from this place the Freeports are 90 feet apart, but the interval between Upper Freeport and Lower Kittanning is barely 200 feet, a little less than in the measured section given above. The Clarion sandstone is massive, 25 feet thick, and rests on the Brookville coal bed, which is a mass of coal and shale 7 feet thick. On the Conemaugh river one finds the Upper and Lower Freeport and Johnstown cement limestones; the Freeport and Kittanning sandstones are distinct, though hardly cliff-making, while the Clarion is massive, 30 feet thick, and rests on the Brookville coal. The coal beds for the most part are not important. The Upper Freeport is often thick, but usually slaty; the Lower Freeport is variable in thickness and always poor, while the Lower Kittanning, though often thick and mined, never yields coal comparable with that obtained from this bed in Cambria county.*

Stevenson's work in Westmoreland and Fayette counties seems to disagree with that of observers in adjacent areas, because his nomenclature

* W. G. Platt: *Indiana* (H 4), pp. 65, 121, 125, 139, 145.

differs from that employed by Mr Platt. At the time his work was done the succession of the Allegheny coal beds had not been determined and the nomenclature had not been fixed. The terms employed by him should be corrected as follows to agree with Professor Lesley's classification published in the Armstrong report in 1880:

| | |
|-----------------------------|--------------------|
| Upper Kittanning limestone. | Johnstown cement. |
| Lower Kittanning. | Middle Kittanning. |
| Clarion coal bed. | Lower Kittanning. |

Stevenson gives a section on the east side of the basin showing 160 feet of conglomerate, beginning at 120 feet below the Upper Freeport, and identifies the coal resting upon it with the Brookville. But this was an error, for there one has merely an enormous expansion of the sandstones at the bottom of the Allegheny, making them continuous with the Pottsville, as in many extensive areas within western Pennsylvania and West Virginia. The interval between the Freeport coals is as variable as in Indiana; at 10 miles south from the Conemaugh, on the east side of the basin, those coals are 92 feet apart, with all members of the section present down to the Johnstown cement; but within a few miles this interval decreases to 39 feet in a section showing all three of the limestones. The general succession in Westmoreland and Fayette is shown by a section in each county, thus:

| | Feet. | Inches. | | Feet. | Inches |
|--|--------|---------|------|---------|--------|
| 1. Upper Freeport coal bed..... | 4 | 0 | | 3 | 0 |
| 2. Interval | 62 | 0 | | 44 | 0 |
| 3. Lower Freeport coal bed..... | 0 | 6 | | 0 | 6 |
| 4. Interval | 18 | 0 | | 30 | 0 |
| 5. Upper Kittanning coal bed and shale | 6 | 7 | 4 to | 7 | 0 |
| 6. Interval | 47 | 7 | } | 118 | 0 |
| 7. Middle Kittanning coal bed.... | 3 to 4 | 0 | | | |
| 8. Interval | 51 | 6 | | | |
| 9. Lower Kittanning coal bed.... | 5 | 0 | | Blossom | |
| 10. Interval | 75 | 0 | | 60 | 0 |
| 11. Brookville coal bed..... | 2 | 0 | 2 to | 3 | 0 |
| 12. Shale and clay..... | 25 | 0 | | 10 | 0 |

to the Pottsville. The Clarion coal bed evidently disappears in southern Indiana, as no trace of it was seen in any Westmoreland section, though in some cases the exposure below the Lower Kittanning (Clarion of Stevenson) is complete. The Brookville is persistent to the Maryland-West Virginia border, often attaining a considerable thickness and yielding good coal, though ordinarily so badly broken by clay beds as to be unavailable. The Lower Kittanning is persistent, but is seldom workable,

for when thick it contains much refuse. Stevenson reports it as 5 feet 11 inches at one locality in Fayette, but Campbell has proved the identification erroneous and the bed is probably higher in the formation. The Middle and Upper Kittanning rarely attain even local importance; usually thin, they sometimes thicken up to a worthless mass of coal and shale. The Lower Freeport is always insignificant. The Upper Freeport becomes very thick on the west side, but is broken by partings. At one locality near the West Virginia line it is 9 feet 7 inches thick, with 16 layers of coal, shale, and clay. On the easterly side it is commonly double, 2 to 6 feet thick, but the coal is tender, sulphurous, and high in ash.

The Upper Freeport limestone appears in most of the sections, but the Lower Freeport appears rarely south from Westmoreland, and the Johnstown seems to be absent from Fayette. The Freeport and Kittanning sandstones are distinct, rarely other than massive in these counties.*

The intervals between the several coal beds show as great variation as in the First basin, but that between the Upper Freeport and the Lower Kittanning shows narrow variations within considerable areas; these may be summarized thus:

| | Feet. | | Feet |
|--|-------|----|------|
| Center (d'Inwilliers) | 163 | to | 176 |
| Clearfield (James) | 168 | | |
| Clearfield (I. C. White) | 169 | | |
| Northwest Cambria (d'Inwilliers) | 163 | to | 168 |
| Western Cambria | 183 | | |
| Indiana (W. G. Platt) | 207 | | |
| Northern Westmoreland (Stevenson)..... | 251 | | |
| Central Westmoreland (Stevenson) | 189 | | |
| Southern Fayette (Stevenson) | 197 | | |

North from Fayette county the presence of the three limestones in almost all of the sections renders the identifications certain. These limestones are non-fossiliferous and show as notable variation in composition and in appearance as they do in the First basin.

Passing over into Preston county of West Virginia, one finds at 12 or 13 miles from the Pennsylvania line the following measurements of cores obtained by diamond drill:

| | Feet. | Inches |
|--|-------|--------|
| 1. Upper Freeport coal bed and partings..... | 10 | 2 |
| 2. Fireclay, limestone, sandstone | 21 | 1 |
| 3. Green shale and sandstone | 14 | 2 |
| 4. Gray sandstone, Upper Freeport [Butler].... | 29 | 8 |
| 5. Lower Freeport coal bed | 1 | 1 |

* J. J.-Stevenson: Ligonier valley (K 3), pp. 89, 135, 158, 172.
 M. R. Campbell: U. S. Geol. Survey folio, Masontown-Uniontown, 1903.

| | Feet. | Inches. |
|---|-------|---------|
| 6. Fireclay, green shale, sandstone | 7 | 6 |
| 7. Hard pebbly sandstone [Freeport]..... | 76 | 4 |
| 8. Black shale, Middle Kittanning coal bed..... | 8 | 5 |
| 9. Slate, shale, fireclay | 61 | 8 |
| 10. Gray sandstone | 6 | 1 |
| 11. Slate and coal | 1 | 0 |
| 12. Shale | 7 | 6 |
| 13. Clarion coal bed [Brookville]..... | 9 | 1 |
| 14. Fireclay | 12 | 10 |

to the Pottsville sandstone. The Upper Freeport is 86 feet below the Brush Creek limestone, which is embedded in black fossiliferous shale immediately overlying the Brush Creek coal bed. The interval from Upper Freeport to the Middle Kittanning is 146 feet, and to the top of the fireclay which underlies the place of the Lower Kittanning 199 feet, almost the same as in southern Fayette. The Brookville coal bed is worthless, in two nearly equal benches of slaty coal, separated by 6 feet 5 inches of fireclay. The Lower Freeport is a double bed and the Upper Freeport is in 13 layers of coal, bone, and slate.

At a few miles farther south this Second basin, owing to the decreasing strength of Chestnut hill, becomes continuous with the western basins, and it will be described in connection with the West Virginia area.*

WESTERN BASINS OF PENNSYLVANIA

The region west from Chestnut Hill anticline to the Ohio line may be considered as one, there being no very strongly marked divisions.

A small area of Coal Measures remains in Tioga and Potter counties near the line of New York, in which the upper part of the section may belong to the Allegheny, but, as Mr David White has shown, the greater part belongs to the Pottsville, according to the testimony of the plant remains. The distance from other areas is too great to admit of correlation on any other basis.

Some isolated patches remain in McKean county, west from Potter, the most northerly being about 10 miles north from the line of Elk county, where the section reaches upward to the Middle Kittanning coal bed. The persistent coals are those named Dagus and Clermont, which Mr Ashburner identifies with the Lower Kittanning and Clarion. Between them is the Vanport (Feriferous) limestone at 8 to 30 feet below the Dagus coal, wanting, however, at the most northerly exposure as well as in the southeastern part of the county, and, where present, somewhat impure, though at times 8 feet thick. The interval between Dagus and

* I. C. White: *Geology of West Virginia*, vol. II, pp. 311, 344.

Clermont varies from 43 at the north to 78 feet in the southeast, an intermediate measurement being 51 feet. A thin coal bed, without value, seen occasionally between the Dagus and Clermont, is regarded by Mr Ashburner as probably the Scrubgrass coal bed of I. C. White, belonging under the Vanport limestone.*

The shallow synclines of northwest Cameron, west from Clinton and Potter, south from McKean, carry patches of Allegheny showing the three coal beds of McKean, which are separated by intervals of 29 feet 6 inches and 52 feet, the interval between Dagus and Clermont being 84 feet 6 inches, 6 feet greater than in the adjacent part of McKean. The Vanport limestone is absent. This section would place the Clermont coal bed at the Brookville horizon.†

The complete Allegheny section is reached in southern Elk county, west from Cameron and south from McKean. The Middle Kittanning is the highest bed in Jones, the northern township, where the intervals are greater than in McKean, and 40 feet of shale separate the Lower Kittanning and the Vanport limestone. The latter, 9 feet thick and double near the northern line, becomes a calcareous chert in the southern part of this township as well as in Ridgway, but in the southeast part of the county it is again a limestone. A thin coal bed, Ferriferous of Ashburner, but clearly the Scrubgrass, directly underlies the Vanport in the northern townships, but is wanting at the southeast in Benzinger, where the Clarion coal bed, 5 inches thick, is at 13 feet below the limestone and 16 feet above the Clermont (Brookville) coal bed.

At the Dagus shaft, near the Clearfield border, Mr Ashburner recognizes the Freeport coal beds, 60 feet apart, with the Johnstown cement limestone at somewhat more than 60 feet below the Lower bed. The Upper Kittanning is not exposed above the shaft, but in the shaft the Middle Kittanning is shown at 163 feet and the Lower Kittanning at 212 feet below the Upper Freeport. The Vanport limestone is 40 feet below the Lower Kittanning, and another coal bed is reached at 25 feet lower, which is correlated with the Clarion, but is more likely to be at the Brookville horizon. The interval between the Lower Freeport coal bed and its underlying limestone varies usually 2 to 5 feet, but in Horton township, near the southern border of the county, it varies from 52 to 69 feet and contains two coal beds, 2 and 3 feet thick; the accuracy of Mr Ashburner's identifications can not be doubted, for all four limestones are present in his sections, the Vanport being richly fossiliferous and 35 feet above the Clarion (Brookville) coal bed. The Upper Freeport is divided by a

* C. A. Ashburner: McKean county (R), pp. 45, 99, 127, 133, 139, 171-172, 189.

† A. W. Sheaffer: Cameron (R R), pp. 46-50.

parting which is from a mere film to 20 feet thick. The most northerly point at which the Vanport is fossiliferous is in Fox township.*

A few patches remain in Forest county near the Elk border, showing 50 feet of shales and sandstone overlying the Clarion (Brookville), which is 2 feet thick and rests on the Homewood sandstone. The Vanport limestone was not seen.†

Venango county, southwest from Forest and west from Clarion, has scattered patches in the south and southeast portion, in one of which Doctor Chance measured:

| | Feet |
|---|---------|
| 1. Ferriferous limestone [Vanport]..... | 8 |
| 2. Blue slate | 2 |
| 3. Coal bed [Scrubgrass] | 1 to 2 |
| 4. Concealed | 8 to 10 |
| 5. Sandstone [Clarion] | 56 |
| 6. Slate | 6 |
| 7. Coal bed [Brookville] | 2 |

The Vanport limestone is of uncertain occurrence.‡

In the extreme northern part of Jefferson county, south from Elk and Forest, west from Clearfield, the Allegheny has been removed, but in most of the county it is the surface formation, and the Upper Freeport is available in an extensive area within the southern third as well as in the north-east near Brockwayville. A section at the latter locality shows:

| | Feet |
|--------------------|------|
| Upper Freeport. | |
| Interval | 43 |
| Lower Freeport. | |
| Interval | 45 |
| Upper Kittanning. | |
| Interval | 54 |
| Middle Kittanning. | |
| Interval | 45 |
| Lower Kittanning. | |
| Interval | 75 |
| Brookville. | |

These intervals vary little from those of Elk county, except that the Freeports are 43 instead of 54 to 70 feet apart, and the interval from Upper Freeport to Lower Kittanning is only 187 feet. The Butler and Freeport sandstones are conspicuous, but the Kittanning interval is occupied by

* C. A. Ashburner: Elk (R R), pp. 69, 73, 106, 112-113, 150, 153, 186, 214, 217-218, 227, 241, 245, 254.

† C. A. Ashburner: Forest (R R), p. 307.

‡ H. M. Chance: Oil Regions (I 3), pp. 437-438.

shale. All of the limestones are here. In the central and northwestern parts of the county the whole interval from the Vanport down is filled with sandstone, mostly massive, but the normal condition exists in the north central part, where one finds the Middle and Lower Kittanning, 55 feet apart, and the Scrubgrass, or Upper Clarion, directly underlying the Vanport limestone, is 35 feet above the Brookville, which rests on the Homewood sandstone. The coal beds of the Kittanning and Clarion groups, though persistent and at times of workable thickness, rarely yield good coal. The Lower Freeport, somewhat variable in thickness, is important, as it yields good coal, while the Upper Freeport, equally persistent, is of little value. The Vanport limestone changes in the northwest part of the county into cherty limestone, and then into calcareous sandstone. Eastwardly it thins out and seems not to extend beyond the middle of the county. Of the other limestones the Johnstown cement is present in sections showing its place, the Lower Freeport is very irregular, and the Upper Freeport, persistent in the east and south, is apparently absent in the middle and northwest portions. The great sandstones are represented usually by shale.*

Indiana county is south from Jefferson and its larger part lies west from Chestnut hill. A narrow area exposing the Allegheny stretches along the west slope of that ridge from Jefferson county to the Cone-maugh river, whence it extends southwardly across Westmoreland and Fayette into West Virginia.

Near the Jefferson border the Upper Freeport shows the structure so often observed in the Second basin and is 5 feet 2 inches thick, but yields worthless coal. The interval to the Lower Freeport is 75 feet and both limestones are present. The Upper Kittanning at 50 feet lower shows at one locality the feature observed already in that bed as well as in the Lower Freeport and to a somewhat less extent in the Middle Kittanning, thus:

| | Feet. | Inches. | Feet. | Inches. | Feet. | Inches |
|-----------------------------|-------|---------|-------|---------|-------|--------|
| Bony coal or cannel. . . . | 1 | 3 | 8 | 3 | 1 | 2 |
| Coal, good but friable. . . | 2 | 7 | 2 | 7 | 2 | 7 |

The upper division has 21 to 24 per cent of ash and the lower 1.6, while the sulphur is practically the same in both, .621 to .654. This "pot" of thick cannel embraces only a few acres. The Johnstown cement limestone is here with the Gorman coal bed 3 feet thick and 2 feet below the limestone. The Lower Freeport farther south is very irregular; the Vanport was not seen by Mr Platt, but Mr Richardson has recognized it

* W. G. Platt: Jefferson (H 6), pp. xxx-xxxii, 100, 111, 187, 190, 199.

in a well on Ramsay run, 4 feet 5 inches thick and 238 feet below the Upper Freeport coal bed. He found traces of it on the slope of Chestnut hill at 80 feet above the Pottsville and 20 feet below the Lower Kittanning coal. On Yellow creek the intervals are much reduced, the Upper Freeport, Lower Freeport, and Upper Kittanning being but 55 and 25 feet apart, the associated limestones being present. A thin double coal bed, often seen in the Second basin, is here at 11 feet below the Upper Freeport and 3 feet above the limestone. The intervals increase southwardly, for on Black Lick creek the Upper Kittanning is 100 and the Lower Kittanning 189 feet below the Upper Freeport. The coals are all poor. The Freeport and Clarion sandstones are conspicuous, fine grained, and current bedded. The Johnstown cement is apparently the only limestone present. From this stream to the Conemaugh the section is clear. The little coal bed below the Upper Freeport persists. The Vanport limestone is present midway in the county where an anticline brings it up.*

Clarion county is south from Forest and west from Jefferson. In the northern portion the section seldom extends above the Middle Kittanning, and the whole section is found only in some widely separated areas within the southern part of the county.

North from the Clarion river one finds all of the coals below and including the Middle Kittanning. The interval from Lower Kittanning to the Vanport limestone varies from 8 to 20 feet without seriously affecting the interval from the limestone to the Middle Kittanning. Doctor Chance shows by a grouped series of sections that the Scrubgrass and Clarion are but splits of one bed. The varying intervals between the beds in southern Clarion are shown by these measurements, which are arranged from east to west:

- I. Near Fairmont, Red Bank township.
- II. In same township.
- III. New Bethlehem, Porter township.
- IV. Wildcat, Toby township.
- V. Hillville, Madison township.

| | Ft. | In. | Ft. | Ft. | Ft. | In. | Ft. | In. |
|------------------------|-------|-----|-----|-----|------|-----|-----|-----|
| Upper Freeport | 4 | 0 | 4 | .. | .. | .. | 2 | 0 |
| Interval | } 108 | 0 | 40 | 45 | } .. | .. | 108 | 0 |
| Lower Freeport | | | 6 | 7 | | | | |
| Interval | | | 95 | 68 | | | | |
| Upper Kittanning | 1 | 1 | 2 | 2 | 1 | 6 | 1 | 5 |

* W. G. Platt: Indiana (H 4), pp. 187, 189, 191-192, 205, 209, 211, 220, 223, 226-227.
G. B. Richardson: U. S. Geol. Survey folios, Indiana, 1904.

| | Ft. | In. | Ft. | Ft. | Ft. | In. | Ft. | In. |
|------------------------|-----|-----|-----|-----|-----|-----|------|-----|
| Interval | 40 | 0 | 45 | 47 | 50 | 0 | 66 | 6 |
| Middle Kittanning | 1 | 3 | 2 | 2 | 3 | 8 | | |
| Interval | 48 | 0 | 30 | 64 | 37 | 0 | 3 | 6 |
| Lower Kittanning | 2 | 6 | 4 | | 3 | 0 | | |
| Interval | 35 | 0 | 33 | 25 | 0 | 0 | 40 | 0 |
| Vanport limestone | 5 | 0 | 4 | 4 | 7 | 0 | 10 | 0 |
| Interval | } | | | 50 | | .. | 22 | 0 |
| Clarion | | | | | | | 2 | 2 |
| Interval | | | | | | | 23 | 0 |
| Brookville | .. | .. | .. | .. | .. | .. | Thin | |

to the Pottsville. The interval from Upper Freeport to Lower Kittanning in the three sections showing both beds is 198, 220, and 176, and to the Vanport 235, 271, and 219 feet, the last in the southwest corner of the county. At one mile north from III the interval between Lower Freeport and Upper Kittanning is but 40 feet, and at two miles south, in Armstrong county, it is only 25 feet, showing a variability in this interval such as has been noted already in southern Elk. Of the limestones, the Upper Freeport is widely distributed, the Lower Freeport and Johnstown cement are irregular, while the Vanport seems to extend in prongs toward the northwest. The Butler, Freeport, and Kittanning sandstones are distinct in the southern townships, but elsewhere their places are filled for the most part by shales, while the Clarion is a well marked sandstone, 20 to 30 feet thick, in most of the county. The Upper Freeport coal bed is good, with little variation in thickness, but the other beds are of no importance except the Upper Kittanning, which, in a small area within Porter township, has a cannel roof of 8 feet.*

Armstrong county, south from Clarion, west from Indiana, and north from Westmoreland, has for its southern boundary the Kiskiminetas, the continuation of the Conemaugh river. In the easterly part of the county the section is followed easily from Clarion line to the Kiskiminetas, though the intervals between the coal beds show notable variations. The Scrubgrass, or Upper Clarion, coal bed does not appear in any of the sections, but the others are persistent, though the Upper Freeport and Lower Kittanning are the only ones of economic importance. The Upper Kittanning has a cannel roof 8 feet thick in a small area adjoining Clarion county, but the cannel is inferior. The Upper Freeport and Vanport limestones are persistent except in a small area central in the county where the lower bed seems to be wanting. The sandstones are insignificant and their places in almost all of the sections are filled with shale.

* H. M. Chance: Clarion (V V), pp. 70-71, 75, 77, 79, 80-81, 88, 90-91, 95, 97, 103, 107, 112, 121, 123, 125-126, 132, 136, 142-143, 147, 153, 158, 160, 175-176, 178, 181.

In the western part of the county, beyond the Allegheny river, one reaches the western limit of the Johnstown cement, which is absent at the north though present at the southwest in unimportant development. Of the other limestones, the Upper Freeport and Vanport are persistent, but the Lower Freeport is very irregular. The Freeport sandstone is conspicuous and at times, as in a portion of Jefferson county, sandstone fills practically the whole interval from the Vanport to the Homewood sandstone. The coal beds are unimportant, though the Upper Freeport is good at the north, and in many places the Upper Kittanning shows its tendency to accumulate cannel slate on top. Two measurements, one at the north, the other at the south, show the relations of beds on this western side:

| | Feet. | Feet. | Inches | Feet. | Feet. | Inches |
|-------------------------|-------|-------|--------|-------|-------|--------|
| Upper Freeport | | 7 | 0 | | 2 | 6 |
| Interval | | 60 | 0 | | 54 | 0 |
| Lower Freeport | 4 to | 1 | 6 | | 1 | 0 |
| Interval | | 65 | 0 | | 35 | 0 |
| Upper Kittanning | 12 to | 0 | 10 | | 1 | 0 |
| Interval | | 45 | 0 | | | |
| Middle Kittanning | | 4 | 0 | | 117 | 0 |
| Interval | 35 to | 40 | 0 | | | |
| Lower Kittanning | | 3 | 6 | 3 to | 4 | 0 |
| Interval | | 33 | 6 | | 25 | 0 |
| Vanport limestone | | 15 | 0 | | Thin | |
| Interval | | 30 | 0 | | 25 | 0 |
| Clarion | 2 to | 3 | 0 | | 2 | 6 |
| Interval | 22 to | 32 | | | | |
| Brookville | | Thin | | | | |

But the interval from the Upper Freeport to the Lower Kittanning is practically the same in both sections.*

Butler county, south from Venango, west from Armstrong, is east from Mercer, Lawrence, and Beaver.

The Vanport limestone is present throughout except in small patches at the northwest. The Lower Kittanning, hitherto the most persistent of the coal beds, is somewhat uncertain on the northern border and seems to be wanting in considerable areas within the central part of the county. The interval to the Vanport varies from 10 to 45 feet, the least thickness being on the Lawrence border at, say, 10 miles south from the Venango line; thence it increases eastwardly to 15, 20, 30, and 45 feet within 10 miles, and similar increase appears southwardly. The Middle Kittanning is persistent, and in the absence of the Lower Kittanning might be

* W. G. Platt: *Armstrong* (H 5), pp. 6, 9, 16, 67, 92, 100, 105, 109, 115, 122, 143, 147, 153, 165, 177, 191, 215, 222, 224, 267, 271, 288.

mistaken at times for that bed, as the interval to the Vanport varies from 45 to 90 feet, diminishing westwardly. This bed is 40 to 60 feet below the Upper Kittanning, which is 110 to 130 feet above the Vanport, and in some of the townships is largely a cannel. The interval between Upper Kittanning and Lower Freeport is as variable as in Elk, Clarion, and Armstrong, the extremes in a single township being 55 and 91 feet. Where the Freeport sandstone, occupying this interval, is divided by shale, a coal bed, the Currie, occasionally appears. The Lower Freeport is roofed by laminated shale and coal a few inches to 10 feet thick, and the Upper Freeport, 50 to 60 feet higher, is uncertain, apparently wanting at many localities.

The Scrubgrass, Clarion, and Brookville coal beds below the Vanport limestone may have been deposited in the greater part of northern Butler, but they are now wanting in the western portion, where for the most part the Clarion sandstone is continuous with the Pottsville. The Freeport limestones appear in only a few sections and the Johnstown cement is absent.*

The surface rocks in southern Butler for the most part are Conemaugh, but the Allegheny beds are reached on the east side in deep valleys tributary to Buffalo creek and on the north and west in the valley of Connoquenessing creek. Two measurements on the east or Armstrong side are important for correlation:

| | Feet. | Inches. | Feet. | Feet. | Inches |
|---------------------------------------|---------|---------|-------|-------|--------|
| Upper Freeport | .. | .. | | 3 | 2 |
| Interval | .. | .. | | 65 | 0 |
| Lower Freeport | Blossom | | 1 to | 2 | 0 |
| Interval | 80 | 0 | } | 147 | 0 |
| Darlington [Upper Kittanning] | 3 | 0 | | | |
| Interval | 70 | 0 | | | |
| Kittanning [Lower] | 10 | 9 | | | |
| Interval | 55 | 0 | | 55 | 0 |
| Ferriferous limestone [Vanport] | 15 | 0 | | 16 | 6 |
| Interval | 20 | 0 | | 12 | 0 |
| Clarion | 2 | 0 | | 3 | 0 |
| Interval | 10 | 0 | | 30 | 0 |

to sandstone. The interval from Lower Freeport to the Upper Kittanning (Darlington) is very like that in much of northern Butler and northwest Armstrong, but nearly double that in southwest Armstrong, while the interval from Lower Freeport to Lower Kittanning is actually

* H. M. Chance: Northern Butler (V), pp. 17, 28, 95, 97, 103, 105, 121, 123, 125, 129, 130, 132, 134, 137.

the same as in the last. The interval between Upper Kittanning (Darlington) and Lower Kittanning in western Armstrong varies from 95 to 117, that between Lower Freeport and Lower Kittanning remaining the same, while in central Butler, Doctor Chance's section shows about 85 feet to the bottom of the Lower Kittanning, differing little from the interval in these measurements by Doctor White. The Lower Kittanning is from 3 to 11 feet thick and one of its benches yields good coal; the other beds are without value. The Butler and Kittanning sandstones are massive. In the southwest corner of the county the Freeport coal beds are 45 feet apart and the Darlington (Upper Kittanning) is 145 feet below the Upper Freeport. The Freeport sandstone is massive and the Upper Freeport limestone is present in most of the sections.

On the Connoquenessing the Freeport coals are of little value and are 55 to 80 feet apart. The interval from the Lower bed to the Darlington varies from 43 to 70 feet, the smaller interval being on the western border, where the Darlington is barely 125 feet below the Upper Freeport. At a few miles north from this exposure a coal bed, known as the Eichenaur and commonly supposed to be a local bed, is seen at 115 feet below the Upper Freeport. It is variable, cannel on top, coal below, but changing into bituminous shale. This is very like the Upper Kittanning (Darlington), which in the neighboring township of Forward is only 120 feet below the Upper Freeport. The Freeport and Butler sandstones are usually massive along the Connoquenessing valley. A boring in Forward township shows the whole interval from the Homewood sandstone up to what may be the Middle Kittanning coal bed filled with sandstone. The Freeport limestones appear in most of the sections, none of which goes down to the place of the Vanport. The coal beds are poor and of no economic importance, though the Lower Freeport and Upper Kittanning (Darlington) are mined for local use.*

The northern border of the Allegheny formation, owing to shallowing of the synclinals, falls southwardly toward the west, so that in Mercer county, west from Venango and Butler and extending to the Ohio line, one finds rocks higher than the Vanport (Ferriferous) limestone only in the southeast corner near the Butler line. Doctor White's sections show the Lower Kittanning at 45 feet above the Vanport limestone and at the same distance below a coal bed termed the Darlington locally. The Darlington of Mercer is not the same with the Darlington of southern Butler; that of Mercer is the Middle Kittanning; that of southern Butler is the Upper Kittanning. The Mercer County measurements are only

* I. C. White: Southern Butler (Q), pp. 90, 92, 94, 95, 110, 111, 112, 117, 119, 120, 130, 133, 135-139.

5 or 6 miles west from measurements in northern Butler where the Middle Kittanning is 70 to 80 feet above the Vanport limestone and 40 feet below the Freeport sandstone, and about 10 miles west from Murrinsville, in that county, where the Upper Kittanning is 120 feet above the Vanport. The Scrubgrass and Brookville coal beds are here, the latter at 27 to 55 feet below the Vanport, the interval decreasing westwardly. The limestone is not persistent, but where present is richly fossiliferous. At one place it is 12 feet thick.*

Areas of Allegheny become more extensive in Lawrence county, south from Mercer and west from Butler. The section lengthens and the Upper Freeport coal bed is reached at many localities. The Darlington coal bed of this county is the Middle Kittanning.

On the east side the Middle Kittanning is 70 to 80 feet above the Vanport (Ferriferous) limestone, the interval depending on that between the Lower Kittanning and the Vanport, which varies from 15 to 25 feet, and that between the coals from 40 to 58 feet, these variations being similar to those in the adjacent part of Butler county. The Upper Kittanning is missing and the Middle is at 140 feet below the Upper Freeport, in the southern part of the county. Westwardly, in the northern and middle parts of the county, the Middle Kittanning is quite regularly 70 to 80 feet above the Vanport, but along the southern border the interval varies from 100 to 65 feet, the latter at the west near the Ohio border. The Vanport limestone is not wholly persistent, being wanting in a considerable area, but it is found in most of the county, 15 to 25 feet thick, always double, gray above, blue below, and everywhere richly fossiliferous in both divisions. The Scrubgrass and Brookville coals appear in a number of the sections, but they as well as the higher coals are of little importance.

The interval from Upper Freeport to Lower Kittanning is 208 feet in eastern Butler, 190 to about 200 in eastern Lawrence, but decreases to 160 feet near the Ohio state line.†

Beaver county is south from Lawrence along the Ohio line. North from the Ohio river one occasionally finds the Brookville and Clarion coals 15 to 50 feet apart and very thin, at times distributed through a mass of carbonaceous shale. The Vanport limestone is very thick, 22 feet, in the northeast, but becomes thinner southward and westward until, on the river near the Ohio line, it is but one foot thick, and soon after crossing into Ohio it practically disappears. At Homewood station, midway

* I. C. White: Mercer (Q 2), pp. 22, 32, 77, 79, 88, 132.

† I. C. White: Lawrence (Q 2), pp. 76, 84, 86, 92, 94, 98-99, 111, 115, 121-122, 131-132, 134-139, 141, 144, 146-147, 152, 159, 161, 162-166, 169, 171, 179, 187, 196, 199.

in this portion of the county, it is replaced by sandstone which is continuous below with the Pottsville. The Lower Kittanning coal bed, at 50 to 80 feet above the Vanport, is persistent throughout the county and rests on a thick bed of clay which is of great economic importance. The Middle Kittanning (Darlington) coal bed is at 50 to 20 feet above the Lower Kittanning, the least interval being on the river one mile from the state line. Near the river this bed is unimportant, but northward it shows some changes which make it locally important. At one locality it shows:

| | Feet. | Inches |
|--------------------|-------|--------|
| Cannel slate | 6 | 0 |
| Cannel | 12 | 0 |
| Coal | 3 | 6 |

The slate is rich in carbonaceous matter, one ton yielding on distillation one barrel of oil; but an enlargement of this kind is very local, thinning out in each direction until only the coal is left, and possibly within a short distance the whole deposit was cut away by the overlying sandstone. The interval to the Lower Freeport coal bed is occupied mostly by sandstone, the continuation downward of the Freeport. Occasionally this mass is interrupted by shale, and then a coal bed is shown at 15 to 20 feet above the Middle Kittanning, which may mark the Upper Kittanning, which otherwise is without representative in this region. The Lower Freeport coal bed is insignificant; the Upper Freeport is usually double or triple, with thin partings and a thickness of about 4 feet; but at one place it resembles the Middle Kittanning, having a roof of coal and cannel 5 feet thick. The Freeport and Kittanning sandstones are usually massive.*

Southward from the line of Beaver, Butler, Armstrong, and Indiana counties the Allegheny formation is nowhere completely above drainage except along the westerly slope of Chestnut hill, in Westmoreland and Fayette and perhaps under the Fayette anticline on the Youghiogheny river in Fayette;† elsewhere to the West Virginia line it is for the most part buried under the Conemaugh, and dependence must be placed upon the records of oil borings.

In Westmoreland and Fayette the Allegheny coals have been mined to very slight extent, owing to proximity of the great Pittsburg coal bed, and exposures in the mountain gorges are usually too indefinite to make accurate measurements possible. The information contained in Stevenson's reports is fragmentary and of little value. The Upper Freeport coal

* I. C. White: Beaver (Q), pp. 40, 42, 47, 48, 50, 110, 194, 209, 225, 233-234, 249, 253, 260, 265; Ohio line (Q 2), 254, 258, 260, 263.

† M. R. Campbell: U. S. Geol. Survey folio, Masontown-UniOntown, 1903.

bed persists along the whole line and is opened at many places for use of the farmers. Usually it is in numerous benches, separated by clay partings, so that although it is very thick at times, 11 to 16 feet, it is apparently unimportant. The Lower Freeport was seen on the Conemaugh at 47 feet below the Upper, and also at several places south from the Youghiogheny river, but it is worthless. The Brookville or possibly Clarion was seen at many places, at times in several benches of fair coal separated by thick clay partings which vary at the expense of the coal. Two other beds were seen which unquestionably belong to the Kittanning group, the lower one being above a sandstone which is probably the Kittanning. This is a well marked rock in the southern part of this strip, and it is called Piedmont in Stevenson's reports, in accordance with Professor Lesley's correlation in the Coke Report. The Freeport limestones seem to be present near the West Virginia line.*

Returning to the north and following the formation under cover, one has oil records, many of which are referred to the Ames limestone as the datum. In Allegheny and Westmoreland counties that limestone is from 280 to 300 feet below the Pittsburg coal bed. In Allegheny north from the Ohio river the occurrence of the coal beds soon becomes very irregular, as might be expected from conditions in adjacent parts of Butler and Beaver. Seven records are available in western Allegheny near the Beaver line. Two of these show no coal, one has three beds, 69 and 34 feet apart, while in one or the other of the remaining wells one or two coals are reported. These are very near the horizons of the Lower Freeport, Middle Kittanning, and Lower Kittanning. The Butler sandstone overlies the highest bed. At Sewickley, a few miles below Pittsburg, Doctor White measured the core of a diamond drill and recognized the Upper and Lower Freeport, the Upper and Lower Kittanning, all very thin and no limestones present.†

A record in northwest Westmoreland shows coals at 44, 127, and 218 feet below the Upper Freeport. Four miles east from this locality Mr W. G. Platt found the Lower Freeport, Lower Kittanning, and Brookville coals at 30, 110, and 217 feet below the Upper Freeport. The agreement is sufficiently close for correlation between the ordinary record and a measured exposure. On the Pennsylvania railroad at Carpenter station the only coals are the Upper Freeport and one at 199 feet lower, which may be the Clarion. Farther south, at Sewickley, the Lower Free-

* J. J. Stevenson: Fayette and Westmoreland (K K), pp. 82, 141, 159, 160, 167, 171, 186, 193, 319, 320.

† J. F. Carll: (I 5), pp. 251-256.

I. C. White: Bulletin no. 65, p. 112.

port and Middle Kittanning are reported, 70 feet apart, with almost continuous sandstone below the latter to the Pottsville.*

Records referred to a definite datum in Fayette county are confined to the southern portion of the county. Mr Campbell gives three which may be cited. In the Mach well the Upper Freeport horizon is marked by 14 feet of shale and coal, the Kittanning sandstone is 49 feet thick and rests on 16 feet of "shale and coal" marking the Clarion-Brookville horizon. Near the Monongahela river, on Cats run, there is no coal in the Allegheny. At a few miles south the first coal bed is very near the place of the Upper Kittanning, and at 65 feet below it is the Kittanning sandstone, 87 feet thick and reaching down to the representative of the Clarion-Brookville, which rests on the Pottsville.†

On the west side of the Monongahela river the section may be followed through Washington and Greene counties of Pennsylvania and the northern "panhandle" of West Virginia, lying between those counties and the Ohio river.

At McDonald station, near the northern line of Washington, the coal beds, all insignificant, are the Lower Freeport, Middle and Lower Kittanning, and the Brookville, the relations being as at Sewickley and Pittsburg. The thickness of the Allegheny is not determinable, but is between 255 and 275 feet. The only recognizable sandstone is the Kittanning. At Washington the Upper Freeport is 548 feet below the Pittsburg, there being a distinct thinning in the lower portion of the Conemaugh, and the Allegheny is 285 feet thick. The only coal bed reported is at 153 feet below the place of the Upper Freeport and represents one of the Kittannings. The Butler and Freeport sandstones are one, 75 feet. This sandstone is present in West Finlay and Mount Pleasant townships, but the records show no coal in those or in Amwell township. Nearer the Monongahela two thin coals are reported, but their relations are obscure. It should be remembered that thin black shale is likely to be reported as coal by the drillers.‡

Passing over into Brooke county of West Virginia, one has at New Cumberland Doctor White's section:

| | Feet. | Feet |
|---|-------|------|
| 1. Ames limestone | | |
| 2. Interval | | 236 |
| 3. Mahoning coal bed [Brush Creek]..... | | 4 |
| 4. Interval | | 90 |
| 5. Lower Freeport coal bed | 2 to | 3 |

* J. F. Carll: (I 5), pp. 221, 225; 1886 Rept., p. 728.

W. G. Platt: (H 5), pp. 6, 27.

† M. R. Campbell: Masontown-Unlontown folio, pp. 18, 19.

‡ J. F. Carll: (I 5), pp. 302, 306, 307, 318; 1886 Rept., pp. 758, 765.

I. C. White: Bulletin no. 65, p. 113.

| | Feet. | Feet |
|-----------------------------------|----------|------|
| 6. Interval | | 100 |
| 7. Middle Kittanning | Blossom | |
| 8. Interval | 20 to 30 | |
| 9. Lower Kittanning coal bed..... | Blossom | |
| 10. Fireclay | | 10 |

The interval from the Ames limestone to the Lower Freeport is 340 feet, whereas at Smiths ferry, 10 miles northeast, it is 366 feet; but the distance from Ames to Lower Kittanning has diminished not more than 3 or 4 feet. The Brush Creek coal bed is the Groff vein coal 7 of the northern Ohio column. Ten miles farther south, opposite Steubenville, Ohio, the Lower Freeport coal bed has been mined. No measurements are available on the West Virginia side of the river, but on the Ohio side the interval to the Ames limestone is 340 feet, which, as appears from many measurements by Newberry, Orton, and Stevenson, is 210 to 220 feet below the Pittsburg coal bed—a notable decrease in the upper part of the Conemaugh, which must be kept in mind. Direct measurement at Steubenville shows the interval to the Pittsburg 550 feet. There the Upper Freeport is present at 42 feet above the Lower and very thin.

At Wellsburg, in Hancock county, 10 miles farther south, this Lower Freeport coal bed is 320 feet below the Ames and 540 feet below the Pittsburg, with a 40-foot sandstone at 70 feet below it. From the Pittsburg to the Pottsville at Wellsburg is only 739 feet, whereas at McDonald, 15 miles east-northeast, it is about 880 feet, there being loss in both Conemaugh and Allegheny, so that the latter is not far from 200 feet thick in this area. No coal, aside from the Lower Freeport, is noted in the Wellsburg record, but Doctor Newberry found thin lower coals on the Ohio side where the Lower Freeport limestone is persistent. Wheeling, in Ohio county, is about 10 miles south from Wellsburg and about 20 miles west from Washington, in Pennsylvania. Three miles east from that city a record shows 4 feet of coal at 530 feet below the Pittsburg and resting on sandstone, thus:

| | Feet |
|-------------------------------|------|
| Gray sandstone | 45 |
| Coarse gray sandstone | 83 |
| Fine white sandstone | 408 |
| Gray and white sandstone..... | 170 |

this sandstone being continuous to the bottom of the Logan. The mass number 3 is apparently homogeneous and the change to number 2 is so marked that the upper 128 feet may be allotted to the Allegheny. The coal bed at 530 is very probably at the Upper Freeport horizon, for the Lower Freeport in the Wheeling well is at 556 feet. This interval of 26 feet is that between the Freeports at a little way north, where Professor

Orton found it varying from 26 to 42 feet within a short distance. The Wheeling record shows two coals, one at 556 and the other at 96 feet lower, resting on 541 feet of sandstone. The lower bed is clearly the Lower Kittanning, the "Clay vein" of the Ohio side, which at exposures up the river is from 100 to 115 feet below the Lower Freeport. This lower bed, the Lower Kittanning, appears in another well on Wheeling creek at 645 feet below the Pittsburg.

Southward, in Marshall county, west from Greene county of Pennsylvania, the record of a well at about 7 miles south from Wheeling shows the "Big lime" of the Lower Carboniferous only 983 feet below the Pittsburg. The top of the Pottsville seems to be at 780, but it is probably higher, the upper portion being shale. The Allegheny shows neither coal nor sandstone. Near Moundsville, 10 miles south from Wheeling, one finds a condition which will be observed many times farther south in Wetzel county of West Virginia, where in a considerable area only sandstone is found in the Allegheny. In one well near Moundsville sandstone begins at 615 feet below the Pittsburg and is continuous for 255 feet, and the "Big lime" is reached at 937. At 5 miles east from Moundsville the sandstone begins at 448 and is continuous to 748 feet below the Pittsburg, the "Big lime" being 958 feet. At Majorsville, in the northern part of the county, on the Pennsylvania line, 12 miles southeast from Wheeling, the interval to the "Big lime" has increased to about 1,100 feet, the Lower Freeport coal bed is at 593 feet, and the Allegheny consists of alternating shales and sandstones. Five miles farther south, near Loudensville, the only coal bed is at 615, and at 40 feet lower is a sandstone 70 feet thick. The relations of this bed are doubtful. It is too high for the Lower Kittanning and too low for the Lower Freeport. In the southern part of the county, on this side, the records give few details, only the sandstones being recorded; but in many wells sandstone predominates in the Allegheny. In one it begins at 640 and is continuous to 960; in another from 566 to 881, and in a third from 450 to 845 feet below the Pittsburg; but in other wells shales predominate to 690, 735, and 743 below that coal. These records are all from a single district extending five miles north from the line of Wetzel county.*

Returning to Pennsylvania, one finds a record at Nineveh, in Greene county, almost at the Washington line and about 12 miles east from Majorsville. Here the Allegheny shows neither coal nor black slate and no important sandstone except the Butler-Freeport, 70 feet thick. In

* I. C. White: *Geology of West Virginia*, vol. i, pp. 350, 352, 363, 365-366; vol. Ia, pp. 218-219, 220, 223-224, 228, 231; vol. II, pp. 460, 464-465.

J. S. Newberry: *Ohio Survey*, vol. III, pp. 741, 760.

E. Orton: Vol. VI, p. 61.

central and eastern Greene sandstones are as marked as those in the West Virginia "spanhandle." Two miles east from Waynesburg, in the central part of the county, 12 feet of sandstone is reported at 620 feet below the Pittsburg, resting on 370 feet of black slate extending into the Pottsville; at 5 miles east, the bottom of the Mahoning interval is reached at 575, and at 607 this succession begins:

| | Feet |
|------------------|------|
| Dark sand | 58 |
| White sand | 390 |
| Dark sand | 80 |

in all, 528 feet of sandstone. No coal is reported. At 4 miles southeast from the last the sandstone begins only at 691 and there is no coal above it. Twelve miles southeast from Waynesburg, at Willow Tree, the only coal bed present is about 830 feet below the Pittsburg, evidently at the Brookville-Clarion horizon. Several miles southwest from Waynesburg the Upper Freeport is at 555 feet below the Pittsburg, and in the succeeding 325 feet there are 250 feet of sandstone, and much of the shale is sandy. No other coal is reported.

Doctor White gives many records in western Greene county, but they are not in detail; they suffice, however, to show that the Allegheny contains no great sandstones in that area.*

OHIO

Doctor White's series of vertical sections connect Pennsylvania with Ohio. The relations of the beds within the latter state were worked out by Professor Orton, whose discussion of the Ohio Lower Coal Measures must always remain preeminent not only for scientific accuracy, but also for the delicacy with which are corrected the errors into which the inexperienced observers of the Second survey fell.

Mahoning county adjoins Lawrence of Pennsylvania. Doctor White's section at Lowellville, one mile west from the state line, is:

| | Feet. | Feet. | Inches |
|---|-------|-------|--------|
| 1. Kittanning [Lower] coal bed..... | | 2 | 4 |
| 2. Concealed | | 40 | 0 |
| 3. Ferriferous [Vanport] limestone | 10 to | 18 | 0 |
| 4. Argillaceous shale | | 2 | 6 |
| 5. Scrubgrass coal bed | | 0 | 6 |
| 6. Sandy shales | | 12 | 6 |
| 7. Clarion coal bed | | 1 | 4 |
| 8. Flaggy sandstone | | 17 | 0 |
| 9. Brookville coal bed | | 0 | 10 |
| 10. Homewood sandstone | | | |

* J. F. Carll: Seventh Rept. on Oil and Gas (I 5), pp. 310, 313, 341-347.
I. C. White: Geology of West Virginia, vol. 1a, pp. 123, 131.

The Homewood sandstone has become very thin, so that the Vanport limestone is but 80 to 110 feet above the Upper Merce~~r~~ limestone, the variation being chiefly below the Brookville coal. The Vanport, so important in western Pennsylvania, quickly becomes uncertain in Ohio, though its horizon is recognizable at many places by means of calcareous sandstone or shale or even impure limestone; but its office as stratigraphical guide is performed by a new limestone, the Putnam Hill of Andrews, Gray of Newberry, which makes its appearance at Youngstown, 9 miles west from the state line, where it is 2 feet 7 inches thick. This, immediately overlying the Brookville coal bed, is from 15 to 50, but ordinarily about 30 feet below the place of the Vanport. In southern Mahoning Professor Orton found the Lower Kittanning at 48 feet above the Vanport limestone, which is represented by "chip slate, calcareous nodules, and cone-in-cone," the last being a characteristic feature of the bed wherever degenerate in western Pennsylvania. Here it overlies the Scrubgrass (locally Canfield) coal bed, which is double throughout this area, the upper division often cancellated. It is about 150 feet below the Upper Freeport, or White limestone of Newberry.*

Columbiana county is south from Mahoning. A boring at Leetonia, 2 or 3 miles south from the Mahoning line, shows the Lower Kittanning (locally Leetonia) coal bed at 47 feet above the Scrubgrass (Upper Clarion). The Clarion coal bed is at 28 feet lower and 11 feet 6 inches above the Putnam Hill limestone. The Lower Freeport coal bed, with its underlying limestone, is in the Leetonia hills at 75 feet above the Lower Kittanning, and the Freeport sandstone occupies most of the interval. The section is very like that at Lowellville, except that the Vanport limestone has disappeared. At New Lisbon, 6 or 8 miles farther south, the top of the Allegheny is reached and the Vanport limestone reappears; the intervals are:

| | Feet. | Inches |
|------------------------------|-------|--------|
| Upper Freeport | 3 | 4 |
| Interval | 22 | 0 |
| Lower Freeport | 1 | 0 |
| Interval | 87 | 0 |
| Middle Kittanning | 0 | 8 |
| Interval | 12 | 0 |
| Lower Kittanning | 1 | 4 |
| Interval | 40 | 0 |
| Vanport limestone | 3 | 0 |
| Scrubgrass and parting | 9 | 0 |

* J. S. Newberry: Ohio Survey, vol. III, p. 803.
 I. C. White: Pennsylvania report (Q Q), pp. 219, 222.
 E. Orton: Ohio Survey, vol. v, pp. 20, 31, 33.

The Freeport limestones are present, as are also the Butler and Freeport sandstones. The interval from the Lower Kittanning to the Scrubgrass is almost the same as at Leetonia, while that from the Upper Freeport to the Lower Kittanning is 162 feet, practically the same as in southern Mahoning, where it is 150 feet from the Upper Freeport limestone. The Lower Freeport becomes locally important as the Whan coal bed within a small area in central Columbiana, but for the most part it is worthless.

The Upper Freeport coal bed is wanting in most of Doctor White's sections in eastern Columbiana, but its limestone is present at 40 to 45 feet above the Lower Freeport. The Middle Kittanning (Darlington) is present to nearly midway in the county, but the Vanport limestone is of uncertain occurrence, at times represented only by fossiliferous shale. In the southern part of the county, Doctor Newberry reports the Lower Kittanning as 115 to 125 feet below the Lower Freeport, and at Liverpool 176 feet below the Upper Freeport.*

Farther south, on the north border of Jefferson county, the section to the Lower Kittanning is shown at several places. Professor Orton gives two measurements on Yellow creek, three miles apart:

| | Feet. | Inches. | Feet. | Inches |
|--|----------|---------|-------|--------|
| Brush Creek coal bed | 4 | 6 | 4 | 0 |
| Interval with Mahoning limestone | 60 | 0 | 67 | 0 |
| Upper Freeport, "Big vein"..... | Blossom | | 4 | 0 |
| Interval with Upper Freeport limestone | 72 | 0 | 61 | 0 |
| Lower Freeport, "Roger vein"..... | Blossom | | 3 | 0 |
| Interval with Lower Freeport limestone | 65 | 0 | 65 | 0 |
| Middle Kittanning, "Darlington".. | Blossom. | | 2 | 4 |
| Interval with thin coal..... | 23 | 6 | 22 | 0 |
| Lower Kittanning, "Creek clay," or "Potters' vein"..... | Blossom | | 2 | 0 |

The Ames limestone is 220 feet above the Upper Freeport near the second measurement. Professor Orton says that the Pittsburg is about 530 feet above the Lower Freeport and the Ames is 260 above the Upper Freeport near the first measurement, a loss of almost 50 feet in 14 miles from Smiths ferry. Southward from Yellow creek the Upper Freeport becomes uncertain and the Lower Freeport, hitherto irregular, becomes very important. The Lower Kittanning, exposed along the river for more than 10 miles below Yellow creek, is accompanied by its important clay bed. The interval between the Lower Freeport and Lower Kittanning is

* I. C. White: (Q Q), pp. 266, 272, 274.
J. S. Newberry: Vol. iii, pp. 108, 113-115.
E. Orton: Vol. v, pp. 37-38.

given to abrupt variations; within a distance of 8 miles below Yellow creek it is 89, 120, and 86 feet. The Vanport limestone seems to be represented at Elliottsville by 3 feet 6 inches of fossiliferous shale at 26 feet below the Lower Kittanning, and the Putnam hill limestone by 5 feet of fossiliferous limestone and slate at 28 feet lower. Underneath the last is the Brookville coal bed, 6 inches, resting on 10 feet of black slate. The Scrubgrass seems to be represented by black shale under the Vanport. The Upper Freeport limestone is persistent in most of the sections where its horizon is reached, but the place of the coal is occupied in some sections by a buff limestone overlying the non-plastic clay marking the horizon. At Steubenville the Lower Freeport or "Shaft coal" is 547 to 551 feet below the Pittsburg, 327 to 331 feet below the Ames limestone. The Lower Kittanning has been found at 80 to 98 feet lower in borings and the Brookville is reached in one boring at 40 feet below the Lower Kittanning. At La Grange, opposite Wellsburg, in West Virginia, the Pittsburg is 540 feet above the Lower Freeport, which is 5 feet 3 inches thick, and at 22 feet above it is a double bed, representing the Upper Freeport. The lower bed retains its thickness farther down the river, where it is 7 to 8 feet thick and good.*

Returning to the northern outcrop, one finds the Putnam Hill limestone extending into Portage county, west from Mahoning, where it overlies the Brookville coal at many places.†

Stark county, south from Portage, is west from Mahoning and Carroll. Newberry's generalized section for the county is:

| | Feet. | Feet |
|--|-------|------|
| 1. Shale and sandstone | 30 to | 50 |
| 2. Buff limestone and ore | 0 to | 6 |
| 3. Black band ore | 0 to | 10 |
| 4. Coal 7 [Upper Freeport] | 1 to | 3 |
| 5. Fireclay | .. | 1 |
| 6. Shale and sandstone, with thin coal near middle | 75 to | 110 |
| 7. Coal 6 [Middle Kittanning]..... | 2 to | 6 |
| 8. Fireclay and shale | 42 to | 65 |
| 9. Coal 5 [Lower Kittanning] | 2 to | 3 |
| 10. Fireclay, shale, sandstone | 42 to | 65 |
| 11. Putnam Hill limestone | 0 to | 4 |
| 12. Coal 4 [Brookville] | 3 to | 6 |
| 13. Fireclay | 1 to | 3 |

the last being 20 to 50 feet above the Lower Mercer, or Zoar, limestone.

* J. S. Newberry: Vol. III, pp. 103, 757, 758, 760.

E. Orton: Vol. v, pp. 50-51, 53, 55-57, 59, 61.

† J. S. Newberry: Vol. III, pp. 137, 142.

The Putnam Hill and Brookville coal are termed the "Upper limestone and coal." The coal has been mined at many places; it is best in the northern part, but deteriorates in quality toward the center of the county, sulphur and ash increasing; toward the south it becomes variable in thickness as well as quality, 1 to 7 feet; sometimes cannel, at others slaty; at times caking, at others open-burning coal. Professor Orton recognizes the Vanport in eastern Stark where a calcareous sandstone is at 30 feet above the Putnam Hill. There the Lower and Middle Kittanning are only 15 to 18 feet apart. A thin coal, marking the Clarion horizon, is seen occasionally above between the Putnam Hill and Lower Kittanning. The Lower Kittanning, usually thin but attaining 4 feet in the eastern part of the county, is accompanied by its clay and is as truly the "clay vein" here as on the Ohio river. The roof is black shale with iron ore. The Middle Kittanning, usually about 50 feet above the Lower, is 4 to 6 feet thick in the southern part of the county, but is thinner toward the north, where it becomes unimportant. The Upper Kittanning is evidently absent and the Lower Freeport is a mere blossom. The Upper Freeport is unimportant, but it is accompanied by the overlying ore which marks the horizon in several counties south and east from Stark. Professor Orton discovered the Freeport limestones in eastern Stark, but elsewhere they were not found. The sandstones are very irregular; occasionally they appear in the Freeport and Kittanning intervals, but the change into shale is abrupt.*

Carroll is between Stark and Tuscarawas at the west and Columbiana and Jefferson at the east. The Freeport coals, both thin, have been opened in the northwest townships, and the upper bed is accompanied by its underlying limestone and overlying ore. Eastward the Upper Freeport becomes important; it can be followed from Yellow creek, in Columbiana county, somewhat decreased in thickness, but in the southern part of the county it is often 4 feet 6 inches and yields good coal. The chief drawback is the frequency with which it is cut out by the overlying sandstone, and these "wants" are so common in some areas that mining operations have been abandoned. The Lower Freeport is persistent, but usually too thin to be utilized. It is rarely more than 30 feet below the Upper. The Upper Freeport limestone is present at almost all localities where its place is exposed.†

Harrison county is south from Carroll and east from Tuscarawas. The section reaches to the Lower Freeport, but that and the Upper Freeport

* J. S. Newberry: Vol. III, pp. 155, 168-169, 170, 171-176.

E. Orton: Vol. v, pp. 66, 70-72.

† E. Orton: Vol. v, pp. 72-73, 77-78, 246-247, 254-255.

are exposed only in the northwest corner of the county; elsewhere they are buried under the Conemaugh and Monongahela. Professor Bownocker gives the record of a well in the eastern portion in which a coal bed is reported at 592 feet below the Pittsburg. It is not altogether easy to determine the place of this bed, but it is very near the place of the Brookville. That coal bed at Steubenville is 673 feet below the Pittsburg, but in this portion of Harrison the interval from Pittsburg to Ames limestone is 85 feet less than near Steubenville, so that the interval to this bed is within 4 or 5 feet of what should be expected.*

Tuscarawas county, south from Stark, is west from Carroll and Harrison. The section in the northern portion differs extremely from that in the southern, but they are connected by intermediate sections showing the gradual change. Full sections have been measured by both Professor Newberry and Professor Orton in the critical localities and their records are in practical agreement, the differences being due apparently to variation in barometric readings. The sections by Newberry are as follows, one at the north and the other at the south:

| | Feet. | Inches. | Feet. | Inches |
|--|--------|---------|-------|--------|
| 1. Sandstone [Mahoning] | 60 | 0 | 30 | 0 |
| 2. Shale | 12 | 0 | 10 | 0 |
| 3. Mountain ore | 0 to 5 | 0 | 0 | 0 |
| 4. Black band | 3 to 8 | 0 | 0 | 0 |
| 5. Coal 7 [Upper Freeport] | 3 | 0 | 4 | 0 |
| 6. Interval | 70 | 0 | 35 | 0 |
| 7. Coal 6a [Lower Freeport] | Thin | .. | 2 | 0 |
| 8. Conglomerate, sandstone, shale [Freeport] | 50 | 0 | 52 | 0 |
| 9. Coal 6 [Middle Kittanning]..... | 4 | 0 | 4 | 0 |
| 10. Shale and fireclay | 33 | 0 | 29 | 0 |
| 11. Impure cannel | 1 | 0 | | |
| 12. Fireclay and dark shale | 26 | 0 | | |
| 13. Coal 5 [Lower Kittanning]..... | 2 | 0 | 2 | 6 |
| 14. Fireclay | 4 | 0 | 10 | 0 |
| 15. Shale and sandstone | 50 | 0 | 79 | 0 |
| 16. Putnam Hill limestone | 3 | 0 | 1 | 0 |
| 17. Coal 4 [Brookville] | 2 | 0 | 5 | 0 |

with to the Zoar limestone an interval of 53 and 46 feet respectively. The Brookville, as a rule, is slaty and sulphurous, with a tendency to become cannel; ordinarily thin, it becomes 5 to 6 feet thick in the southern part of the county, but with no improvement in quality. The Putnam Hill limestone carries ore, is flinty, and rich in fossils. The Lower Kittanning, important in the eastern part, is uncertain, often wanting in the western part, as in Carroll county, and the coal exhibits notable

* J. J. Stevenson: Vol. III, p. 203.
 J. A. Bownocker: Bulletin no. 1, p. 231.

variations in ash and sulphur. The underlying clay retains its importance, is often non-plastic, and is utilized in manufacture of firebrick. The interval to the Middle Kittanning varies from 50 feet in the northern portion to 20 and 30 feet in the southern part of the county. Near Zoar, on the northern border, a cannel 1 foot to 18 inches is at 16 to 26 feet above the Lower Kittanning, but it is wanting southward. The Middle Kittanning, as in Stark, is important and is the Coal 6 of central and southern Ohio. It is from 3 feet 6 inches to almost 6 feet thick, and, while varying somewhat in quality, it is usually good, always caking, though generally containing too much ash for a good merchantable coke without washing. As a rule, it is double, with a copperas band at about a foot from the top. The roof is a black shale, often carrying "large calcareous nodules or concretions, filled with beautifully preserved Coal Measure fossils" and at times becoming bony cannel in the lower portion. The bed identified with the Lower Freeport is indefinite and the accuracy of the correlation is open to question, at least for the northern part of the county. The Upper Freeport is persistent, rarely yields good coal, and is double, the parting varying from 8 inches to 15 feet. This characterizes the bed in Guernsey county.

The Vanport limestone reappears in many sections and is fossiliferous; it is seen occasionally midway in the county, but more commonly in the western portion, where the Lower Kittanning coal bed is wanting.*

Guernsey county, south from Tuscarawas, shows the whole Allegheny section in the western portion. The Upper Freeport coal bed is 200 to 255 feet below the Ames limestone. The Cambridge limestone of the Conemaugh becomes characteristic here and is an important stratigraphical guide southward. Professor Orton's section in northwestern Guernsey is:

| | Feet. | Inches |
|---|-------|--------|
| 1. Cambridge limestone | 2 | 0 |
| 2. Interval | 111 | 0 |
| 3. Upper Freeport coal bed [Cambridge]..... | Thin | |
| 4. Clay, Upper Freeport limestone | 10 | 0 |
| 5. Interval | 50 | 0 |
| 6. Lower Freeport coal bed | Thin | |
| 7. Interval | 100 | 0 |
| 8. Middle Kittanning | 3 | 0 |
| 9. Fireclay and shale | 30 | 0 |
| 10. Lower Kittanning | 2 | 6 |
| 11. Fireclay | 20 | 0 |
| 12. Interval | 16 | 0 |
| 13. Putnam Hill limestone | 4 | 0 |
| 14. Brookville coal bed | Thin | |

* J. S. Newberry: Vol. III, pp. 61-62, 64-66, 67-70.

E. Orton: Vol. v, pp. 92-93, 268, 274, 279, 282.

The Upper Freeport coal bed is from a few inches to 5 feet or more in thickness, the variations being so great that the bed is only locally important. The Lower Freeport is unimportant. A thin coal was seen at a little way northeast from the village of Cambridge, which Professor Orton is inclined to refer to the Upper Kittanning. The Middle Kittanning shows its characteristic roof, in which the nodules often contain a nucleus of sphalerite. The coal is good enough for local use and the bed is 3 to 4 feet thick. The Lower Kittanning is accompanied by its fireclay. The Brookville varies from 18 inches to 5 feet and yields poor coal. The interval to the Middle Kittanning in one township is only 26 feet, the Putnam Hill limestone being present.*

In Belmont county, east from Guernsey to the Ohio river, the Allegheny is deeply buried. No information is available for this county aside from the record of a well in Washington township 3 or 4 miles from the river, which shows only shales for 750 feet below the Pittsburg coal bed to a great sandstone which belongs to the Pottsville.†

Returning to the west: In Wayne county, west from Stark, Mr Read identifies with Coal 6, the Middle Kittanning, a bed only 25 to 30 feet above the Gray or Putnam Hill limestone. It is 2 to 4 feet thick, with black lustrous caking but sulphurous coal. It has the characteristic roof, black fossiliferous shale. The Brookville coal bed underlies the limestone and is 2 to 4 feet thick, sometimes cannel and generally slaty and sulphurous. The Freeport sandstone was seen at one locality 25 feet thick and, as in parts of Stark, Tuscarawas, Carroll, and Harrison, very coarse or finely conglomerate.‡

Holmes county is south from Wayne and west from Tuscarawas. Professor Wright's generalized section for the county is:

| | Feet |
|---|------|
| 1. Upper Freeport coal bed (7)..... | |
| 2. Shaly sandstone | 30 |
| 3. Lower Freeport coal bed (6a)..... | |
| 4. Freeport sandstone | 45 |
| 5. Middle Kittanning coal bed (6)..... | |
| 6. Shale and iron ore | 25 |
| 7. Lower Kittanning coal bed (5)..... | |
| 8. Sandy shales | 20 |
| 9. Ferriferous limestone [Vanport]..... | |
| 10. Clarion coal bed | |
| 11. Sandstone and shale | 25 |

* E. B. Andrews: Vol. II, p. 538.

J. J. Stevenson: Vol. III, pp. 223-224, 231.

E. Orton: Vol. V, pp. 82, 89, 283-285, 289.

† J. A. Bownocker: Bulletin no. 1, p. 220.

‡ M. C. Read: Vol. III, pp. 531, 535.

| | Feet |
|---|------|
| 12. Putnam Hill limestone | |
| 13. Brookville coal bed | |
| 14. Tionesta sandstone [Homewood] | 20 |

The Brookville coal and its overlying limestone are present in perhaps every township; the coal, according to Professor Wright, is from 1 to 2 feet thick and always poor; Mr Read found it 3 feet 6 inches at one locality. The Vanport is present as a gray limestone at several localities, but in some townships it is represented only by tough more or less flaggy sandstone. A Clarion coal bed underlies this limestone at many places, usually very thin and never exceeding 2 feet. From the observations of both Read and Wright, it is clear that the Lower Kittanning is present only in the southeasterly part of the county, and that westward and northward the interval between it and the Middle Kittanning disappears, permitting, as suggested by Professor Wright, the two beds to come together. In the southeast the Middle Kittanning is 64 feet above the Clarion coal and 83 feet above the Putnam Hill limestone, but on the western border the interval to the limestone is but about 35 feet at the most and to the Clarion only 22 feet. The interval in Wayne county between Middle Kittanning and Putnam hill increased southwardly from 25 to 35 feet and the increase is continuous and gradual to southeast Holmes. The Middle Kittanning is the important bed and shows the same features as in Tuscarawas—double, with sulphur near the top, the coal coking, ash purple, and the roof bone or cannel underlying the richly fossiliferous black shale. The Freeport sandstone is massive; the Lower Freeport is but a blossom. Mr Read states that the upper Freeport, 4 to 6 feet thick, is present on the western border at only 40 feet above the Middle Kittanning and accompanied by a buff limestone. In the southern part of the county the interval is 73 to 76 feet. Mr Read reports a black limestone in the eastern part of the county at 12 to 15 feet above the Brookville.*

Coshocton county is south from Holmes and west from Tuscarawas and Guernsey.

The Brookville coal bed and Putnam Hill limestone persist throughout the county; the former is from a few inches to several feet thick, but it seldom yields good coal, being so broken by partings as to be dirty, but sometimes changing into cannel or cannel slate. At varying distances, 10 to 30 feet, above the Putnam Hill is the "Black marble" overlying a coal bed. Professor Hodge observed this limestone in five townships and

* M. C. Read: Vol. III, pp. 554-555, 557-558.

A. A. Wright: Vol. v, pp. 818-819, 828, 830-831, 836, 839, 840-842.

in one the coal bed is 30 feet above the lower limestone. The place of this limestone, evidently the same with Read's black limestone of Holmes, is very uncertain, for it sometimes approaches very closely to the Middle Kittanning. It is not far from the place of the Lower Kittanning, which at one time was mined near Coshocton, where it is 30 feet below the Middle Kittanning and 44 feet above the Putnam Hill, and there the Marble is represented by a calcareous sandstone. The great variability of intervals in Coshocton county adds to the difficulty of correlating this limestone. As it overlies the coal, one may be justified in regarding it as representing the Vanport and the underlying coal as a Clarion bed; so that where it approaches closely to the Middle Kittanning the interval to and including the Lower Kittanning has disappeared as it does in Holmes county.

The Middle Kittanning, according to Professor Orton, Jr., is from 32 to 79 feet above the Putnam Hill limestone; there is no place for error in the small interval, for the section is distinct down to the Lower Mercer coal bed. The greatest interval was found near the Holmes line and the least at 8 or 10 miles south. Professor Hodge's sections show even greater variation in this interval. In the northeast corner it is 90 to 100 feet; 6 miles west it is 100; barely 6 miles farther west it is 40 to 50 feet; in the south central part of the county it is 46 to 65, but in the southern tier of townships along the Muskingum border it is 80 to 90 feet. There is no possibility of error in the identification, as the "Black marble," Putnam Hill, and Zoar (Lower Mercer) limestones are present in most of the sections and the Middle Kittanning shows the usual features throughout. The last is the important coal of the county.

Very little information is available for the higher beds. No trace of the Upper Kittanning appears.

Professor Hodge reports a 1 foot 6 inches bed at 90 feet above the Middle Kittanning, near the Holmes line, and in an adjoining township is a limestone at 65 feet above the Middle Kittanning. This may be the very fossiliferous buff limestone seen in Bedford township at 130 feet above the Putnam Hill limestone. A coal bed is in two townships at 60 to 70 feet above the Middle Kittanning and near Coshocton it is 87 feet. This bed, 60 to 90 feet above the Middle Kittanning, may be the Lower Freeport. The Upper Freeport, wholly unimportant, is reached in the northeastern part of the county, where Mr Hodge found it 115 feet above the Middle Kittanning and underlying ore and limestone as in Tuscarawas and Stark.*

* J. T. Hodge: Vol. III, pp. 570-571, 573, 578-579, 580, 582, 586-587, 589, 591.
 E. Orton: Vol. v, p. 93.
 E. Orton, Jr.: Vol. v, pp. 855-857.

Muskingum county is south from Coshocton and west from Guernsey and Noble. In the northern part of the county Stevenson recognized both Freeport coals, the Middle Kittanning, and the Brookville. The last is persistent, usually an inferior cannel, and varying in thickness from 7 inches to 4 feet. The Putnam Hill limestone is often flinty and usually carries some ore, but no trace of the Coshocton "Black marble" appears in any of the sections. A coal bed appears in one township between the Middle Kittanning and the Putnam Hill limestone, 18 to 55 feet below the upper coal and it may be at the Lower Kittanning horizon; it certainly is wanting at many localities where the exposure of the interval is complete. The Middle Kittanning shows the same features as in Coshocton and is from 80 to 105 feet below the Upper Freeport. The latter bed is worthless except in the eastern side of the county, where it is mined. The interval to the Middle Kittanning increases eastwardly. The Freeport sandstone at times fills almost the whole interval to the Upper Freeport and occasionally is conglomerate.*

The section changes somewhat in the southern part of the county, for there the Upper Freeport and the Middle and Lower Kittanning coal beds are each of them important within circumscribed areas and the Brookville coal bed becomes irregular, being reported by Professor Andrews from only three townships. It certainly is absent in many places where the exposures appear to be complete. A coal blossom appears on top of the Putnam Hill limestone in one section at Zanesville and the Clarion coal is present at Zanesville as well as at some other places at varying distances above the Putnam Hill. The Vanport limestone is present at Zanesville as a nodular bed; elsewhere it was seen by Professor Orton, who describes it as drab, weathering yellowish white, fossiliferous, and associated with iron ore. It is very near the place of the Coshocton marble, which, according to Hodge, sometimes is drab and always is fossiliferous. It is at the place of the Lower Kittanning and is never seen in this county when that coal bed is present.

The Lower Kittanning is 65 feet above the Putnam Hill limestone at Zanesville, but the interval decreases southward to 38 feet at Del Carbo. Along this line the coal is from 3 to 5 feet thick and is mined; but southward within 2 or 3 miles it disappears, and the Vanport limestone reappears at 21 feet above the Putnam Hill; farther south on the Perry County line the coal is again present and mined. Eastward from this narrow area the bed is very uncertain. It is present in Washington township east from Zanesville, and again in Perry, where Andrews reports it as 2 feet thick and 3 feet above a sandy limestone and ore, evidently

* J. J. Stevenson: Vol. III, pp. 247, 249, 250, 254, 258.

at the Vanport horizon. The Middle Kittanning is thoroughly persistent, though not always of workable thickness. It attains its chief importance along a narrow space southward from Zanesville to the Perry line, but eastward it becomes unimportant. It has the features already mentioned, but occasionally becomes triple. The Lower Freeport is reported as a blossom, but it is not always present, as sandstone often fills nearly the whole interval to the Upper Freeport. The Upper Freeport limestone is shown in many sections. The Upper Freeport coal, like the beds below, is good in the strip extending southward from Zanesville, where it is known as the Alexander coal and is about 4 feet thick, yielding a coal low in ash, though rather high in sulphur. Elsewhere for the most part it is very thin, though near the Guernsey border it sometimes is 3 feet. Everywhere it is somewhat uncertain; frequently the clay and limestone are present without any trace of coal; in others it is in patches, having been removed from intervening spaces during deposit of the overlying sandstone.*

Southward from Muskingum one enters Perry county and passes into the Hocking Valley coal field, embracing portions of Perry, Hocking, and Athens counties. This region was studied first by Professor Andrews, afterward by Mr Read, and finally the whole work was revised by Professor Orton.

Passing out of Muskingum county at Roseville, one soon reaches McLuney, in Perry, where the Upper Freeport is at 107 feet above the Middle Kittanning and is accompanied by the blackband ore which has been missing for nearly 50 miles, as the outcrop in the intervening space is too far east to catch it. Professor Orton observed long ago that the blackband is only on the border of the field, associated with thin coal, while toward the interior of the field the blackband diminished and the coal became thicker. Here the ore and coal are but 3 feet. At New Lexington, 8 or 9 miles southwest and beyond the final outcrop of the Upper Freeport, both Kittannings are mined and are from 20 to 30 feet apart, as in southern Muskingum. The Putnam Hill limestone is present here, limestone and flint, with the Clarion coal bed at 10 to 15 feet above it; but southward it changes and soon becomes worthless as a stratigraphical guide, its office in that respect being taken by the "Baird ore," 15 to 30 feet higher, the Ferriferous limestone of Andrews, the "Limestone ore" of the southern counties, which is very near the horizon of the Vanport limestone. Six miles farther south the Kittannings are both present, but the Lower is only 1 foot thick 15 feet above

* E. B. Andrews: Vol. i, pp. 320-321, 324-327, 330, 332, 334-335.
E. Orton: Vol. v, pp. 96-97, 99, 100, 878.

the Vanport and 34 feet above the Putnam Hill; thence the Middle Kittanning thickens rapidly and within 2 miles becomes the "Great vein" of Shawnee and Straitsville, 8 to 12 feet thick. The bed holds its thickness across Ward township of Hocking into York of Athens, where it is the Nelsonville coal, 6 to 10 feet thick; thence it decreases, so that in Waterloo township of Athens it is but 3 feet 6 inches and is known as the Carbondale or Mineral City seam. The Lower Kittanning appears in most of Professor Andrews's sections along this west side in Perry, Hocking, and Athens counties. The Vanport limestone with its ore is persistent and the Clarion coal bed is shown in some of the sections; but the Brookville, underlying the Putnam Hill limestone, is very indefinite south from the Muskingum line. The interval from Middle Kittanning to the Baird ore (Vanport) decreases from 45 feet at 6 miles south from the Muskingum line to 38 feet at Waterloo, in Athens county.

The higher members of the formation are followed without difficulty, but at some distance farther east. Several deep valleys on the west side of the field show the whole series, while Sunday creek, on the east side, shows the section down to the Lower Kittanning, in Monroe of Perry, Trimble, and Dover townships of Athens. Three sections suffice to exhibit the variations:

I. Moxahala, in Perry county (Read).

II. Shawnee, in Hocking county (Orton).

III. Nelsonville, in Athens county (upper part from Orton, lower by Read).

| | Feet. | Inches. | Feet | Inches | | | |
|---|--------|---------|------|--------|----------|---|----|
| 1. Upper Freeport | 4 | 6 | 3 | 0 | 6 | | |
| 2. Interval | 31 | 0 | 18 | 0 | 32 | | |
| 3. Limestone and ore | .. | .. | 2 | 0 | 3 | | |
| 4. Interval | 15 | 0 | 34 | 0 | 18 | | |
| 5. Lower Freeport | 6 | 0 | 1 | 0 | 2 | | |
| 6. Lower Freeport limestone | 41 | 0 | { | 0 | 6 | 1 | |
| 7. Sandstone or shale..... | | | | 25 | 0 | } | 34 |
| 8. Shale | | | | 20 | 0 | | |
| 9. Middle Kittanning | 12 | 0 | 10 | 0 | 8 | | |
| 10. Interval | 26 | 0 | 26 | 0 | 23 | | |
| 11. Lower Kittanning | 3 to 5 | 0 | 3 | 0 | 4 to 8 | | |
| 12. Fireclay and sandstone or clay | 9 | 0 | 12 | 0 | 15 to 35 | | |
| 13. [Vanport] ore and lime- stone | 0 | 10 | 1 | 0 | 2 to 3 | | |

The Shawnee or Upper Freeport limestone is at 18 to 30 feet below its coal bed. It rarely shows any flint, but usually carries iron ore; it is buff on weathered surface, is non-fossiliferous, and is almost as useful

in carrying the section as is the Vanport, Cambridge, or Ames limestone. The Lower Freeport limestone, Norris and Snow Fork of Orton, rarely appears in the sections. The Freeport sandstone is conspicuous at the north, but becomes indefinite southward. The Lower Freeport coal is widespread, but varies greatly in thickness; it is the Black coal of New Lexington, the Fowler of Moxahala, both in Perry; it is the Juniper and Frank coal of Waterloo, in Athens, where it is 15 to 20 feet below the Shawnee limestone and 26 feet above the Middle Kittanning. The Upper Freeport coal bed, known as "Stallsmith," "Norris," and "Bayley's run," is mined at many places, but rarely attains commercial importance. Occasionally it is 4 to 6 feet thick, but in much of the area it is wanting and its horizon can be traced only by means of the Shawnee limestone. All of the coal beds in this field, except the Middle Kittanning, are irregular, but each is workable at some locality. The interval from the Upper Freeport to the Middle Kittanning varies from 107 feet in northern Perry to 76 feet in the southern part of the county. At Nelsonville it is 100 feet, and Andrews found it about 100 feet near Athens, in the central part of the county.*

Eastward between the Hocking valley and the Ohio are the counties of Morgan, Noble, Monroe, Washington, and Meigs, in which the Allegheny is very deeply buried. A few records of oil borings are available, which afford some scanty information.

Morgan county, south from Muskingum, east from Perry and Athens, is west from Noble and Washington. On the western border a well shows the Upper Freeport coal bed, 6 feet thick, at 70 feet below the Cambridge and 206 feet below the Ames limestone. It is persistent in this oil district. The wells go no deeper. Midway in the county, at McConnellsville, a coal bed is reported at 347 feet above the Maxville limestone ("Big lime") and underlying a sandstone 44 feet thick. As the Pottsville is very thin here as compared with counties farther east, this may be Upper Freeport. It is only 276 feet from the surface, where the horizon can hardly be much more than 100 feet below the place of the Pittsburg, if Professor Andrews be accurate in his identifications.†

Noble county, south from Guernsey and east from Morgan, affords no information. A well in the extreme southern part, near Macksburg, has three coal beds at 339, 383, and 438 feet below the Ames limestone, the lowest bed being about 640 feet below the place of the Pittsburg; it is 730 feet below the Meigs coal, which is from 80 to 100 feet above the

* M. C. Read: Vol. iii, pp. 665, 679, 705.

E. Orton: Vol. v, pp. 101, 108, 112.

E. B. Andrews: Rept. for 1869, plate of grouped sections.

† J. A. Bownocker: Bulletin no. 1, pp. 142, 145.

Pittsburg. It is not easy to correlate the higher beds, all of which are below the Upper Freeport, but the bottom bed is very near the place of the Brookville.*

In Monroe, east from Noble, the available records are better than in the counties referred to. This county, south from Belmont, extends eastward from Noble to the Ohio river, there adjoining Wetzel and Tyler counties of West Virginia. In the northwestern corner, within Summit township, only 6 or 8 miles south from the Belmont line, a record shows the Pittsburg present, though very thin. Sandstone begins at 453 feet below that coal bed; it is 45 feet thick and possibly is in part Mahoning. A great sandstone, at top the Butler-Freeport, begins at 10 feet lower and is almost continuous to 678 feet, where it overlies a coal bed, the same with that seen about 20 miles to the southwest at 640 feet. The Conemaugh thickens rapidly for a few miles from the western outcrop in Guernsey and Muskingum and its bottom in this region is not far from 480 to 490 feet below the Pittsburg. The Brookville is recorded again in Perry township, where, as in Summit, it is 350 feet above the Maxville or "Big limestone," but the interval to the Pittsburg is 705 feet, showing an increase in the Conemaugh. The interval remains constant for a considerable distance eastward, for in a well on the Ohio river the Pittsburg is 1,050 feet above the Maxville; but the Brookville coal is not recorded; that bed, however, is present beyond the river, in Tyler county, at 704 feet below the Pittsburg.†

Washington is south from Monroe and Noble and east from Morgan. The intervals are greater here than on the western outcrop. At Macksburg, in the northern part of the county, toward the Morgan border, the great sandstone below the Brookville is at 760 feet below the Meigs (Macksburg) coal bed, but the Brookville coal is not recorded; all coals seem to be wanting. The sand at the Butler-Freeport horizon is 78 feet thick and is known locally as the Dunkard; its top is about 460 feet below the place of the Pittsburg. Farther southeastward, in the Cowrun region, one finds the Monroe interval again. At Macksburg the Ames is about 190 feet below the Pittsburg; on Cowrun the exposures make it about 230 feet. In the Centennial well on Cowrun the Brookville is at 701 feet below the Pittsburg, with another coal at 63 feet higher; near Macksburg the next coal is 65 feet above the Brookville. The Allegheny shows in all only 66 feet of sandstone; but it is worthy of note that here, as in the West Virginia counties east from Washington,

* J. A. Bownocker: Bulletin no. 1, p. 160.

† J. A. Bownocker: Bulletin no. 1, pp. 196, 212, 216.

I. C. White: Geology of West Virginia, vol. I, p. 356; vol. II, p. 391.

the red beds reach down into the Allegheny, for beginning at 503 feet below the Pittsburg is a great mass of red shale 64 feet thick and extending to the Kittanning horizon. In the same region Professor Andrews reports the Brookville coal bed at about 688 feet below the Pittsburg, but the interval from the Pittsburg to the well curb was not measured carefully and the difference in interval may be apparent, not real. Several miles farther south and near the Ohio the interval seems to be about 713; the measurement is approximate, but the increase is to be expected in this direction. At Marietta, 6 miles west from the last, the interval seems to be somewhat less than 725 feet, as will be seen in the discussion of the Conemaugh of this region. It is worthy of note here that in Monroe and Washington the Brookville is the only persistent coal horizon.*

Meigs county is south from Washington, along the Ohio river. Here also, for the most part, the Allegheny is deeply buried and the exposures rarely go down to the Upper Freeport, even in the western part of the county, where that coal bed is at 112 feet below the Upper Cambridge, about 85 feet below the Lower Cambridge limestone. The only available record is at Pomeroy, on the Ohio river, where the Cambridge limestone, apparently the Lower, is at 285 feet below the Pittsburg (Pomeroy) coal bed, about 40 feet more than at 6 miles west. The bottom of the Mahoning is at 431 feet, and at 15 feet lower begins a sandstone 58 feet thick. The first coal bed is at 529 feet below the Pittsburg, the second at 580, and the third at 675 feet. The first is at 210 feet below the Cambridge limestone. The lowest coal at 390 feet below the Cambridge is 10 feet above a massive pebbly sandstone, 62 feet thick, separated by 7 feet of shale from another thick sandstone, in which the well was stopped. This bottom bed appears to be the Brookville, as the interval from Pittsburg to Cambridge is fully 40 feet less than at the exposures east from Marietta, where the interval to the Ames is about 230 feet. Excepting that at 529 feet, the coals in the Pomeroy well are indefinite, being mere streaks distributed through 11 feet of shale, so that the condition at Letart, 10 miles east, in Mason county of West Virginia, is that to be expected, for there the coals are wholly absent from the Allegheny.†

Returning to the western outcrop and entering Vinton county, south from Hocking and west from Athens, one reaches the "Hanging Rock" district, embracing portions of Vinton, Jackson, Scioto, Athens, Gallia, and Lawrence counties, to the southern boundary of Ohio. In this nar-

* E. B. Andrews: Vol. II, pp. 497, 502.

E. Orton: Vol. VI, p. 399.

J. A. Bownocker: Bulletin no. 1, pp. 161, 169, 176.

† E. Orton: Vol. VI, p. 397.

row area one has the detailed measurements by Professor Andrews, supplemented by Professor Orton's close revision, made ten years later, as well as local contributions by Messrs McMillin, Bownocker, and I. C. White. Throughout most of the area the main stratigraphical guides persist, though in some portions the Ames limestone of the Conemaugh becomes shale and the Putnam Hill limestone for the most part can be followed only with uncertainty. The several coal beds are present with more or less regularity, but each of them seems to be absent from considerable areas.

In Vinton county the Upper Freeport is often absent, and when present is so thin that it appears only as a "blossom" in Professor Andrews's sections; but its place is followed easily by means of its clay and the underlying limestone, here known as the Shawnee or Buff limestone. The interval to the limestone varies from 18 feet on the northern edge of the county to 58 feet at 18 miles south, and in this distance the interval from Upper Freeport to Middle Kittanning increases from 90 to 116 feet. The Lower Freeport coal bed does not appear in any of the sections by Andrews and its existence here is uncertain. At one time the important coal bed at Hamden furnace was thought to be at this horizon, but closer study proves it to be the Middle Kittanning. That bed is present throughout, though variable and decreasing in importance southward. It is from 18 to 50 feet above the Lower Kittanning, which is present in most of the sections, though seldom more than 2 feet thick. The least interval is in the northern part of the county, but in the southern townships it rarely exceeds 25 feet. The Lower Kittanning is 10 to 20 feet above the Vanport limestone and ore, below which, at 3 to 15 feet, is the Clarion or "Limestone bed," which is persistent, triple, and 2 to 4 feet thick. The Brookville—25 to 37 feet according to Andrews, 30 to 50 feet according to Orton—below the Clarion, is usually present and is workable in four townships, yielding a good coal, though rather high in ash and sulphur. Its thickness is from 2 feet 6 inches to 6 feet 7 inches.*

In Jackson county, south from Vinton, the complete section is shown on the Gallia border, thus:

| | Feet. | Inches |
|-------------------------|-------|--------|
| 1. Upper Freeport | | |
| 2. Sandstone | 50 | 0 |
| 3. Lower Freeport | 4 | 0 |
| 4. Interval | 30 | 0 |
| 5. Sandstone | 25 | 0 |

* E. B. Andrews: Vol. I, pp. 93, 107-111, 113, 115, 117-118, 120, 124.
E. Orton: Vol. III, p. 932; vol. V, pp. 999, 1003; vol. VII, p. 280.

| | Feet. | Feet |
|------------------------------|-------|------|
| 6. Lower Kittanning..... | 2 | 6 |
| 7. Clay and shale | 27 | 0 |
| 8. [Vanport] limestone | | |
| 9. Clarion | | |
| 10. Hecla sandstone | 50 | 0 |
| 11. Brookville | 2 | 6 |

or somewhat less than 200 feet for the whole formation. The Upper Freeport, known locally as the Lucas coal, is in small areas on the hill-tops and shows 4 to 6 feet of good coking coal, but it has not been developed. The Lower Freeport is insignificant. The Middle Kittanning, known as the Sheridan coal, is double, but not important within this county. The bottom bench of the Hocking Valley field has disappeared, and there remain only the middle and upper, the latter yielding poor coal; so that, although the bed is sometimes 3 feet 6 inches thick, it is seldom worth working. It is 60 to 70 feet above the Vanport limestone and the interval to the Lower Kittanning is 32 to 44 feet. This lower bed, known as the Newcastle, is the important coal bed of the county and underlies a massive sandstone, at times conglomerate. The Clarion, 1 to 2 feet below the Vanport, and the "steadiest" coal seam in the county, is double and yields somewhat more than 3 feet of fairly good coal. The Brookville, 40 to 50 feet below the limestone, underlies the massive Clarion sandstone, known as the Hecla, and varies from 2 to 4 feet, but is not mined, as the coal has much refuse.*

In Gallia county, east from Jackson and south from Meigs, one finds the section reaching to the Lower Kittanning within the western townships, but the Allegheny is wholly buried along the Ohio. In the western townships the Middle Kittanning is about 480 feet below the Pittsburg, and the place of the Brookville, according to a boring, is 129 feet lower, or 609 feet below the Pittsburg. No well records are available for Gallia except along the Jackson border, but Doctor White gives one in Mason county of West Virginia directly opposite Gallipolis, in Gallia. It begins about 200 feet below the place of the Pittsburg coal bed, the figures being approximate only, as that coal bed is wanting at Gallipolis, though it was found by Andrews, very thin, at a few miles back. In this well the first coal bed is at 472 feet and the second at 238 feet lower, or 710 feet below the Pittsburg. The relation between the coal beds is that between the Upper Freeport and the Brookville in western Gallia, and in this well the bottom coal bed rests, as in western Gallia and at so many other places farther north, on a great sandstone. It is evidently

* E. B. Andrews: Vol. 1, pp. 154, 159, 160-161.
E. Orton: Vol. v, pp. 1026-1031.

the Brookville, and the increased interval as compared with 10 miles farther west is in accord with what has been found all the way southward, but the actual interval from the Pittsburg is probably barely 700 feet.*

Returning to the western outcrop in Scioto, one finds the whole section on the Lawrence border, where at Panther hill the thickness of the formation is barely 175 feet. At a few miles east, in northern Lawrence county, Mr McMillin's section shows all of the coal beds present except the Clarion and the total thickness is approximately 200 feet. The Upper Freeport, in most of the region unimportant, reaches great development in the Waterloo field of northern Lawrence and the adjacent part of Gallia, where it was first correlated accurately by Mr McMillin. It is a double bed, 5 to 6 feet thick. The Lower Freeport is persistent within a broad strip of western Lawrence, where it is commonly about 4 feet thick and is known as the Hatcher bed. The Middle Kittanning (Sheridan, Coal 6) is a "steady and excellent seam," usually more than 3 feet thick and yielding in many places an open burning coal. It is a double bed, apparently without the lower or bottom bench of the Hocking valley. The Lower Kittanning (Newcastle) is a good coal, 3 feet 6 inches thick in the western part of the county. The Clarion (Limestone coal), underlying the Vanport, enters from the north as an important bed, but decreases quickly southward and eastward and disappears, but the Brookville persists, though becoming thinner southward and worthless throughout.

Sections by Professor Orton, Doctor White, and Mr McMillin have been measured on the Ohio at and above Ironton, on the southern border of Lawrence county, which make the thickness of Allegheny 240 feet, showing a notable increase in 12 miles southward. No sections have been obtained along the easterly side of the county along the Ohio, as the character of the surface prevents exposures; nor are there any well records; but at Central City, in Cabell county of West Virginia, 10 or 12 miles southeast from Ironton and at the same distance from Mr McMillin's measurements in northern Lawrence, a well record shows black slate at 670 feet below the Pittsburg coal bed, with a limestone at 203 feet above it. This is the relation of the Shawnee limestone and Brookville coal farther west. The interval, Pittsburg to Brookville, is 630 at Ironton, about 700 feet at Gallipolis, and in each case, as here, the great sandstone of the Pottsville begins below the coal. The black shale at

* E. Orton: Vol. v, pp. 1028, 1049-1050.

I. C. White: Geology of West Virginia, vol. 1, p. 273.

J. A. Bownocker: Bulletin no. 1, p. 279.

Central City represents the Brookville coal bed, which has persisted more thoroughly than any other from Tyler county of West Virginia and Monroe of Ohio.*

KENTUCKY

Passing over into Kentucky, one enters Greenup county opposite Lawrence of Ohio. The Allegheny area is bounded at the west by the Little Sandy river, which flows northward from Elliott county through Carter and Greenup to the Ohio river, reaching that stream at about 10 miles below Ironton. Boyd county, east from Greenup, extends to the Big Sandy river, the state line. Professor Crandall's generalized section for Greenup, Boyd, and Carter counties is:

| | Feet |
|--|------|
| 1. Sandstone [Buffalo and Mahoning]..... | 75 |
| 2. Coal bed 9 [Upper Freeport]..... | |
| 3. Sandstone and shale | 50 |
| 4. Coal bed 8 [Lower Freeport]..... | |
| 5. Shale and sandstone | 40 |
| 6. Coal bed 7 [Middle Kittanning]..... | |
| 7. Shale and sandstone | 40 |
| 8. Coal bed 6 [Lower Kittanning]..... | |
| 9. Sandstone or shale | 13 |
| 10. Ore and limestone [Vanport]..... | |
| 11. Shale and sandstone | 30 |
| 12. Coal bed 5 [Brookville]..... | |
| 13. Interval | 37 |
| 14. Coal bed 4 [Tionesta]..... | |

Two limestones are important in these counties; the lower, or First Fossiliferous, is between the Freeport coal beds at 10 to 25 feet above the Lower, and is present in all sections where not cut away by the Butler sandstone; it is often termed the "Yellow limestone," as is the Shawnee, its equivalent in Ohio. It seems to be non-fossiliferous in Ohio, but in Kentucky it carries a characteristic Carboniferous fauna. The Second Fossiliferous limestone is in the Conemaugh and is the Lower Cambridge of southern Ohio. These two limestones are persistent and enable one to carry the section where the coal beds are absent or concealed. The Vanport limestone is practically continuous along the western outcrop into Elliott county, beyond which it has been recognized at a few points in Morgan county as well as in northern Breathitt farther south; but in both Morgan and Breathitt the localities are somewhat widely separated and the continuous outcrop ends in Elliott. This limestone seems to be

* E. Orton: Vol. III, p. 928; vol. v, pp. 1038, 1046, 1054.
 E. McMillin: Vol. v, p. 122, and personal communication.
 I. C. White: Bulletin no. 65, p. 135.

non-fossiliferous throughout Kentucky. It is accompanied, as in Ohio, by an important iron ore; this at one locality in Elliott county is so loaded with quartz pebbles as to be worthless. Eastwardly the Vanport limestone disappears along the Ohio river at about 4 miles below Catlettsburg, and its eastern limit appears to be a line extending almost due south from Ashland on the Ohio for about 30 miles into southern Lawrence, beyond which information is lacking. The ore persists eastwardly for a short distance beyond the limestone, but it too disappears before the state line has been reached.

The Clarion coal bed is wanting along the Ohio river; the Brookville is missing in a section below Hanging Rock, but is present near Ironton and persists thence to where it passes under the river. It is not reported at Catlettsburg on the state line. The Clarion (Hecla) sandstone overlies the Brookville and in one section fills the whole interval to the Vanport limestone. The Lower and Middle Kittanning, Lower and Upper Freeport coal beds are apparently persistent along the Ohio border, but the only one holding its thickness is the Lower Kittanning. The Middle Kittanning, 7 feet thick at Ironton, becomes a mere trace at Catlettsburg, while the Freeport beds are thin everywhere. A massive sandstone overlies the Lower Kittanning and near the West Virginia border another underlies it, no doubt continuous with the Clarion, as the Vanport limestone has disappeared.

Along the western outcrop in Greenup, Carter, Elliott, Morgan, and northern Breathitt the exposed section rarely extends much above the Vanport horizon, though occasionally it includes the whole formation. In Greenup and Carter the Clarion coal bed appears occasionally directly under the Vanport limestone and resting on the Clarion sandstone; but the bed is so irregular throughout that it is not included in the numbered scale. The Brookville is present in those counties wherever its horizon is exposed, but in Elliott no trace of it has been discovered, and there is no certainty that it exists in Morgan; there seems, however, to be no doubt respecting its presence in northern Breathitt, where Mr Hodge's sections showing the Vanport limestone are sufficiently clear. In that county it is from 20 to 50 feet below the limestone, the interval varying as in Carter county. At one place it seems to be triple, the benches in a vertical space of 20 feet, and the interval to the Vanport is filled with sandstone, the Clarion. The Brookville, usually either cannel or splint, rarely attains economic importance.

The Kittannings seem to be traceable into Elliott and the Middle is occasionally workable. The Lower Freeport, usually thin, apparently

disappears before reaching Elliott county. The Upper Freeport is seen rarely. In Elliott county the rocks of the Allegheny become coarse, this condition becoming more marked southwardly, so that beyond that county the section above the Vanport horizon can be followed only with extreme difficulty. The Lower and Middle Kittannings should be reached in northeast Breathitt, where the section extends at one locality to 450 feet above the Tionesta coal bed, or to about 350 feet above the place of the Vanport limestone.*

In Boyd and Lawrence counties, east from the narrow outcrop, the Brookville seems to be persistent. Ordinarily it is thin, but in central Lawrence, near Louisa, it is a mass 10 feet 8 inches thick with this structure:

| | Feet. | Inches |
|--------------------------|-------|--------|
| Coal | 0 | 8 |
| Shale | 1 | 8 |
| Coal and sandstone | 0 | 7 |
| Shaly coal | 3 | 0 |
| Impure coal | 2 | 3 |
| Coal | 2 | 6 |

The Kittannings and the Lower Freeport are generally present, but the Upper Freeport is absent in considerable areas. The Butler sandstone is often continuous with the Mahoning above and at times extends downward, so as to cut out the Upper Freeport (First Fossiliferous, Shawnee) limestone. It is quite possible that the absence of the Clarion in so much of Kentucky is due to the upward extension of the Clarion sandstone. In southern Lawrence the coal beds become uncertain and in some of the sections they seem to be wholly wanting. In much of Johnson county, south from Lawrence, the Allegheny has been removed, but it is probable that the whole section is preserved in portions of Martin county, east from Johnson, along the West Virginia line; the tracing, however, is not sufficiently close to make possible the correlation of coal beds.

Still farther south the conditions become very complex; the coal beds divide, the intervals thicken, and the true relations will be determined only by patient tracing in detail. Correlations offered by Professor Crandall and Mr Hodge as the result of rapid reconnaissance must be accepted, in accordance with their suggestion, as merely tentative. The

* A. R. Crandall: Geol. Survey of Kentucky, Greenup, Carter, and Boyd counties, pp. 22, 33, 49, 53, 59, 63; pl. 1, 25; fig. 2, 26; fig. 1, 31; sections 34, 35, 51-52, 56, 58-59, 61-62, 69, 78, 82; Elliott county, pp. 10, 11-13; Morgan, Johnson, and Magoffin, p. 17.

J. M. Hodge: Southeastern Kentucky coal fields, p. 107, sections 56, 81, 84-85, 87.

work by those observers seems to show that Allegheny beds extend south-westwardly to not less than 75 miles beyond Martin county.*

WEST VIRGINIA

Returning now to the east side and entering West Virginia in Monongalia county, west from Chestnut ridge, one may follow thence to the Kanawha river the easterly boundary of the Allegheny and afterward, mostly by means of oil-boring records, trace the section across the state to make connection with Ohio.

Morgantown is about 8 miles south from the Pennsylvania line. The exact section there was obtained by Doctor White's measurements of a core. Other measurements by him between that place and Webster, 25 miles southward, in Taylor county, may be grouped with that at Morgantown:

- I. Near Morgantown, 9 miles south from Pennsylvania line.
- II. Booth's creek, 6 miles south from Morgantown.
- III. White Day, 12 miles west of south from Morgantown.
- IV. Valley Falls, 20 miles west of south from Morgantown.
- V. Webster, 5 miles southeast from Valley Falls.

| | I | | II | | III | | IV | | V | |
|--|------|-----|----------|-----|------|-----------|------|-----|-----|----|
| | Ft. | In. | Ft. | In. | Ft. | Ft. | In. | Ft. | In. | |
| 1. Pittsburg coal | | | | | | | | | | |
| 2. Interval | 561 | 0 | ... | .. | .. | { } | | | | |
| 3. Upper Freeport coal..... | 5 | 0 | 6 | 0 | 3 | { 7 8 } | | 624 | 0 | |
| 4. Fireclay | 7 | 0 | } 60 0 | } | | { 55 0 } | | | | |
| 5. Sandstone [Butler] | 53 | 0 | | | | | | | | |
| 6. Lower Freeport coal..... | Thin | | 4 | 0 | | | 8 9 | | 2 | 0 |
| 7. Shales and fireclay | 22 | 0 | } | } | } 87 | { 16 0 } | | | 53 | 0 |
| 8. Sandstone and fireclay .. | 7 | 0 | | | | | | | | |
| 9. Black shale, sandstone... | 15 | 0 | ... | .. | .. | { } | | | | |
| 10. Upper Kittanning coal... | 2 | 10 | ... | .. | .. | { 1 0 } | | | | |
| 11. Shales, fireclay | 32 | 6 | 120 | 0 | .. | { 37 0 } | | | | |
| 12. Middle and Lower Kittanning coal | 8 | 0 | ... | .. | 15 | | 5 0 | | 4 | 9 |
| 13. Fireclay shale | 15 | 0 | | | | | | | | |
| 14. [Kittanning] sandstone .. | 54 | 2 | ... | .. | 57 | | 45 0 | | 44 | 0 |
| 15. Shale | 2 | 4 | | | | | | | | |
| 16. [Brookville] coal | 1 | 6 | 2 | 3 | 5 | | 1 2 | | 5 | 10 |
| 17. Fireclay, shale | 21 | 6 | ... | .. | 13 | | 25 0 | | 10 | 0 |

to the Pottsville sandstone. At Morgantown the Lower Freeport coal is 627 feet below the Pittsburg coal bed and at Webster it is 624 feet. At Morgantown the Upper Freeport is 274 feet below the Ames limestone;

* A. R. Crandall: Greenup, etc., pp. 68-69, pl. 28, figs. 2, 4, 30; fig. 7, 31; fig. 5; Morgan, etc., p. 21.

at Grafton, a few miles northwest from Webster, it is 250, and at Webster it is about 255, assuming the same interval to Lower Freeport as at Valley Falls. At Valley Falls the interval from Lower Freeport to Brookville is only 88 feet, but at Webster it is 102 feet. At the latter locality the sandstone below the Brookville is practically continuous for 220 feet, to the bottom of the boring.

The Allegheny is about 250 feet thick near Morgantown, but the thickness decreases southwardly; on Booth's creek it is 192 plus the interval between Brookville and Pottsville; on White Day it is 179; at Valley Falls, 196 feet 7 inches, and at Webster not more than 175 feet, thus showing a loss of at least 75 feet in less than 25 miles. The writer is responsible for the correlations, the local names for the beds being different in many places from those given. The lowest bed on Booth's creek is known locally as the Lower Kittanning and the lowest at Webster as the Lower Freeport.

It is necessary to give the relations in detail for this area, as it is the critical area for determination of the relations farther south. Within this area one observes the somewhat abrupt change from the Pennsylvania section to that of the eastern outcrop in West Virginia. The section at White Day enables the writer to correct his identification of the Brookville at Webster with the Lower Kittanning in the tentative correlation offered in description of the Pottsville section for the eastern outcrop. This correction makes necessary the transfer of the Roaring Creek sandstone to the Pottsville, but it in no wise affects the conclusions respecting the Pottsville of the Kanawha area.

On Deckers and Booths creeks of Monongalia county a dark shale, the Uffington of I. C. White, intervenes between the Upper Freeport coal and the overlying Mahoning sandstone. It is extremely rich in marine fossils and in many ways closely resembles the dark shale associated with the Brush Creek limestone of the Conemaugh.*

Ascending the Valley river from Webster, one finds at Moatsville, in Barbour county, the great sandstone of the Webster boring forming bold cliffs with, as at Webster, a variable coal bed at 10 feet above it. This bed, 3 feet thick at Moatsville, is 12 feet 6 inches half a mile away, where it has a sandstone parting 8 feet. The bottom of this Brookville coal bed at Moatsville is 149 feet below the top of a 3-foot coal bed, but at the other locality the interval is 147 feet. The upper bed is the Upper Freeport. At 5 miles southeast from Moatsville a record and boring at the Hall well show the Lower Freeport at 607 feet below the

* I. C. White: *Geology of West Virginia*, vol. Ia, p. 151; vol. II, pp. 230 and 346, 233, 356 and 605, 347, 355.

Pittsburg and 295 below the Ames limestone. The Brookville is at 105 feet lower, or 712 feet below the Pittsburg and 538 feet above the red shale of the Lower Carboniferous. At Philippi, 4 miles farther south-east, a boring shows the Lower Freeport at 106 feet above the Brookville, the latter at 522 feet above the red shale. There the Lower Kittanning is 3 feet thick and 25 feet above the Brookville. Doctor White gives a combined exposure and record just below Philippi, thus:

| | Feet. | Inches |
|---|-------|--------|
| 1. Sandstone and shale | 70 | 0 |
| 2. Upper Freeport coal | 3 | 0 |
| 3. Concealed and sandstone | 75 | 0 |
| 4. Upper Kittanning coal | 4 | 3 |
| 5. Concealed, shale, sandstone | 40 | 0 |
| 6. Middle and Lower Kittanning coal | 6 | 0 |
| 7. Shale | 15 | 0 |
| 8. Clarion [Brookville] coal | 2 | 0 |
| 9. Shale | 10 | 0 |
| 11. Roaring Creek sandstone [Pottsville]..... | | |

making the interval from Upper Freeport to Brookville 140 feet and the whole thickness of the Allegheny 155 feet. The relation of the Brookville to the Pottsville is the same as at Webster and Moatsville, as well as at Newburg, in Preston county, 10 or 12 miles east from Webster. The Freeport sandstone overlying the Upper Kittanning is coarse and much of it is pebbly. A limestone is present at a few feet above the Brookville coal at Webster, Moatsville, Valley Furnace, and at Meriden below Philippi. It was used as a flux at Valley Furnace, where it is 10 feet above the coal; this is suggestive of the Putnam Hill horizon. The Roaring Creek sandstone, about 60 feet thick, is continuous with the lower sandstones in much of the area southward, and, forming bold cliffs, makes easy the tracing of the coal bed. The Brookville (Arden, Roaring Creek) coal bed retains its place at 10 to 15 feet above the sandstone, constantly rising, so that near the southern border of Barbour county it is 200 feet or more above the Valley river. The structure is complex, there being nine layers of coal and shale, in all 14 feet thick, with one bench of coal 3 feet 1 inch.*

From this locality southward the Brookville is high up in the hills and no detailed section of the rocks above it is available until one reaches the Kanawha waters. The bed retains its tendency to divide and is from 6 to 10 feet thick in Randolph south from Barbour. In Webster, south from Randolph, it is from 5 to 7 feet thick and its top bench is

* I. C. White: *Geology of West Virginia*, vol. Ia, pp. 346, 348; vol. II, pp. 297, 312, and 605, 357, 360, 425.

occasionally either splint or impure cannel. Overlying the coal in this county is a succession of massive more or less pebbly sandstone, shown on one knob in three benches, but with the intervals concealed. The thickness is 200 feet. This great sandstone mass, the Charleston sandstone of M. R. Campbell, is a conspicuous feature from Randolph county southward. Passing over into Nicholas county, one finds the blossom of the Brookville near Gilboa under 150 feet of massive pebbly sandstone, all other coal beds appearing to be absent. Two miles west from this locality the Kanawha black flint appears, just over the Brookville coal bed and under the great mass of sandstone. In western Nicholas, the Flint is 8 feet thick and 10 feet above the Brookville, which is triple, two of the benches being splint. From this locality, Doctor White has followed the Brookville eastward and southward; it breaks into many benches and the shale partings show great variations in thickness. At Powell mountain in this county the section is:

| | Feet. | Inches |
|--|---------|--------|
| 1. Massive pebbly sandstone | 180 | 0 |
| 2. [Upper Freeport] coal | 5 | 0 |
| 3. Concealed | 5 | 0 |
| 4. Massive sandstone | 85 | 0 |
| 5. [Kittanning] coal | Blossom | |
| 6. Sandstone, shale | 50 | 0 |
| 7. [Brookville] coal, including shale 10 feet..... | 15 | 3 |

At this Nicholas locality one is on the waters of Gauley river, along which the Brookville coal bed is seen in all the hills to the Kanawha river, in Fayette county, where one has this section at the mouth of Armstrong creek:

| | Feet. | Inches |
|---|-------|--------|
| 1. Massive sandstone | 80 | 0 |
| 2. Shale | 10 | 0 |
| 3. Number 5, block [Kittanning] coal..... | 5 | 4 |
| 4. Concealed | 5 | 0 |
| 5. Massive sandstone | 65 | 0 |
| 6. Concealed | 5 | 0 |
| 7. Kanawha black flint | 10 | 0 |
| 8. Shales, concealed | 12 | 0 |
| 9. [Brookville] coal | 3 | 6 |

Number 9 is the Stockton coal bed of the Kanawha region. The exact relations of the "Number 5" coal bed can not be determined. The interval between it and the Stockton shows great variation along the Kanawha, but the bed is characteristic throughout, its coal differing from that of any other bed in the section. It is apparently the intermediate bed occasionally seen farther north and doubtless represents a Kittanning

horizon. The Flint holds the place of the limestone seen in Barbour county.*

Returning now to Barbour county at the north, another line may be followed to the Kanawha river at Charleston.

At many places along the Valley river as well as in the Roaring Creek region, one finds at 10 to 25 feet below the main Brookville another bench resembling the main coal in structure, but usually of inferior quality.

The Brookville (Arden, Roaring Creek) coal bed is mined at many localities in Barbour, Upshur, and Randolph counties, in what is known as the Roaring Creek field, where it usually yields, after removal of partings, about 7 feet of coal. In its tendency to break up into many benches it resembles the Upper Freeport of southern Pennsylvania even more than it does the Brookville in that area, and this resemblance, added to the presence of the great overlying sandstone, led Stevenson into the mischievous error of correlating this bed with the Upper Freeport. The variations in thickness and quality are extreme, there being at one locality, according to Stevenson, 22 feet of shale and coal, wholly worthless, while at a short distance away the bed is double and only 4 feet 6 inches thick. Doctor White's sections show it in this area 10 feet or less above the Roaring Creek (Pottsville) sandstone and underlying a massive pebbly sandstone often unbroken for 60 feet.

The Buckhannon enters Valley river at about 5 miles south from Philippi. In ascending this stream one goes southwest for somewhat more than 5 miles and the Brookville coal bed remains above water level; but at the Barbour-Upshur line the direction is changed to west and the coal goes under quickly, so that at Buckhannon, 12 or 13 miles southwest from Philippi, it is thought by Doctor White to be not less than 300 feet under the stream's bed. Southward from that place it rises rapidly, and at Cutrights, where it is thought to be about 80 feet under the river, the exposed section is:

| | Feet |
|---------------------------------|---------|
| 1. Silicious limestone | 5 |
| 2. Concealed, red shale | 70 |
| 3. Massive sandstone | 30 |
| 4. Coal | Blossom |
| 5. Marly shale, concealed | 35 |
| 6. Massive sandstone | 25 |
| 7. Concealed | 50 |
| 8. Coal | 3 |
| 9. Fireclay and shale | 6 |
| 10. Massive sandstone | 30 |
| 11. Concealed to stream | 25 |

* I. C. White: Geology of West Virginia, vol. II, pp. 363-366, 368-369, 370-371, 459.

A thin coal bed is reported here just below the section in the river bed. The coal bed, number 8, is between 140 and 150 feet above the Brookville; it comes down to the railroad grade within a short distance, where it underlies a black shale filled with marine fossils. As the coal bed is in the place of the Upper Freeport, this is evidently the Uffington shale of the Morgantown region. At Sago, 7 miles south from Buckhannon, the Brookville comes up, 4 feet 6 inches thick and 10 feet above the massive Roaring Creek sandstone; but at 3 miles farther south the bed is double, the upper part, more than 3 feet thick, being largely cannel shale, while the lower portion, 11 feet 11 inches thick, is in 8 layers of coal and shale and still only 10 feet above the sandstone. Here the Upper Freeport is 150 feet above the Brookville, 4 feet 2 inches thick and in 5 benches of coal and slaty coal. It overlies a massive sandstone, but the interval to the Brookville is mostly concealed. At Alexander, 15 miles south from Buckhannon, the Brookville is far up in the hills, 13 feet thick and 10 feet above the Roaring Creek sandstone, with another massive pebbly sandstone, 60 feet thick, beginning at 5 feet above it. The most remarkable feature in this whole region is the uniformity of the interval between the Brookville and Roaring Creek sandstone, which varies little from 10 feet in an area of more than a thousand square miles.

On the east side of Lewis county, about 6 miles west from Buckhannon, a well record is given by Doctor White on the authority of Mr F. H. Oliphant. This shows the great sandstone overlying the Brookville 80 feet thick, but divided midway by 20 feet of shale, a breaking up in the westerly direction, which, as will be seen, becomes so marked that this, like the other sandstones of the whole section, can be traced with little certainty. The coal bed, 12 feet thick, is said to be 775 feet below the Pittsburg, and no higher coal is noted in the record. Near Ireland, in southern Lewis, and about 12 miles west from Alexander, in southern Upshur, a section and boring combined show coal 3 feet 5 inches at 612, a thin coal at 697, and a third, not measured, at 721 feet below the Pittsburg. The highest bed is evidently the Lower Freeport, and the interval would place the lowest at the Brookville horizon, though the distance to the Pittsburg is about 50 feet less than that assigned farther north. At a few miles south the Brookville is exposed, 13 feet thick, with a sandy parting which occasionally becomes 8 feet of sandstone. The coal above is soft, but that below the parting is splinty. Many well records exist for Lewis county, but for the most part they are incomplete, noting only the sandstones.

Passing over into Braxton county, west from Webster and southwest from Lewis, one finds at 5 miles east from Sutton the Upper Freeport (Mason) coal 150 feet above the Brookville, 22 to 24 inches thick and underlying 3 feet of dark plant-bearing shales on which rests a 3-inch coal bed. It is 160 feet below the first red bed. This interval of 140 to 150 feet between Upper Freeport and Brookville prevails in most of this area of Upshur, Lewis, Webster, and Braxton counties, though occasionally it is a little less, as Doctor White's section in western Webster, near the Braxton line, shows:

| | Feet |
|---|------|
| 1. Concealed and deep red shale | 40 |
| 2. Concealed, massive sandstone | 140 |
| 3. [Upper Freeport] coal bed | 2 |
| 4. Concealed, massive sandstone, pebbly | 130 |
| 5. Dark shale | 5 |
| 6. [Brookville] coal bed | 10 |
| 7. Concealed, massive sandstone | 160 |

Here the Brookville shows the sandstone parting 3 feet thick, and the coal of both divisions is poor. The great sandstone mass, Charleston of Campbell, is well marked thus far west. The Brookville passes under Elk river $2\frac{1}{2}$ miles from Sutton, and, just before passing under, it apparently breaks up as it does farther north, the section being

| | Feet. | Inches |
|----------------|--------|------------|
| Coal | 0 | 0 to 10-12 |
| Interval | 30 | 0 |
| Coal | 3 to 2 | 6 |

and the lower division is splinty. The bed shows much variation in a little area of a few square miles, but remains comparatively thin, seldom exceeding 5 feet. At a mile and a half below Sutton the coal is 160 feet below the surface, 6 feet thick, underlying the massive white sandstone 80 feet thick and resting on the Pottsville sandstone, which is continuous for 280 feet. The Upper Freeport is below the surface here. At 5 or 6 miles below Sutton, near Frametown, in southern Braxton, a coal 2 feet 6 inches is present at 550 or possibly 600 feet below the Pittsburg, 140 feet below the lowest red bed of the Conemaugh and just above a massive sandstone; it is evidently the Upper Freeport. At many places in Braxton and Lewis the Upper Freeport is overlain by dark shale carrying great numbers of plant impressions.

Thus far the tracing of the section has been comparatively simple. The thickness of the Allegheny decreased from 250 feet near the Pennsylvania line to barely 175 feet in southern Taylor county; thence to

southern Braxton it has varied from 150 to 165. In much of the area the Upper Freeport has been accompanied by its plant-bearing shales and in most of the area the interval to the Brookville coal bed has been occupied by sandstone; whether or not an intermediate coal bed is persistent is uncertain; it is wanting in the well records.

For a distance of about 16 miles from Frametown no sections are available, but at Clay Courthouse, in Clay county, southwest from Braxton and northwest from Nicholas, is a section by Doctor White, thus:

| | Feet |
|--|--------|
| 1. Concealed with much red shale | 90 |
| 2. Coarse pebbly sandstone | 60 |
| 3. Concealed, shales, some red | 100 |
| 4. Massive sandstone, large quartz pebbles | 60 |
| 5. Concealed and sandy shales | 130 |
| 6. Coal bed | 2 to 3 |
| 7. Fireclay, shale | 10 |
| 8. Sandstone, massive, pebbly | 90 |
| 9. Concealed and sandstone | 160 |
| 10. Black shale and thin coal | 3 |
| 11. Massive sandstone and concealed | 100 |

As Number 10 is just below the Black Flint, it is at the Brookville-Stockton horizon. The interval between this bed and Number 6 is too great, the measurements having been made without regard to the dip, and the thickness is probably nearer to 230 feet. This is 90 feet more than the interval between the Brookville and Upper Freeport at 12 miles eastward in northern Nicholas. Associated with the upper bed are plant-bearing shales, from which were obtained the specimens discussed by Mr David White, who referred them to the Freeport horizon. The Brookville is much degraded at Clay, being merely black shale with streaks of coal.

Five miles below Clay, near Yankee Dam, the upper coal bed is 3 feet 4 inches thick and 310 feet above the Coalburg coal bed, somewhat less than at Clay, where the interval is about 330 feet. This, if the interval between the lower coals remain the same, would place the upper bed at about 210 feet above the Brookville-Stockton. The Upper Freeport here is 150 feet below the top of a great pebbly sandstone on which rest reddish shales succeeded by deep red beds.

According to Doctor White, this bed is traceable in the river hills from the Yankee Dam locality to and beyond Queens shoals; at that place, 10 miles west from Clay, the coal is 175 feet above the Black Flint, with 200 feet of mostly massive pebbly sandstone intervening between it and the first red beds of the Conemaugh, which are 410 feet

above the flint. The Stockton coal bed appears 2 miles farther up the river at 7 feet below the flint which is in the river bed at the shoals. At Clendenin, 5 miles below the shoals, the upper bed is mined at the water's edge, and it soon goes under, to come up again at 5 or 6 miles from Charleston, where it is mined at the Graham mines near Mason. On Two-mile creek, near Charleston, Doctor White's section is:

| | Feet |
|--------------------------------------|------|
| 1. Sandstone and concealed | 85 |
| 2. Sandstone, massive, pebbly | 75 |
| 3. Mason coal bed | 2 |
| 4. Shales | 10 |
| 5. Sandstone, coal near middle | 120 |
| 6. Shales | 10 |
| 7. Black flint | 5 |
| 8. Shale | 2 |
| 9. Stockton coal bed | |

The Mason coal bed is that mined at Mason, Clendenin, and Queens shoals, the interval to the Flint having decreased 35 feet from the last place. At all of these localities it underlies a bed of shale rich in fossil plants which have been studied by Mr David White. Comparison of the flora from this bed with that obtained at Clay leads him to regard the beds as at different horizons, the bed at Clay being Freeport and that at Queens shoals nearer to the Kittanning. Mr M. R. Campbell comes to the same conclusion on stratigraphical grounds. Detailed sections between Clay and Queens shoals are unpublished; lacking those, one may make use only of such material as is available. The interval from Upper Freeport to Brookville evidently decreases westward from Clay, losing 20 feet in 5 miles; at Queens shoals, 5 miles farther, the interval between the upper coal and the Brookville is about 187 feet, 23 feet less than below Yankee Dam, while at Charleston, somewhat more than 20 miles southwest from Queens shoals, the interval is but 147 feet. As will be seen in succeeding paragraphs, the interval between this Mason coal bed and the Brookville shows much variation along the Kanawha southeast from Charleston.*

Ascending the Kanawha river from Charleston, one finds the interval between the Mason and Brookville-Stockton increasing from 135 feet at Porters run to 198 feet at Witchers run, 14 miles southeast. The intermediate coal, noted in the Two-mile section and known as the "Number 5, block," is very thin and only its blossom has been seen thus far, but at North Coalburg, 2 miles farther up the river, it is 3 feet 10 inches thick,

* David White: Bull. Geol. Soc. Am., vol. 11, pp. 171-173.

M. R. Campbell: Jour. of Geol., vol. xi, pp. 462, 465, 467.

90 feet below the Mason and 65 feet above the flint. The Stockton is concealed here, but at Coalburg the coals are all shown and the interval from Mason to Stockton is 186 feet. The "Block" is mined at a number of places farther up the river at 41 to 75 feet above the flint, but no higher bed is exposed until near the Fayette County line, where, at lock number 3, a bed supposed to be the Mason is at 206 feet above the flint, 40 feet more than at Coalburg and 76 feet more than at Porters run, near Charleston. Whether this be the Mason or not can not be determined, intermediate measurements being wanting.

At Coalburg the Mason is accompanied by its plant bed. The coal is insignificant near the eastern outcrop, but it becomes 17 feet thick, partings included, near Coalburg, whence northwestward it decreases so as to become insignificant as it approaches Charleston, though, as already seen, it becomes economically important along Elk river, northeast from that city. The "Block" is a valuable bed on the upper Kanawha, yielding an excellent open-burning coal coming out in blocks. The thickness of this part of the bed near the Fayette border is from 5 to 6 feet; down the river, however, the thickness decreases, and at Coalburg it is 2 to 3 feet, but retaining its "blocky" feature; thence it quickly diminishes, and near Charleston it is only a few inches and is often wanting, cut out by the sandstone. A thin coal bed occurs at some places just above the flint, but it appears to be absent at Charleston. The flint varies from 5 to 10 feet; changes from tough typical flint to silicious shale and usually is fossiliferous, as is also the shale associated with it. The interval to the Stockton-Brookville coal bed is from nothing to 18 feet. This bed is so irregular that it is of uncertain value economically. One of its partings thickens at times so as to separate the divisions into two distinct beds, and the parts are known as the Stockton and Lewiston. At times one or the other of the divisions is wanting. The coal varies from splint to cannel, but usually one finds some layers of soft coal.

The Charleston sandstone of Mr Campbell includes the great mass of sandstones succeeding the flint along the Kanawha and its tributaries. It is the "series of coarse sandy or conglomeratic beds which separates the Kanawha formation from the red and green shales and green sandstones of the formation next above." The Kanawha formation has the flint as its upper boundary; the formation above the Charleston sandstone is termed Braxton by Mr Campbell. The sandstone, made up of beds of coarse material separated by shales and coal beds, is about 300 feet thick at Charleston, but farther south on Coal river, in Boone county, it is about 400. At a little way northwest from Charleston it is

at least 405 feet, but near Winfield, in Putnam county, it is apparently only 175 feet.*

This great mass of sandstone, coarse and in many portions pebbly and marking the eastern border of the field, includes not merely the Allegheny but also the lower part of the Conemaugh. It is in a narrow strip, with a width of not far from 25 miles in a northwesterly direction. It is not characteristic of the Pennsylvania and Maryland area east from the Alleghanies; it is not found in the southward continuation of the First Pennsylvania bituminous basin until one reaches Randolph county, though suggestions of it occur farther north; thence to the Kanawha the sandstone appears in increasing quantity and coarseness, so that the several sandstones which have been recognized and named in the northern portion of the field become practically continuous. The great mass and coarseness of these beds in Webster, Braxton, Nicholas, Clay, and Kanawha counties of West Virginia suggest that the shoreline at the east suddenly extended westward near the latitude of southern Barbour county. Southwestwardly from the Kanawha this mass of sandstone can be traced to the Kentucky line across Boone, Logan, Wyoming, and Mingo counties. Northwestwardly from the narrow strip referred to, the mass breaks up quickly, shales increase, and the several divisions, as is ordinarily the case with sandstones, become traceable with little certainty; but locally one finds most unexpectedly conditions which are recalled by Mr Campbell's description of the Charleston sandstone.

It is necessary now to return to the Pennsylvania line, that the section may be traced southward under the western counties of the state to the line of the Chesapeake and Ohio railroad—a task of no little difficulty, as the key rocks disappear, and the coal beds which were formed only around the borders of the field soon thin out. The sole dependence in most of this area must be upon the records of borings which have been published in the *Geology of West Virginia*.

Beginning with the measurements at Morgantown, one has the following approximate intervals from the Pittsburg coal bed:

| | Feet |
|------------------------------------|------|
| Upper Freeport coal bed | 560 |
| Lower Freeport coal bed | 625 |
| Upper Kittanning coal bed | 670 |
| Lower Kittanning coal bed | 705 |
| Kittanning sandstone, top | 730 |
| Kittanning sandstone, bottom | 785 |
| Brookville coal bed | 785 |
| Pottsville sandstone | 805 |

* M. R. Campbell: U. S. Geol. Survey folios, Charleston, p. 5.

As the sandstones of the Pottsville are as variable as those of any other formation, the bottom of the Allegheny, for comparison, must be taken as the Brookville coal bed.

Ten miles northwest from Morgantown a record shows the Upper Freeport, Upper Kittanning, and the bottom of the Kittanning sandstone as at Morgantown, and the sandstone in the Pottsville is at 820, though in a neighboring well it is at 792, having thickened at the expense of the overlying shale. Ten miles southwest, near Fairview, in Marion county, the Upper Freeport is ill defined in a mass of coal and shale beginning at 556; no other coal is reported. Another record here shows a great sandstone beginning at 565 and continuing to 761 with only two breaks of shale, 28 and 17 feet respectively. No coal whatever is noted in this record except a thin bed at 805 feet below the Pittsburg and 11 feet above the first sandstone in the Pottsville. Eight miles southwest from Fairview, at Mannington, the Hamilton well shows sandy rocks prevailing in the Allegheny and has apparently the same coal horizon at 824, which is too low for the Brookville, unless there be a local thickening of the section. The sandstones vary greatly. Within 3 or 4 miles of Mannington, southwest and west, a sandstone, 115 to 177 feet thick, begins at 647 to 682 and ends at 791 to 804; but in one well it begins at 603 and ends at 913, while in another no sandstone appears between 491 and 728, whence it is continuous to 858. Farther west the mass is less, beginning at 685 to 696 and ending at 742 to 765, but a lower sandstone begins at 785. Three or four miles northwest from Mannington the variations are more notable, wells on a single farm showing the upper sandstone 30 to 170 feet thick and beginning at 623 to 650, while the lower sandstone is found in only one well extending from 742 to 867. Farther west and northwest sandstone predominates in the Allegheny, and the bottom of the formation is not far from 760 feet below the Pittsburg, including in this the shales and clays underlying the place of the Brookville. The Mahoning interval is indefinite and no trace of the Freeport coals exists, so that the boundary between Allegheny and Conemaugh can be fixed only approximately. The latter formation is not far from 540 feet thick. The only coal appearing in any of the records is one at 672 in a well near Joetown, in western Marion—very near the place of the Lower Kittanning. This horizon is occupied by sandstone in most of the records.

Wetzel county is west from Monongalia and Marion. As one passes into this county he enters the area in which the section of Allegheny and Conemaugh shortens.

Near Brink, on the Marion line, the Butler sandstone is present at 565, and another begins at 720, which passes down into the Pottsville. Five or six miles northward, in the northeast corner of the county, the section varies abundantly; in one well sandstone begins in the Conemaugh at 446 and is continuous to 911 feet below the Pittsburg—a condition very similar to that in many wells within the adjoining county of Marshall, at the north, as well as in some portions of Greene county, Pennsylvania, and along the southeast outcrop toward the Kanawha; but in a well near the last this sandstone is broken by shale at 546 and 763, while in three others there is no sandstone whatever in the Allegheny. The extreme bottom of the Allegheny here can not be more than 770 feet; but the interval is less westward, for at Silver hill, 10 miles away, on the Marshall line, the Lower Freeport coal bed is only 575 feet below the Pittsburg, and the first sandstone in the Pottsville begins at 762. Westward the section shortens and the interval from Pittsburg to the first sandstone of the Pottsville decreases from 752 to 714 feet, the last near the Ohio river. In the central part of the county the sandstones are so variable that correlation is impossible and in many of the records the Allegheny and Pottsville are practically all shale. No coal is reported in any of the records, which are very numerous.*

Tyler county is south from Wetzel, along the Ohio river. A detailed record is given at Wick, a few miles east from the Ohio river, which shows a great sandstone beginning at 539 feet below the Pittsburg and continuing for 135 feet; it is separated from the Pottsville sandstone by 30 feet of shale, holding at its base a trace of the Brookville coal bed resting on the Pottsville sandstone at 704 feet. This shale and its coal have been replaced in many places, for midway in the county and south-westward sandstone prevails. At Middlebourne there is sandstone from 537 to 957; in other localities it begins at 490, 514, 550, 595, 600, 602, and is from 200 to 400 feet thick, always replacing the Brookville horizon except at Sistersville, where it ends at 685, but no record of the underlying rock is given. On the southeast, or Doddridge County side, the sandstones are ordinarily less conspicuous, though one record shows a bed extending from 581 to 896 feet below the Pittsburg. No trace of coal, aside from that of the Brookville, appears in any of the records.

Pleasants county, north from Ritchie, is west from Tyler, and, like that county, adjoins Washington county of Ohio.

No coal is noted in any of the numerous records available for this

* I. C. White: *Geology of West Virginia, Monongalia*, vol. 1, pp. 239-240; vol. 1a, pp. 156-157; *Marion*, vol. 1, pp. 241-242, 245, 346, 348; vol. 1a, pp. 161-162, 164, 174-175; *Wetzel*, vol. 1, pp. 343-345; vol. 1a, pp. 177-189, 200-203, 212-213.

county, but in Ohio, on Cowrun, a few miles west, the Brookville coal bed is present at 701 feet below the Pittsburg. The sandstones are unimportant on the westerly side, but a detailed record in the central part of the county shows a sandstone 70 feet thick beginning at 515 and another at 645 extending to 735 and cutting out the Brookville horizon.*

Returning to the east, one may follow the section across Harrison, Doddridge, Ritchie, and Wood counties to the Ohio river.

Near Flemington, in Taylor county, 5 miles west from Webster, in the same county, the Lower Freeport is at 590 feet below the Pittsburg, and the Brookville is at 750 feet, with probably the Lower Kittanning at 711. The combined Mahoning-Butler sandstones are 113 feet, cutting out the Upper Freeport. The only other sandstones are 31 and 21 feet thick, the latter at the Clarion horizon above the Brookville; but at Clarksburg, in Harrison county, 10 miles farther west, the succession as shown by a boring is:

| | Feet |
|----------------------------------|------|
| 1. Pittsburg coal bed | |
| 2. Interval | 421 |
| 3. Mahoning sandstone | 84 |
| 4. Shale | 35 |
| 5. Upper Freeport coal bed | 3 |
| 6. Slate | 27 |
| 7. Sandstone | 145 |
| 8. Slate | 20 |
| 9. [Brookville] coal bed | 2 |
| 10. Slate | 36 |
| 11. Sandstone | 87 |

Here the interval from Upper Freeport to the Brookville is 192 feet and the lower bed is at 737 feet below the Pittsburg. The sandstone, Number 11, is in the Pottsville. The notable change is in the appearance of the sandstone Number 7, which is almost wanting at the east in the sections near Flemington and at Webster. Ten miles west of south from Clarksburg no sandstone appears until 750 feet below the Pittsburg, where the Pottsville begins. The only coal bed recorded is at 600, which can hardly be correlated. In the northwest corner of the county, 9 or 10 miles southwest from Mannington, no coal is reported; a sandstone 110 feet thick begins at 492 feet below the Pittsburg, cutting out the Freeport coal horizons, and another begins at 702, which continues into the Pottsville. At Browns mills, 4 miles southwest and 8 miles northwest from Clarksburg, the upper sandstone is present, ending at 592, but below it are only "slate and shells" for 300 feet. Cherry Camp is 7 miles

* I. C. White: *Geology of West Virginia*; Tyler, vol. 1a, pp. 242, 248, 253, 256, 266; vol. 11, p. 391; Pleasants, vol. 1a, pp. 269, 270-271, 273-274.

south from Browns mills and 10 miles west from Clarksburg. The only sandstone recorded there is 80 feet thick and begins at 642 feet below the Pittsburg. It is clearly the lower part of the sandstone at Clarksburg, which ends at 715 feet. The first sandstone in the Pottsville is at 822 feet below the Pittsburg.

Doddridge county, west from Harrison, is southeast from Tyler. In the northeast corner, near Center Point, 10 miles west from Browns mills, in Harrison, and 10 miles south from Smithfield, in Wetzel, a detailed record shows no trace of coal, but a sandstone 150 feet thick begins at 615 feet and ends at 765, so passing beyond the Brookville horizon. No trace of coal is noted in any record within northern Doddridge; even black shale seems to be wholly absent. Sandstone is unimportant for the most part near the Harrison border and equally so on the Tyler border. The records are dreary lists of slate and "limestone."

Long Run is 10 miles south from Center Point and 8 miles west from Cherry Camp. A coal bed is here at 652 feet below the Pittsburg, a Kittington horizon, and a sandstone 45 feet thick begins at 688; it is separated by 10 feet of shale from another sandstone beginning at 743 feet. The intervening shale is at the Brookville horizon. A higher sandstone, 544 to 589, represents the Butler interval. In southern Doddridge the sands vary greatly, but that above the place of the Brookville is usually represented to some extent. Coals are absent from both Allegheny and Conemaugh in this portion of the county, but it is possible that a 4-foot coal bed at 15 feet above the "Salt sand," in the southwest corner, may be the Brookville.*

Ritchie county, west from Doddridge, is south from Tyler and Pleasants.

The Pittsburg coal bed is of uncertain occurrence in most of this county, being recognized only in the eastern portion, where, however, it is wanting in many places. Its horizon can be fixed very closely by means of the Logan ("Big Injun") sandstone below and the Washington coal bed above in the Dunkard formation.

At Tollgate, on the eastern edge of the county, a sandstone at the Butler horizon is from 480 to 545 feet below the Pittsburg, the Mahoning sandstone ending at 470 feet. Shales only are below into the Pottsville and no trace of coal is recorded. One mile west a sandstone is reported as beginning at 691 feet and continuing into the Pottsville. At 10 miles west, in the Whiskey Run district, several detailed records are available, one of which shows the Pittsburg coal bed. The Mahoning

* Geology of West Virginia: Harrison, vol. 1, pp. 248, 251; vol. 1a, pp. 317-318, 328-329, 335.

interval is filled with red shale which extends downward into the Allegheny, ending at 565 feet. No sandstone is here, but a coal bed is reported at 755 feet below the Pittsburg, which seems to be too low for the Brookville, as that coal is at 737 feet in Harrison county far toward the east. Near Harrisonville, about 9 miles south from the Whiskey Run wells, a sandstone 105 to 95 feet thick begins at 585 feet below the assumed place of the Pittsburg, and in a well north from the village a great mass of red rock ends at 470, reaching possibly into the Allegheny.

In the eastern part of the county, south from the Baltimore and Ohio railroad, the sandstones are more distinct, the bottom of the Mahoning being at 461 to 501 feet below the Pittsburg. The first sandstone of the Allegheny begins at 572 to 597 and ends at 603 to 673 feet, while a lower sandstone begins at 719 and is continuous into the Pottsville, if, indeed, it be not wholly in the Pottsville; but a well shows only sandstone from 596 to 946 and another from 600 to 1,090 feet, showing the condition already observed locally in other counties. No Allegheny coals are reported in any of the wells within the eastern part of the county. In the western part of the county the sandstones are less important, most of the records showing only shales below the Mahoning to many feet down in the Pottsville; but on the Wood County border a sandstone appears in the lower part of the section, extending from 645 to 720 feet below the Pittsburg. Near Cairo red shale is present in the upper part of the Allegheny, one well showing a bed of 15 feet at 513 and another showing 13 feet at 524 feet below the Pittsburg. On the western border the top of the Pottsville is approximately 735 feet below the Pittsburg, and there is no evidence of coal in the Allegheny formation.

Wood county, west from Ritchie, Wirt, and Pleasants, adjoins Washington and Meigs counties of Ohio. The Pittsburg coal bed can not be recognized with certainty and the varying thickness of the Pottsville and Lower Carboniferous render the "Big Lime" a not altogether satisfactory guide. It is best to begin at the north, where the section is clear in its connection with Ohio.

At Marietta, in Washington county, Ohio, the Brookville is 830 feet above the Berea grit; at Parkersburg, in Wood county, West Virginia, it is 843—a very close agreement in view of the fact that the measurements were made by cable and not by steel tape. No other trace of coal appears at Parkersburg. At this place the Brookville is 275 feet below the top of a sandstone, whose upper portion is in the Mahoning interval, this top being 1,125 feet above the Berea. At the Hendershot well, in northern Wood, about 11 miles south from Marietta and 5 or 6 miles east from Parkersburg, the top of this sandstone is 1,111 feet above the Berea. The

top of the "Salt sand" at Marietta is 805 feet above the Berea, but at Hendershot the sandstone extends upward to 916 feet, cutting out the Brookville horizon. Southward the "Big Lime" appears and the Logan thickens, so that the intervals to the Berea are increased nearly 200 feet. The Mahoning sandstone ends at 465 feet below the place of the Pittsburg coal bed and only shales are present below to 841 feet, where the first great sandstone of the Pottsville is reached. No trace of the Brookville or other coal is here, but three red beds, 25, 40, and 25 feet respectively, are in the Allegheny, the bottom of the lowest being 650 feet below the assumed place of the Pittsburg. It is possible that the place of that coal bed has been placed too high, and that it may belong 50 feet lower, within a great mass of red shale, in which case the first of the red beds would be in the Conemaugh. At a little distance west a deep well shows sandstone 110 feet beginning at 553, and the "Salt sand" begins at 1,020, with an intermediate sand at 713 feet; this is at the top of the Pottsville, and the higher sandstone is one which in part or in whole is followed readily in much of Ohio as occupying the middle of the Allegheny.*

Returning to the east, the section may be traced across the remaining counties to the Kanawha river and the Chesapeake and Ohio railroad.

At Vadis, on the Lewis-Gilmer line, a detailed section shows the Mahoning sandstone ending at 490 feet below the Pittsburg and only shales thence to 715 feet, where begins a sandstone 83 feet thick and evidently in the Pottsville. The condition is as in Harrison county, 15 miles northwest. Five miles southwest, near Troy, in Gilmer county, the same condition appears, except that the sandstone in the Pottsville begins at 748 feet. At Glenville, 10 miles southwest from Vadis, the Mahoning ends at 534 and sandstone 80 feet thick begins at 660 feet, reaching into the Pottsville. Near Stouts mills, 8 miles southeast from Glenville, on the Braxton border, the succession is practically all sandstone from 549 to 949 feet below the Pittsburg, there being only two interruptions, one of 25 feet at 614 and one of 3 feet at 774, the last being a coal bed which is too low for the Brookville; but at 2 miles northward shale is present for 110 feet above the sandstone at 777 feet, while above the shale is a continuous sandstone into the Conemaugh. Three or four miles east in Braxton county there are only two thin sandstones in the Allegheny, and a coal bed in the upper part is very near the Lower Freeport horizon. At Stumptown, 12 miles southwest from Stouts mills, the lower half of the Allegheny is sandstone, extending to 715 feet below the Pitts-

* *Geology of West Virginia*: Ritchie, vol. 1, p. 318; vol. 1a, pp. 410, 412-413, 415, 417-419, 420-422, 425-426, 431, 433-435, 439-440; Wood, vol. 1, pp. 285, 287, 294-297.

burg, very near the place of the Brookville coal bed. In southern Gilmer a record at Rosedale shows almost no sandstone. At Tanner, 8 miles west from Glenville, the sandstone seen at the latter place is only 68 feet thick and is divided midway by 23 feet of shale.

Calhoun county is west from Gilmer. The records here are somewhat indefinite, as the Pittsburg is wanting. Two records in the northern part of the county show a sandstone, 40 feet in one, 28 feet in the other, which belongs to the interval of that seen at Glenville 660 feet below the Pittsburg. A lower sandstone beginning at 674 feet is in the Pottsville.*

Wirt county, southwest from Ritchie and northwest from Calhoun, is east from Wood.

The Cowrun anticline of Washington county, Ohio, passes across the eastern side of Wirt and brings up the Ames limestone, which is exposed frequently near Burning Springs. The Pittsburg coal bed is rarely present either in exposed sections or in well records, but a record on the east side and another on the west side show that bed and afford means of comparison. Two records in detail near Burning Springs are referable to the Ames limestone, which in the Cowrun area of Ohio is about 240 feet below the Pittsburg coal bed and 150 feet above the Upper Freeport, but the lower interval increases eastwardly.

In the wells within the Burning Springs area a sandstone persists 44 to 71 feet thick and beginning at 682 to 687 feet above the "Big Lime." At the Ritchie line, 5 miles east, a sandstone 60 feet thick begins at 725 feet above that limestone and is 553 feet below the Pittsburg. The sandstone at Burning Springs is 269 feet below the Ames limestone, so that limestone, if the relations to the "Big Lime" be the same as at the Ritchie border, would be 311 feet below the Pittsburg, which is highly improbable. It is better to regard the lower portion of the section as thinning westward and to accept 725 at the Ritchie border as equivalent to 686 at Burning Springs. On this basis one may place the coals recorded in one of the wells thus:

| | | |
|----|-----------------------------|------------------------------|
| 1. | 188 feet below the Ames.... | 472 feet below the Pittsburg |
| 2. | 290 " " " " | 574 " " " " |
| 3. | 358 " " " " | 642 " " " " |
| 4. | 409 " " " " | 693 " " " " |
| 5. | 510 " " " " | 794 " " " " |
| 6. | 546 " " " " | 830 " " " " |

The error is very slight; numbers 1 and 4 are very near to where one should expect the Upper Freeport and the Brookville. In Wood county

* *Geology of West Virginia: Gilmer, vol. I, pp. 257-258, 260; vol. Ia, pp. 378, 380, 383-384, 386; Calhoun, vol. Ia, p. 396; vol. II, p. 395.*

the interval from Pittsburg to Brookville is about 700 feet and in Cabell, on the Ohio, it is 680 feet. The Freeport sandstone, 50 feet or more in thickness, is hard and in part pebbly, at times reaching below the second coal bed. The third bed is near the place of the Lower Kittanning and the two beds at the bottom are in the Pottsville.

Eight or 10 miles north from Burning Springs, Stevenson measured the following section:

| | Feet |
|---------------------------------------|---------|
| 1. Shaly sandstone | 20 |
| 2. Red shale | 105 |
| 3. Shaly sandstone | 30 |
| 4. Red shale | 55 |
| 5. Sandstone, shaly to massive | 65 |
| 6. Chert | 5 to 12 |
| 7. Shale with nodular limestone | 9 |
| 8. Black shale | 3 |
| 10. Coal bed [Upper Freeport]..... | 1 |
| 11 Shale and sandstone | 120 |

The Ames limestone should be in the lower part of the upper red shale, which is in the place of the "Big Red" of Washington county, Ohio, but it was not observed. The black shale overlying the coal is rich in fossils similar to those obtained by the writer 35 years ago from shales overlying the Upper Freeport near Morgantown. The coal is evidently the Upper Freeport and the sandstone is in the Mahoning interval. The presence of the chert in this position accompanied by the fossiliferous shales was regarded by Stevenson as proving the identity of the Upper Freeport with the Stockton of the Kanawha region.

Roane county is south from Wirt and west from Calhoun. The Pittsburg coal bed can not be identified with certainty, but at Spencer, 15 miles south from Burning Springs, the Washington coal bed of the Dunkard formation is present in the hills. The place of the Pittsburg is taken to be 474 feet below this coal bed on top of a sandstone 38 feet thick. In Ritchie county the interval is 494 feet.

Three sandstones are recorded at Spencer; the first, beginning at 470 feet below the assumed place of the Pittsburg, is 130 feet thick and 30 feet above a second, which is 20 feet thick. The third begins at 718 and is in the Pottsville. No trace of coal is here, but black slate at 660 to 688 feet below the Pittsburg may hold the carbonaceous material of the Brookville horizon. These sandstones are recognizable in wells 6 and 10 miles southeast from Spencer, in one 6 miles east and in that on Yellow creek, though of course, like all sandstones, they vary greatly in thickness and so in the upper and lower boundaries. In the well 6

miles east the upper sandstone begins at 70 feet lower than at Spencer and underlies 90 feet of red rock, most of which belongs in the Allegheny. A coal bed 2 feet thick is here, which, according to the relations assumed at Spencer, should be 558 feet below the Pittsburg. The record shows a coal bed 4 feet thick at 550 feet above it, which may be the Pittsburg coal bed. At 25 miles southeast from Spencer and 10 miles northwest from Clay Courthouse, a great sandstone occurs, practically continuous for 335 feet, being broken by only three shale beds in all 30 feet thick. This is evidently the mass termed by Mr Campbell the Charleston, which in its lower portion is Allegheny and in its upper Conemaugh.

In Jackson county, west from Roane and Wirt and south from Wood, the records can not be interpreted by the writer. Mason county is west from Jackson and adjoins Meigs and Gallia of Ohio. On the eastern border, which is 10 miles southeast from Pomeroy, Ohio, the Mahoning sandstone ends at 465 and the first Pottsville sandstone is at 685 feet below the Pittsburg coal bed. The Allegheny, about 200 feet thick, contains two sandstones 85 and 50 feet thick, but no trace of coal. Twelve miles southwest, on the Ohio river opposite Gallipolis, a coal bed is present at 422 feet, a sandstone 67 feet thick begins at 532 feet, and a coal bed ends at 669 feet below the Pittsburg, resting on a great double sandstone, 413 feet thick, extending to within 45 feet of the "Big Lime." The bottom coal bed is at the Brookville horizon, but the relations of the upper bed are uncertain.

In Putnam county, southeast from Mason, one has at Winfield, 27 miles southeast from Gallipolis, the complete record reported by Mr Campbell and Doctor White. A sandstone 70 feet thick begins at about 540 feet below the Pittsburg and rests on slate and coal 20 feet, reaching to sandstone beginning at 629 and ending at 735 feet below the Pittsburg. These sandstones represent the lower portion of the mass seen near Charleston, the upper portion being replaced in great part by shale. The Brookville coal bed is not noted in the record, but it belongs not far from the bottom of the sandstone, for at lock number 6, 20 miles southeast from Winfield and 5 miles northwest from Charleston, it is about 750 feet below the Pittsburg and underlies a sandstone, 405 feet thick, extending almost 200 feet into the Conemaugh. In a boring about 12 miles southwest from Winfield a coal bed is reported at 750 feet above the "Big Lime" underlying a sandstone, 105 feet thick, with no higher sandstone within 300 feet. This may be the Brookville, whose place at

* *Geology of West Virginia*: Wirt, vol. i, p. 262; vol. *ia*, pp. 464-465, 467-468; Roane, vol. i, pp. 264, 268; vol. *ia*, pp. 470, 472; vol. ii, pp. 398-399.

J. J. Stevenson: *Proc. Am. Phil. Soc.*, 1875, vol. xiv, p. 395.

Winfield is somewhat less. It is evident that the sandstone of the Kanawha region is becoming replaced by shale.

Cabell adjoins Putnam at the west and reaches to the Ohio river opposite Lawrence county of Ohio. In the absence of surface measurements, it is difficult to interpret the well records in the eastern part of the county, but on the west side, at Central City, is a record directly referable to the Pittsburg coal bed, which is mined in hills overlooking the river only 10 or 12 miles away from its outcrop on Greasy ridge, within Ohio. There the Brookville horizon is marked by 10 feet of black shale ending at 680 feet below the Pittsburg coal bed and underlying a double sandstone in all 105 feet, but divided midway by 50 feet of shale. This represents the lower part of the mass at Charleston. At Greenbottom, on the Ohio near the northern edge of the county, a coal bed is recorded at 832 feet above the "Big Lime." At Central City the Brookville is 630 feet and at Gallipolis, 15 miles northwest from Greenbottom, 458 feet above that limestone. The coal bed at Greenbottom must be at least 250 feet above the place of the Brookville and therefore in the Conemaugh.*

Beyond the Kanawha river the massive sandstones of the Allegheny have resisted erosion, so that they cap the high hills of western Fayette, northwestern Raleigh, northwestern Wyoming, and probably enter Buchanan county of Virginia. One should expect to find the formation in Pike county of Kentucky. The rocks fall toward the northwest, and the Upper Freeport (Mason) and Brookville (Stockton-Lewiston) coal beds have been followed with more or less certainty across the counties of Boone, Fayette, Lincoln, Wayne, Logan, and Mingo to the Kentucky line; but the relations of the coal beds are somewhat indefinite, as the sandstones are variable, limestone is wanting, and the Black Flint disappears very quickly beyond the Kanawha river. Much work has been done within this area, but the section has not been carried in detail, so that the more or less tentative correlations by the several observers are not wholly in accord.

Mr d'Invilliers obtained a measurement in northern Raleigh, on Marsh fork of Coal river, about 25 miles southwest from the mouth of Gauley river:

| | Feet. | Inches |
|-------------------|-------|--------|
| 1. Coal bed | 7 | 4 |
| 2. Interval | 51 | 0 |
| 3. Coal bed | 3 | 8 |
| 4. Interval | 126 | 0 |

* *Geology of West Virginia*: Mason, vol. 1, pp. 281-282; vol. ii, p. 412; Putnam, vol. ii, pp. 401-402, 483; Cabell, vol. 1, p. 275; vol. 1a, pp. 484, 488, 490-494.

M. R. Campbell: U. S. Geol. Survey folios, Charleston, p. 3; Huntingdon, p. 3.

| | Feet. | Inches |
|------------------------------|-------|--------|
| 5. Coal bed | 9 | 11 |
| 6. Interval | 141 | 0 |
| 7. Lewiston coal bed | 5 | 10 |
| 8. Interval | 123 | 0 |
| 9. Coal bed | 3 | 8 |
| 10. Interval | 184 | 0 |
| 11. Winifrede coal bed | 4 | 0 |

The identification of the Lewiston and Winifrede beds is taken by Mr d'Inwilliers to be correct, but the relations of the other beds are very uncertain. The intervals seem to suggest that coals numbers 1 and 3 belong to the Conemaugh. No measurements are available for 18 miles down the river, where one finds what appears to be the Brookville-Stockton bed, 4 feet thick and underlying 155 feet of sandstone and shales. A somewhat higher bed was seen by Mr Campbell at 6 miles south from Charleston, belonging at the horizon of the Black Flint, while at a little distance away is a bed thought by him to be near the place of the North Coalburg. Mr Campbell does not find the number 5 Block coal here, though he recognizes it at a short distance eastward.

In northeastern Lincoln county, on Cobbs creek, a branch of Little Coal river, Mr d'Inwilliers measured:

| | Feet. | Inches |
|--|----------|--------|
| 1. Sandstones, shales, and red beds..... | 400 | 0 |
| 2. Coal and shale | 6 | 0 |
| 3. Sandstone | 35 | 0 |
| 4. Coal bed | Blossom | |
| 5. Sandstone, fine conglomerate at bottom. | 60 | 0 |
| 6. Coal bed and partings, splint | 4 | 3 |
| 7. Massive sandstone | 35 to 45 | 0 |
| 8. Coal bed, splint, about | 4 | 0 |
| 9. Sandstone | 40 | 0 |
| 10. Coal bed | 3 | 6 |

At 3 or 4 miles farther down the river, Mr Campbell found three coal beds, 54, 30, and 97 inches thick, partings included, separated by intervals of 120 and 20 feet. He places the lowest coal near the horizon of the Black Flint, in this agreeing with Mr d'Inwilliers, who is inclined to look for the place of the Flint at a little way above his lower splint bed. The highest bed in each case is close to the place of the Upper Freeport.

The Guyandotte flows northwardly across western Lincoln. Mr Campbell reports an important coal bed in the southern part of the county, coming up from the river near Sheridan. His measurements and those made many years ago by Dr. John Locke show it is about 5 feet at Sheridan, but increasing southwardly, so that at one locality it is about 10 feet without serious partings. Mr Campbell places this at about 70 feet below

the top of his Charleston sandstone, so that it seems to be near the Upper Freeport horizon. At Sheridan the upper part is cannel. A lower bed arises from the river above Sheridan, and at 7 miles from that place is 115 feet above the river. Twelve miles farther south, on Stone Coal branch, in Logan county, Mr d'Inwilliers finds a coal bed 5 feet 6 inches thick at a little more than 500 feet above the Campbells Creek (Sharon) coal bed. This is 712 feet above the river and it may be the same with Mr Campbell's lower bed. The section at Dingess, in Mingo county, makes possible that this is at the Brookville horizon.

Twelve-pole creek flows northwardly through Wayne county, both forks rising in Mingo county. Mr Campbell finds the upper horizon in his Charleston persistent in the southwest corner of Wayne, where the coal was opened at Radnor, Ferguson, and elsewhere, but proved to be worthless. Doctor White states that this bed rises from the creek at a little way above Wayne. He describes it as double on Cave creek, where the splits are separated by 30 feet of sandstone. This bed, which he correlated with the Upper Freeport, becomes cannel westwardly from Twelve-pole creek and the cannel persists to the Kentucky line. Mr Campbell finds another coal bed at 100 feet lower, also poor, and one still lower is shown near the Kentucky line. All of these coals are so badly broken by partings as to be practically worthless.

At Dingess, in northern Mingo, Doctor White describes a coal bed 8 feet 1 inch thick in seven layers of coal and shale and about 480 feet above the Warfield (Sharon) coal bed. It is near the place of the Brookville, for at a few miles west, in Lawrence county of Kentucky, the Warfield (Sharon) coal bed is about 680 feet below what appears to be the Upper Freeport limestone. The section near Nolan, 10 miles farther south, as given by Doctor White, is:

| | Feet. | Inches |
|--|-------|--------|
| 1. Sandstones and red shale | 290 | 0 |
| 2. Mason coal bed | 2 | 1 |
| 3. Concealed and coarse sandstone | 60 | 0 |
| 4. Number 5 Block coal bed, mostly splint | 3 | 11 |
| 5. Fireclay and mostly coarse sandstone | 150 | 0 |
| 6. Stockton coal bed, splint, with parting | 2 | 0 |

One is here on the border and the conditions are very like those observed along the southeast outcrop northwardly beyond the Kanawha.*

* E. V. d'Inwilliers: Geological report on West Virginia and Ohio railroad line, pp. 9, 46, 48; map of New river and Kanawha coal field; also personal communication of unpublished material.

B. S. Lyman: Proc. Am. Phil. Soc., vol. xxxiii, pp. 286-288.

M. R. Campbell: Charleston folio, pp. 6, 7, 8; Huntingdon folio, pp. 4, 5, 6.

I. C. White: West Virginia Survey, vol. II, pp. 376-377, 541-543.

CONEMAUGH FORMATION

CORRELATION

The southern limit of the Conemaugh can not be determined in the present state of our knowledge, but there seems to be little room for doubt that the lower members of the formation are present as far south as Pike county of Kentucky, southwest from Mingo county of West Virginia. Owing to the absence of any beds of coal, limestone, or iron ore possessing economic value in any considerable area, the Conemaugh has been regarded as "barren," but its coal and some other horizons prove to be quite as persistent as those of the other formations and its variations are quite as interesting as those of the Pottsville. The interval between the Upper Freeport and the Pittsburg coal bed decreases westward from about 600 feet along the northerly outcrop in Pennsylvania to about 300 feet along the western outcrop in Ohio and to somewhat less in Kentucky, if one may draw conclusion from the portion remaining in that state.

The noteworthy horizons in the Conemaugh are numerous, but, owing to abrupt variations in character and thickness of the detrital beds, there has been some confusion respecting the relations. The succession in descending order is:

- Little Pittsburg limestone.
- Little Pittsburg coal bed.
- Little Clarksburg coal bed.
- Morgantown sandstone.
- Elk Lick coal bed.
- Washington reds.
- Ames limestone.
- Harlem coal bed.
- Pittsburg reds.
- Barton coal bed.
- Cowrun sandstone.
- Anderson coal bed.
- Cambridge limestone.
- Buffalo sandstone.
- Brush Creek limestone.
- Brush Creek coal bed.
- Upper Mahoning sandstone.
- Gallitzin coal bed.
- Mahoning limestone.
- Lower Mahoning sandstone.
- Uffington shales.

The Pittsburg limestone of H. D. Rogers consists of one or more beds within an interval of about 25 feet below the Pittsburg coal bed, the

higher one often almost directly under that coal. Sometimes these limestones are brecciated and they frequently contain minute univalves, whose relations have not been determined.

The Little Pittsburg coal bed of H. D. Rogers refers to a horizon rather than to a single coal bed. At varying intervals down to 50 feet below the Pittsburg coal bed, one or at times two coal beds are seen, usually thin, but occasionally, as in the case of the Jeffers (E. B. Andrews) in southern Ohio and possibly in western Maryland, attaining local importance. Non-fossiliferous limestone is present in some localities associated with the coal.

The Little Clarksburg coal bed of I. C. White, frequently accompanied by a limestone, is a well marked horizon at 100 to 130 feet below the Pittsburg; but it is confined to southern Pennsylvania and northern West Virginia, being unrecognizable at any considerable distance west from Chestnut hill, in the former state. Like many other coal beds, its only representative at times is a black shale containing fragmentary remains of fishes.

The Elk Lick coal bed of J. P. Lesley (Barton of Pennsylvania reports L and K) is an important bed at the type locality in Somerset county of Pennsylvania. The horizon is marked by a thin coal bed at many localities in Pennsylvania and northern West Virginia, while in Ohio it often carries thin coal or black shale. Its place is well defined on the east side of the basin, as it underlies the rather persistent Morgantown sandstone. On Elk creek it overlies the Elk Lick limestone, but that bed is uncertain elsewhere, having been observed very rarely outside of Somerset county.

The Ames limestone of E. B. Andrews (Crinoidal of northern Ohio, Green Fossiliferous and Crinoidal of Pennsylvania) is one of the most persistent and in some respects the most remarkable horizon in the Conemaugh. It is wanting, or perhaps not recognized, in the northern portion of the first and second bituminous basins of Pennsylvania, but is present in the southern portions of those basins in Pennsylvania, Maryland, and West Virginia. Though thin, seldom more than 6 and often less than 3 feet thick, it has been followed in exposed sections from Barbour county of West Virginia along the eastern and northern outcrops in Maryland and Pennsylvania into Ohio, where it persists along the western outcrop to the last exposure of its place near the Kentucky line; and in this last state it may be the fourth fossiliferous limestone of Professor Crandall's sections, which is present certainly as far south as the middle of Lawrence county. Southward from Barbour county of West Virginia, along the eastern outcrop, it has not been reported, but Doctor White has identified it with the Two-mile limestone near Charleston, a

fresh-water limestone associated with deep red shales. Whether or not it is present in the central counties of the state, where its place is deeply buried, can not be determined, as the oil-well records can not be depended on for recognition of thin limestones; but it is certainly present under the Cowrun anticline along the central part of the basin in Washington county of Ohio, Pleasants, Wirt, and Ritchie of West Virginia and it is also present in northern Wayne of the latter state, near the Kentucky line. The color is usually greenish, but often masked by iron stain, and the percentage of silica is often large, though the bed is reported as cherty at no place where the identification is complete. The fourth limestone is cherty in Lawrence county of Kentucky, where one is near its place of disappearance, for at a few miles farther it is represented by only a green calcareous sandstone. The Ames limestone carries a marine fauna at all localities where it has been recognized certainly. In northern West Virginia, for 30 to 40 miles southward from the Pennsylvania line, fossiliferous shales of considerable thickness underlie the Ames, which is the highest horizon in the Appalachian basin at which marine life flourished.

The Harlem coal bed of J. S. Newberry (*7b* of northern Ohio, Crinoidal of Pennsylvania, Friendsville of Maryland) is not so persistent as the Ames limestone, but is present at nearly all localities in Ohio where its place is exposed, is reported frequently along the northern outcrop in Pennsylvania, but more rarely along the eastern outcrop, though the horizon is marked by thin coal or black shale at many localities apparently as far south as Upshur county of West Virginia. Many oil records note it as coal or black shale and it is present as a coal bed under the Cowrun anticline in Washington of Ohio and Wirt of West Virginia. It may be the Coal 12 of Kentucky. Usually it is very thin, but occasionally, as at the type locality in Carroll county of Ohio, it is of workable thickness. For long distances it underlies the Ames limestone directly and it is known as the "Fossil coal" at two widely separated localities, one in Ohio, on the northwestern outcrop, and the other in central West Virginia. At both the upper part of the bed contains fine specimens of mollusca characterizing the overlying limestone.

The Barton coal bed of P. T. Tyson (Bakerstown of Pennsylvania and Maryland, not Barton of Lesley and Stevenson, which is Elk Lick) is a well marked horizon a little above midway between the Ames and Cambridge limestones and above the Cowrun sandstone. Coal is at this place in western Maryland and in most of the counties in western Pennsylvania, but it is rare in Ohio. It may be represented by the Patriot (E. M. Lovejoy) and Slate (E. McMillin) coals of southern Ohio,

but it seems to be wanting in Kentucky, though it may be represented by Coal 12. The Barton coal is rarely of economic importance.

The Anderson coal bed of E. B. Andrews (Norwich of northern Guernsey, Ohio) has been taken for the Barton (Bakerstown) in some portions of Pennsylvania and West Virginia. It seems to be wanting on the east side of the basin, the most easterly locality being in southern Butler of Pennsylvania; thence to the Ohio line it is utterly insignificant. It becomes distinct in Brooke county of northern West Virginia, whence through Ohio it is persistent into Kentucky, where it is the Coal 11. It is a few inches to 15 feet above the Cambridge limestone in Ohio, but the interval increases to between 30 and 40 feet in Kentucky. The bed is of economic value in only a small area within central Ohio.

The Cambridge limestone of E. B. Andrews (Pine creek of western Pennsylvania) is probably the same with a limestone at about 50 feet below the Ames in the second bituminous basin of Pennsylvania as well as in northern West Virginia just west from Chestnut hill and in western Maryland; but it is first clearly recognizable along the northern outcrop in Armstrong county of Pennsylvania, where in many respects it resembles the Ames. Its occurrence as far as Beaver county is a little irregular, but thence along the western outcrop through Ohio into Kentucky it is as persistent as the Ames. The interval between these limestones varies from 90 to 130 feet along the northern and western outcrops. The Cambridge limestone is present at the southwest corner of West Virginia, but it seems to be wanting under the Cowrun anticline, even in Washington county of Ohio. It is persistent only on the west side of the basin, the occurrence on the east side being very irregular. The bed is much more variable than the Ames. In Pennsylvania the color is from dark to gray; in northern Ohio from gray to blue and often weathers buff; while farther south it is a dark limestone associated with dark shales; yet in some portions of southern Ohio it is the "White fossiliferous" limestone. In Noble county of Ohio a new limestone appears directly over the Anderson coal bed, and thence southward there are two Cambridge limestones, 10 to 30 feet apart, designated as Upper and Lower by Professor Edward Orton, one or the other being absent at times for several miles. The Lower is the Cambridge limestone proper, equivalent to Doctor I. C. White's Pine creek. Unlike the Ames, both beds tend to be cherty toward the south. In Kentucky the interval between the Cambridge limestones increases to about 50 feet, with the Anderson at about one-third of distance below the Upper. This limestone carries a rich marine fauna in Ohio and western Pennsylvania, as also in West Virginia at many places north from the Baltimore and Ohio railroad and

in western Maryland; but no fossils were seen in the second basin within Pennsylvania.

The Brush Creek limestone of I. C. White (not Brush Creek limestone of Ohio, volume v), separated from the Cambridge in its type area by the Buffalo interval of 30 to 60 feet, is the Black Fossiliferous limestone of the Pennsylvania reports; it is widely distributed in Pennsylvania, Maryland, and northern West Virginia, but it quickly disappears westward in Ohio and is wanting in the greater part of that state as well as in Kentucky. Professor Newberry found it occasionally in Columbiana county of Ohio and Professor Orton discovered it at one locality in Guernsey county, 40 or 50 miles toward the southwest. Originally it may have been continuous between these localities and may have been removed during deposit of the coarse overlying rock. The limestone is dark, sometimes nodular, carries an abundant marine fauna, and is associated commonly with black fossiliferous shales.

The Brush Creek coal bed of I. C. White (in Pennsylvania, Dudley of Broad Top, Rose of Somerset; Groff and 7 of northern Ohio, Brush creek of southern Ohio; Masontown and Mason in northern West Virginia) is even more persistent than the Harlem around the border of the basin. It has been recognized in Broad Top, in Maryland, in northern West Virginia, in all of the counties of Pennsylvania where its place is exposed, and it seems to be equally persistent in Ohio; but it seems to be wanting under the Cowrun anticline and it can not be recognized in the oil-well records. Mr McMillin's section in Lawrence county of Ohio shows the bed double, with the splits 24 feet apart. This coal bed can not be recognized in the sections of northern Kentucky. Coal 10 of Professor E. R. Crandall underlies the Lower Cambridge directly; it rests on the Buffalo sandstone and is very thin. The horizon is a new one, of which no trace appears in the Ohio sections. At one locality only is there any trace of coal at the Brush creek horizon; that is in southeast Carter county certainly 23 miles from the Ohio and on the extreme western outcrop.

Little reference has been made to the apparently anomalous section of Somerset county within the first bituminous basin of Pennsylvania. There the Conemaugh contains a large number of coal beds and limestones, some economically important, most of which can not be correlated with beds farther west. For the description, the reader is referred to pages which follow. Efforts to recognize these beds led to errors in counties farther west. The Rose coal bed of Somerset is the Brush creek, and above it at a little distance is the Philson, possibly a split from the Rose

or perhaps representing at the east a horizon which at one place in western Pennsylvania shows a trace of coal.

Several sandstones have been recognized and have received names. The Connellsville sandstone of J. P. Lesley seems to be fairly persistent, as sandstones go, along the eastern side in Fayette and Westmoreland counties of Pennsylvania as well as in West Virginia; but the name is useful chiefly to designate the interval between the Little Pittsburg and Little Clarksburg coal beds. One usually finds some sandstone in this interval, often thick and sometimes conglomerate. The Morgantown sandstone of J. J. Stevenson is a more noteworthy deposit in the interval between Little Clarksburg and Elk Lick coal beds. This is remarkably persistent in the eastern half of the basin, and not infrequently some sandstone is present in this interval at Ohio localities. It varies greatly in thickness, at times extending upward as sandstone into the Connellsville interval or downward to below the Ames limestone, while again the whole interval is occupied by shale. Ordinarily it is moderately coarse, at times even conglomerate, and usually so well cemented as to be a durable building stone. It is the first oil rock of Greene county, Pennsylvania. Somewhat lower down is the Cowrun sandstone of the Ohio oil-well drillers overlying the Anderson coal bed. It marks the interval between the Barton coal bed and the Cambridge limestone. This interval frequently shows massive sandstone along the northern outcrop, at times continuous with the Buffalo sandstone below. Like all the other sandstones, this is variable and often absent. It has been a somewhat important oil horizon in Ohio and has yielded some oil in West Virginia, where the drillers' records often note it under the name "Salzburg" sandstone. The Buffalo sandstone of I. C. White (Salzburg of Stevenson) is in the interval between the Cambridge and Brush Creek limestones. The type locality is in southwest Armstrong county, where the mass is 60 feet thick and conglomerate. It is persistent along the northern and eastern outcrop in Pennsylvania and in West Virginia and a sandstone is usually shown in this interval by the oil-well records of the latter state. Along the western outcrop in Ohio and in Kentucky this interval usually contains more or less of coarse sandstone.

The Mahoning interval, between the Brush Creek and Upper Freeport coal beds, is occupied typically by the Upper and Lower Mahoning sandstones, separated by variable shales, but at times one finds the whole interval filled with shale, at others with sandstone. In much of Pennsylvania and West Virginia both sandstone plates are present, but on the western side of the basin throughout the upper plate and most of the intervening shale disappear, so that the Brush Creek coal bed comes down

almost to the Lower Mahoning sandstone. The shale separating the sandstone plates varies greatly in thickness within the first and second bituminous basins of Pennsylvania as well as for almost 20 miles west from Chestnut ridge, in that state, and to this variability are due some of the errors in reports upon that area.

The Gallitzin coal bed of Franklin Platt (Mahoning of western Pennsylvania, not Brush creek of Ohio) is confined to the eastern side of the basin and is in the shales overlying the Lower Mahoning. It may be single, double, or even quadruple. It overlies the Mahoning limestone of I. C. White (not Mahoning limestone of H. D. Rogers), which is divided as is the coal bed, so that the Upper Gallitzin coal may be accompanied by an Upper Mahoning limestone. The Upper Gallitzin coal bed was mistaken for the Philson of Somerset county by W. G. Platt in Indiana and Jefferson counties and by Stevenson in the Ligonier valley, for there the shales are so thick that the Upper Gallitzin is as far above the Upper Freeport as is the Rose (Brush creek) in Somerset. The synonymy is:

- Gallitzin coal bed..... Speer of Broad Top, Mahoning of western Pennsylvania.
- Upper Gallitzin Philson of Indiana and Jefferson counties, and Ligonier valley of Fayette and Westmoreland counties.

The Gallitzin beds disappear in western Pennsylvania along with the Upper Mahoning, and the Brush Creek coal bed is let down to the Mahoning limestone, which in volume v of the Ohio reports is referred to the Brush Creek limestone. This Mahoning limestone is widely distributed either as limestone or calcareous iron ore, but especially along the northern and western sides of the basin.

The Lower Mahoning sandstone is more persistent than the Upper. It is the Mahoning sandstone of most of the reports on counties west from Chestnut hill in Pennsylvania and is the only member present in Ohio and Kentucky. It is the "Dunkard" sandstone of most of the well records, though the Upper Mahoning appears under the same name in many records from the east side of the basin.

Along the southeastern outcrop within West Virginia the rocks of the lower Conemaugh become very coarse, and there is an almost continuous mass of more or less conglomerate sandstone from the bottom of the Allegheny, 400 feet being recorded in one well below Charleston. This condition disappears for the Conemaugh as for the Allegheny within a very few miles toward the northwest; but in some localities, far away from the coastline and in the very middle of the basin, one finds sandstone the

prevailing rock throughout the section. A similar condition has been noted for the Allegheny.

Underlying the Mahoning and separating it from the Upper Freeport coal bed is a shale, the Uffington shale of I. C. White. It is not persistent, having been removed from wide areas during deposit of the overlying sandstone. Near Morgantown, in northern West Virginia, it is crowded with marine forms which are abundant even at contact with the coal; elsewhere except in Upshur and Wirt counties the fauna seems to be wanting, but the shales have yielded many plant remains.

The reappearance of red and green shale much resembling that of the Shenango beds of the Lower Carboniferous at the top of the Allegheny was noticed on a previous page. In the Conemaugh formation, red shale occurs within the Mahoning interval in Gilmer, Ritchie, Calhoun, and Wood counties of West Virginia, where some wells show a great thickness, the whole interval being filled and the mass being continuous with reds above. A bed 25 feet thick in Wetzel county may belong in its lower part to the Upper Mahoning, and thin streaks referable to this interval are reported in Greene and Washington counties of Pennsylvania. The only occurrence in Ohio is a bed 10 feet in Tuscarawas county resting on the Lower Mahoning, but this may belong to the next interval above, as the Upper Mahoning is not present in Ohio. Practically the reds of the Mahoning are confined to the four central counties in West Virginia.

Reds of the interval between Mahoning and the Cambridge limestone are more widely distributed. They are thick and variable in Ritchie and Wood, very thick in Calhoun, less thick in Jackson and Clay, all of them in the central area. These reds are found elsewhere in widely separated localities—Wetzel, Webster, Brooke, and Ohio of West Virginia; Cambria, Indiana, and Westmoreland of Pennsylvania, and occasionally in the Hocking valley of Ohio. The distribution in this interval is certainly much wider than in the Mahoning interval, but away from the central area in West Virginia their occurrence is very irregular and for the most part the beds are very thin; but in the next interval, between the Cambridge and Ames limestones, one finds a great expansion. Immediately below the Ames or, if present, the Harlem coal bed is the mass termed by Doctor White the Pittsburg reds, which is so widespread that it deserves to be ranked with the most persistent beds of other types. In the central area—Lewis, Gilmer, Roane, Ritchie, and Jackson of West Virginia—the Pittsburg reds are very thick and at times continuous with the Washington reds above the Ames limestone, while in several of those counties there are still lower beds within this interval. In Calhoun and Wood counties the Pittsburg reds are less important than in the other

mentioned, but the beds are thick in southeast Washington and portions of Meigs and Gallia of Ohio and they seem to be present in Boyd of Kentucky. Apparently, however, they are absent in Lawrence of that state, as they are not shown in any of Professor Crandall's numerous sections. Along the western outcrop in Ohio the reds of this interval are wanting or very thin until one approaches the northern border in Jefferson and Columbiana counties, where Newberry reports 50 feet. They are somewhat irregular along the northern outcrop and in the first bituminous basin are rarely seen, and when present are very thin, but they are present and well marked in most of the counties west from Chestnut hill. They seem to be wanting in the northeast corner of the West Virginia field, but are rarely wanting in the northern counties of that State. Reds of all horizons are practically absent from the first bituminous basin of Pennsylvania and are insignificant in the second.

Immediately above the Ames is another deposit, known to the Ohio drillers as the "Big Red," which may receive as a geographical designation the name Washington reds, its stratigraphical importance having been recognized first in Washington county of Ohio. In the central area—in Lewis, Gilmer, Ritchie, and central Roane of West Virginia—the mass is thick, at times apparently continuous with the Pittsburg reds below and not rarely extending upward into the Morgantown interval. Away from this area, eastwardly and northwardly, it is irregular; it seems to be wanting along the eastern outcrop, is indefinite northwestwardly toward the Panhandle, but is well marked in Marion and Monongalia counties, one well showing it evidently continuous with the Pittsburg reds and another showing it extending into the Morgantown interval. It is reported in one Washington County well, but elsewhere in Pennsylvania it seems to be wanting except in northern Allegheny. West from the area of greatest development it is not reported in the wells of Wood and Jackson, but in Pleasants, north from Wood, it is thick, while in Washington of Ohio, adjoining Pleasants of West Virginia, it is from 74 to 100 feet thick; thence westwardly and southwestwardly it is thin and irregular, but northwestwardly it persists into Muskingum county, where it is usually thin, though 60 feet thick at one locality; thence northwardly it is evidently absent.

The interval between the Morgantown sandstone and the Pittsburg coal bed frequently shows red beds, but these are extremely irregular in thickness and distribution. They occur especially within the central area, already referred to, where sometimes they are continuous with the Washington, while in many wells within Ritchie, Calhoun, Roane, and Jackson the reds of this interval are almost or altogether continuous with a

higher horizon which, notably in Wood of West Virginia and Washington of Ohio, extends well up into the Monongahela; but in probably by far the greater portion of the Conemaugh area red beds are wholly absent above the Morgantown sandstone.

The horizontal expansion of the reds reached its maximum during the interval between the Cambridge and Ames limestones, reaching then even to the southeastern outcrop, as it exists today; thenceforward the area constantly decreased until toward the close of the Conemaugh it included only the several counties of West Virginia spoken of as the central area. The conditions prevailing during deposit of the Pittsburg reds did not return until well on in the Dunkard formation.

The non-conformabilities within the Conemaugh are not great in absolute measure, but they are proportionately great, for the formation loses half its thickness in passing from the east to the west side of the basin. This is in accord with conditions observed in the earlier formations, the extent of subsidence decreasing toward the west. But while this decrease is noticeable in all of the intervals it is especially noteworthy in the Mahoning and Morgantown, the Upper Mahoning being unrepresented in Ohio and the Morgantown being insignificant, so that the Ames limestone remains in Ohio, as in Pennsylvania, almost midway between the Upper Freeport and Pittsburg coal beds.

EAST FROM THE ALLEGHENIES

The Conemaugh is somewhat more than 500 feet thick in the Broad Top coal field, but above the Mahoning it is ill-exposed and available details are few. A coal bed, 2 to 4 feet thick, known in Huntingdon county as the Dudley, occurs at a few feet above the Mahoning in all parts of the field and is about 400 feet below the bed there accepted as the Pittsburg. In Huntingdon it underlies a massive sandstone, but in Bedford the overlying rock for 30 feet is shale. The Mahoning is double, the section in Bedford county being

| | Feet |
|-----------------|------|
| Sandstone | 50 |
| Coal bed | 1 |
| Clay | 3 |
| Sandstone | 40 |

The upper plate varies from coarse grained and somewhat conglomerate to fine grained and even shaly, but the lower plate, 25 to 40 feet thick, is usually massive and conglomerate, sometimes almost wholly made up of white quartz pebbles. The coal bed known as the Speer in Bedford county occasionally becomes workable, but it disappears northward and

appears to be absent from Huntingdon county. This bed is at the Galitzin horizon and the Dudley is at that of the Brush Creek.*

The Georges Creek and Potomac area is farther southwest, beginning in Bedford and Somerset counties of Pennsylvania and continuing across Maryland into West Virginia. The observations in Pennsylvania are somewhat conflicting, but the sections are clear in the other states. The intervals at Barton in Maryland are:

| | Feet. | Inches |
|---|-------|--------|
| 1. Pittsburg coal bed | | |
| 2. Shales, sandstone, and concealed | 143 | 9 |
| 3. Franklin coal bed and partings | 6 | 10 |
| 4. Shales, sandstone, and concealed | 259 | 0 |
| 5. Bakerstown coal bed | 3 | 0 |
| 6. Concealed and sandstone | 92 | 0 |
| 7. Masontown coal bed | 1 | 7 |
| 8. Shale and sandstone | 51 | 5 |
| 9. Sandstone | 33 | 6 |
| 10. Shale | 3 | 6 |
| 11. Upper Freeport coal bed | | |
| Total | 594 | 7 |

The Franklin, or "Dirty Nine-foot," coal bed is thought by Doctor Martin to be at the Little Clarksburg horizon. The Bakerstown is evidently the Barton of Tyson; farther southwest, at Blaine, it is about 357 feet below the Pittsburg and about 90 feet above the Masontown, which is the Brush creek. This lower bed at Blaine underlies the fossiliferous Brush Creek limestone, which is associated with its characteristic black shale.

The horizon of the Mahoning coal bed is marked at many places by coal seldom more than 20 inches thick, and at one locality in West Virginia Doctor White saw a great thickness of limestone at the Mahoning horizon. The Brush Creek coal bed is thoroughly persistent, usually less than 2 feet thick, though at times yielding nearly 3 feet of coal and in one instance swelling to a mass 9 feet thick, with five benches of coal 3 feet 8 inches in all. At one locality it shows 1 foot of coal underlying 5 feet of black shale with coal streaks, while at another the upper part for 2 feet 5 inches is an alternation of bone, slate, and coal. The Barton is variable, but locally becomes thick and good. The variations in this bed, as shown by figures in volume v, are worthy of careful study, for the bed varies from apparently solid coal 3 feet thick to a double, triple, or even quadruple bed with thick bone at top or bottom, while at times it is a

* J. J. Stevenson: Bedford and Fulton counties (T 2), pp. 242, 659-662.
I. C. White: Huntingdon county (T 3), pp. 47-50.

mass of black shale with only thin streaks of coal. All of these changes appear within an insignificant area.

The Harlem (Friendsville) coal bed has been recognized in the northern, or Georges Creek, region at about 100 feet above the Barton, but it is very thin. The Elk Lick coal bed and another a few feet higher seem to be equally persistent. The Franklin, certainly very near the Little Clarksburg horizon, shows variations as abrupt and as interesting as those of the Barton and Brush Creek. A bed at 50 to 90 feet below the Pittsburg, sometimes divided into two beds, is correlated with the Little Pittsburg of western areas. The unstable conditions still prevail, for the bed is often broken by partings whose thickening leads to distinct division of the bed.

In Tucker county of West Virginia Doctor White finds coal beds at 16, 130, 173, 204, and 404 feet below the assumed place of the Pittsburg coal bed, the lowest being 180 feet above the Upper Freeport. The only limestone is 20 feet thick and 42 feet above the Upper Freeport; therefore at the Mahoning horizon. The lowest coal bed is not far from the place of the Barton, but the relations of the higher beds can hardly be determined in the present state of information.

The exposed sections and bore-hole records show no red shales in the Conemaugh east from the Alleghenies.

Professor Clark and his associates have recognized the Morgantown and Connellsville sandstones as well as the Pittsburg and Clarksburg limestones; whether or not the correlations of the several coals, limestones, and sandstones be absolutely exact is unimportant; they show sufficiently the similarity of conditions east and west from the Allegheny mountains.*

FIRST BITUMINOUS COAL BASIN OF PENNSYLVANIA

The Conemaugh is recognizable in this basin with certainty no farther north than Center county, where a few feet of rock overlie the Upper Freeport coal bed. In Clearfield county Doctor Chance finds the Mahoning at Morrisdale with the Gallitzin coal bed near the bottom and separated by 40 or 50 feet of shaly measures from a coal bed which he correlates with the Upper Freeport. Near Houtzdale, 8 miles southwest, Doctor White's section shows the Mahoning 100 feet thick and holding the

* I. C. White: *Geology of West Virginia*, vol. II, p. 235.

C. C. O'Harra: *Maryland Survey, Allegany county*, p. 119.

C. S. Prosser cited in same, p. 122.

G. C. Martin: *Garrett county*, pp. 127-128, 134.

W. B. Clark et al.: *Vol. v*, pp. 307-308, 344, 348-349, 350-368, 372, 376.

Gallitzin. The Mahoning is often represented by pebbly rock in the southern part of the county, but it is mere shale quite as frequently.*

Almost 150 feet of Conemaugh remain in northern Cambria, but exposures for measurement are reached first at Bennington on the Cambria-Blair border, 20 miles south from the Clearfield line. There Mr Platt's section shows a 10-inch coal bed separated by 35 feet of shaly measures from the Upper Mahoning sandstone, 50 feet thick, which overlies a 2 feet 8 inches coal bed, with 55 feet of shaly beds intervening to the Upper Freeport coal bed. The highest coal, 142 feet above the Upper Freeport, seems to be the Brush Creek and the intermediate bed is the Gallitzin. At Gallitzin, a few miles west in Cambria, Doctor White finds the Brush Creek 140 feet above the Upper Freeport; but at Cresson the section shown in a shaft is:

| | Feet. | Inches |
|-----------------------------------|-------|--------|
| 1. Slates | 60 | 0 |
| 2. Sandstone | 9 | 0 |
| 3. Fireclay | 8 | 0 |
| 4. Sandstone | 109 | 0 |
| 5. Coal | 1 | 0 |
| 6. Fireclay | 9 | 0 |
| 7. Sandstone | 17 | 0 |
| 8. Clay, shale, sandstone | 34 | 0 |
| 9. Sandstone | 33 | 6 |
| 10. Slate and sandstone | 14 | 0 |
| 11. Upper Freeport coal bed | | |

This is not unlike sections in the second basin and one may regard the coal, Number 5, as an upper split of the Gallitzin, the place of a lower split being on top of the fireclay, Number 8.

Mr Fulton's section near Johnstown, in southwest Cambria, shows the Gallitzin at 67 feet above the Upper Freeport with the Mahoning limestone or Johnstown ore at a few feet below it. The Brush Creek coal bed is absent and at 148 feet above the Upper Freeport is a red bed, this being the most northerly locality at which red shale occurs. The section extends upward to 302 feet, but neither here nor at Cresson are there any traces of the Barton coal bed or of the limestones belonging in that interval.†

In the deep Salisbury subbasin of southeastern Somerset county a full section may be compiled from the measurements made by F. and W. G. Platt, which accords somewhat closely with that made by Doctor White

* H. M. Chance: Revision of Clearfield county (H 7).

I. C. White: U. S. Geol. Survey Bull. no. 65, p. 124.

† F. Platt: (T), p. 95; (H 2), p. 61.

J. Fulton: (H 2), p. 97.

A. A. Prosser and D. B. Hardin: Appendix to H 3, p. 369.

in the same area. The Conemaugh is 600 feet thick and contains many coal beds and limestones, several of which can not be correlated with any beds in basins farther west. A sandstone, apparently the Morgantown, and 77 feet thick, rests on the Elk Lick coal bed, which at the typical locality overlies the Elk Lick limestone, 8 feet thick. At about 80 feet lower is a limestone which Doctor White correlates with the Ames. It is from 300 to 320 feet below the Pittsburg coal bed and overlies a thin coal correlated with the Harlem. The Brush Creek coal bed is at 100 feet above the Upper Freeport, and at a few feet higher is a limestone which has been correlated with the Brush Creek. This immediately underlies a thin coal bed, the Philson of W. G. Platt. All of the limestones are non-fossiliferous. These coal beds and limestones seem to be persistent in the northwestern part of the county and 2 feet of red shales are associated there with the Ames limestone, the most northerly appearance of the "Pittsburg reds." Farther south on this west side, near Bakersville, Mr Platt found a dark fossiliferous limestone, evidently the Brush Creek, while still farther south are two limestones, 60 to 70 feet apart, of which the upper is clearly the Ames, as shown by its fossils as well as its physical character, while the lower may be at the Cambridge horizon.

A compiled section in the southwestern part of the county shows the Brush Creek coal bed (Rose of F. Platt) at 263 feet below the Elk Lick limestone and 105 feet above the Upper Freeport. The coal bed underlies black shales with calcareous nodules, representing the Brush Creek limestone and black shale. The intervals decrease southwardly and westwardly; at Confluence, near the western border, the interval between Elk Lick limestone and Upper Freeport is 345 feet, but within five miles eastwardly it increases to 375 feet.*

Passing over into Garrett county of Maryland, one finds Mr Martin's section on Castleman river, in the Salisbury subbasin, and another at Friendsville, in the Johnstown subbasin.

In the former the Little Pittsburg coal bed is present, but without its limestone, and a thin coal bed at 137, the same with that seen by W. G. Platt in Somerset county, may be the Little Clarksburg. The Ames limestone at 328 feet below the Pittsburg is present with all its characteristic features and overlies directly the Harlem coal bed (Friendsville of Martin). The Barton (Bakerstown) coal bed is here and red shales appear 50 feet below it at the horizon of those seen in eastern part of Cambria. The Brush Creek limestone (Lower Cambridge) is dark

* F. and W. G. Platt: (H 3), pp. 23, 40, 63, 76, 179, 223, 239, 244, 258, 266, 282.
I. C. White: U. S. Geol. Survey Bull. no. 65, p. 76.

colored and fossiliferous, with, below it, the Brush Creek coal bed at 97 feet above the Upper Freeport.

The Clarksburg limestone is present in the Friendsville section at 39 feet above the Morgantown sandstone, which is 84 feet thick and in part conglomerate. The Elk Lick, Harlem, Barton, Brush Creek, and Gallitzin coal beds are all present, though all are thin, none exceeding 1 foot 9 inches. The Elk Lick, Ames, Cambridge, and Brush Creek limestones are distinct, though the first is practically only calcareous shale, and all except the Elk Lick are fossiliferous. Red shale is associated with the Cambridge limestone at nearly 200 feet above the Upper Freeport. There is much sandstone above the Clarksburg limestone and some of it is conglomerate, representing perhaps the Connellsville sandstone.*

SECOND BITUMINOUS COAL BASIN OF PENNSYLVANIA

Within the Second basin the Mahoning is present in small areas as far north as northern Center county, where it is the protecting cover for the Upper Freeport coal bed. At Karthaus, in Clearfield, Mr James describes it as 72 feet thick, with a 2 feet coal bed, the Gallitzin. Doctor Chance's section in southern Clearfield shows two sandstone plates, 40 and 50 feet respectively, separated by 30 feet of shale, which holds at the bottom the Gallitzin coal bed and the Mahoning limestone, this being the most northerly point at which that limestone has been observed. The lower Mahoning is coarse and at times conglomerate.†

Mr d'Invilliers obtained a number of sections within a small area in northwestern Cambria, which illustrate the variability of the lower part of the Conemaugh. Two of these are:

| | Feet. | Inches. | Feet |
|--------------------|-------|---------|------|
| 1. Shales | 20 | 0 | 20 |
| 2. Sandstone | 95 | 0 | 85 |
| 3. Shales | 25 | 0 | 40 |
| 4. Coal bed | 0 | 8 | 2 |
| 5. Shales | 35 | 0 | 60 |
| 6. Sandstone | 40 | 0 | 35 |
| | 215 | 8 | 242 |

In these there are two plates of sandstone, as in southern Clearfield, and in each case a coal bed above the middle. The bottom of the upper plate is at 100 and 137 feet above the Upper Freeport and the coal bed at 75 and 95. In another section the coal bed is at 137 feet, with only

* G. C. Martin: Garrett county, pp. 128, 130, 134-135, 138-139.

† H. M. Chance: (H 7), p. 132.

sandstone in the interval to the Upper Freeport, while in a fourth the bottom of the upper sandstone is at 141 feet, the interval containing aside from shale three thin coal beds at 25, 75, and 141 feet.* The two sandstone plates are apparently the same with those seen near by in Clearfield, but the intervening shales have become thicker, so that the Mahoning in two of the sections is about 220 feet thick instead of 120, as in Clearfield. The several coal beds may be taken as representing the Gallitzin horizon, and in following the section southward this interpretation will be accepted.

In northeastern Indiana county, west from Cambria, Mr Platt found at 4 or 5 miles west from the area of Mr d'Invilliers' sections a coal bed at 90 feet above the Upper Freeport, separated by 40 feet of shale from the massive "Mahoning" sandstone which rests directly on the Upper Freeport. At a mile or so farther west he saw a coal at 60 feet above that coal bed, and at a little distance farther measured this section:

| | Feet. | Inches |
|---|-------|--------|
| 1. Thin sandstone and sandy shale..... | 47 | 0 |
| 2. Slates | 5 | 0 |
| 3. Philson coal bed [Upper Gallitzin]..... | 3 | 1 |
| 4. Concealed | 50 | 0 |
| 5. Gallitzin coal [Lower Gallitzin]..... | 3 | 0 |
| 6. Mahoning sandstone [Lower Mahoning]..... | 65 | 0 |
| | 173 | 1 |

to the Upper Freeport coal bed, the same with the Cambria condition. No trace of any higher coal bed was seen. About 8 miles farther south and 3 miles west from the Cambria line the section reaches to a massive sandstone which Mr Platt correlates with the Morgantown. It is probable that here, as in northern Westmoreland, that sandstone is continuous downward to the Ames horizon, and that the coal bed here called Elk Lick is in fact the Harlem. At 130 feet below this coal bed is a Black Fossiliferous limestone, 212 feet above the Upper Freeport. The Black limestone overlies a mass of limestone and shale 26 feet thick, its bottom 35 feet above a thin coal bed. The whole mass represents the Brush Creek limestone, while at 65 feet higher is a thin limestone which may be at the Cambridge horizon. The Brush Creek and Upper Gallitzin coals are at 152 and 120 feet above the Upper Freeport. Three or four miles southwest on the Conemaugh river the section is:

* E. V. d'Invilliers: Final Summary Report, pp. 418, 419.

| | Feet. | Inches |
|---|-------|--------|
| 1. Shales, with 2 feet red band at 25 feet from top | 62 | 0 |
| 2. Upper Mahoning sandstone 20 feet | 45 | 0 |
| Upper Mahoning shale 10 feet | | |
| Upper Mahoning sandstone 15 feet | | |
| 3. Philson coal [Upper Gallitzin] | 0 | 6 |
| 4. Limestone [Upper Mahoning] | 5 | 0 |
| 5. Fireclay, sandstone, rusty shale | 20 | 0 |
| 6. Gallitzin coal [Lower Gallitzin] | Trace | |
| 7. Black shale | 4 | 0 |
| 8. Limestone [Lower Mahoning] | 4 | 0 |
| 9. Lower Mahoning, mostly sandstone | 55 | 0 |

giving 133 feet for the Mahoning, with both Gallitzin coal beds accompanied by limestone. The Brush Creek limestone belongs in the upper half of Number 1.*

This conclusion respecting the relations of the Black Fossiliferous limestone is confirmed by Stevenson's section on the Conemaugh river in Westmoreland county near the Cambria line, where that limestone is 170 feet above the Upper Freeport and 30 feet above the top of the Mahoning. The last consists of two sandstone plates, 45 and 50 feet respectively, separated by 45 feet of variegated clays, in all 140 feet, with the Upper Gallitzin directly underlying the upper plate.† The interval from Upper Freeport to Gallitzin is 25, and that to the Brush Creek limestone is 42 feet less than at 4 miles north in Cambria county. Within a mile or two farther south the Upper Gallitzin is about 50 feet above the Lower Mahoning and 10 feet below the Upper, and the Upper Mahoning limestone underlies it by 6 to 20 feet. The Upper Gallitzin was seen again at 3 or 4 miles southeast, where the Lower Gallitzin is present though only 3 inches thick. Farther south, at 12 miles from the Conemaugh river and still on the east side of the basin, the Ames and Brush Creek limestones were seen, 126 feet apart by barometer, each thoroughly characteristic and the latter overlying the Brush Creek coal bed, 8 inches thick. A coal bed, evidently the Lower Gallitzin, is at 100 feet lower.

An incomplete section obtained midway in the basin near Ligonier shows a Little Pittsburg coal bed at 60 feet below the Pittsburg, resting on its limestone, which is persistent. Another coal, at 140 feet, with an uncertain limestone, may represent the Little Clarksburg horizon. The Morgantown sandstone, beginning at 160 feet and 115 feet thick, extends downward to the Ames horizon, while at 18 feet below it is a coal bed correlated by Stevenson with the Elk Lick. It is the Harlem, and

* W. G. Platt: (H 4), pp. 76, 100, 103, 121, 125, 128.

† The error of correlating the Upper Gallitzin with the Philson of Somerset county affects the work of both W. G. Platt and Stevenson throughout the Second basin.

the fragments of Ames limestone seen below it belong above. Here, as in Cambria county, a limestone 2 feet thick is found at about 50 feet below the Harlem coal, and that coal bed is approximately 223 feet above the Upper Gallitzin (Philson of the text). The Brush Creek limestone is exposed at many places, and at one exposure the Barton coal was seen at 80 feet above it. The Upper Mahoning is usually thin in the southern part of the county and the Lower Mahoning is apt to be shaly. The Upper Gallitzin coal is persistent in this portion of the area and at one locality near the Fayette County line the Lower Gallitzin with the Lower Mahoning limestone is only 36 feet 8 inches above the Upper Freeport.*

In Fayette county, midway in the basin and 6 miles south from the Westmoreland line, the Harlem coal bed (Elk Lick in the text) is 306 feet above the Upper Freeport and overlies the "Pittsburg reds," 20 feet thick. One hundred feet lower is a coarse pebbly sandstone termed Salzburg by Stevenson, 40 feet thick; near by, the Brush Creek coal is at 138 and the Lower Gallitzin at 45 feet above the Upper Freeport. South from the Youghiogeny, on the east side of the basin, the Barton coal was seen at 238, the Salzburg sandstone at 170, and the Brush Creek coal at 138 feet above the Upper Freeport, the Barton being associated with red shale. This Salzburg sandstone is practically equivalent to the Buffalo sandstone of Doctor White and it can hardly include the sandstone overlying the Cambridge limestone. The Gallitzin coal bed, single in this county, is at 50 to 65 feet above the Upper Freeport and its underlying limestone appears occasionally in the sections. The Ames and Brush Creek limestones are present on the west side of the basin. Exposures are few and in most cases imperfect throughout this basin south from Clearfield county.†

In Preston county of West Virginia Doctor White examined diamond drill cores obtained near Masontown about 10 miles south from the state line. One of them shows:

| | Feet. | Inches |
|---|-------|--------|
| 1. Barton coal bed | | |
| 2. Interval to boring | 47 | 0 |
| 3. Sandstone | 8 | 6 |
| 4. Fireclay and shale | 19 | 0 |
| 5. Pebbly sandstone [Buffalo] | 54 | 0 |
| 6. Black shale and fossiliferous limestone [Brush Creek] | 5 | 9 |
| 7. Coal bed [Brush Creek] | 0 | 9 |
| 8. Fireclay, green shale, sandstone, and fireclay... | 42 | 5 |
| 9. Sandstone, shaly at bottom | 35 | 4 |

* J. J. Stevenson : (K 3), pp. 115, 116, 117, 120, 121, 129, 138, 163, 170, 172.

† J. J. Stevenson : (K 3), pp. 67, 84, 91, 110, 113.

to the Upper Freeport. The Barton is 134 feet above the Brush Creek, which is 78 feet above the Upper Freeport. Here the Buffalo sandstone overlies the Brush Creek limestone directly and there is no trace of the Cambridge. Another boring, barely a mile away, shows the Barton only 86 feet above the bottom of the Black fossiliferous shales, which are 104 feet above the Upper Freeport. There also the coarse Buffalo sandstone overlies the black shale; but at 5 miles northwest, in the Third basin, the interval from Brush Creek limestone to the Upper Freeport is but 50 feet. In all of the cores that limestone and its shales are characteristic, both of them black and richly charged with fossils.

The Mahoning is very thick in the northern part of the basin, but becomes thinner southward, while the interval between Brush Creek and Ames limestones, small at the north, increases southward, so that toward the West Virginia line the section becomes comparable with those in the Third basin and beyond.

Measurements by Doctor White at Newburg, 10 miles south from Masontown, show the interval above the Ames to the Pittsburg thicker than in Westmoreland county. The Elk Lick coal bed is at 259 feet below the Pittsburg and the Ames is represented by shales at 344 to 357, with the Harlem coal bed at 357.*

In Preston county the second basin becomes continuous with the third.

WESTERN BITUMINOUS BASINS OF PENNSYLVANIA

The Mahoning is present in small patches within southern Elk county, where it is in two more or less shaly divisions separated by a thin Gallitzin coal bed.†

Mr Platt's report shows scattered areas of Conemaugh in Jefferson county, but except in the eastern portion, near Chestnut ridge, the thickness remaining rarely exceeds 100 feet. In Clarion, west from Jefferson, some insignificant fragments remain, but the exposures are too imperfect for measurement.

The information respecting eastern Jefferson is indefinite, as the exposures seem to be very poor. Coal beds were seen in the east-central part of the county at 85 and 105 feet above the Upper Freeport, while on the Indiana border at the south are beds at 135, 310, and 385 feet, the last one 15 feet below an argillaceous limestone, 403 feet above the Upper Freeport. Two beds of red shale, 2 and 6 feet respectively, are at 185 and 222 feet, but the whole column is without notable sandstone except at the bottom, where the "Mahoning" is a massive rock. This

* I. C. White: *Geology of West Virginia*, vol. II, pp. 233, 269, 310.

† C. A. Ashburner: (*R R*), pp. 209, 227.

Mahoning, from 50 to 70 feet thick, varies somewhat abruptly from massive and coarse, even pebbly, to shaly. Limestones are reported at 70, 90, and other distances above the Upper Freeport, but for the most part the intervals as given are merely estimates and the matter is indeterminate throughout. The Gallitzin coal bed seems to be present in Gaskill township, on the Indiana border, where it rests on the "Mahoning," and the coal bed in Young township, the next west, at 138 feet, may be the Brush Creek.*

The section is still obscure in northern Indiana west from Chestnut ridge. In the central part of the county, 12 miles south from the Jefferson line, Mr Platt finds coal beds at 40, 95, 147, and 177 feet above the Upper Freeport. That at 147 is not far from the place of the Brush Creek, for the lower coals are clearly the Gallitzin beds, as they are accompanied by the Upper and Lower Mahoning limestones, the Upper being represented by calcareous ore, which Mr Platt correlates with the "Johnstown ore" of Cambria county. The "Mahoning" of Jefferson is evidently the Lower Mahoning. Farther southwest, between Blairsville and Chestnut ridge, the whole of the Conemaugh is present. The Pittsburg limestone and shale, beginning at 20 feet below the coal, are 7 feet thick. A Little Pittsburg coal with its limestone persists at 45 feet, while at 125 feet is a coal and limestone exposure which may be at the Little Clarksburg horizon. Mr Platt finds a massive sandstone, 40 feet thick, beginning at 145 feet, which he takes to be the Morgantown; but it is extremely variable, for 2 miles away the interval is occupied by shales containing two red bands 5 and 3 feet, another bed of 7 feet being found at 210. The place of the Ames limestone is concealed in most of the sections reported, but that bed was seen, 3 feet thick, at 9 miles north from Blairsville, where it overlies the thick "Pittsburg reds" and is by barometer 280 feet above the Upper Freeport. The Brush Creek (Black Fossiliferous) limestone was not seen by Mr Platt and in all probability it is wanting, as the Mahoning is very thick in this corner of the county. If present it should be at about 130 feet below the Ames. The thickness of the Conemaugh as determined from exposures by Mr Platt is approximately 600 feet, but Mr Richardson gives it as 675 feet in the deep boring at Blairsville.† Mr Platt thinks the Mahoning at least 150 feet thick east from Blairsville, where an exposure shows Upper Mahoning massive, somewhat pebbly, and 50 feet thick. The Gallitzin (Philson) coal bed is in three benches and, including 8 feet of

* W. G. Platt: (H 6), pp. 21-23, 35, 73-74, 124.

† G. B. Richardson: U. S. Geol. Survey folios, Indiana (102), 1904.

clay partings, is 11 feet 9 inches thick, with the Mahoning limestone 5 feet thick and 2 feet 6 inches below it. The Lower Mahoning is said to be at least 75 feet thick.

Westward from Blairsville the rocks come up along the Kiskiminitas river (formed by union of the Conemaugh and Loyalhanna) and the lower beds are reached toward the western border of the county, near Salzburg, where the section is:

| | Feet |
|--|-------|
| 1. Red shale | |
| 2. Sandstone [Buffalo] | 100 |
| 3. Sandy shale [black] | 10 |
| 4. Sandstone [Upper Mahoning] | 50 |
| 5. Coal bed [Upper Gallitzin] | Trace |
| 6. Variegated shale | 15 |
| 7. Sandstone | 15 |
| 8. Coal bed [Lower Gallitzin] | Trace |
| 9. Ferruginous limestone and ore [Mahoning]..... | |
| 10. Shale | 10 |
| 11. Sandstone [Lower Mahoning]..... | 20 |
| 12. Slates | 8 |

to the Upper Freeport, giving 124 feet as the thickness of the Mahoning, which is no longer wholly a massive sandstone as east from Blairsville. Stevenson states that the shales Number 3 are dark and argillaceous, carrying nodular ore which farther up the river becomes a continuous layer; so that here one finds the Brush Creek limestone.* The sandstone Number 2 includes not only the Buffalo, which is between the Cambridge and Brush Creek limestone, but also the Cowrun of Ohio, and the red shale is evidently near the Barton horizon. This sandstone becomes less prominent northward and at 12 miles from Salzburg the Brush Creek limestone was seen. That limestone was observed also farther north on the Armstrong border, where Mr Platt's section shows coal streaks at 58, 73, 100, and 117 feet below, with a limestone, 4 feet, underlying that at 73. The Upper Freeport is at only a few feet lower.† The limestone is representative of the Mahoning and the four coal streaks may be taken as illustrations of irregularities in subsidence and deposition at the Gallitzin horizon.

Armstrong county, west from Indiana, south from Clarion, and north from Westmoreland, is divided by the Allegheny river. East from that stream the Conemaugh is for the most part the surface formation and the Pittsburg coal bed is reached in the southeast corner.

* J. J. Stevenson: (K 2), p. 318.

† W. G. Platt: (H 4), pp. 157, 170, 174, 244, 257, 270, 280, 284.

Entering at the southeast, one finds the lower part of the section as at Salzburg, but at 5 miles from the county line, near Apollo, the Brush Creek (Black Fossiliferous) limestone is present at 134 feet above the Upper Freeport and 76 feet above the Lower Gallitzin, which is accompanied by the Mahoning limestone as at Salzburg. Already the great sandstone mass overlying the Brush Creek limestone has broken up and the Cambridge limestone, at 40 feet above the Brush Creek, is greenish gray, fossiliferous, and in many features much like the Ames, as at many localities in Ohio. The Ames (Green Fossiliferous) is given in the generalized section as about 215 feet below the Pittsburg coal bed and as resting on the Harlem coal. It is 24 feet below the Morgantown sandstone, which is 34 feet thick. The Pittsburg limestones are at 21 and 43 feet, but no trace of the Little Pittsburg and Clarksburg coals appears. The highest red shales are between the Morgantown and the Ames.

Northward from the Kiskiminitas the section is traced with ease along the east side of the county, where the great sandstones prevail for several miles. The Brush Creek coal bed is at 140 feet above the Upper Freeport, underlying the Buffalo-Cowrun sandstone, on which rest 8 feet of red shale. The Barton coal is shown in many places at about 75 feet below the Ames limestone, or 225 feet above the Upper Freeport, and the Gallitzin is represented by one or the other of its splits at several localities. On the west side of the Allegheny river the Ames is at 260 to 270 feet above the Upper Freeport and the Pittsburg reds are conspicuous as at several localities east from the river.*

Butler county is west from Armstrong and north from Allegheny. In the northern half one rarely finds more than 100 feet of Conemaugh. The Gallitzin (Millerstown of Chance) is at 35 to 55 feet above the Upper Freeport and occasionally becomes thick, 5 feet 10 inches at one locality, but the coal is inferior. Both divisions of the Mahoning are present and vary from massive to shaly sandstone.†

Entering southern Butler at the southeast, one has Doctor White's section showing two massive conglomerates, each 60 to 70 feet thick, separated by sandy shales, giving in all 160 to 170 feet. The Upper, or Buffalo, is the coarser, the pebbles being as large as hickory nuts, and its bottom at the type locality is 120 feet above the Upper Freeport. There the interval between it and the other plate, the Lower Mahoning, is concealed, but Doctor White's section on the Armstrong County border shows the conditions:

* W. G. Platt: (H 5), pp. 5, 21, 36, 68, 90-91, 163, 280, 288.

† H. M. Chance: (V), pp. 56, 90.

| | Feet |
|-------------------------------------|-------|
| 1. Ames limestone | 3 |
| 2. Red shale | 30 |
| 3. Gray shale | 100 |
| 4. Coal bed [Anderson] | 1 |
| 5. Limestone [Cambridge] | 1 |
| 6. Concealed | 10 |
| 7. Buffalo sandstone | 50 |
| 8. Sandy shale | 35 |
| 9. Gallitzin coal bed [Upper] | Trace |
| 10. Sandy shale | 35 |
| 11. Lower Mahoning sandstone | 55 |

giving 317 feet from the Ames limestone to the Upper Freeport coal bed. The Buffalo sandstone is easily followed in all but the western townships of southern Butler; in those it evidently loses its conglomerate character and becomes less important. The Lower Mahoning, very coarse at the east and southeast, becomes shaly westward, while decreasing somewhat in thickness. The Gallitzin horizon is represented by thin coals at numerous localities, there being at least one bed wherever the interval is exposed. The highest is that in the Freeport section; elsewhere the highest is at 70 feet. In Forward township three beds are present at 20, 25, and 63 feet above the Upper Freeport, and two are shown at 35 and 60 in Jackson. The Mahoning limestone appears to be wanting throughout.

The Brush Creek coal and limestone seem to be almost wholly unrepresented in the eastern townships. The horizon is recognizable at many places as black, sometimes coaly, shale underlying the Buffalo sandstone, but the coal as such is distinct first in the western third. A Forward Township section shows 6 inches of coal separated by 10 feet of black shale from the overlying Buffalo; it is 115 feet above the Upper Freeport and 52 feet above the Upper Gallitzin. In Connoquenessing it is scattered through the black shale at 119 feet above the Upper Freeport and is 72 feet above a Gallitzin coal. In the southwest corner of the corner both coal and limestone are well shown, the type locality being on Brush creek, in Cranberry township.

The Cambridge (Pine Creek) limestone, shown in the Freeport section, is absent at all other localities where its horizon is reached. It is not noted in any of Doctor White's numerous sections, but the Anderson coal bed belonging above it is persistent at 5 to 20 feet above the Buffalo sandstone. The Barton (Bakerstown) coal bed is present in some of the townships along the Allegheny County border at 80 to 85 feet below the Ames limestone, but it is no longer an important member of the forma-

tion. The Cowrun sandstone, between it and the Cambridge limestone, is represented by shale in Butler county, though it is a well marked sandstone in Allegheny county. The Ames limestone is always seen where its horizon is exposed, as are also its underlying red shales, but the Harlem coal bed seems to be wholly wanting. The Elk Lick coal bed was seen in the only townships in which its horizon is reached.*

In southeastern Lawrence, west from Butler, a double coal bed is apparently persistent at 55 to 65 feet above the Upper Freeport limestone and overlying a fireclay containing much calcareous iron ore which at one locality is limestone, representing the Mahoning. In one place it is overlain by 20 feet of shale, but in another by a massive conglomerate.†

Beaver county, extending to the Ohio line, is south from Lawrence and west from Butler and Allegheny. Extensive erosion by large streams has removed the Conemaugh from much of the county north from the Ohio river, so that in the central portion that formation occurs in somewhat widely separated areas. The Elk Lick horizon is reached in a few places and the coal bed is shown. The Ames limestone and the Pittsburgh reds are persistent, but the Harlem, Barton, and Anderson coal beds are apparently absent throughout. The place of the Cambridge limestone is rarely exposed, but that bed is present on both sides of the county at about 120 feet below the Ames and 60 to 65 feet above the Brush Creek. The Buffalo sandstone varies from coarse to fine sandstone or sandy shale and at one locality it is replaced by variegated shale.

In the northern tier of townships one finds at 6 miles southwest from the Lawrence County exposures, already referred to, a coal bed, evidently the Brush Creek, at 80 to 90 feet above the Upper Freeport and 12 feet below the decomposed Brush Creek limestone. Like that in Lawrence, this is a double bed, the upper portion more or less resembling cannel. The interval in Lawrence is 55 to 65 feet. Farther west a coal blossom appears on the hilltops at 58 to 70 feet above the Upper Freeport, with at 3 to 4 feet below it a slabby limestone, while still farther west, near the Ohio line, the interval is 60 to 65 feet. Four miles west, in Columbiana county of Ohio, Doctor White finds a coal at 50 feet, the interval being, as in northwest Beaver, concealed. This is the Coal 7, or the Groff vein, of northeast Ohio. Farther south in Beaver county one finds on the east or Butler County side the Brush Creek coal bed, 12 feet below its limestone, 185 to 207 feet below the Ames limestone and about 90 feet above the Upper Freeport, with a thin Gallitzin bed at

* I. C. White: (Q), pp. 24, 73-74, 76, 79, 80, 84, 87, 89, 91, 96, 99, 101-103, 106, 115, 123, 128-129, 135-136.

† I. C. White: (Q 2), pp. 76, 79, 80, 81, 82.

40 feet. At the next exposure, 7 or 8 miles west, the limestone already referred to is at 50 to 70 feet above the Upper Freeport, but no coal appears above it. Still farther west the coal is shown on the hilltops at 65 feet, while at 5 miles beyond, in Columbiana county of Ohio, Doctor White finds the interval 55 feet, with the massive conglomerate Buffalo sandstone resting on it.

Going southward along the Ohio line, one has this section at the Ohio river:

| | Feet |
|--|------|
| 1. Sandy shale | 20 |
| 2. Pine Creek [Cambridge limestone] | 2 |
| 3. Buffalo sandstone and sandy shale | 65 |
| 4. Brush Creek limestone | 1 |
| 5. Brush Creek coal and concealed | 5 |
| 6. Mahoning sandstone, massive | 80 |

to the Upper Freeport coal bed. At 3 miles east the massive Buffalo

sandstone rests directly on the Brush Creek coal, which is 95 feet above the Upper Freeport. There seems to be no escape from the conclusion that the coal bed, 55 to 65 feet above the Upper Freeport in Lawrence and 99 to 65 feet in Beaver, is the same bed and at the Brush Creek horizon. If the limestone seen in central Beaver be the Mahoning of the eastern counties, the Upper Mahoning interval disappears northward and westward, bringing the Brush Creek coal down to the place of the Gallitzin coal.

A new coal horizon appears in eastern Beaver at 30 to 40 feet above the Brush Creek coal, dividing the Buffalo sandstone. Its place is exposed at only one locality.*

Southward from the area thus far described the Monongahela soon becomes the surface formation, and, except where anticlines are cut by streams, one finds only the upper portion of the Conemaugh exposed and the records of oil borings are the chief source of information. The thickness of the Conemaugh at the north is about 600 feet, but it decreases southward to about 560 feet at the West Virginia line.

South from the Kiskiminitas and east from the Monongahela river are eastern Allegheny, Westmoreland, and Fayette counties, the last extending to the West Virginia line. The Little Pittsburg coal beds, approximately 20 and 60 feet below the Pittsburg, are fairly persistent, though never economically important. Three limestones, 0 to 13, 45, and 60 feet below the Pittsburg, are shown at many places, though one rarely finds them all in a single section. The Clarksburg limestone

* I. C. White: (Q), pp. 179, 180-181, 183, 187-189, 208, 213-214, 223, 226, 235, 240, 245, 257, 260, 263; (Q 2), pp. 276, 282.

and its overlying coal bed or black shale are reasonably persistent. The Connellsville sandstone is usually somewhat massive, though at many places it becomes shaly or even is replaced by a more or less clayey shale, while the Morgantown is a characteristic sandstone not far from 50 feet thick. At a few feet below the last is the Elk Lick coal bed (Barton of Lesley and Stevenson) and the Ames limestone, 280 to 300 feet below the Pittsburg, appears almost invariably wherever its place is exposed, but the Harlem coal bed is reported from only one locality in Allegheny and one in Fayette. The Barton (Bakerstown) coal bed is apparently constant in Fayette county at about 75 feet below the Ames, but does not appear in sections within the other counties. The Cambridge limestone does not appear in any of Stevenson's sections, and the Buffalo-Cowrun sandstone, so conspicuous on the Kiskiminitas, disappears rapidly southward, where one finds only shales in its place above the Brush Creek (Black Fossiliferous) limestone, which rests on the Brush Creek coal bed. The Mahoning varies from massive sandstone to mere shale, and the Gallitzin coals, so persistent at the north, seem to be absent from southern Westmoreland and from Fayette. The red beds, except that underlying the Ames limestone, become insignificant and are practically unrepresented in Fayette.*

The records of oil borings in these counties west from the narrow strip of exposed Conemaugh for the most part give little detail or are not referable to any fixed datum. A record in northwestern Westmoreland shows the Buffalo sandstone 70 feet thick and beginning at 110 feet below the Pittsburg reds. The Mahoning, beginning 20 feet below the Buffalo, is double and rests on the Upper Freeport at 595 feet below the Pittsburg. The Pittsburg red is the lowest red bed, but a record near Irwin, on the Pennsylvania railroad, shows three reds, 20, 32, and 5 feet thick respectively, at 395, 459, and 546 feet below the Pittsburg coal bed. The upper Freeport is reached at 605 feet and only shales are present to 280 feet above it. A record in central Fayette county gives a thickness of 590 feet for the Conemaugh and red shale is absent.†

Northern Allegheny, south from Butler, is between the Allegheny and Ohio rivers. The exposed section extends from the Upper Freeport at the north to the Pittsburg at the south. The Ames limestone is shown in every township at from 280 to 300 feet below the Pittsburg coal bed and the Elk Lick coal, at 25 to 35 feet above the Ames, occasionally overlies a black fossiliferous limestone which may be the equivalent of the

* J. J. Stevenson: (K K), pp. 64, 74, 75, 137, 141, 171, 172, 182, 274, 316, 318, 348.

† J. F. Carll: Oil and Gas Report for 1889, pp. 214, 221, 226, 320-322.

I. C. White: Geology of West Virginia, vol. 1a, p. 115.

Somerset Elk Lick limestone. The Harlem coal appears in many sections, but is distinctly absent from others. The Pittsburg reds are a striking feature wherever their horizon is reached, and the Bakerstown (Barton) coal bed, 75 to 80 feet below the Ames, occasionally attains workable thickness. Between it and the Cambridge limestone there is sandstone or sandy shale 40 feet thick, the Cowrun of Ohio. The Anderson coal is wanting and the sandstone rests on the limestone. The interval between the Cambridge and Brush Creek limestones, ordinarily about 60 feet, is sometimes filled by the Buffalo sandstone. In one of the southern townships the Salzburg condition is repeated and the Buffalo is continuous with the Cowrun, giving a continuous sandstone about 100 feet thick. Toward the Beaver County line the Buffalo becomes less conspicuous and at times is replaced in great part by shale. The sandstone sometimes cuts out the underlying Brush Creek limestone, which here has all its characteristic features, and is separated by a few feet of black shale from the Brush Creek coal bed, which is from 60 to 100 feet above the Upper Freeport. The variation in this interval is due chiefly to changes in the Lower Mahoning, which at times almost disappears. At one locality the Upper Gallitzin is at 45 feet and the Mahoning limestone at 10 to 15 feet above the Upper Freeport.

Above the Ames there are few persistent beds. The Morgantown sandstone is constant, often forming cliffs; a red bed 20 feet thick begins at 90 feet above the Ames and is present in many sections. The Pittsburg limestones are irregular.*

West from the Monongahela and south from the Ohio are western Allegheny, Washington, and Greene, the last extending to the West Virginia line at the south. The surface formation is the Monongahela and except along the Monongahela river and along the northern border of the area the Conemaugh is deeply buried. The exposed section at the north extends but a little way below the Ames limestone.

In western Allegheny two limestones within 30 feet below the Pittsburg coal bed are commonly found; they are more or less brecciated in structure and in most localities contain minute fossils, which are supposed to be of fresh-water types. Another at 140 to 150 feet may be at the Little Clarksburg horizon. Red shale beds were seen at 65, 89, 106, 175, and 194 feet, but not all of them in any one section; that seen at 106 is evidently the lower portion of a 50-foot bed observed elsewhere at 89 feet; that at 194 feet is apparently equivalent to one seen in northern Allegheny at 90 feet above the Ames. Within short distances the

* I. C. White: (Q), pp. 149, 154, 158, 159, 160-165, 171-178.

whole section changes and neither limestone nor red shale appears. The Ames limestone, 280 to 300 feet below the Pittsburg, is constant and at many places is accompanied by the Harlem coal bed. In the Painter well, on the Monongahela river above Pittsburg, the Cambridge limestone is at about 420 feet below the Pittsburg and a coal, probably the Gallitzin, is at 528. The Mahoning is represented by shale.*

In Washington county one finds at the extreme north the Elk Lick coal bed, 10 feet below the 90-foot Morgantown sandstone or 260 feet below the Pittsburg and 35 feet above the Ames limestone, which rests on the Harlem coal. The Little Pittsburg coals are wanting, but there are two persistent limestones within 30 feet. On the Monongahela 3 limestones occur in this interval and the Little Pittsburg coal is represented by black shale.

The records of oil borings show irregularity in the Conemaugh section. The interval from the Pittsburg coal bed to the Mahoning varies from 463 to 488 feet, that rock in some cases being almost continuous above with the Buffalo. Both divisions of the Mahoning are distinct and are usually sandstone, though varying greatly in thickness; occasionally, however, one or the other is replaced by shales, and changes of this kind are frequently abrupt. One of two wells near the borough of Washington shows the Upper Mahoning all sandstone, but in the other it is all shale.

The Buffalo sandstone is represented by shale at McDonald; at other localities it is distinct as a sandstone, but very variable. In one well at Washington it begins at 413 feet, evidently replacing the Cambridge limestone, and is separated by but 4 feet of shale from the Mahoning at 488, thus giving an almost continuous mass of sandstone, 107 feet thick; but in the other well it begins at 428, is only 20 feet thick, and is separated by 100 feet of "slate and shells" from the Lower Mahoning. At Beallsville, east from Washington, it begins at 448 and is 25 feet thick. The sandstones above the Buffalo are equally irregular; the Morgantown horizon is sufficiently well marked, but the other beds, some of them very thick, can not be correlated with any at exposed sections. No coal is recorded anywhere except at McDonald, where the Little Clarksburg is at 175 and a Gallitzin bed at 501 feet below the Pittsburg.

The red beds are important members of the formation, though they are extremely variable. There are three horizons, 129 to 174, 236 to 310, and 367 to 413, within which these beds occur in almost all of the

* J. J. Stevenson : (K), pp. 296, 298, 324-326, 306-309, 310, 314.
I. C. White : *Geology of West Virginia*, vol. 1a, pp. 101-102.

wells, the whole interval in some cases being filled with red shale. Thin beds are found in different wells at 528 and 567 feet.*

In Greene county the upper 250 feet of the Conemaugh are shown on the Monongahela river. Impure limestone is at 4 feet below the Pittsburg coal, and a little Pittsburg coal bed is at 40 feet overlying a limestone. The Clarksburg limestone and its overlying coal bed are at 130 to 140 feet, and the Morgantown sandstone, 95 feet thick, is well shown overlying the Elk Lick coal bed, which is 2 feet 4 inches thick and 245 feet below the Pittsburg. A fossiliferous shale with many lamelli-branches was seen near Greensboro at 148 feet.

Records of oil borings in the interior of the county are available for the north border, the center, and the southern border near the West Virginia line. No coal is noted in any boring except at the south, where the Barton is at 350 feet below the Pittsburg. The thickness of the Conemaugh in that part of the county is 560 to 565 feet. The Connessville sandstone is present in the north and center, with its base at 120 and 128 feet below the Pittsburg; the bottom of the Morgantown is from 226 to 235; the Buffalo horizon is marked in the north and center by a mass beginning at 390 and 401 feet, and in the north it is 90 feet thick. The Upper Mahoning is present in two records, beginning at 481 and 451 and ending at 511 and 486. It is wanting in the west central part of the county, where only shales are recorded to 140 feet below the Buffalo sandstone. The Lower Mahoning is present in all records except that of the west central region, the bottom being at 591, 560, and 565, in the last resting directly on the Upper Freeport. The intervals within which the red beds appear are 120 to 183, 205 to 290, and 385 to 415, answering to those of Washington county; each of these is almost filled with red shale in one or other of the wells. A lower horizon is at 500 to 510. The greatest thickness in all of red shale is in the central part of the county, where 135 feet is found in the first and second intervals, there being none in the third; the least is near the Monongahela, where a single bed, 5 feet thick, is reported at 351 feet.†

THE NORTHERN PANHANDLE OF WEST VIRGINIA

It is well to carry the section to the Ohio river across the narrow strip in West Virginia adjoining at the east southern Beaver, Washington, and Greene counties of Pennsylvania.

* J. J. Stevenson: (K), pp. 178, 207, 271, 279, 280, 283.

J. F. Carll: Ann. Rept. for 1886, pp. 762, 764.

I. C. White: Geology of West Virginia, vol. *ia*, pp. 112, 113, 117, 118.

† J. J. Stevenson: (K), pp. 90-91, 94, 115-116.

J. F. Carll: Oil Rept. for 1889 (15), pp. 31, 35.

I. C. White: Geology of West Virginia, vol. *ia*, pp. 122-123, 130.

The most northerly patch of the Pittsburg coal in West Virginia is in Brooke county, a few miles north from Steubenville, though in Jefferson county of Ohio a similar patch is found nearly 10 miles farther north. Doctor White's measurements in the Kings Creek region of that county give a somewhat greater thickness to the Conemaugh than do those on the Ohio side, the interval to the Steubenville shaft coal bed, the Lower Freeport, being 580 feet and to the Upper Freeport 515 feet. Professor Newberry's measurement on Wills creek, in Ohio, are 493 and 558 feet; but the intervals vary here with great abruptness. The Morgantown sandstone, Elk Lick and Anderson coal beds are exposed, the last underlying the massive Cowrun sandstone 40 feet thick. The Ames, Cambridge, and Brush Creek limestones are present, the last two being 70 feet apart. The Brush Creek limestone and black shale rest on the Brush Creek coal bed, under which is calcareous shale representing the Mahoning limestone. The Lower Mahoning is represented by massive sandstone resting on the Upper Freeport, which is 50 feet below the Brush Creek. Red shales are shown above the Morgantown sandstone as well as under the Ames and Cambridge limestones, but the beds are thin.

Nine miles farther south the Upper Freeport is absent, and the interval from Ames limestone to Lower Freeport coal bed is 324 feet. On the Ohio side of the river the distance from Pittsburg to Lower Freeport is 556 feet, making the Ames about 225 feet. At Wheeling the interval between the two coals is 556 feet, with the Anderson coal bed at 355 and only "variegated shale" for 280 feet above that bed; but at 3 miles southeast from Wheeling a sandstone, 150 feet thick, begins at 136 feet below the Pittsburg, and a coal bed is reached at 395 feet which is too high for the Brush Creek, but is very near the place of a bed seen in northern Beaver and seen frequently in Jefferson county of Ohio. Two red beds 20 and 25 feet are in the interval between the sandstone and this coal bed. The Mahoning interval is filled with shale and the first sandstone is in the Allegheny at 545 feet. Three miles south from Wheeling there is little aside from shale between the Pittsburg and a coal bed at 530 feet which rests on a great sandstone continuing to the bottom of the Carboniferous. Red shale begins at 50 feet below the Pittsburg and thence it predominates. It is altogether probable that the coal bed at 530 feet is the Upper Freeport, as the intervals increase slightly southward.

At 12 miles southeast from Wheeling, in Marshall county and on the Pennsylvania border, 12 miles west from the boring in northern Greene county, a record shows coal beds at 333 and 593 feet below the Pittsburg; the latter is the Lower Freeport, but the former is too high for the

Anderson, which is due at about 370. It may be at the Barton horizon, which is marked by coal at a number of places in Jefferson county of Ohio. The Mahoning, almost wholly sandstone, begins at 478 and continues into the Allegheny at 558 feet. Six thin red beds, in all only 45 feet, are recorded, the lowest being at 378 feet. Near Moundsville, on the Ohio river, 10 miles south from Wheeling, a sandstone 85 feet thick begins at 197 feet below the Pittsburg and ends at 282, very nearly as at 3 miles southeast from Wheeling. It rests on 70 feet of red shale, separating it from a sandstone 60 feet resting on coal at 437 feet, which is near the Brush Creek horizon. In southern Marshall the well records note only the sandstones. The Mahoning, as a sandstone, begins at 450 to 480 feet and ends at 526 to 532, where it can be differentiated from the Allegheny beds. The Lower Freeport, in Wetzel county south from Marshall, is at 575 feet below the Pittsburg. In the wells of southern Marshall, as in those of northern Wetzel, a sandstone, the Cowrun (Salzburg of the records) begins at about 300 feet below the Pittsburg.*

OHIO

Passing over into Ohio, one finds the most northerly exposures in Columbiana county adjoining Beaver of Pennsylvania. At Palestine, in the northern part of the county, the Brush Creek coal is at 50 feet above the Upper Freeport and the Mahoning limestone is absent. At other localities, according to Professor Newberry, the interval is 60 feet. This is Coal 7 of the northern Ohio series, known locally as the "Groff vein." Farther south, toward the border of Jefferson county, numerous sections measured by Professor Newberry show the interval from 58 to 52 feet, with the Mahoning limestone at 3 to 8 feet below the Brush Creek coal. The Lower Mahoning is "sandstone and shale" 20 to 40 feet thick. A limestone, 10 feet thick, including shale, appears in some of the sections at 0 to 20 feet above the Brush Creek coal. This, cut out in many places by the overlying sandstone, is black, nodular, contains many fossils, and is the Brush Creek limestone of Pennsylvania. The Buffalo sandstone is irregular in southern Columbiana, at times very coarse, as near Wells-ville, but for the most part rather fine grained and often mere shale. Sections along the Columbiana-Jefferson border reach in several instances to the Ames limestone, which overlies the Pittsburg reds, 50 feet thick, and is 225 to 255 feet above the Brush Creek coal bed. At Irondale the interval between Ames and Brush Creek is occupied wholly by red and

* I. C. White: *Geology of West Virginia*, vol. 1, pp. 363, 366-367; vol. 1a, pp. 214, 217, 226, 231; vol. 11, p. 241.

olive shale. A thin coal bed rests on the Ames limestone at this place, but elsewhere it is 20 feet above, with green and red shale between them. It appears to be at the Elk Lick horizon. Nearer the Ohio river the Harlem coal is immediately under the Ames, the Barton is at 50 to 60 feet below, and the Lower Mahoning is coarse and pebbly sandstone. The interval between the Brush Creek and Upper Freeport varies from 35 to 69 feet between Irondale and the Ohio river, and the Mahoning limestone (Gray limestone of Newberry) is present in most of the sections.*

Southward in Jefferson county numerous direct measurements by Newberry, Orton, and Newton show that the interval from the Ames limestone to the Brush Creek coal varies within 16 miles from 199 to 230 feet, the least interval being at Steubenville, the most southerly measurement. This interval is filled mostly by red and olive shale, but at several localities a coal bed appears at 27 to 46 feet above the Brush Creek, marking a horizon first seen in eastern Beaver of Pennsylvania. The interval from Brush Creek to Upper Freeport varies along this line from 37 to 85 feet. At 3 miles southeast from the northwest corner of the county Professor Newberry found the Harlem coal immediately under the Ames limestone and another coal bed at 114 feet lower, immediately above an impure limestone, the Cambridge, at 118 feet. This, the Anderson coal bed, underlies variegated shale, but 10 miles away toward the southeast, in Brooke county of West Virginia, it is 100 feet below the Ames and underlies the massive Cowrun sandstone, 40 feet thick. A bed at the Barton horizon is noted at several localities 55 to 65 feet below the Ames limestone.

The interval from the Pittsburg coal bed to the Ames limestone varies from 149 feet in northern Jefferson to 225 feet in the southern part of the county. A limestone is usually seen at 1 to 25 feet below the Pittsburg; a coal and limestone marking the Little Clarksburg horizon are exposed occasionally in northern Jefferson, and at one locality cannel occurs at a Little Pittsburg horizon 40 to 50 feet below the coal. The Elk Lick horizon is marked by coal at many places 20 to 35 feet above the Ames; but the section shows much variation, the whole interval being occupied at one place by blue and sandy shales to 180 feet above the Ames. Red beds are at several horizons, but, excepting those associated with the Ames, they are thin and of uncertain occurrence. The interval from Pittsburg to Upper Freeport is 498 feet in northern Jefferson, 493 at

* This is the Brush Creek limestone of volume v.

Wills creek, and about 515 feet at Steubenville as well as at 10 miles farther south.*

Carroll county is west from Jefferson. The careful work of the Third Ohio Survey superseded the reconnaissance made by Stevenson in 1872 and resolved the difficulties that so perplexed that observer. Two sections by Professor Orton suffice to show the variations. Midway in the county the Brush Creek coal bed at 130 feet below the Ames limestone is 45 feet above the Upper Freeport, but at 10 miles farther south the intervals are 195 and 71 feet, both sections showing the Mahoning and Cambridge limestones, the latter at 120 feet below the Ames. In both sections the Lower Mahoning is shale, the Upper Mahoning, as apparently at all localities in Ohio, being absent. The Pittsburg reds, so conspicuous farther east, are wanting and the only red bed in the section is 20 feet thick, at 70 feet above the Ames and underlying a limestone whose top, at 115 feet, can not be more than 40 feet below the Pittsburg coal. According to Stevenson, the Ames limestone is double midway in the county, where the Harlem coal bed occasionally attains workable thickness, especially near the village of Harlem. A coal horizon, evidently the Anderson, is distinct at 75 to 105 feet below the Ames limestone, the interval increasing southward.†

The whole of the Conemaugh is exposed in Harrison county, south from Carroll and west from Jefferson. The Ames limestone is rarely more than 150 feet below the Pittsburg coal bed. Even in the southeast corner of the county the interval is but 149 feet, though at 6 miles eastward, in Jefferson, it is 225. The Harlem coal bed is shown at many places and occasionally attains workable thickness. The Anderson coal is distinct at 90 to 104 feet below the Ames, as is the Brush Creek at 42 feet above the Upper Freeport. The Elk Lick coal was seen frequently as coal or coaly shale at 8 to 12 feet above the Ames limestone. Neither the Cambridge nor the Mahoning limestone is noted in any of the sections. Limestone is persistent almost directly below the Pittsburg coal, but aside from that none of the beds above the Ames is persistent.‡

Belmont county, south from Harrison and Jefferson, extends to the Ohio river. On the river side the exposed section reaches downward to

* J. S. Newberry: Ohio, vol. III, pp. 96, 99, 107, 731-732, 736, 739, 740, 746, 750, 751, 753.

J. S. Newberry and Henry Newton: Vol. II, sections, sheets nos. 1, 2.

J. J. Stevenson: Vol. III, pp. 765, 768, 771, 773, 778.

E. Orton: Vol. V, pp. 50-51, 53-54, 61.

I. C. White: Pennsylvania (Q Q), p. 282.

† J. J. Stevenson: Vol. III, pp. 180, 182-183.

E. Orton: Vol. V, p. 255.

‡ J. J. Stevenson: Vol. III, pp. 205-206, 208.

little more than 100 feet below the Pittsburg, and the rocks, aside from a limestone at 1 to 17 feet, are almost wholly sandstone. The record of an oil boring in Washington township 6 or 8 miles from the river shows only shales for 750 feet below the Pittsburg coal, resting on the Pottsville, a sandstone 258 feet thick. Red beds 25 and 155 feet thick begin at 30 and 95 feet below the coal. This is not more than 2 miles from Moundsville, in West Virginia, where a massive sandstone 85 feet thick begins at 197 feet below the Pittsburg and is separated by 70 feet of red shale from a lower bed of sandstone 60 feet thick. In the western part of the county the section reaches to the Ames limestone, which is barely 140 feet below the Pittsburg. Limestone 4 to 30 feet thick is at 0 to 12 feet below the Pittsburg, but thence to the Ames one finds in the north-west part of the county little aside from sandstone, while in the south-west part much of the interval is filled with shale.*

Some small outliers of Conemaugh remain in Tuscarawas county west from Carroll and Harrison, where Professor Newberry found the Brush Creek (7a) at 53 feet above the Upper Freeport (7). The Lower Mahoning, 30 feet thick, is the Stillwater conglomerate of Newberry and underlies 10 feet of red shale. Overlying the Brush Creek are 60 feet of mostly olive shale, replacing the Buffalo sandstone.†

Guernsey county, south from Tuscarawas and west from Belmont, has the whole Conemaugh section exposed. In the northeastern part, near the Belmont line, the Ames limestone is 148 to 152 feet below the Pittsburg coal bed, with, in the interval, limestones at 12 and 68 feet, but no coal, very little sandstone, and no red shale. In the southeast portion the interval to the Ames varies from 138 to 160 feet, with limestones at 10, 27, and 53 feet, and a red bed 20 feet thick beginning at 54 feet. At one locality Professor Andrews found a fossiliferous limestone 1 foot thick 65 feet above the Ames, and at another probably the same bed at 80 feet below the Pittsburg. The Ames limestone persists throughout the county. A section in the central part of the county by Professor Orton is:

| | Feet. | Inches |
|---------------------------------|-------|--------|
| 1. Limestone | | |
| 2. Concealed | 68 | 0 |
| 3. Anderson coal bed | 2 | 6 |
| 4. Red shale | 10 | 0 |
| 5. Cambridge limestone | 4 | 0 |
| 6. Fireclay and red shale | 15 | 0 |

* E. B. Andrews : Vol. ii, p. 547.

J. J. Stevenson : Vol. iii, pp. 262-263.

J. A. Bownocker : Fourth Survey, Bull. no. 1, p. 220.

† J. S. Newberry : Vol. iii, p. 81.

| | Feet. | Inches |
|---|-------|--------|
| 7. Concealed | 20 | 0 |
| 8. Sandstone, heavy [Buffalo] | 25 | 0 |
| 9. Fossiliferous black shale [Brush Creek]..... | 5 | 0 |
| 10. Brush Creek or Groff coal bed | 1 | 0 |
| 11. Concealed | 25 | 0 |
| 12. Upper Freeport coal bed | | |

Red shale is not reported as associated with the Ames limestone in the northern part of the county, and it was seen at that horizon in the southern part only near the Belmont County line. The Harlem coal is reported from one locality in northern Guernsey, where, according to Stevenson, it is roofed by cannel which is "full of aviculoid shells." For the most part its place is concealed in sections by Andrews, but it is reported by him twice in the southern part of the county at 12 to 18 feet below the Ames.

The Anderson coal bed of Andrews, Norwich of Stevenson, is at most 86 feet below the Ames, 10 feet above the Cambridge limestone, and is persistent, having been seen in all parts of the county. The Cambridge limestone is present throughout the western townships at 86 to 96 feet below the Ames; it is below the surface in the eastern portion. The interval from it to the Upper Freeport (locally Cambridge of Andrews and Stevenson) varies from 91 to 137 feet, increasing toward the southern border. The Brush Creek fossiliferous shales have not been observed in the interval between western Jefferson and central Guernsey, being removed at most localities during deposition of the overlying Buffalo sandstone or sandy shale. The Brush Creek coal is worthless at all exposures in Carroll, Harrison, and Guernsey, and the Lower Mahoning is usually represented by shale. The average thickness of Conemaugh in this county is about 350 feet—a decrease of almost 250 feet from McDonald, in Washington county of Pennsylvania.*

In Muskingum county, west from Guernsey, the section north from the Baltimore and Ohio railroad reaches upward to the Ames limestone. The Harlem coal persists at 2 to 17 feet below that limestone and the Cambridge limestone was seen at 69 feet below the Ames. The Anderson coal at 1 to 9 feet above the Cambridge limestone is equally persistent with the Harlem, but for the most part both beds are mere streaks. The Cambridge limestone is fossiliferous, buff on weathered surface, and often flinty and is 127 feet above the Upper Freeport (Cambridge) coal. The Lower Mahoning, fully exposed at one place, consists of two sandstone plates, 20 and 7 feet, separated by 21 feet of mostly sandy shale.

* E. B. Andrews: Vol. ii, pp. 533-534, 535-539, 540-541.

J. J. Stevenson: Vol. iii, pp. 225-228.

E. Orton: Vol. v, pp. 82, 84, 87.

The section in southern Muskingum is complete and the following generalized succession may be compiled from measurements by Professor Andrews:

| | Feet. | Inches |
|------------------------------------|----------|--------|
| 1. Pittsburg coal bed | | |
| 2. Interval | 1 to 2 | 0 |
| 3. Limestone | 1 | 0 |
| 4. Sandstone | 27 | 0 |
| 5. Limestone | 2 | 0 |
| 6. Red shale | 25 | 0 |
| 7. Coal bed | Trace | |
| 8. Shale | 90 | 0 |
| 9. Ames limestone | 1 to 2 | 0 |
| 10. Shale and sandstone | 27 | 0 |
| 11. [Harlem] coal bed | 0 to 2 | 6 |
| 12. Concealed and sandstone | 44 to 48 | 0 |
| 13. Anderson coal bed | 2 | 6 |
| 14. Clay and shale | 10 | 0 |
| 15. Cambridge limestone | 8 to 12 | 0 |
| 16. Clay and shale | 50 | 0 |
| 17. Limestone [Brush Creek] | Thin | |
| 18. Concealed | 3 | 0 |
| 19. Brush Creek coal bed | Thin | |
| 20. Clay | 6 | 0 |
| 21. Lower Mahoning sandstone | 40 | 0 |

to the Upper Freeport coal bed. Number 8 contains at some places 60 feet of red shale, the "Big Red" of counties farther south; the red bed, Number 6, is apparently the same with that seen in the eastern localities. No trace of the Elk Lick coal appears in any of the sections and the Harlem is very uncertain, but the Anderson is persistent at about 70 feet below the Ames, sometimes resting almost directly on the Cambridge limestone. The sandstone, Number 12, is at the place of the Cowrun. The Brush Creek coal and limestone are very thin and the former is reported very rarely.*

Morgan county is south from Muskingum. In the central and northern portion the Pittsburg coal bed is 142 to 150 feet above the Ames limestone. A thin limestone appears occasionally at a few feet below the Pittsburg and a 2-foot coal bed is at 73 feet, possibly the Jeffers of more southern localities. The Harlem coal bed is double in some places, the upper division directly under the Ames, and the lower, occasionally of workable thickness, at 20 or even 30 feet lower and resting on the Ewing limestone. Still lower is the Patriot coal of Lovejoy, about 40

* E. B. Andrews: Vol. i, pp. 314 et seq.
J. J. Stevenson: Vol. III, pp. 284-289.

feet above the Cambridge limestone in Morgan county and overlying the Cowrun sandstone, an important rock in northwest Morgan, where it is the First oil sand of the Federal Creek and Buck Run districts. It is the 140-foot sand of the Macksburg area and the Cowrun of Washington county. An oil-well record given by Professor Bownocker in Union township shows an almost continuous red bed beginning at 33 feet above the Ames and extending upward to 156 feet, to the place of the Pittsburg, which is wanting. Only 6 feet of red shale are reported below the Ames, and that limestone is 131 feet above the Cambridge, which is only 70 feet above the Upper Freeport coal. It is worth noting that while the interval from Ames to Cambridge has increased, that from Ames to Upper Freeport is but 201 feet—only about 10 feet more than in southern Muskingum. The Cambridge is double in much of Morgan and at times both divisions are flinty, but in several townships only the upper division is present. The interval between the divisions varies from 5 to 10 feet and holds the Anderson coal bed.

Professor Bownocker reports several oil records from eastern Morgan. One at Browns Mill, near the southeast corner, shows the "Big Red" ending at 4 feet above the Ames limestone, and the Cowrun sandstone, 29 feet thick, beginning at 92 feet below it. A red bed at 184 feet above the Ames is very near the place of the Pittsburg coal. Seven miles west the "Big Red," 125 feet thick, ends at 22 feet above the Ames, and another, 16 feet, ends at 40 feet above the Cambridge limestone. These reds are very irregular, for in a well 4 miles farther west the only red between Ames and Cambridge is 42 feet and ends at 65 feet above the Cambridge, whereas in an adjacent well there are two beds 10 and 40 feet. In the most western well coal is recorded at 165 feet below the Ames, 58 feet below the Cambridge, evidently the Brush Creek, and black shale at 42 feet lower is very near the place of the Upper Freeport. The Conemaugh in eastern Morgan is not more than 360 feet thick.*

Noble county is east from Muskingum and Morgan, south from Guernsey. For the most part the Conemaugh is deeply buried, but it is brought up by an anticline midway in the county. According to Professor Andrews, the interval from Pittsburg to the Ames in the northwest portion is 150 feet. Farther east on the Guernsey border this interval contains two thin limestones at 46 and 54 feet above the Ames and another, very thin, at the Pittsburg horizon. The Cambridge limestone becomes double near the Guernsey line, a new, upper division making its appearance,

* E. B. Andrews: Vol. 1, pp. 295-297, 303, 305.

E. Lovejoy: Vol. vi, pp. 631-635.

J. A. Bownocker: Bulletin no. 1, pp. 134, 136, 142.

which becomes the important bed in Morgan and other counties beyond toward the south. Here Professor Andrews found 6 inches of fossiliferous ore on 6 inches of fossiliferous shale resting on the Anderson coal bed, 1 foot 6 inches thick and 10 feet above the Cambridge limestone proper, also fossiliferous, which is 125 feet above the Upper Freeport (Cambridge) coal bed. Farther south he finds a fossiliferous limestone, below which, at 90 feet, is another fossiliferous limestone, dark blue and sandy, resting on a coal bed. Still farther south, and near the Washington County line, he finds the lower limestone resting on its coal bed. The higher limestone is the Ames and the lower, or main portion of the Cambridge, is about 100 feet below it. An oil record on the border of Washington county and 18 miles northeast from the Browns Mill well, in Morgan county, shows the Ames at 125 feet above the Cambridge with the 140-foot, or Cowrun, sandstone, 5 feet thick and 26 feet above the Cambridge. It overlies a thin coal bed separated from the limestone by red shale.*

Monroe county is east from Noble and extends to the Ohio river. The Conemaugh and even much of the Monongahela formation are deeply buried. The Pittsburg coal bed is insignificant and in a great part of the county it is wanting; the well records are of the ordinary type and the thinner limestones can not be recognized, but the "Big Lime" of the Lower Carboniferous is persistent. The Mahoning and other sandstones, so insignificant on the western outcrop, reappear in these records, and it is not altogether easy to correlate them with those in Noble and Morgan, as the "Big Lime" is not present in those counties. Professor Bownocker gives records of borings in Summit, Wayne, Perry, Jackson, and Green townships, and Doctor White adds one on the Ohio river opposite Sisterville, in Tyler county of West Virginia. These extend southeastward across the county, the first being about 6 miles west from the Noble County line. A thin coal bed is present in most of them and it is taken as the main horizon, the numbers indicating distance below it.

| | Feet. | Feet. | Feet. | Feet. | Feet. | Feet |
|--------------------------|-------|-------|-------|-------|-------|------|
| Coal bed [Pittsburg].... | | | | | | |
| Big Red: | | | | | | |
| Top | 153 | | 105 | | | |
| Bottom | 253 | | 245 | | | |
| Cowrun sandstone: | | | | | | |
| Top | 453 | 507 | 520 | 470 | 534 | 430 |
| Bottom | 678 | 900 | 540 | 485 | 565 | 480 |
| Coal bed [Brookville] .. | 678 | | 705 | | | |
| "Big Lime" | 1032 | | 1060 | | 1060 | 1050 |

* E. B. Andrews: Vol. II, pp. 510, 511, 513, 515, 517, 518.

J. A. Bownocker: Bulletin no. 1, p. 160.

Where no numbers are given the well record is incomplete. In many cases the sandstones alone are recorded. The coal bed, sometimes wanting and always very thin, is the Pittsburg. It is evident that the "Cow-run" is not the same bed in all of these wells. At the Summit locality one is at little more than 12 miles northeast from the well in southern Noble, where both Ames and Cambridge limestones are present and the latter is about 300 feet below the Pittsburg. The interval from Pittsburg to the "Big Lime" in Monroe does not justify the supposition that there is any notable thickening of the measures in this direction. Evidently the sandstone beginning at 430 to 453 and ending at 480 to 485 is the Mahoning, which in the Summit well is continuous with the Allegheny and in the Wayne well is continuous through the Allegheny into the Pottsville. The Brookville coal bed at 678 and 705 feet will prove to be a useful guide in Washington county.*

The Hocking Valley coal field of Ohio embraces portions of Perry, Hocking, and Athens counties along the western outcrop. Professor Orton's generalized section for the lower portion of the Conemaugh in the western part of these counties is:

| | Feet. | Inches |
|--|----------|--------|
| 1. Ames limestone | 5 | 0 |
| 2. Shale, red or drab | 45 | 0 |
| 3. Ewing limestone | 3 | 0 |
| 4. Shale, red or drab | 40 | 0 |
| 5. Cambridge limestone, black, in 2 benches..... | 10 | 0 |
| 6. Shale | 25 | 0 |
| 7. Mahoning (?) [Buffalo] sandstone | 20 | 0 |
| 8. Brush Creek coal | 2 | 6 |
| 9. Shale | 15 | 0 |
| 10. Brush Creek [Mahoning] limestone | 0 to 3 | 6 |
| 11. Mahoning sandstone or shale | 15 to 25 | 0 |

the Cambridge limestone being 98 feet below the Ames and about 80 feet above the Upper Freeport coal bed; but the variation is extreme in the outlying areas of Perry and Hocking. At one locality in the former, according to Professor Orton, the section begins with the Elk Lick coal at 16 feet above the Ames and reaches to the Upper Freeport, giving in all only 115 feet from Ames to Upper Freeport, all members of the section being present, thus making less than 275 for the whole of the Conemaugh; but another section farther east in the same county shows the Cambridge 94 feet 6 inches above the Upper Freeport and 52 feet above the Brush Creek coal bed. The section in Hocking county covers the

* J. A. Bownocker: Bulletin no. 1, pp. 201, 210, 212.
 I. C. White: Geology of West Virginia, vol. 1, p. 356.

whole of the Conemaugh. Mr Read found the Pittsburg coal bed 145 feet above the Ames limestone and the latter 112 feet above the Cambridge, which is only 72 feet above the Upper Freeport, giving thus a thickness of 329 feet for the Conemaugh. The Brush Creek coal bed and the Mahoning limestone are present in his sections, the latter being sometimes only an ore bed.*

Athens county is south from Perry and Morgan and east from Hocking. Professor Andrews finds the Ames limestone 138 to 145 feet below the Pittsburg (Federal Creek) coal and the Cambridge limestone at 85 to 90 feet lower, with, at some localities, the intermediate Ewing limestone at 50 feet above the Cambridge. The Ames is 180 to 190 feet above the Upper Freeport (Baileys run) coal bed, practically the same as in Read's Sunday Creek section in Morgan county, so that the Conemaugh in all is about 330 feet thick. Limestones, not wholly persistent, are 4 to 6 and 75 feet below the Pittsburg. The Harlem coal seems to be persistent at about 25 feet below the Ames and at times underlies a sandy black fossiliferous shale. The interval between Ames and Cambridge is fully exposed near Athens, midway in the county, where, aside from the Harlem coal and Ewing limestone, it contains only shale and laminated sandstone, 34 feet of the latter resting on the Cambridge limestone, the Cowrun sandstone. The Cambridge limestone is double in the northern part of the county and the interval between the divisions is at times more than 25 feet; but the lower division, underlying the Anderson coal bed, disappears midway in the county, to reappear irregularly farther south. In this region the upper division is persistent. Occasionally one or both are flinty, but the upper is sometimes pure enough to yield good lime. The interval between Ames and Pittsburg in the eastern township of Ames is 140 feet, according to Andrews, but Mr Lovejoy finds it 171 farther west, where the section shows great variation. A coal and limestone—perhaps the Jeffers—are sometimes present at 54 to 57 feet; a white limestone underlies the Pittsburg at one locality, but at another, one finds 28 feet of red shale; while at a third, heavy sandstone fills the whole interval to the Ames.

On the Morgan-Athens border the Ames is 170 feet below the Pittsburg, and in Ames township of the latter it is 115 feet above the Cambridge limestone, evidently the Upper Cambridge, for it underlies 33 feet of sandy shale, representing the Cowrun sandstone. Here, at 6 miles east from the line of Washington county, Professor Bownocker's measurements and oil-well records make the Cambridge limestone 285 feet below

* M. C. Read: Vol. III, pp. 679, 705.

E. Orton: Vol. v, pp. 100-101, 920.

the Pittsburg. The "Big Red" rests on the Ames, but is only from 15 to 40 feet thick. Two other reds, 5 and 20 feet, are at 10 and 30 feet above the Cambridge, but are not present in all of the wells.*

Crossing into Washington county, east from Morgan and Athens, south from Noble, and extending to the Ohio river, one finds the Conemaugh for the most part deeply buried; but the Cowrun anticline brings it up in a narrow strip east from the middle line of the county.

A well record reported by Professor Bownocker from the northwestern part of the county shows the Cambridge limestone at 120 feet below the "Big Red," which is 95 feet thick, broken by 15 feet of shale. The Ames is not reported here, but it is present at 3 miles northeast, on the Morgan border, where it is 4 feet below the "Big Red." The Pittsburg coal is wanting at both places and no coal appears in the section for 180 feet above the place of the Ames. In one record a sandstone 35 feet thick and overlying a thin limestone is at 135 feet above the Ames, evidently belonging almost directly under the place of the Pittsburg. In the more northerly well the Cambridge is apparently about 125 feet below the place of the Ames, and so somewhat less than 300 feet below the Pittsburg. Macksburg, on the Noble County border, is at 17 miles northwest; there the Ames is 125 feet above the Cambridge and the latter is 363 feet below the Macksburg coal bed, which is about 90 feet above the Pittsburg. The first, or 140-foot, sand of this region, the Cowrun, is 35 feet thick at Macksburg and its top at a mile east in Noble county is 99 feet below the Ames. The interval from Pittsburg to Cambridge is somewhat less than in western Washington. A great sandstone 78 feet thick begins at 176 feet below the Cowrun and continues to 523 feet below the place of the Pittsburg. This has been correlated with the Mahoning, but it belongs more probably in the Allegheny in part, for the bottom of the Mahoning in southern Monroe, 18 miles northeast, can not be placed lower than 480 feet below the Pittsburg.

Thirteen miles east of south from Macksburg and 15 miles southwest from Green township of Monroe county is Cowrun, in Lawrence township of Washington. The Cowrun uplift passes north and south through this township and exposes the Conemaugh to about 70 feet below the Ames limestone. Good exposures of the interval above the Ames are rare, but Professor Andrews found a limestone at 98 feet below the Pittsburg, 136 feet above the Ames in both Lawrence and Newport townships, and in the latter a coal bed at 40 feet above the limestone, which is at the

* E. B. Andrews : Vol. i, pp. 264-265, 270, 273-274, 278, 280, 289.

E. Lovejoy : Vol. vi, pp. 632-633, 645-646.

J. A. Bownocker : Bulletin no. 1, pp. 132-133.

place of the Jeffers coal of Gallia county—probably a Little Pittsburg. He gives a record from Lawrence near Cowrun on the authority of the late F. W. Minshall, for whom the well was drilled. The section, beginning at 140 feet below the Pittsburg coal bed, is:

| | Feet. | Inches |
|---|-------|--------|
| 1. Alluvium | 22 | 0 |
| 2. Red and blue shale | 74 | 0 |
| 3. Fossiliferous limestone [Ames]..... | 1 | 6 |
| 4. Yellow shale | 18 | 0 |
| 5. Coal [Harlem] | Thin | |
| 6. Interval | 20 | 0 |
| 7. Sandstone | 30 | 0 |
| 8. Clay | 4 | 0 |
| 9. Interval, coal [Brookville] near bottom..... | 377 | 0 |
| 10. Sandstone | 130 | 0 |

Here one has the "Big Red" over the Ames, and the Harlem coal is at 256 feet below the Pittsburg. The interval to the Ames is as large as that to the Cambridge along the western outcrop, which misled Andrews into identifying this limestone with the Cambridge. The bottom of the sandstone, Number 7, regarded by him as the Cowrun, is 305 feet below the Pittsburg coal. In the record of the Centennial well published by Professor Bownocker the top of the Cowrun sandstone is 314 feet below the Pittsburg, and that bed is 47 feet thick, resting on 23 feet of red shale. The bottom of the "Big Red" is at 223 feet. A sandstone 10 feet thick at 479 feet is at the place of the Mahoning. There is no thickening of the measures here as compared with more northerly localities, for the Brookville coal bed, at 705 feet in the Monroe well, is here at 701, and in the Minshall well at about 686 feet. The bottom of the sandstone below this coal is 814 in the Minshall well, 828 in the Centennial, and 800 feet in one of the Monroe wells.

Going southward into Newport township, one finds on the Ohio river Professor Andrews' section of the Ames and associated rocks, which is almost exactly the same as in the Minshall boring. In a well near by, drilled for Mr Minshall, the Harlem coal bed rests directly on 44 feet of pebbly sandstone, below which for 210 feet are blue and red shales resting on 100 feet of sandstone, beginning at 508 feet below the Pittsburg, and at 709 feet is the Brookville coal, with black shale resting on 120 of sandstone to 828 at the bottom of the well. The 100 feet of sandstone must be taken as belonging within the Allegheny. At 6 or 7 miles northwest from this locality and at the same distance west from the Cowrun wells is the record of a well at Marietta published by Professor Orton. There the Pittsburg and the "Big Lime" are wanting and the

only horizons to be depended on are the "Big Red" and the Brookville coal bed at the bottom of the Allegheny. The succession is:

| | Feet |
|--------------------------------|---------|
| 1. Sandstone | 20 |
| 2. Red rock | 95 |
| 3. Sandstone | 35 |
| 4. "Big Red" | 100 |
| 5. Shale | 20 |
| 6. Red rock and slate | 150 |
| 7. Red sandstone and mud | 40 |
| 8. Mahoning sandstone | 10 feet |
| Mahoning black shale | 20 feet |
| Mahoning sandstone | 30 feet |
| 9. Slate | 15 |
| 10. Sandstone | 80 |
| 11. Slate | 105 |
| 12. Sandstone | 30 |
| 13. Slate and shale | 15 |
| 14. Coal bed | 5 |
| 15. Slate | 25 |
| 16. Sandstone | 70 |

Here one has the little coal bed of the other wells. The high red bed is that associated with the Pittsburg coal at many places in Ohio, while the overlying sandstone is the Pittsburg sandstone, which farther west and south approaches very closely to the coal. The place of the Ames is in the upper part of Number 6. The Cowrun sandstone is wanting and the Mahoning is represented by Number 8.

Four miles below Marietta, along the Ohio river, one has a partial record published by Doctor White:

| | Feet |
|-------------------------------|------|
| First Cowrun sandstone | 23 |
| Interval | 157 |
| Sandstone | 100 |
| Interval | 90 |
| Second Cowrun sandstone | 15 |

Professor Bownocker says that the highest sandstone, at its bottom, is about 100 feet below the "Big Red," 85 feet thick and overlying a thin limestone which he thinks may be the Ames. The middle sandstone would be about 520 below the Pittsburg and equivalent to that in the Minshall well of Newport township, belonging therefore to the Allegheny, there being no sandstone here at the Mahoning horizon.*

* E. B. Andrews: Vol. II, pp. 497, 502-503, 505.
 E. Orton: Vol. VI, p. 399.
 I. C. White: Geology of West Virginia, vol. I, pp. 286, 288.
 J. A. Bownocker: Bulletin no. 1, pp. 134-136, 169, 175-176.

Returning to the western outcrop: A few insignificant areas in Vinton county reach to the Cambridge limestone, which is gray fossiliferous and 108 feet above the Shawnee or Upper Freeport limestone. Coal beds are at 31 and 50 feet below it, possibly Brush Creek, and that at an upper horizon dividing the Buffalo sandstone as at some localities farther north. But here, as in Jackson county, where Professor Orton found a coal bed at 93 feet above the Upper Freeport and underlying a conglomerate, the section is a single instance and so far from any other exposure that no positive identifications can be made.*

In Meigs county, south from Athens and extending eastward from Jackson to the Ohio river, one finds the Conemaugh deeply buried in the eastern portion, but exposed in the western. In this area, as in southern Athens, the Pittsburg sandstone overlies the Pittsburg (Pomeroy) coal or is separated from it at most by 17 feet of sandy shale. Professor Andrews gives many sections. Seven miles west from Pomeroy the Ames and Cambridge limestones are respectively 147 and 236 feet below the Pittsburg coal bed, but nearer Pomeroy the latter interval is only 221. In the western townships the Cambridge is frequently a "whitish fossiliferous" limestone, and a coal bed at the Harlem horizon often appears about 60 feet above it. At 25 feet below the Cambridge is a coarse sandstone and conglomerate, of which 30 feet were seen; it is in the place of the Buffalo sandstone, which belongs under the Lower Cambridge limestone of southern Ohio, the Cambridge limestone of Pennsylvania and northern Ohio. Mr Lovejoy finds the Cambridge limestone double in the northwest part of the county, but the lower division becomes very uncertain at a little way south. The Upper Cambridge, 27 feet above the Lower, is 112 feet above the Upper Freeport within the interval, the Anderson at 19 and the Brush creek at 45 feet below it. At another locality, 2 miles away, Professor Andrews found the Upper Cambridge at 47 and 109 feet above the Brush Creek and Upper Freeport coals.

Five or six miles west from Pomeroy, red shale, 19 feet thick, is at 50 feet below the Pittsburg, and a coal bed near the Barton horizon is at 203 to 205 feet. Red shale is exposed above the Ames at one locality, and at another that limestone overlies a bed, 35 feet, the place of the Pittsburg reds. The Mahoning is often sandstone, and Mr Lovejoy gives it as 56 feet in one measurement. The whole thickness of Conemaugh at 6 miles west from the Ohio river is about 350 feet.

Professor Orton publishes the record of a well drilled at Pomeroy, beginning 64 feet below the Pittsburg coal bed. The record is im-

* E. B. Andrews: Report for 1870, p. 117.

E. Orton: Vol. v, pp. 1025-1026.

portant because the samples were carefully examined and tested when brought up. Pomeroy is 6 miles east from the locality at which Professor Andrews found the Ames and Cambridge 147 and 236 feet below the Pittsburg. In the boring, red rock 38 and 42 feet was found beginning at 93 and 151 feet below the Pittsburg, the latter being the "Big Red" belonging above the Ames. A fossiliferous limestone at 285 is the Cambridge, the interval being 47 feet greater than at the western locality. The Cowrun sandstone overlying the Cambridge is coarse. The Mahoning (Lower) sandstone is at 379 to 431 feet, a more or less pebbly rock, while the great sandstone of the Allegheny begins at 15 feet lower, as in Newport township of Washington, and the Brookville coal bed is at 675 feet. Dark shale overlying limestone is reported directly under the Mahoning and it may be the Upper Freeport, thus giving a little more than 430 feet as the thickness of the Conemaugh—an increase of nearly about 70 feet in six miles—while it is 50 feet less than in eastern Washington county and the interval from Pittsburg to Brookville is also 40 feet less. The boring does not reach to the "Big Lime," which, at a point 6 miles southeast, is at 1,190 feet below the Pittsburg coal bed. At Pomeroy one is 40 miles southwest from Marietta.*

Passing over into Gallia county, extending along the Ohio river south from Meigs and adjoining Mason county of West Virginia, one finds near the western border an outlier of the Pittsburg coal bed with the Cambridge limestone at 240 feet below it. This is in Perry township, 10 miles west from Gallipolis, on the Ohio, and 20 miles southwest from Pomeroy. About 6 miles farther north, according to Professor Orton, the limestone is again double, the interval between the divisions being 18 feet. At 57 feet below the Upper Cambridge is a coal blossom which is 77 feet above the Upper Freeport, while at 28 feet above the latter is a limestone, thus making the thickness of the Conemaugh about 375 feet—an increase of about 25 feet over the average in Meigs. At about 5 miles northwest from Gallipolis the Cambridge is 248 feet below the Pittsburg (Pomeroy) coal bed and is, as in much of Meigs, a white limestone. The Ewing limestone was seen, at about 4 miles west from Gallipolis, 183 feet below the Pittsburg and underlying 20 feet of red shale. Another measurement only 2 miles from Gallipolis shows the Cambridge at 200 feet below the Jeffers coal, or about 250 feet below the Pittsburg, and red shale 16 feet thick is at 30 feet above it. Two feet of limestone at 50 feet above the Cambridge may represent the Ewing. The place of the Ames

* E. B. Andrews: Vol. 1, pp. 249, 250-253.

E. Orton: Vol. vi, p. 397.

E. Lovejoy: Vol. vi, p. 633.

limestone is concealed in the sections by Andrews and Gilbert, but it was seen by Mr Lovejoy in the northern townships, along the Meigs border, at 5 or 6 miles southwest from Pomeroy. The Jeffers coal, separated by 40 to 50 feet of sandstone and shale from the Pittsburg, occasionally attains economic importance in the eastern part of the county, where it is accompanied by a persistent impure limestone 1 to 10 feet below it. Near Gallipolis a bed of red shale 20 feet thick begins at 132 feet below the Pittsburg, very near the horizon of the "Big Red."†

Lawrence county is south from Gallia and extends along the Ohio river, adjoining Cabell and Wayne counties of West Virginia and Boyd of Kentucky. The section, as measured by Mr Emerson McMillin near Greasy ridge and Arabia, about 12 miles north from Central City, in West Virginia, and nearly 20 miles west of south from Gallipolis, is:

| | Feet. | Inches |
|--|----------|--------|
| 1. Pittsburg coal | | |
| 2. Interval | 150 | 0 |
| 3. Ames limestone | 2 to 4 | 0 |
| 4. Interval | 92 | 0 |
| 5. Slate coal | 2 | 6 |
| 6. Interval | 35 | 0 |
| 7. Cambridge limestone | 3 | 0 |
| 8. Coal bed [Anderson] | 3 | 0 |
| 9. Shale | 10 to 25 | 0 |
| 10. Lower Cambridge limestone | 3 | 0 |
| 11. Shale | 6 | 0 |
| 12. Sandstone [Buffalo] | 42 | 0 |
| 13. Coal bed [Brush Creek, Upper]..... | 3 to 4 | 0 |
| 14. Clay | 4 | 0 |
| 15. Shale | 20 | 0 |
| 16. Coal bed [Brush Creek, Lower]..... | 2 | 0 |
| 17. Ore bed [Mahoning] | 2 | 0 |
| 18. Mahoning sandstone | 20 | 0 |

to the Upper Freeport (Waterloo) coal bed, giving in all about 400 feet for the Conemaugh; but this is the minimum, the maximum being between 420 and 430 feet. The Upper Cambridge is at 280 feet below the Pittsburg, very nearly the same as in the Pomeroy well. The Slate coal bed is very near the Barton horizon, at which coal has appeared sporadically at many places along this western outcrop. In a personal communication, Mr McMillin states that the Upper Cambridge is comparatively pure, usually yielding a good line, but the lower is always siliceous, often flinty, and frequently represented only by calcareous shale. The in-

* E. B. Andrews: Vol. I, pp. 232, 235-236.
 E. Orton: Vol. v, p. 1049.
 E. Lovejoy: Vol. vi, p. 632.

terval between the beds varies from 10 to 30 feet and the Anderson coal seems to be present generally; the coal Number 13 is from 28 to 50 feet below the Anderson. The Mahoning interval at times increases to 40 feet. In this part of the county the Cambridge is about 260 feet above the Vanport (Ferriferous) limestone.

The Cambridge limestone is very persistent and appears in many of the sections measured by Andrews and Gilbert in various parts of the county, sometimes single, sometimes double, the upper division separated from the Anderson coal bed by black shale. It is 230 feet above the Vanport (Ferriferous) limestone, on the Ohio river at about 3 miles below Ironton, the only direct measurement obtained along the river. At 7 miles north from Catlettsburg, Kentucky, the Upper Cambridge is 12 feet above the Anderson coal bed and 120 above the Upper Freeport. Measurements along the river or within 3 or 5 miles west or north from it are wanting, as the rocks are mostly soft and the slope rises in benches covered by loose material so deep as to mask everything.*

KENTUCKY

Passing over into Kentucky, one finds Professor Crandall's generalized section for the northeastern counties as follows:

| | Feet |
|--|------|
| 1. Greenish sandstone and shale | 60 |
| 2. Impure limestone [Ames (?)]..... | |
| 3. Concealed | 16 |
| 4. Coal bed 12 [Harlem (?)]..... | |
| 5. Sandstone and Ore | 55 |
| 6. Impure limestone [Upper Cambridge] | |
| 7. Sandstone and shale | 21 |
| 8. Coal bed 11 [Anderson] | |
| 9. Sandstone or shale | 39 |
| 10. Ore and Second Fossiliferous limestone [Lower Cambridge] | |
| 11. Coal 10 | |
| 12. Sandstone, some shale [Buffalo and Mahoning]..... | 60 |
| 13. Coal bed 9 [Upper Freeport]..... | |

but the intervals vary greatly from those given in this section.

The Upper Freeport coal bed is absent from much of the area. Only the lowest members of the formation reach into Greenup county and the western outcrop passes through western Boyd and eastern Carter; the highest beds are reached in Lawrence county.

* E. McMillin: Vol. v, p. 122. This section as published by Professor Orton has been modified in accordance with Mr McMillin's notes.

E. B. Andrews: Report for 1870, pp. 195, 204, 207.

The Lower Cambridge (Second Fossiliferous) limestone is at 60 to 75 feet above the Upper Freeport coal bed, the greatest interval being in northeastern Boyd and the least in southeastern Carter. The Upper Cambridge (Third Fossiliferous) limestone is 50 to 60 feet above the Lower. Doctor White finds at Catlettsburg a dark fossiliferous limestone 160 feet above the Upper Freeport coal bed, evidently the Upper Cambridge, as at a little way southwest Professor Crandall measured 150 feet as the interval. Mr McMillin's section in southeastern Ohio gives the interval to Lower Cambridge as 99 feet and that to Upper Cambridge as at most 131 feet, with the Anderson coal bed at 15 to 25 feet above the Lower. The interval between the limestones has almost doubled in 15 miles. Coal bed 10 is present at many places almost directly under the Lower Cambridge limestone; this is a new horizon, apparently without coal in other states, except perhaps in Wayne county of West Virginia. The interval between Upper Freeport coal and Lower Cambridge limestone is frequently filled with sandstone in Boyd county, the upper portion, equivalent to the Buffalo sandstone, being ordinarily very coarse, as in southern Ohio. No representative of the Brush Creek coal is reported anywhere except in southeast Carter, where at one locality a thin coal bed was seen 45 feet above the Upper Freeport and underlying the coarse Buffalo sandstone; it is at the place of the Upper Brush Creek coal bed in Mr McMillin's section.

In northwestern Lawrence the Lower Cambridge is 70 feet above the Upper Freeport coal bed and 100 feet below the Fourth Fossiliferous limestone, which may be either the Ames or the Ewing limestone, both of which are persistent in southern Ohio. At one point on the East fork of Little Sandy the interval between Lower Cambridge and the Anderson coal bed is 50 feet; the coal is 3 feet 6 inches thick, but elsewhere in Lawrence as well as in Boyd the bed is unimportant. On Jourdans branch the Upper Cambridge, gray, is 50 feet above the Lower and 133 feet above the Upper Freeport. At 95 feet above the Lower Cambridge is a cherty limestone, the Fourth, at a short distance above a coal, which is the highest observed in this part of the state and may possibly be at the Harlem horizon. Elsewhere, as may be seen by reference to the generalized section, the intervals are greater. The highest deposits remaining are near Louisa, in the central part of Lawrence county, where one finds greenish beds above the place of the Fourth limestone. At Louisa the Upper Cambridge is 200 feet above the Lower Freeport coal bed, 190 feet above the Upper Freeport (Shawnee) limestone. The Fourth limestone may disappear as limestone not far south from Louisa. In the northwestern part of the county it is a fossiliferous limestone; on Jourdans

fork it is represented by cherty limestone, but near Louisa its place is occupied by green calcareous sandstone. The Lower Cambridge limestone is present at 12 miles south from Louisa, near the line of Johnson county.

Coarse rocks occur commonly between the Upper Freeport and the Lower Cambridge in the northern part of Lawrence, but southwardly the deposits are finer and there is little of coarse material. Red shale is reported only from Catlettsburg, in northeast Boyd, where it underlies the place of the Upper Cambridge.

Southward from Lawrence county the section is uncertain. The anticline in Johnson and southern Lawrence has led to removal of Conemaugh and much of Allegheny from a broad strip, beyond which at present correlation is impossible. It seems altogether probable that some Conemaugh remains in Pike county; it is possible that there may be some even in southwestern Virginia, but at present no correlation may be attempted. Mr J. M. Hodge's revised section in Wise county of Virginia shows that the material on which the writer depended for that area is unexpectedly incomplete, and that the plane of separation drawn between Pottsville and Allegheny in southwestern Virginia and the adjacent portion of Kentucky may be incorrect.*

WEST VIRGINIA

Returning to the east and entering West Virginia on the west side of Chestnut ridge, in continuation of the Third bituminous basin of Pennsylvania, one has Doctor White's Morgantown section, which, condensed, is:

| | Feet. | Inches |
|--|-------|--------|
| 1. Pittsburg coal bed..... | | |
| 2. Interval | 34 | 0 |
| 3. Little Pittsburg coal bed | 1 | 6 |
| 4. Sandy shale | 17 | 0 |
| 5. Limestone [Pittsburg] | 1 | 0 |
| 6. Interval | 27 | 0 |
| 7. Sandstone and sandy shale [Connellsville]... | 60 | 0 |
| 8. Shales | 20 | 0 |
| 9. Black shale [Little Clarksburg] | 1 | 0 |
| 10. Clarksburg limestone | 1 | 0 |
| 11. Shale and sandstone. 45 feet } Sandstone 20 feet } [Morgantown] | 65 | 0 |
| 12. Elk Lick coal bed | 3 | 0 |

* A. R. Crandall: Greenup, Carter, and Boyd counties, p. 25, plates 1, 26; figs. 1, 7; 30, fig. 4; sections 26, 47, 62, 65, 70-71, 78, 81, 85, 87; Southeast Kentucky coal field, p. 28.

J. M. Hodge in personal communication.

| | Feet. | Inches |
|-------------------------------------|-------|--------|
| 13. Shales and concealed | 55 | 0 |
| 14. Ames limestone | 1 | 6 |
| 15. Variegated shale | 85 | 6 |
| 16. Cambridge (?) limestone | 1 | 0 |
| 17. Shales | 14 | 0 |
| 18. Buffalo sandstone | 3 | 6 |
| 19. Shale and shaly sandstone | 30 | 0 |
| 20. Mahoning sandstone | 100 | 0 |
| 21. Shales | 40 | 0 |

to the Upper Freeport—in all, 561 feet. The Mahoning deposit continues upward, so as to pass the place of the Brush Creek coal and limestone. Nine miles south from Morgantown the Conemaugh is said to be 587 feet thick, the increased thickness being above the Ames limestone. The Brush Creek coal bed is at 99 feet above the Upper Freeport and underlies directly the massive Buffalo sandstone, which is 53 feet thick. The Barton and Anderson coal beds and the Cowrun sandstone do not appear in these sections.

Westward from the Monongahela one is dependent wholly upon the records of oil borings. Possibly because these are very numerous, the variability of the sandstones and red beds is much more marked in them than in the less numerous measurements of exposures. It may be that some of the variations are due to the inaccuracy of measurements by the drillers. In any event, it is necessary at the outset to state that while it is not altogether difficult to recognize any given sandstone horizon, still the correlation is never wholly exact, since, using the Pittsburg coal bed as the fixed horizon, one finds the top or bottom of each sandstone shifting in such fashion that the determination can not be in close detail. The limestones, so important in tracing the section by exposures, are very thin and do not appear in the records. The coal beds quickly become indefinite and disappear, while the red beds are distributed with such irregularity that they seem to mark localities of lagoons.

In Monongalia and Marion counties, west from the Monongahela river, the interval from Pittsburg to Upper Freeport varies from 560 to 578 feet. In the former county at 10 miles northwest from Morgantown it is 570 and in the latter at 12 miles southwest it is 578 feet. The Morgantown sandstone is well defined in many records and varies in thickness from 50 to 120 feet, its top being at 140 to 160 feet below the Pittsburg; yet in not a few records it is represented only by shale. The Cowrun sandstone, overlying the Cambridge limestone, does not appear in the Monongalia wells except near the western border, but it is recorded occasionally in the Marion wells at about 350 feet below the Pittsburg.

The Buffalo, on the other hand, is persistent though variable, sometimes replacing the underlying shales and encroaching upon the place of the Upper Mahoning. Its top is from 382 to 387 in Monongalia, 380 to 407 in Marion, the bottom being from 395 to 430 in the former and from 406 to 457 in the latter, the thickness of the sandstone varying from 5 to 50 feet. The Mahoning interval is more variable than the Buffalo. Typically it has two sandstone plates, upper and lower, separated by shales; the lower is the more persistent, the upper being replaced by shale very frequently; but in some localities the whole interval is occupied by massive sandstone. Ordinarily one finds between the sandstone and the Upper Freeport from 10 to 40 feet of shales, but occasionally the shale is replaced and the sandstone rests directly on the coal bed. The top of the Mahoning sandstone in Monongalia is from 421 to 475 feet below the Pittsburg, but from 436 to 515 feet in Marion; the bottom in Monongalia is from 515 to 521, in Marion from 538 to 578 feet, in the last case extending downward to the Upper Freeport.

The Anderson coal horizon is marked by a coal bed at 375 feet, reported in a Monongalia well, and a coal at 275 in a Marion well is very near the place of the Harlem.

The red beds in northern Monongalia are immediately under the Morgantown sandstone, 245 or 265 feet below the Pittsburg coal, to 330 or 340 feet, thus including the "Big Red" of Ohio overlying the Ames and the Pittsburg reds underlying that limestone. In southern Monongalia and in Marion red beds occur in some portion of this interval at almost all localities and occasionally higher beds appear—in one well at 86 to 111 feet, in two others at 127 to 230 feet, and in a third a great bed is at 161 to 326, replacing the Morgantown sandstone. The lowest bed recorded is in a well on the Marion-Monongalia border 341 to 381 feet below the Pittsburg. This is wanting in other records.*

In western Marion, on the border of Wetzel county, there appears at one locality to be only shale for 603 feet below the Pittsburg to the Butler or Upper Freeport sandstone, or possibly the (Lower) Freeport sandstone. Crossing over into Wetzel county, one finds, at 10 miles southwest, the only sandstone at 480 to 510 feet, while midway between the wells this sandstone is at 500 to 515 feet, the Lower Mahoning. Eight or 10 miles northward the sandstones are at 406 to 446 and 470 to 548 feet, and at 10 miles northwest, on the Marshall border, the only sandstone is at 509 to 569, with the Lower Freeport coal bed at 575, the place of the Upper Freeport in eastern Monongalia and Marion. The sand-

* I. C. White: Geology of West Virginia, Monongalia county, vol. I, pp. 234-236; vol. II, p. 134; vol. II, pp. 230, 269; Marion county, vol. I, pp. 238, 240, 242, 245, 247, 348.

stone at the last two localities includes the Butler and the Lower Mahoning. On the Marshall border a well shows a sandstone 37 feet thick beginning at 318 feet, which is at the place of the Cowrun.

Six red beds are recorded midway in Wetzel, in all 109 feet thick. A double bed begins directly under the Pittsburg coal and three others are in the interval, 166 to 383 feet. The lowest is 25 feet thick, beginning at 443 feet, so that it extends into the Mahoning interval.

Passing over into Tyler county, south from Wetzel along the Ohio river, one finds in the northern part of the county the first sandstone at 490 to 515 feet below the Pittsburg coal bed. Three miles southwest a double sandstone is at 440 to 480 and the first coal bed is at 704 feet, underlying a great sandstone extending from 529 to 664 feet. The same condition is found in another boring 3 miles farther west, where the first sand is at 437 and the second at 537, while near the Ohio the sands are at 425 and 555 feet. Three miles north in Ohio the sandstones are at 430 to 480 and 535 to 685 feet.

In eastern Wetzel one has reached the area of decreasing intervals. The bottom of the Mahoning there is at most 515 feet below the Pittsburg, as also in northern Tyler. Westward toward the Ohio river the thickness of the Conemaugh decreases until it is barely 500 feet. The conditions in Monroe county of Ohio amply confirm Doctor White's correlation of the Tyler "Cowrun" sandstone with the Mahoning. The coal bed at 704 feet below the Pittsburg, in Tyler, is the Brookville, at the bottom of the Allegheny.

In this region and in Pleasants county, west from Tyler along the Ohio river, one finds the condition already noted in description of the Allegheny, the prevalence of sandstone, which in some cases is continuous from the top of the Mahoning interval to the Pottsville. The red beds of Tyler and Pleasants can not be traced readily, as details are given in very few records. Two beds are noted in Tyler, 52 and 6 feet thick, beginning at 148 and 294 feet, in all 58 feet thick; but in Pleasants there are 75 feet within the interval 148 to 300, the mass being almost continuous from 80 to 195 feet below the Pittsburg. The only traces of coal in Tyler and Pleasants are at 148 in the former and 345 in the latter, marking the Little Clarksburg and Anderson horizons.*

Returning now to the east, the section may be traced westward through the next tier of counties—Taylor, Harrison, Doddridge, Ritchie, Wirt, and Wood—to the Ohio river opposite Washington county of Ohio.

* I. C. White: *Geology of West Virginia, Wetzel*, vol. i, pp. 339, 340-341, 343, 348; vol. ii, pp. 176-177, 200-203.

Tyler: Vol. ii, pp. 241-242, 255-256, 258, 266-267.

Pleasants: Vol. ii, pp. 269, 273, 274, 286.

At Grafton, in Taylor county, 20 miles south from Morgantown and in continuation of the Pennsylvania Second bituminous basin, the Ames limestone, Harlem coal bed, and the Pittsburg reds are well shown, the last being 30 feet thick. A massive pebbly sandstone is at 25 feet above the Ames, and another, at 190 feet below that limestone, rests on dark plant-bearing shales with a thin coal at the bottom, the coal being at 250 feet. Two miles south, at Webster, the Ames is at 308 feet below the Pittsburg, and a thin coal bed is at 195 feet below the limestone, underlying calcareous and black shale. This is 120 feet above the bed identified on a previous page as the Lower Freeport, and the Mahoning interval is filled mostly by shale. The thin coal at Grafton appears to be at the Upper Freeport horizon and that at Webster is the Brush Creek.*

Harrison county, west from Taylor, is south from Marion. Near Clarksburg, 15 miles west from Grafton, the interval from Pittsburg to Upper Freeport is 540 feet, 35 feet less than at the nearest well recorded in Marion county. The first sandstone is at 365, 35 feet thick, and the Mahoning interval is marked by a continuous sandstone from 421 to 505 feet below the Pittsburg and resting on 35 feet of shale. This sandstone, in its upper part, reaches beyond the place of the Brush Creek coal bed and encroaches on the Buffalo interval, the higher sandstone reaching into the Cowrun. Two records are available in northern Harrison near the Marion line, where the Cowrun sandstone is persistent, its top being at 352 and 362; but in the latter case it is continuous with the Buffalo and downward into the Upper Mahoning at 457 feet. In both records the Upper Mahoning is almost wholly shale, and the Lower Mahoning sandstone, beginning at 492 and 512, extends downward into the Allegheny, its bottom being at 592 and 602 feet below the Pittsburg. The red beds are in characteristic contrast, for, though the wells are but 2 miles apart, the great bed of 100 feet seen in one at 102 feet below the Pittsburg is wholly wanting in the other, where one finds only a 40-foot bed beginning at 232 feet, which is represented in the former by 15 feet, beginning at 262 feet. This last is at the horizon of the "Big Red" of oil records in Washington county, Ohio. At West Milford, 10 miles south from Clarksburg, the first trace of coal is at 600 feet below the Pittsburg, probably at the Lower Freeport horizon in the Allegheny. Some red rock is at 95 feet and a 50-foot bed begins at 375 feet. At Cherry Camp, 10 miles west from Clarksburg, the only sandstone is 30 feet thick, beginning at 343 feet below the Pittsburg; all else is shale to a sandstone in the Allegheny at 642 feet. The higher sandstone is, at least

† I. C. White: Vol. II, pp. 232, 298.

in part, at the Cowrun horizon. The red beds are thick, 43 and 50 feet at 119 and 208 feet respectively, the latter above the place of the Ames limestone and equivalent to the Ohio "Big Red." The Pittsburg reds do not appear in the Harrison County records.*

Doddridge county is west from Harrison and south from Tyler. Near Long run, 6 miles west from Cherry Camp, a thin sandstone is at the Morgantown horizon, but the Cowrun interval is filled with shale, while there is sandstone, 406 to 452, within the Buffalo; the Upper Mahoning is shale, the Lower Mahoning is sandstone in part, extending into the Allegheny at 589 feet, and the only red bed is one of 97 feet, resting on the Buffalo, which is in part the Pittsburg red. In northern Doddridge, near Center, several wells show a 30-foot sandstone just below the Connellsville horizon, but no other. The red beds vary; in three wells within a small area one finds them at

| | | |
|-----------------|-----------------|------------|
| 218 to 242..... | 155 to 163..... | 75 to 110 |
| 267 to 340..... | 293 to 320..... | 290 to 540 |

feet below the Pittsburg coal bed, while farther west, near the Tyler border, the whole red is in two beds, 15 and 30 feet, beginning at 235 and 411 feet respectively, only 35 feet in all, contrasting with one of the Center wells, in which the red is continuous from the Pittsburg reds into the Allegheny. At this western locality the Morgantown, Buffalo, and Mahoning intervals contain only 11, 25, and 20 feet of sandstone. In southeastern Doddridge, on the Harrison-Lewis border, one record shows sandstone in the Upper Mahoning at 440 to 480, but for the most part that interval holds only shale; sandstone is in the Lower Mahoning 35 feet thick.†

Ritchie county, west from Doddridge, is south from Tyler and Pleasants. The Pittsburg coal bed is of uncertain occurrence, but in areas where it is present the interval to the "Big Lime" of the Lower Carboniferous varies within sufficiently narrow limits to justify use of the lower horizon in tracing the section. Midway in the county, near Harrisville, as well as in the Whiskey Run district, 10 miles northeast, no persistent sandstone appears in the Conemaugh. At Harrisville a thick sandstone overlies the place of the Pittsburg coal, but no other sandstone is recorded until the Allegheny is reached. In Whiskey Run area one well shows two thin streaks of sandstone in the Conemaugh; the others none. At Cairo, 3 miles west from Harrisville, sandstone is seen in one well continuing from 409 to 487, in another from 443 to 483, and in the latter

* I. C. White: Vol. I, pp. 248, 250; vol. Ia, pp. 317-318, 325.

† I. C. White: Vol. I, pp. 321, 325, 328, 329, 331-332; vol. Ia, pp. 282-284, 293, 295.

it rests on Black slate at the Upper Freeport horizon. In western Ritchie the sandstones are very uncertain, some wells showing only shales above the Buffalo-Mahoning, while others show occasional streaks, and in one well a sandstone 55 feet thick begins at 305 feet below the Pittsburg, representing in great part the Cowrun horizon. The red beds are as irregular as the sandstones. At Harrisville the first red is at 85 feet, and thence to 470 feet are three beds, 20, 170, and 165 feet—in all, 355 feet. In a well on Whiskey run the first red underlies the Pittsburg coal and is 40 feet thick; the second, representing the "Big Red" and Pittsburg reds, begins at 197 feet and is 150 feet thick, while a third, 30 feet thick, begins at 430 feet; but in a neighboring well the great middle mass is altogether wanting. The same contrast appears at Cairo, where thick beds in one well are wholly unrepresented in another barely half a mile distant. Coal beds are reported at various localities as occurring at six horizons below the Pittsburg coal bed. The last two are in the Allegheny. It would not be difficult to make correlations for the others, but except in the numbers, there would be no justification for such correlation. No coal beds are recorded in the Conemaugh of Doddridge; the records of Wetzels, Tyler, and Pleasants are almost equally barren, and the references to coal in the Ritchie records are uncertain, a great number noting no coal. If these coals be coal and not black slate, they can be only accumulations of drifted material at best and probably they bear no relation to the coal beds near whose horizons they occur.*

Wirt county is west and southwest of Ritchie. On the eastern border the Pittsburg coal bed is 1,260 to 1,278 feet above the "Big Lime," and the first sandstone, 15 feet, is at 408 to 423 feet; the second, 60 feet, begins at 553 feet below the Pittsburg. Three wells at Burning Springs, a few miles farther west, show a sandstone, 34 to 77 feet thick, whose top is at 686 to 688 feet above the "Big Lime," while the top of the thick sandstone beginning at 553 below the Pittsburg on the eastern border is at 725 above the "Big Lime." If 260 feet be taken as the interval from Pittsburg coal to Ames limestone, the sandstone near Burning Springs is 529 feet below the Pittsburg, for the Ames limestone is at the surface. There the sandstone is 99 feet below a 15-foot sandstone, while on the eastern border it is 130 feet below the same sandstone. The interval between Pittsburg and Ames is 235 feet at Cowrun, 30 miles north in Ohio, and the intervals increase in this direction. The upper sandstone is toward the top of the Upper Mahoning and the thick lower sandstone, persistent in much of the county, belongs within the Allegheny. The Harlem coal bed is shown near Burning Springs, where it underlies the Ames

* I. C. White: Vol. I, pp. 302-306, 313, 317.

limestone and "large unbroken shells of *Allorisma*, *Myalina*, and other forms are frequently found embedded in the upper part of the coal itself, though still in contact with the overlying limestone." The Morgantown sandstone forms bluffs along the Little Kanawha river at 40 to 50 feet above the Ames. On the west side of the county the Mahoning interval contains a sandstone at 422 to 482 feet below the Pittsburg, present in wells near the junction of Wirt, Wood, and Jackson counties. The detailed records in Wirt county begin, for the most part, below the usual horizons of red beds, but one near Burning Springs shows the Pittsburg reds.*

Wood county, west of Wirt and Ritchie, adjoins Washington and Meigs counties of Ohio. The Conemaugh is buried deeply, the Pittsburg coal can not be identified with certainty in most of the county, the Pottsville varies greatly in thickness, and the "Big Lime" is absent in the western portions.

In western Wirt the interval from Pittsburg coal to "Big Lime" is about 1,260 feet, but under the Cowrun anticline of Washington county, Ohio, that interval varies from 1,107 to 1,181 feet, and where the Pittsburg coal bed reappears farther south the measurement is about 1,120 feet.

In the northern part of Wood county, about 2 miles south from Marietta, one finds the "Big Red" 100 feet thick and 118 feet above what seems to be the Cowrun sandstone, 22 feet thick, 130 feet above a micaceous sandstone, 76 feet thick and very like that at 4 miles west in Ohio. The Mahoning interval holds only shale. Midway in the county one finds the "Big Lime" at 1,220 feet below the top of a sandstone very like that which farther south either overlies the Pittsburg directly or is separated from it by a score of feet. This rests on a great mass of red shale, 175 feet thick, broken in one well by 40 feet of shale. This red bed, associated with the Pittsburg, has been mentioned as occurring in central Wetzel and in central Ritchie. Here it extends upward into the Monongahela formation. A second bed, 30 feet thick, begins at 220 feet in one well, 210 in another, and a third, 72 feet in one, 105 in the other, ends at 412 and 415 feet below the assumed place of the Pittsburg. In the former well sandstone, extending from 412 to 465 and resting on 25 feet of red rock, underlies the red bed, but in the other this space is filled by shale, and a double sandstone is at 465 to 510 resting on 30 feet of red rock. It may be that these sandstones are the same, the smaller interval due to disappearance of the shales in the western well. The lowest red is unquestionably in the Allegheny.

* I. C. White: Vol. 1a, pp. 463, 465, 467-468; vol. II, p. 261.

Five miles southwest from the last well is Parkersburg, where neither Pittsburg coal bed nor "Big Lime" is present; but the relations may be determined approximately as at Marietta, 10 miles north in Ohio. A sandstone is here, 31 feet thick and resting on "red, blue, and gray shales," 415 feet, succeeded by 70 feet of gray shales, in all 485 feet, to a great sandstone, 105 feet thick, and at 760 feet is a coal bed. This bed is 208 feet above the Salt Sand and 843 feet above the Berea, while at Marietta the intervals are 225 and 830 feet. At Parkersburg it is 275 feet below the top of the 105 feet sandstone; at Marietta it is 280 feet below the top of the sandstone, there taken to be the lower part of the Mahoning, which at Parkersburg is continuous with the sandstone below, though at Marietta separated from it by 15 feet of shale. Evidently the section shows no material change and the Conemaugh is about 480 feet thick. The most notable feature is the great increase of reds, the upper one extending, as at Marietta, into the Monongahela, while other beds of considerable thickness are in the Allegheny.*

Returning to the eastern outcrop in Barbour and Upshur counties, the section may be followed westward across Lewis and Braxton, Gilmer, Calhoun, and Roane, Jackson and Mason to the Ohio river.

In northern Barbour a record about 10 miles southward from Webster, in Taylor county, shows 607 feet from the Pittsburg to the Lower Freeport. Two coal beds are present at 274 and 331 feet below the Pittsburg; the upper one, resting on a thin limestone, has been correlated with the Elk Lick; the lower bed, 270 feet above the Lower Freeport, underlies red shales containing the Ames limestone, so that it is at the Harlem horizon. There is little sandstone in the Conemaugh, and the red rock, in all, can hardly exceed 35 feet and is distributed in several layers within the lower part of the formation; but near Philippi, in this county, the Mahoning interval contains a massive sandstone. Ten or 12 miles southwest, in northern Upshur, a record shows a coal bed, possibly the Harlem horizon, about 285 feet below the Pittsburg and 255 feet above what may be the Upper Freeport. This record begins at about 100 feet. In 396 feet it shows only 65 feet of sandstone and 46 feet of red rock, three beds of each. At a few miles south from Buckhannon, in this county, a coal bed is shown in the river hill at 110 feet above the Upper Freeport, underlying 30 feet of massive sandstone on which rest red shales—very like the Brush Creek coal bed and Buffalo sandstone.

On the Lewis County border a record beginning at 220 feet below the Pittsburg shows 125 feet of red rock at 245 feet below that coal, succeeded by shales which continue into the Allegheny. The mass of reds

* I. C. White: Vol. I, pp. 285, 291, 295-297.

marks the double horizon above and below the Ames limestone. Twelve miles farther south, near Ireland, in Lewis county, coal beds are at 240, 372, and 429 feet below the Pittsburg. Doctor White sees in the upper beds the Elk Lick and the Barton. It is worth noting that these beds are 4 feet 6 inches and 2 feet 4 inches thick, and that they yield good coal. Eastward the Conemaugh coals are insignificant. On the west side of Lewis county the Vadis record shows that the Morgantown sandstone, 80 feet thick and beginning at 226 feet, continues to beyond the Harlem horizon. Sandstone in the Mahoning interval is 39 feet thick and ends at 490 feet. No coal is recorded and the red beds are

125 feet, beginning at 101 feet below the Pittsburg;

38 feet, beginning at 362 feet below the Pittsburg;

but the great bed seen in eastern Lewis is not here.

The records in northern Braxton county are somewhat indefinite, as the distance from the Pittsburg to well curbs is not given exactly. A record said to begin about 350 feet below the Pittsburg shows two red beds, 10 and 30 feet at 71 and 91 feet from the surface, and a third, not measured, is at 145 feet; thence for 365 feet the record is "slate, red rock, and shells" for 365 feet. Other records in this area show a similar condition, so that the great sandstone of the lower Conemaugh, so conspicuous in eastern Braxton, is here replaced by shale.*

In Gilmer county one finds near Stouts mills, only a little way west from the Braxton line and 12 miles west from Ireland, in Lewis county, the Morgantown sandstone, 85 feet thick and ending at 274 feet below the Pittsburg. A coal bed is here at 325 feet, but its relations are obscure. The red beds are numerous and are distributed through the section; the highest begins at 99 and the lowest at 529 feet below the Pittsburg; three thin beds are in the interval of the highest bed at Vadis; a fourth bed answers to the lower one at Vadis, but the reds associated with the Ames limestone are wanting. There is little sandstone below the Morgantown. Fifteen or 16 miles southwest, near Rosedale, on the Braxton border, are the records of a number of wells, all beginning at 100 to 150 feet below the Pittsburg coal bed. Taking the latter as the interval, the first sandstone, 126 feet thick, begins at 184 feet and rests on 102 feet of red rock, which is separated by 38 feet of sandstone from 100 feet of "slate and red rock." The first looks very like the Morgantown sandstone and its underlying reds. In these wells sandstone is insignificant in the lower Conemaugh as well as in the Allegheny, yet at barely 10 miles southeast the shales are replaced very largely by sand-

* Geology of West Virginia: Barbour, vol. II, p. 238; Upshur, vol. II, p. 349; Lewis, vol. I, pp. 255, 257; vol. II, p. 239; Braxton, vol. II, pp. 391-392, 453.

stone. The boring at Glenville, 8 miles northwest from Stouts mills, begins at the Morgantown horizon, but that sandstone is replaced and the record shows red beds extending from 192 down to 340 feet below the Pittsburg. Sandstone is unimportant, even that in the Mahoning interval being only 39 feet, ending at 534 feet below the Pittsburg. A coal bed at 444 feet may be the Brush Creek horizon. The Tanner well, in western Gilmer, shows that the sandstones are wholly insignificant, but the red beds are more than 200 feet thick; a similar condition is shown by records in southwestern Gilmer near the Calhoun border.

The records in Calhoun are a little obscure and determinate boundaries between the formations can hardly be set. The sandstones are variable, one record showing 83 feet in three beds, while another shows 152 feet in four beds. The red beds are important, but they are differentiated in only one record which shows

| | |
|------------------------|------------------------------|
| 111 feet, beginning at | 53 feet below the Pittsburg; |
| 20 " " " " | 169 " " " " |
| 71 " " " " | 214 " " " " |
| 10 " " " " | 338 " " " " |
| 122 " " " " | 403 " " " " |

the place of the Pittsburg bed being assumed, as the bed is absent; the reds make up at least three-fifths of the Conemaugh section. A coal bed appears in one record at 113 feet below the assumed place of the Pittsburg.

In Roane county, west from Calhoun, the Spencer record shows only 40 feet of sandstone in the Conemaugh, and the first great sandstone is at 495 feet, most probably wholly in the Allegheny. A great red bed, 140 feet thick, begins at 153 feet below the place of the Pittsburg, which is represented in another well by 80 feet, beginning at 112 feet; lower beds are reported here and there in records, but they have no relation to each other. In a record obtained 10 miles southwest from Spencer the only red is a bed 35 feet thick, beginning at 55 feet below the place of the Pittsburg. Throughout the north and west parts of the county the sandstones are insignificant and coal is altogether absent.

Jackson county, west from Roane, is south from Wood along the Ohio river. The records are difficult to interpret, but less so for the Conemaugh than for the Allegheny. A record in the southern part of the county shows no sandstone in the upper part of the Conemaugh, but red beds are distributed throughout the formation. At Ravenswood, on the Ohio, 17 miles east from Pomeroy, Ohio, a coal bed, evidently the Pittsburg, is at 1,364 feet above the Logan sandstone. At Letart, 10 miles farther west, the Pittsburg is 1,354 feet above that sandstone. In con-

trast with Roane and eastern Jackson, sandstones are present, there being three beds, 44, 38, and 30 feet thick, beginning at 64, 316, and 364 feet below the Pittsburg; on the other hand, the reds have diminished to 56 feet in three beds, all above the middle of the formation.

At Letart, in Mason county, 10 miles west from Ravenswood and 10 miles southeast from Pomeroy, there is no sandstone in the upper part of the Conemaugh, the only beds being 12, 18, and 50 feet respectively, beginning at 350, 382, and 415 feet below the Pittsburg, the last being in the Mahoning interval. The reds again become important in the upper half of the formation, there being a mass, 191 feet thick, which begins at 85 feet below the Pittsburg and includes the "Big Red" of Washington county, Ohio.

Returning now to the east: In Webster, Nicholas, eastern Braxton, and in Clay counties a bold sandstone overlies the Upper Freeport. In northern Webster the section extends 180 feet above the Upper Freeport, and deep red shale is shown in the uppermost 40 feet, but in the rest of the section the prominent feature is massive sandstone. At Powell mountain, in Nicholas, a massive pebbly sandstone is apparently continuous up to 180 feet above the Upper Freeport. Bold sandstone bluffs are on Elk river below Sutton, in Braxton county, and at Clay Courthouse the succession is:

| | Feet |
|--|------|
| 1. Concealed and much deep red shale | 90 |
| 2. Course gray pebbly sandstone | 60 |
| 3. Concealed and shales, some pale red | 100 |
| 4. Massive sandstone, large quartz pebbles | 60 |
| 5. Concealed and sandy shale | 130 |

to the Upper Freeport coal bed. The sandstones are all pebbly and the lowest reds are about 200 feet above the Upper Freeport. In Webster the lowest reds are at 140, so that displacement of shale by sandstone reaches at Clay as far up as at Powell mountain, more than 15 miles eastward; but the record suggests that the sandstone is not continuously coarse as at Powell, rather that it is broken by sandy shale. Twelve miles below Clay Courthouse the top of "a great massive sandstone" is at 430 feet above the Brookville succeeded by red beds, evidently the same with Number 4 of the Clay section. A well record on the Roane County border 9 or 10 miles northwest from Clay shows red beds 60 feet, resting on an apparently almost continuous sandstone 330 feet thick, but not reported as containing pebbles.

* *Geology of West Virginia*: Gilmer, vol. 1, p. 260; vol. 1a, pp. 384-386; vol. 11, pp. 243, 388; Calhoun, vol. 1a, p. 395; vol. 11, p. 396; Roane, vol. 1, p. 264; vol. 11, p. 369; Jackson, vol. 1, pp. 283-284; vol. 1a, pp. 477-478; Mason, vol. 1, pp. 281-282.

Along the Kanawha river the Conemaugh comes into the section at 2 or 3 miles below the line of Fayette county. Near lock number 3 155 feet of sandstone are above the Upper Freeport, and down the river coarse or pebbly sandstone appears above that bed wherever the horizon is reached, but becoming less coarse toward Charleston. A small area of what seems to be the Pittsburg coal bed exists below Charleston, and thence to the Upper Freeport the distance according to Doctor White's measurements is 643 feet. There is much massive sandstone up to 175 feet above the Upper Freeport, one section showing 75 feet of pebbly rock just above that bed and another showing 25 feet of similar rock ending at 175 feet. This condition continues for several miles, as a record at lock number 6 shows continuous sandstone for 405 feet above the Brookville-Stockton coal bed or to at least 200 feet above the place of the Upper Freeport. At Charleston the upper portion of the Conemaugh has about 120 feet of sandstone, much of it massive. There is much red shale, one bed about midway being 50 feet thick. This contains the "Two-mile" limestone, yielding fresh-water crustaceans. Two other thin limestones, non-fossiliferous, are here, but their relations are uncertain. Doctor White suggests that the "Two-mile" limestone may be at the Ames horizon. Two thin beds of impure coal appear in this section, but it is difficult to correlate them.

Mr Campbell gives the record of a boring at Winfield, in Putnam county, about 20 miles northwest from Charleston. The Conemaugh has five sandstone beds in the lower 300 feet, in all 105 feet thick. The Mahoning interval has a double sandstone, 10 and 35 feet, with 25 feet of shale intervening. The conditions characterizing the lower Conemaugh along the eastern outcrop have practically disappeared and the sandstone has been replaced largely by shale, while the sandstone which does occur seems to be without pebbles. Red shale is unimportant here, there being only three beds, 45 feet in all, and those are in the middle third of the formation.

The area of the Raymond City coal bed, taken usually to be equivalent to the Pittsburg, is very small and the coal thins away in all directions. Mr Campbell in working out the Huntingdon and Charleston quadrangles evidently hesitated to accept the reference of the coal bed to the Pittsburg, and in view of its circumscribed area was unwilling to take it as the plane of division between formations. Finding no other reason for separating the green and red shales and sandstones under the place of that coal from the similar rocks above it, he grouped the whole series above the Charleston formation into the Braxton formation. That formation in Putnam county and westward, where the upper part of the Charleston

sandstone has been replaced by shale, is equivalent to the Conemaugh and Monongahela formations and in some places may include a portion of the Dunkard.

Westward from the Kanawha river to the Ohio and in Putnam and Cabell counties the surface formation for the most part is evidently Conemaugh, but no details are available at present for closer description. There are many records of oil borings in Cabell, but in the absence of surface measurements they can not be connected up with the eastern localities. At Central City, on the Ohio, the Pittsburg coal bed is 340 feet above the river, but exposures are rare. The Ames limestone with all its characteristic features is present near Huntington and the Cambridge limestone is seen below Central City.*

Beyond the Kanawha, in southwestern West Virginia, one finds the full section of the Conemaugh only in Putnam county near Raymond, but the lower beds extend southward into northern Raleigh and apparently even into southern Mingo, so that they should be found in Pike county of Kentucky; but there are few details given in any of the reports.

Mr Campbell finds two coal horizons in Putnam county, one at 50 feet above the top of the Charleston sandstone and the other 300 to 400 feet higher. At Griffithsville, in eastern Lincoln, a coal is mined which he refers to the lower horizon. Mr d'Invilliers measured on Cobbs creek in this portion of Lincoln:

| | Feet |
|---|------|
| 1. Shales, sandstones and some red beds | 150 |
| 2. Massive sandstone | 25 |
| 3. Concealed, sandstone and red shale | 150 |
| 4. Shales and stiff clay slates | 75 |
| 5. Coal bed | 6 |

This seems to be Conemaugh above the coal bed, which has been taken to be the Upper Freeport. Mr d'Invilliers's section in northern Raleigh has been given; it seems to show that a considerable part of the Conemaugh remains even there.

Doctor White finds the Ames limestone in the northwestern part of Wayne county, and at 3 miles from the mouth of Twelve-pole creek what appears to be the double Cambridge limestone is shown overlying the Kentucky Coal bed 10, which is only a few feet above the Buffalo sandstone. This limestone is shown frequently along the Big Sandy river from the mouth southward to Big Blaine creek, in Lawrence of Ken-

* *Geology of West Virginia*: Webster, vol. ii, p. 453; Nicholas, vol. ii, p. 459; Clay, vol. ia, p. 472; vol. ii, p. 289; Kanawha, vol. ii, pp. 240, 400, 502-503, 518, 522; Putnam, vol. ii, p. 401; Cabell, vol. ia, p. 495.

M. R. Campbell: U. S. Geol. Survey folios, Huntington, p. 3.

tucky. The conditions observed along the eastern border northward from the Kanawha appear in Mingo county, where one has 170 feet of sandstone, mostly pebbly, to calcareous red shales, which may be at the horizon of the Ames limestone and the Pittsburg reds. No trace of limestone is seen at more than 4 or 5 miles east from the Big Sandy.*

ALLEGHENY AND CONEMAUGH IN THE ANTHRACITE FIELDS

SOUTHERN AND MIDDLE FIELDS.†

The column in the southern field is much longer than in the Middle, approximately 2,500 feet remaining in the deepest parts of the former, while only 1,500 feet are reported from the latter. The succession, descending, near Pottsville, in the Southern field, is:

| | Feet |
|-----------------------------------|------|
| 1. Brewery coal bed | |
| 2. Interval | 220 |
| 3. Salem coal bed | |
| 4. Interval | 100 |
| 5. Faust coal bed | |
| 6. Interval | 175 |
| 7. Tunnel coal bed | |
| 8. Interval | 165 |
| 9. Peach Mountain coal bed | |
| 10. Interval | 155 |
| 11. Yard coal bed | |
| 12. Interval | 70 |
| 13. Tracy coal bed | |
| 14. Interval | 46 |
| 15. Tracy coal bed | |
| 16. Interval | 65 |
| 17. Little Clinton coal bed | |
| 18. Interval | 55 |
| 19. Clinton coal bed | |
| 20. Interval | 110 |
| 21. Little Diamond coal bed | |
| 22. Interval | 40 |
| 23. Diamond coal bed | |

* E. V. d'Inwillers: West Virginia and Ohio railroad, p. 9.

M. R. Campbell: Charleston and Huntington folios.

I. C. White: Vol. II, pp. 259, 279, 280, 377.

† Detailed references to authorities will not be given for the anthracite fields. Descriptions of the coal beds, for the most part, have been compiled from Mr A. W. Smith's summary in the Final Report of the Second Survey; the features of the intervals between coal beds were ascertained by comparison of sections given in the atlases accompanying Report A A. The work by Messrs Ashburner, Hill, and Smith is so interlocked that one finds difficulty in assigning proper credit to each observer. Use has been made also of Mr B. S. Lyman's studies in the northern part of the Southern field.

| | Feet |
|-----------------------------------|------|
| 24. Interval | 180 |
| 25. Little Orchard coal bed | |
| 26. Interval | 27 |
| 27. Orchard coal bed | |
| 28. Interval | 110 |
| 29. Primrose coal bed | |
| 30. Interval | 55 |
| 31. Holmes coal bed | |
| 32. Interval | 115 |
| 33. Seven-foot coal bed | |
| 34. Interval | 20 |
| 35. Mammoth coal bed | |
| 36. Interval | 75 |
| 37. Skidmore coal bed | |
| 38. Interval | 143 |
| 39. Buck Mountain coal bed | |

each of the intervals being true only for the single locality at which the measurement was made.*

The Buck Mountain coal bed is the conventional boundary between Pottsville and higher measures, and it is taken here as the bottom of the Allegheny, to conform with usage in an earlier part of this work; but Mr David White has offered cogent reasons against accepting this plane of division. They will be referred to in another connection. The beds below the Holmes are known as "White ash," while that bed and those above are known as "Red Ash" beds. This distinction, however, is not absolute, as ash from the Mammoth and lower beds frequently shows the red tint.†

Several of the coal beds in both fields divide and subdivide even more perplexingly than do those of the Pottsville, in the Kanawha region, and intervals between the principal coal beds show abrupt variations. Were it not for great mining operations, extending continuously, in some cases for many miles, positive correlation would be impossible; but in those mines the "splits" have been followed as they separated and again united, so that no doubt remains respecting some of the most remarkable variations within the beds and in the intervals separating them.

The Buck Mountain coal bed is present in both fields. It is hardly recognizable in the western prongs of the southern field, but is 2 feet to 3 feet 6 inches thick just east from the union of the prongs, where it is slaty and impure; thence eastwardly it increases in importance until at Pottsville and beyond it is inferior only to the Mammoth, the thickness on

* Final Report, plate 366, opposite p. 2076.

† According to analyses tabulated by Mr Ashburner in Annual Report for 1885, pp. 314-315.

the northerly side being 13 to 19 feet, with 12 to 18 feet of good coal, as measured by Mr Lyman. Near Pottsville the bed is in three splits, with a total of 3 to 16 feet, but at Tuscarora, 8 miles east, the splits have united into a bed 10 to 17 feet thick. Still farther east two splits appear, 20 to 100 feet apart; which unite again eastward, and at the east end of the field the bed is from 9 to 12 feet.

In the western Middle, east from a line passing rudely north and south through Pottsville, the bed is important, 10 to 18 feet thick, and at the east end single. Westward it is less important and at Mahanoy City is in two splits 20 feet apart. Beyond this it decreases slowly on the southern side of the field, for at 14 miles it is still 4 to 5 feet thick. Northwestwardly from Mahanoy City the decrease continues for a short distance, but the bed recovers and at 10 miles northwest it is 15 feet thick; thence westwardly it loses steadily, becoming 6 feet within 4 miles, 2 to 10 feet, but with little good coal, at 7 miles, while at the western end it is a worthless mass of black slate. It remains available farther west in this than in the Southern field, for it is good enough to repay working at Shamokin, whereas it is worthless at 14 miles southeast, in the Southern field.

The variations of this bed in the eastern Middle are unlike those in the other fields. The bed is important to the northern border in the extreme eastern portion, showing at times 25 feet of coal; but westward, in a north and south strip 7 or 8 miles wide, it is worthless. This is north from the area of chief importance in the Southern field. Beyond this space it increases to its former thickness, and so continues to the western end, this portion being north from the important area northwest from Mahanoy City. The "splits" do not separate widely in the eastern Middle.

The Seven-foot coal bed of the Southern and western Middle is the Gamma of the Eastern. It is often thick, but, except near Mahanoy City, it is a mass of coal and slate in the former fields; it is sometimes 6 feet thick, with good coal, in the eastern part of the eastern Middle.

The Skidmore coal bed of the Southern, Wharton of the Middle, is persistent in the Southern field, where it is practically worthless except at the extreme east end, though occasionally workable at a little farther west. It is less irregular in the western Middle, where, however, it is important chiefly in the area northwest from Mahanoy City. Farther west in that field it is usually worthless except near Shamokin. In the eastern Middle it is good in the strip where the Buck Mountain is worthless, but is better farther west, where the lower bed also attains importance.

The Mammoth is the great bed of both fields. In the Southern, toward the end of the northern prong, it is but 2 to 4 feet thick; thence it increases and attains its maximum at the east end of the field, where, within a small area, its splits are united into one bed 114 feet thick with 105 feet of coal. Mr Ashburner's section at one locality toward this end shows three splits, 25, 13, and 8 feet, in a vertical distance of 83 feet; at another locality the splits are two, 57, and 16 feet, 95 feet apart, while at a third the bed is single and 115 feet thick. Similar variations occur in the Pottsville and Tremont areas, while northwest, in the Hecksherville area, the bed is in two or three splits in a vertical distance of 175 to 214 feet. In the western Middle, east from Mahanoy City, the splits are usually three in a vertical distance of 150 to 200 feet; but the intervals diminish westwardly until at Shenandoah the bed is single, 40 to 60 feet thick. Beyond that place the coal diminishes, and at Shamokin the splits are 8 and 7 feet and from 10 to 150 feet apart. Like the Buck Mountain and Skidmore, this is a coal bed much farther west here than in the Southern field. In the eastern Middle the Mammoth is thick everywhere except in a small area within the Black Creek basin, where it is only 12 feet. Ordinarily it is a single bed 20 to 60 feet thick, attaining its greatest thickness in the eastern part of the field; occasionally it is in two splits, never widely separated.

The Holmes coal bed is persistent in the Southern and western Middle, but it has not been recognized in the eastern Middle. It is from 3 to 17 feet thick and carries a great proportion of refuse, except in the extreme eastern part of the Southern and the western part of the western Middle, in both of which it is important and yields good coal.

The Primrose coal bed, like the Mammoth and the Buck Mountain, tends to divide, but the interval between the splits is never great. It varies greatly in thickness within the Southern field and, like the lower beds, decreases westwardly; yet it is more persistent in that direction than even the Mammoth, for at the last exposure in the northern prong it still has more than 2 feet of good coal. In the western Middle it has 6 to 7 feet of coal near Mahanoy City, but westward it is poor, until near Shamokin it becomes important with 7 feet of marketable coal. It is reached at only two localities in the eastern Middle and is not mined. At most places the coal is poor and the bed is known generally as the "Rough coal."

The Orchard coal bed is persistent in the Southern field, where, unlike the lower beds, it is best only near the beginning of the northern prong; elsewhere it is almost worthless. In the western Middle it is fit to mine only near Mahanoy City and Shamokin, but the refuse at the former

locality is almost 50 per cent, so that the bed is at its best only in the western part of these fields. It is not reached in the eastern Middle. The Diamond is a variable bed, occasionally workable in the Southern field, but disappearing in the western part. It has been recognized near Mahanoy City in the western Middle, but, unlike the lower beds, it seems to be wanting in the Shamokin area. The Tracy and Little Tracy show similar variations. These are the highest beds recognized in the western Middle. The Peach Orchard remains in an area so small that its variations are unimportant, but in the Pottsville and Llewellyn districts it is from 4 to 10 feet thick and is one of the best beds in the whole column, the coal being of exceptional purity. It was apparently the last important deposit, for, although the section extends 700 feet above it, none of the higher beds, excepting perhaps the Tunnel, appears to be worth working.

The important period of coal accumulation within the Southern and Middle fields ended with the Mammoth; for while the total amount of coal formed during the remaining time was probably as great, yet accumulation was continuous nowhere for long enough time to form a great bed over any considerable area. The irregular local movements causing the splitting of the Mammoth and Buck Mountain were no greater than those occurring in later intervals of similar length, as is evidenced by the varying intervals between higher beds. The variation is more striking in the Mammoth and Buck Mountain only because confined in each case to what becomes at times a single bed. It must be remembered that the time required for accumulation of coal in those beds was probably longer than that required for accumulation of half the mass above the Mammoth; so that the only cause for wonder is that, in any locality, the subsidence could be so slow and so regular long enough to permit accumulation of 105 feet of anthracite coal. Great variations in conditions existed during the formation of all beds except the Mammoth, for even the Buck Mountain shows a broad area in which the carbonaceous matter is distributed through a mass of coal slate, while some other beds, usually alternating thin layers of coal and slate, occasionally become sufficiently good to repay mining.

In this connection it is well to consider the variations in some intervals. The sections suggest that in the Southern field the intervals between Buck Mountain and Mammoth and between Mammoth and Holmes increase toward the west; but one may not offer a generalization, as complete presentation of details might prove this only an apparent condition. But variations in intervals below the Mammoth are important, as they are wholly clear in the multitude of sections gathered by

Messrs Ashburner, Hill, and Smith during their close study of the fields. In much of the Southern field the interval between Mammoth and Skidmore varies from 75 to 125 feet, but on the northern border, where that field is in contact with the western Middle, survey sections and those by Mr Lyman show:

| | Feet. | Feet. | Feet. | Feet |
|----------------|-------|-------|-------|------|
| Mammoth | | | | |
| Interval | 13 | 20 | 44 | 80 |
| Skidmore | | | | |
| Interval | 43 | 61 | 27 | 23 |
| Gamma | | | | |

these variations being in a distance of two miles and a half, the last at Mahanoy tunnel, on the border between the fields. In the western Middle the interval between Mammoth and Skidmore, west from Mahanoy City, varies from 6 to 33 feet. In the eastern Middle one finds this interval varying from 8 to 114 feet within a short distance, the Buck Mountain at the latter locality being 300 feet below the Mammoth. In the Hazleton basin, within a distance of 8 miles, one finds the interval, Mammoth to Skidmore, increasing westwardly from 35 to 41, 110, and 200 feet, the workings being continuous. While farther north, in the Black Creek basin, the interval between those beds varies from nothing to 50 feet, that from Mammoth to Buck Mountain varies from 66 to 200 feet in the same area. Thus in Little Black Creek basin the Wharton (Skidmore) is distinctly a split from the Mammoth, and the great decrease in interval to the Buck Mountain is such as to press the suggestion that that lower bed also unites with the Mammoth-Wharton somewhere in the eroded area.

The sections tell of great variability in coarseness of the material between the coal beds; limestone appears to be wanting everywhere; shale and sandstone, the latter often conglomerate, fill the intervals.

The material between Buck Mountain and Mammoth, in the eastern part of the Southern field, is for the most part sandstone, with at times immense beds of conglomerate; but near Pottsville slate predominates, while southeast from Tremont there is no conglomerate and more than half of the interval is filled with slate. Farther west the predominating rock is sandstone, with little conglomerate, but at Lykens, in the northern prong, conglomerate 48 feet thick is at 100 feet below the Mammoth. Beds of conglomerate fill intervals between the Mammoth splits at a number of localities. In the western Middle coarse material, sandstone, and conglomerate predominate east from the line of Mahanoy City; west from that line there is much variation. At times conglomerates are on the Buck Mountain and under the Mammoth, but near Shamokin the

interval shows only alternating shales and sandstones. In the eastern Middle sandstone, conglomerate, and comparatively little slate are at the south and east, but in the northerly and northwesterly basins shale appears abundantly in many sections, at times predominating.

Above the Mammoth there is much greater variation. In the eastern part of the Southern field conglomerate occurs only in thin beds, though one section shows 37 and another 78 feet of conglomerate near the Holmes. In some sections shales predominate for a long distance above the Mammoth and coarse beds appear only in the higher portions. In the eastern Middle, which is north from the eastern end of the Southern, sandstone prevails above the Mammoth, but even in the Southern basin, Beaver meadow, the proportion of slate is very large. At the north, in the Big Black creek basin, the coarsest rocks are midway in the basin and slates prevail on the western side. In the central part of the Southern field, near Pottsville, slates predominate to the Little Tracy at 1,450 feet above the Buck Mountain, the beds being from 25 to 100 feet thick, while the total of conglomerate is not more than 45 feet. Southeast from Tremont the interval, Mammoth to Orchard, shows fully 200 feet of slate in beds 10 to 33 feet thick, but fine conglomerate is associated with the Holmes, Primrose, and Orchard coal beds. The coals frequently succeed or precede a bed of conglomerate. In the sections beyond Pottsville, westward, there is little, aside from slate, to the Primrose, though occasionally a section shows more sandstone than slate, and even some thin streaks of conglomerate. Near the origin of the northerly prong sandstone is the rock for 60 feet above the Mammoth, beyond which there is mostly shale to the Orchard; but above that bed for 150 feet there is little aside from sandstone. Farther west, at Lykens, sandstone prevails to 400 feet above the Mammoth. In the western Middle, west from the line of Mahanoy City, fine sediments predominate above the Mammoth, there being alternating shales and sandstones; but one section near Shamokin differs from others in that region, as in 316 feet below the Holmes it shows but 60 feet of slate.

On the whole, materials are markedly coarser in the eastern parts of the fields; but even there the sections prove erroneous the opinion so long prevalent that shales are lacking, while in the greater part of the western areas shales are present in large proportion. The presence of so much coarse material in the northern prong has interest for the geographer.

NORTHERN FIELD

In the northern part of this field the Coal Measures column is but 400 feet, but the length increases southwardly until, in the deep basin between

Wilkesbarre and Nanticoke, there remains a thickness of about 1,800 feet. The lower coal beds seem to be fairly recognizable in the several basins, but much doubt exists respecting the higher beds. Even in the lower beds identifications must be made with hesitation at times, as the beds in splitting become thin and continuous workings are not possible. The succession and probably synonymy are as follows, descending:

| | |
|--|------------------------------------|
| Auble coal bed, | |
| Snake coal bed, | |
| Abbott coal bed, | |
| Kidney coal bed, | |
| Olyphant coal bed I, Brisbin, | |
| Olyphant coal bed II, Richmond, Hillman (?) | |
| Diamond coal bed, | |
| Rock coal bed, Checker, | |
| Pittston coal bed, Grassy island, Slope, Big, Baltimore, | |
| Marcy coal bed, New County, Four-foot, Ross, | |
| Shaft coal bed, Archbold, Clark, Four-foot, | |
| Dunmore coal bed III, Cliffford, | } Dunmore, Red Ash, Buck Mountain. |
| Dunmore coal bed II, | |
| Dunmore coal bed I, | |

The Dunmore coal beds are subject to great variation in the northern part of the field; six beds are shown in a vertical distance of 136 feet at Carbondale, of which one is workable, but farther north, at Forest City, all are thin. The interval from the Shaft coal bed to the top of the Pottsville, near Carbondale, is 125 feet, but at Forest City it is 180. Still farther southwest, near Priceville, Olyphant, and Blakely, the Dunmore beds are all thin, but at one locality on the northerly side they seem to have united into one bed with 14 feet of good coal, and the interval from Clark (Shaft) coal to Pottsville has increased to 260 feet. Toward Scranton three Dunmore beds are worked at 202 feet below the Clark (Shaft) coal, with a total of 16 feet of coal and partings in a vertical space of 32 feet; but these intervals are unusually small, as the Dunmore beds are distributed ordinarily in a vertical space of about 100 feet and highest one is from 170 to 35 feet below the Clark, this interval decreasing southwestwardly. In the Pittston area the Dunmore beds are represented by the Red Ash, or Powder Mill, coal bed, which is usually triple in the northeastern portion, the intervals between the splits varying from a few inches to 60 or 70 feet, though where the bed is double the interval rarely exceeds 20 feet. In the western portion the bed is usually double, with the splits, 5 and 4 feet, about 25 feet apart; but in the Boston colliery they are united with a thickness of 10 to 12 feet. In the eastern portion of this area the Clark is 80 feet above the top split, but in the

southwest, where the bed is single, the interval is 140 feet. The Red Ash becomes very important in the Wilkesbarre region, the splits uniting to make a bed 10 to 12 feet thick; farther southwest the thickness increases to 15 or 20 feet, occasionally swelling to 40 feet, though the interval between the splits sometimes reaches 50 feet. At the last exposure southward the bed is still 5 to 9 feet thick, and is known as the Buck Mountain.

The Shaft, Clark, or Archbold coal bed is double near Carbondale, where the interval between the "top" and "bottom" splits varies from nothing to 40 feet; but at the north end of the field, near Forest City, the bed seems to be always single. In the Priceville, Olyphant, and Blakely region it is single, 9 to 10 feet at the north, but decreasing southwardly to 3 or 5 feet, and at length to a mass of coal and slate which can hardly be recognized in the borings. Still farther southward it is important, becoming 10 to 12 feet near Hyde Park, in the Scranton area; but again it decreases, and in the Pittston area is 2 to 8 feet thick, with "Rough coal" so high in refuse that it is hardly worth mining. This deterioration evidently continues, for the bed seems to be unknown in the Nanticoke area at the south end of the field.

The New County, Marcy, or Ross coal bed is represented by the Four-foot coal bed of the Priceville area; but it becomes important first in the Scranton region, where at times it is from 7 to 9 feet thick, with 5 to 7 feet of good coal. It is good as far as Pittston, but thence deteriorates for several miles, though retaining its thickness. It varies greatly in the Wilkesbarre region, 4 to 20, and in one colliery even 40 feet thick. The interval to the Red Ash is 50 to 150 feet. The bed is sometimes in two splits, 5 to 10 feet apart; these diverge toward the Nanticoke area until they are 50 feet apart, with the thickness respectively of 15 and 9 feet; but this interval is very irregular. At the Wanamie colliery the bed is single and 15 to 25 feet thick; at Glen Lyon the splits are sometimes near enough to be mined as one bed, but followed westwardly in the tunnel they diverge widely. At Glen Lyon the interval to the Red Ash is 40 to 100 feet, increasing westwardly.

The Slope, Grassy Island, Big, Pittston, Baltimore coal bed is 130 feet above the Clark at Carbondale, though farther north, at Forest City, the interval is but 80 feet. In this northern part of the field the bed is about 5 feet thick, but it increases southwardly, so as to have a thickness of about 8 feet in the Jermyn basin, where the interval to the Clark has become 200 feet. In the Scranton area the "Big" bed averages 12 feet and is 100 to 150 feet above the Clark; farther southward, near Pittston, the "Pittston" coal averages 10 feet 6 inches and is 125 feet above the

Clark. The "Baltimore" coal of the Wilkesbarre area is believed to be the same bed; there it is often in two splits, the Bennett and Cooper, which are mined separately. When united, the thickness averages 20 feet. It is single from Wilkesbarre to Ashley, but splits northeast from the former place, the interval being 20 to 40 feet and the thickness of coal 16 feet. It is always split west from South Wilkesbarre, with only 10 feet of coal and the splits about 50 feet apart. The interval to the Red Ash is about 300 feet. The relations in the Nanticoke area are uncertain. A bed found there at 90 to 140 feet above the Ross, and known as the Twin, or Wanamie, is very near the place of the Baltimore; but it is so variable that some think it the equivalent of one of the thin beds seen above the Ross farther north. Two higher beds have been taken by some to be equivalents of the Bennett and Cooper splits of the Baltimore, and the beds bear those names. The lower one is 50 to 100 feet above the Twin and the other is 30 to 40 feet higher. The lower bed is mined at some places, 4 to 6 feet 6 inches thick, but the upper bed is extremely variable and of little importance. In any event, whether the equivalent of the Baltimore be the Twin or the higher beds, it is evident that the great bed has become insignificant in passing from Wilkesbarre to the Nanticoke area.

There seems to be a persistent coal horizon at 15 to 100 feet above the Big, or Baltimore, bed; it is the Rock coal of the Jermyn-Priceville area, traceable thence into the Pittston area, where it is known as the Checker. It becomes important here and there, varies from 6 to 10 feet, and generally yields rather poor coal.

In the Jermyn-Priceville area the sections show three coal beds above the Rock within a vertical space of about 200 feet; these are the Diamond, Olyphant 2 and 1. They yield good coal, but are rather thin. They have been recognized in the Scranton region, showing the same features. In the Pittston area a coal bed, the Hillman, is at an average distance of 175 feet above the Checker, 6 to 8 feet thick, and preserved in only a small space. A coal bed known as the Hillman occurs in the Wilkesbarre area at an average distance of 270 feet above the Baltimore bed, and is from 7 to 10 feet thick, with much clean coal. As the areas of the higher beds are very small near Pittston and Wilkesbarre, it is difficult to make correlation; but the Hillman of both Pittston and Wilkesbarre seems to be one bed and very near the place of Olyphant 2. A Hillman coal is in the Nanticoke region at 240 feet above the Twin coal. It is very near the place of the Wilkesbarre Hillman, if the Twin be taken as the Baltimore.

In the deep basin between Wilkesbarre and Nanticoke, there are above the Hillman several coal beds, some of which are fairly regular; but the accumulation of coal in available beds seems to have ceased at about 1,200 feet above the Red Ash bed and the higher measures are barren; south-east from Nanticoke to Dundee the upper measures for 900 feet have been proved by borings to be without workable coal.

Respecting the relations of the coal beds in this field to those in the others, nothing can be determined by stratigraphy; a gap of almost 25 miles separates the areas. The Red Ash and the Baltimore are supposed to be equivalent to the Buck Mountain and Mammoth respectively. The important Shaft, or Archbold bed, evidently disappears southward before reaching the Nanticoke area, and the Baltimore, the second important bed above it, becomes so obscure and uncertain that its equivalent in the Nanticoke region is still undetermined. The only coal beds retaining their importance are the Red Ash, or Dunmore; the Ross, which, owing to disappearance of the Archbold, becomes the second bed, and the Hillman. It has been seen that in the nearest portion of the eastern Middle the Mammoth and Skidmore prove to be one bed, and that the interval between that bed and the Buck Mountain is so diminished as to suggest that they may unite at but a little way northward. It seemed possible, therefore, to seek in the Red Ash of the northern field the equivalent of the Buck Mountain, Skidmore, and Mammoth; but this suggestion appears to be contrary to the evidence furnished by plant remains, as read by Mr David White, so that it may not be accepted. The solution of the problem remains with the paleontologist.

The material filling intervals between coal beds in the northern end of this field is for the most part rather fine. Sandstone prevails above the Clifford-Dunmore, and one section shows 51 feet of conglomerate resting on that bed; but, higher up, sandstone and shale are in alternating beds. Near Carbondale the sandstones are fine and the proportion of slate is large, but near Jermyn the sections show little aside from sandstone. This is the condition near Olyphant even to the Diamond coal bed. On the easterly border, near Winton, conglomerate appears in most of the sections between the Dunmore and Clark beds; but in the Priceville-Dunmore-Scranton region coarse rocks are usually wanting and shale is present in great proportion for 240 feet above the bottom. The change from sandstone to slate is very abrupt in many places and a record in Scranton shows a notable bed of conglomerate.

Farther southwest one finds a persistent conglomerate above the Red Ash in the Lackawanna-Pleasant Valley district; it is within the first 120 feet above that coal bed, and varies from 9 to 80 feet in thickness.

Sandstone predominates in the sections, though thick beds of shale are not wanting. Near Pittston and Wyoming the interval between Red Ash and Checker is filled with sandstone or with clay and sandstone, there being no coarse material aside from some thin streaks of conglomerate near Wyoming; but a conglomerate 18 to 42 feet thick overlies the Checker. Near Luzerne some sections show a variable conglomerate above the Ross, but for the most part there seem to be only sandstone and shale up to 520 feet above the Red Ash. Southeastwardly, however, near Wilkesbarre and thence toward the easterly edge of the field conglomerate appears in many sections between the Red Ash and the Baltimore, between Baltimore and Hillman, as well as above the last bed, and the conglomerates are thick, 10 to 130 feet. In some records no conglomerate is noted, but in all the deposits are coarse and there is little shale. Near Plymouth one record gives 86 feet of conglomerate between Red Ash and Ross, but other records, extending 800 to 1,300 feet above the Red Ash, show no conglomerate, while shales or clays make up nearly half the mass. Near Ashley and Sugar Notch, southeast from Plymouth and toward the easterly border, conglomerate is reported occasionally, but not as in the Wilkesbarre area on this side of the field, and the interval, Red Ash to Baltimore, is filled usually with sandstone, while shales become abundant higher up in the column.

Conglomerate appears between Red Ash and the place of the Baltimore near Nanticoke and Glen Lyon, at the southern end of the field, sometimes resting on the Red Ash, and in one case very near the "Bennett." Still, many records show only sandstones in this interval. Deposits are finer above the place of the Baltimore, and there is much shale.

Limestone occurs only in the upper part of the column, and seems to be confined to the Wilkesbarre-Nanticoke region. The first notice of this limestone was by Mr Ashburner, who gave a section which, condensed, is as follows:

| | Feet |
|---|------|
| 1. Slate, thin coals, and sandstone | 138 |
| 2. Mill Creek limestone | 1 |
| 3. Sandstone | 25 |
| 4. Canal limestone | 2 |
| 5. Slates, sandstones, and coal beds | 134 |
| 6. Limestone | 2 |
| 7. Slate, sandstone, conglomerate, coal beds..... | 155 |
| 8. Hillman limestone | 3 |
| 9. Slate | 10 |
| 10. Hillman coal bed | 16 |
| 11. Conglomerate, slates, sandstone, coal beds..... | 341 |
| 12. Coal bed E, Baltimore | 16 |
| 13. Sandstones, conglomerates, coal beds | 351 |

in all 1,194 feet to the Pottsville. The fossils were obtained from the Mill Creek limestone, which is about 700 feet above the Baltimore coal bed; the other limestones, so far as known, are non-fossiliferous.* The collections were examined by Professor Angelo Heilprin, who gave a list of about twenty species. Comparison of these forms with those obtained in southwestern Pennsylvania and the adjacent portion of West Virginia leads to no positive conclusion respecting the place of the limestone. Three forms, *Eumicrotis hawni*, *Monopteria gibbosa*, and *Chonetes millepunctata*, have not been reported from any other locality in the Appalachian basin. The other forms are widely distributed, most of them having been found below the Mahoning interval. Somewhat similar grouping of forms occurs in a black shale near Dundee, which Mr Hill places about 250 feet above the Mill Creek limestone. As far as the testimony of these fossils is concerned, the Mill creek is as likely to be Allegheny as Conemaugh; but the coal-making period seemed to have ceased in great measure after the Hillman bed, so that here one finds conditions characterizing the Conemaugh in the bituminous areas.

It seems altogether probable that the higher beds of the Northern fields are wholly unrepresented in the Southern field. In an earlier part of this work it was seen that the Pottsville diminishes northwestwardly, so that the vast pile of the Southern is represented by a very short column in the Northern field. In the higher measures one finds that the interval, Buck Mountain to Tracy, diminishes almost to one-half in passing from the neighborhood of Pottsville into the western Middle. If the change continue in this upper portion as in the Pottsville, the great column of the Southern field should be represented by less than the lower half of the column in the Northern field; so that one might regard the rocks above the Hillman coal bed as without equivalent in the Southern field.

* Annual Report for 1885, pp. 449 et seq.