

REPORT  
OF THE  
FOSSIL FLORA,  
AND OF THE  
STRATIGRAPHICAL DISTRIBUTION OF THE COAL  
IN THE  
KENTUCKY COAL FIELDS,  
BY  
LEO LESQUEREUX, PALEONTOLOGICAL ASSISTANT.

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## INTRODUCTORY LETTER.

COLUMBUS, O., January 31st, 1860.

*D. D. Owen, M. D. :*

DEAR SIR: According to your instructions, I spent the months of May and June, 1858, in a detailed exploration of the coal fields of Union, Crittenden, Hopkins, Christian, Muhlenburg, Ohio, Daviess, and Henderson counties, of which I had, the previous year, made only a short reconnoissance. The months of August and part of September, of the same year, were employed in surveying the distribution of the coal strata of Bath, Montgomery, Powell, Morgan, Owsley, and Breathitt counties. In the first of these explorations I was accompanied by Mr. Alfred Owen; in the second by Major T. C. Downie. To both these gentlemen I wish to express my gratitude for kind and valuable assistance. Continuing the explorations of the eastern coal fields, during the month of May and part of June, 1859, I surveyed Greenup, Carter, Lawrence, Johnson, and Floyd counties. But owing to the sudden sickness of Mr. Alfred Owen, my assistant, I had to perform the greatest part of the work alone. The difficulty of the task would have been severe but for the assistance and hospitality which I received everywhere from the inhabitants, who generally manifested the greatest interest in the survey. It is the result of those different explorations that I take the liberty to present to you, sincerely desiring that it may meet your approbation.

Since the publication of my former report, the final report of the Geological Survey of Pennsylvania has appeared, contrary to general expectation. In this work, I am accused by Prof. H. D. Rogers, formerly director of the Geological State Survey of Pennsylvania, of plagiarism, or of a breach of literary obligation, for the quotation of half a page of my own report, delivered to him in 1854, and of the disposal of which I had since been left entirely ignorant. It is evident that no general

conclusion can be drawn from palæontological researches, except from a comparison of the distribution of the fossil plants in the coal strata of many and far distant localities. To prevent a geologist from making such comparisons, by denying him the use of his own observations, till a publication, though indefinitely postponed, of his report, is made, is truly the same as depriving a workman of his tools. I was thus forced to recall a few of the observations made by myself years ago, in Pennsylvania; and as I was careful to mention the source of the quotation and the right of property of the Pennsylvania survey, the accusation of Prof. H. D. Rogers will appear to every impartial mind as unjust as unaccountable.

Very respectfully yours,

LEO LESQUEREUX.

## INTRODUCTORY REMARKS.

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My first palæontological explorations in Kentucky were made in too short a time, and extended over too large an area of country, to give at once satisfactory and reliable results. They embraced a general reconnoissance of the western coal fields of Kentucky; therefore, my first report gave only a very general survey of the western coal measures, to be completed by subsequent and more detailed researches. Even now, it is not to be supposed that this report will satisfy the expectations of every coal proprietor. Although prepared to mark the geological horizon of most of the beds of coal which I had an opportunity of surveying, there are still many out-crops, even open coal beds, which could not come under my examination; either for want of time to visit them, or because the beds being still unopened, the characters of the shales and fossils could not be ascertained.

There is, indeed, a great difficulty attending the application of palæontology to the identification of the coal strata. The fossil plants being, of course, unequally and irregularly distributed in the shales of the coal beds, and the shales themselves being sometimes entirely wanting, obscure out-crops of coal can scarcely be studied, and, therefore, cannot be placed with accuracy, when they are not exposed by a good entry.

This deficiency in the application of palæontology to the determination of geological levels of the coal, induced me to extend somewhat the range of my explorations, and to examine and report the stratigraphical distribution of the coal as often as it was possible to do so with advantage. I have always endeavored, first, to determine the position of each coal bed by the fossil plants of the shales; and afterwards, even if the examination gave entire satisfaction, I have made, when it was possible, a section either of the coal itself, with the adjoining strata, or of the measures exposed in its connection.

In reporting a number of these sections, I may possibly have to go over a few that have already been published; but this reviewing of sections, even if it should be of frequent occurrence, will still become useful for the following reasons:

*First.* The explorations of the coal strata form now a distinct part of the geological survey. It would, therefore, be advantageous to reconsider the different data which have been collected and present them all together.

*Secondly.* The reliability of palæontological evidence has been, and may still be, often disputed. It is therefore necessary to prove its correctness by comparative sections, made in different localities. This comparison cannot always be established upon unpublished sections only.

*Thirdly.* Good, comparative lithological sections, of actual superposition, combined with palæontological evidence, afford the only means of ascertaining the relation of the strata in the different coal fields of Kentucky and of America. The identity of the fossil plants of a bed of coal, more or less distant from another, offers at once evidence of horizontal equivalence, and affords easy means of comparing entire sections. All the sections published without this fixed point as a basis of a common geological horizon, may be interesting for some particular locality, but are more or less uncertain, and often useless, in a general examination of the coal measures. Moreover, these comparative sections furnish the best indications to direct the researches for coal in the intervening localities.

The plan of this report is, therefore, easily traced; it is first necessary to review the general character, either palæontological or stratigraphical, of each bed of coal, and to establish the value of these characters by some local sections. This mode of examination may be somewhat tedious, but it will afford solid materials for the true history of our coal formations.

I shall then make a general section of each county which I have surveyed, pointing out all the beds of coal examined, and their relative position in the section.

A comparison of the distribution of the coal strata, in both the western and eastern basins of Kentucky, must necessarily follow, and must be extended as far as possible over the coal measures of Ohio, Pennsylvania, etc.

I deeply regret that I was unable to extend my explorations over the

entire coal fields of Kentucky; but the time, as yet, has been too limited for such a work, and therefore much remains still to be done for a full description of the Kentucky coal measures. According to the directions of the State Geologist, I have examined the richest parts of the coal fields, especially those which are easy of access, and the more likely to attract the attention of the miner and the capitalist.

#### NATURAL DIVISION OF THE COAL MEASURES.

If I had to report on the western coal fields of Kentucky only, I should have little or nothing to communicate on any beds of coal under the conglomerate. But the exploration of the eastern coal basin has shown that the true coal measures begin there immediately above the sub-carboniferous limestone, or, when this limestone is absent, the coal succeeds immediately to the sub-carboniferous knob sandstone, or the upper division of the Chemung group. As some beds of these inferior strata of coal are of workable thickness and of excellent quality, it becomes of the first importance that their position should be described, and their characters, as far as they are determined, made known.

The coal measures below the conglomerates have been generally distinguished by a peculiar name from the measures above; they have been called false coal measures, proto-carboniferous formations, &c. I see no good reason for this distinction. If it is based on the fact that the inferior coal beds are not generally found over the whole extent of the coal fields of America, the same can be said of the coal strata between the Mahoning and the Anvil Rock Sandstone, and particularly of the upper coal measures above the Anvil Rock. If this separation is made, from the thickness and extent of the great deposit of sandstone named *conglomerate*, or from its composition of coarser and more pebbly materials, the same reason for a further separation of the coal measures might be found in the thickness, extent, and composition of the Mahoning, and even of the Anvil Rock Sandstones. A separation of the inferior coal beds from the higher measures associated with them, could only be authorized by a difference in the vegetation of which the coal has been formed, and consequently in the species of plants found in the shales. But this difference does not exist, as we shall see presently. It is, therefore, more rational to take the coal measures in their whole vertical extent,

as a single and inseparable formation, dividing them, for the sake of a better understanding, in four different parts.

1. The coal measures below the conglomerate.
2. The measures between the conglomerate and the Mahoning sandstone.
3. Those between this last sandstone and the Anvil Rock.
4. The upper coal measures above it, with their top still undetermined.

COAL MEASURES BELOW THE CONGLOMERATE.—GENERAL DISTRIBUTION.

They appear in the western coal fields of Kentucky—

1st. Near Caseyville, in Crittenden county, in a stratum of black shales containing a thin coal. This shale is well exposed at a short distance from Bell's mine, on the bank of the creek.

2d. In Breckinridge and Meade counties, where two beds of thin coal have been observed in the thick strata of sub-carboniferous limestone,\* they have not yet exposed a workable bed.

In the eastern coal fields, those low measures are much better developed, and exposed nearly all along the western edges of the basin. I examined the first outcrops of their coal near Jas. Wills', in Montgomery county; then between Slate and Beaver creeks, on the road to McCormick's, as also just above Mr. McCormick's house, on the road to Hazlegreen, and a few miles south of the head waters of Emmet's fork of Indian creek.

The most northerly outcrops of these coals which I visited, was at Clear creek, in Bath county, and the farthest southward at L. Bush's, on Walker creek, Owsley county, on the road between Proctor and Hazlegreen.

South of Owsley county, or even in this county, the inferior coal measures appear to thicken considerably in some places. Near Proctor, and in Pulaski and Rockcastle counties, they contain three to five beds of coal, one of which is worked four to five feet in thickness.† Above the shales of the Cumberland river, in Wayne and Clinton counties, Mr. Jas. Lesley, jr. reports two, and sometimes three beds of coal, below the conglomerate. In Northern Tennessee, near the limits of Kentucky, Prof. J. M. Safford has observed five (5) veins of coal in the same

\* My first Report, diagram 4th and section, vol. 2, p. 89.

† Report 1st, diagram 4th, p. 222-237.



situation, one of which attains, in some pot holes, a thickness of five feet. In Virginia, south of the Kanawha Salines, Dr. S. H. Salisbury has seen five (5) beds of coal below the conglomerate, one of which is formed of alternate layers of slate and coal six to seven feet thick. The sub-conglomeratic coal has been observed, also, by boring salt in the interior of the coal measures. The section of Warfield, on Tug river, will show its position.

It is a remarkable fact that this lower coal has never been seen along the western edge of the coal measures of Ohio, where in many places the conglomerate attains to a great thickness, when on the contrary, the sub-conglomeratic coal appears to be developed in Mercer and McKean counties of Northern Pennsylvania.

#### PALÆONTOLOGY OF THE LOWEST COAL MEASURES.

As far as has been ascertained, the palæontology of the coal beds below the conglomerate is very uniform. I have only found in the shales covering them the leaves, the cones or catkins, and the bark of different species of *Lepidodendron*. Judging from analogy, I suppose that this peculiar flora of the low coal will be found generally of the same nature in the whole extent of the measures below the conglomerate, with the exception of a few particular species to each different bed of coal; but this supposition wants to be sustained by sufficient palæontological evidence.\*

At S. Wills' coal, the shales intermediate to the two beds of coal are entirely covered with the leaves of *Lepidodendron*. These leaves (*plate 3, fig. 2*) are easily known by their resemblance to long and narrow blades of grass. Although the appearance and nature of these shales is very different in two exposures of the same coal, being at one place hard, black, and fissile, when at a few yards distance they are replaced by a kind of yellow, soft clay, these leaves of *Lepidodendron* are found in the same abundance in both.

On the head waters of Emmet's fork, the bed of coal worked by Mr. McCormick is 75 feet below the conglomerate, and apparently on a lower level than the former, yet the shales covering the coal contain only leaves of *Lepidodendron*, with a few cones of the same tree, (*Lepidos-*

\*Since writing this, I have had opportunity to survey the sub-conglomeratic coal measures of Western Arkansas, and found their flora characterized by some peculiar species, but rich and varied, indeed. *Neuropteris flexuosa* and *Flabellaria borassifolia* are as abundant in the shales below the conglomerate as above.

*trobi.*) The lower part of the coal, which is soft and slaty, (brash coal,) contains, besides the stems of *Lepidodendron*, a few prints of *Calamites*. The coal itself, which is of a very black, hard, and beautiful appearance, is mostly covered, in its horizontal sections, by thin layers of charcoal, marked especially with prints of small branches of *Lepidodendron*.

On Clear creek, in Bath county, the shales covering the coal are also marked by leaves and the bark of the same species.

By its fossil plants, the coal worked at Proctor might be referred to the same sub-conglomeratic series. Unhappily, I could not carefully examine it, being there prostrated by sickness. Mr. Downie, my able and efficient assistant, found in the shales of McGuire's coal, a piece of bark of a *Lepidodendron*, and some *Lingula*, with a *Flabellaria*. These two last species are generally characteristic of a higher coal; but such isolated specimens are not sufficient for conclusive evidence. The *Lingula umbonata* appears to have a wider range than was first supposed; and the *Flabellaria*, although more abundant in the No. 1 B. coal above the conglomerate, is a plant of the sub-conglomerate coal also.

These remarks on the characters of the sub-conglomeratic coal flora are confirmed by the observations of Mr. J. Lesley, jr., who, from his camp in Pulaski county, writes that he has only found, in the shales below the conglomerate, these leaves of *Lepidodendron*, with some prints which, from his sketch, evidently belong to scales of the cones of *Lepidodendron*, viz.: to the genus *Lepidophyllum*, of which two species have been figured in my former report. (*Pl. 7, fig. 7 and 8, vol. III, Geol. Survey of Ky.*)

In a catalogue of the fossil plants of America, published by the Scientific Association of Pottsville, I have described and figured a new species of *Pecopteris*, (*Pecopteris Sheafferi*), found in McKean county by my friend, Prof. P. W. Sheaffer, of Pottsville. The coal in the shales, of which this species was found, is said to belong to the sub-conglomeratic measures. Except this plant, the shales which bear it do not show any other remains but leaves and fruits of *Lepidodendron*.

The specimens of shales collected in the Geological Survey of Arkansas, under the direction of Dr. D. D. Owen, and which were submitted to me for examination, are mostly covered with the same leaves above mentioned. There is besides part of the frond of a fern related to *Alethopteris nervosa*, but specifically different. Dr. Owen remarks, on

the Spadra coal, which, like all the other coals of Arkansas, belongs to the sub-conglomeratic series, that *some obscure stems, and long slender leaves or glumes, of some plants can be discovered by splitting up the shales.*\* These long slender leaves are the leaves of the *Lepidodendron*, and this observation confirms what I have before said about the general appearance of the flora. Mr. E. T. Cox, Assistant Geologist in the same survey, speaks of the coal strata in Crawford and Johnson counties, Arkansas, as containing in their shales mostly *Lepidodendron*, with *Sphenopteris*, *Calamites*, and *Pinnularia*.† I have seen no specimens of these last genera of plants in the shales examined, and do not know whether there are any new species among them. These remarks of Mr. Cox, who is very particular and careful in observations, tend to show that the different beds of the lowest coal measures must be characterized by some peculiar species.‡

I may mention here this curious coincidence. In the shales of the low coal of North Carolina, of which some beds are intercalated in the old red sandstone below the conglomerate, my friend Mr. J. P. Lesley found specimens of a *Lepidodendron* which I had never seen, except in the red shales below the conglomerate at Mauch Chunk and Pottsville, Pa.

#### STRATIGRAPHY OF THE SUB-CONGLOMERATIC COAL MEASURES.

The respective position of the coal beds below the conglomerate appears to be as variable as their horizontal distribution.

In the first report of the Geological Survey of Kentucky, Prof. D. D. Owen gives a section of 227 feet, in which the place of the highest coal is not fixed relatively to the conglomerate, but is shown to be 140 feet above the main coal of Proctor. On the same section are also marked two coal beds 4 and 6 inches thick, at 35 and 40 feet below the same main coal.

Three miles south of Jas. Wills', near the eastern limits of Montgomery county, a bed of coal 22 inches thick rests immediately upon a soft, buff-colored sub-carboniferous sandstone, containing, in great abundance, the shells of the Chemung group, and which, at this place, overlies another bed of sandstone, covered mostly with *Fucoides Cauda-Galli*. The coal is covered by 12 feet of black, soft shales, easily breaking,

\* First Report Arkansas Survey, by D. D. Owen, p. 130.

† Ibid, p. 227-230.

‡ Vide note, p. 339.

marked by the fossil plants mentioned before, and containing pebbles of carbonate of iron. These pebbles are generally of the size of a common potato, having the same oblong form. From the top of these black shales to the base of the conglomerate sandstone, there is yet a covered space of 10 feet, which, according to the evidence of Mr. Wills, contains a streak of coal 4 to 6 inches thick.

In the hills just opposite the house of Mr. J. Wills, the formation containing *Fucoides Cauda-Galli*, about 100 feet thick, rests upon the lower sub-division of the Chemung group, and is surmounted by a conglomerate sandstone, containing here a great abundance of fossil shells, especially pieces of *Cyathophyllum*, *Cystiphyllum*, etc. In these hills there is no trace of coal or of limestone; but on the road to McCormick's, in crossing the hills between Slate and Beaver creeks, three miles east of Mr. Wills', the limestone makes its appearance with a stain of coal above it. In this part of the country, viz.: on the limits of Powell, Montgomery, and Morgan counties, the sub-carboniferous limestone is extremely variable, either entirely wanting, or appearing here and there in strata from 6 inches to 25 feet thick. Just above the house of Mr. McCormick, on the road to Hazlegreen, the limestone is seen succeeding the knob sandstone, first, as a thin layer of a few inches, cherty, perforated, coarse-grained, resembling a bastard limestone, then rapidly increasing in thickness to 15 feet, and becoming hard, fine-grained, and fossiliferous. It also supports here a bed of coal from 12 to 22 inches, capped by 5 to 6 feet of black shales, with the same plants as at Mr. Wills' coal. This coal, however, is too full of stems of *Lepidodendron*, and its quality is very inferior. The shales of this coal are overlaid by a ferruginous sandstone, probably a member of the conglomerate.

On the head waters of Emmet's fork of Indian creek, five miles south of McCormick's, the coal is 70 feet below the conglomerate, which forms picturesque bluffs of from 150 to 200 feet high. The bed measures 15 inches of hard, fine, bituminous, block coal, underlaid by 6 inches of shaly (brash) coal. The section is as follows:

	Feet.
Conglomerate .....	150
Shaly ferruginous sandstone.....	55
Black shales, with carbonate of iron.....	15
Hard coal.....	1 $\frac{1}{3}$
Soft shaly coal.....	6 inches.
Fire clay to level of the creek.	

The coal, equivalent of the former, on Clifton bank, one mile south of

the road to Hazlegreen, is 22 inches thick. At Jas. Gibbles'; on the head waters of Brush fork of Beaver creek, it is reported of the same thickness; but I had no opportunity to examine it.

Although the distance between the coal and the conglomerate is much greater here than at Wills', I am satisfied that it is the same coal. Its characters and the nature of the shales are the same; and as for the measures below the conglomerate, we have already seen how variable they prove. The bed of ferruginous sandstone, which is here superposed on the shales, takes the place of conglomerate sandstone, or of millstone grit.

At the head waters of Clear creek, in Bath county, three miles above the furnace, a coal, the equivalent of the former, has been worked, about 35 feet below the conglomerate. It is cut in two by four feet of black shales, bearing the same characters as those intermediate to the two coals of Mr. Wills. Its base was covered with mud and water, and I could not see it well opened. It is reported by Prof. D. D. Owen, who also visited it, as being 1 foot and 10 inches in its upper member.

On Yocum creek, north fork of Licking, near the western limits of Morgan county, a coal 4 inches thick crops out just at the base of the conglomerate, without any shales above it; I consider it as the equivalent of the upper coal of Mr. Wills, but being like the following, at the level of the creek, the inferior strata were not exposed.

On the road from Proctor to Hazelgreen, on Walker creek, and on the property of L. Bush, there is a bed of coal 8 to 10 inches thick, which also crops out just at the base of the conglomerate, without intermediate shales. The hard sandstone covering of this coal contains two or three streaks of coal, one to two inches thick, running very irregularly. These irregular streaks of coal are often remarked above the coals immediately covered by sandstone, and are formed of detached parts of the woody matter of the coal, rolled and imbedded in the sand by waves or currents.\*

It is purposely that I have until now delayed to speak of the Caseyville low coal, of which the true position has been subject to, and is still under discussion, among the geologists of the State Survey of Kentucky. The coal under consideration, said to be 18 inches thick, was struck in a

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\* A coal in the same position, just below the conglomerate, is reported by Dr. D. D. Owen, in the 1st volume of the Arkansas Survey.

well near the old distillery, above Caseyville, at a depth of 70 or 80 feet below Casey's coal bank, opened near by. When I visited the place in 1857, in company with Mr. E. T. Cox, on my first tour of exploration, I was shown only the shales of Mr. Casey's coal bank, and pronounced them the equivalent of those of Bell's and Casey's coal veins. Last year, having again visited the same place, with better information, I found under a heap of rubbish dug from the well, some shales of this low coal differing from those which cover Casey's and Bell's coal; they are soft, breaking irregularly, very black, marked with a few leaves of *Lepidodendron* only, and mixed with a great abundance of oval pebbles of carbonate of iron, like those mentioned in the black shales below the conglomerate elsewhere. In fact, the characters of the shales found near the mouth of the boring of Mr. Casey's well, compare exactly with those indicated in the description of the Wills and McCormick coal.

The presence of small pebbles of carbonate of iron in black shales, of which the palæontology is not distinctly marked, would, no doubt, have appeared unreliable and accidental, were it not supported by stratigraphical evidence. While I was investigating the question, in the vicinity of Bell's mine, Mr. Wheatcroft, the director of the mines, informed me that he had made many borings around Bell's vein, and had never found any coal below it, except a seven inch bed at a depth of 103 feet.\*

To place the matter beyond question, he showed me, about half a mile from the entry of Bell's mine, in a small creek running into Tradewater river, a bank of shales, with a coal at its base, exposing the lower part of the measures, crossed in his different borings. The section is:

	Feet.
Fire clay and shaly sandstone under the Bell coal, extending downwards to top of the bluff, (covered space) .....	40
Hard, coarse sandstone in bank .....	16
Black shales, with pebbles of carbonate of iron .....	40
Coal, bituminous and soft .....	½
Hard, black fire clay .....	4
Yellow, shaly fire clay .....	1
Fossiliferous limestone, in bed of creek .....	1

Comparing this section with the place of the sub-conglomeratic coal of Owsley, Montgomery, and Bath counties, the analogy of distribution is striking, and when it is confirmed by palæontological evidence, and by the same mineral distribution, one can no longer question the identity

\* No one is better acquainted with the geological strata of the country around Caseyville than this gentleman, who has been director of Bell's, Casey & Spigert's mines, and he asserts that, from topographical and stratigraphical evidence, these veins are all equivalent to the Casey coal opened above Caseyville.

of the coal, found below the Bell's and Casey's mines, with the coals of the sub-conglomeratic series.

It is true that the 16 feet sandstone above the black shales is but a thin substitute for the conglomerate; but near this western edge of the coal fields the conglomeratic appearance of the sandstone has nearly disappeared, and the thickness of the millstone grit is much reduced, and extremely variable. Opposite Caseyville, on the Illinois shore, where this millstone grit attains a good size, the distance from Dr. Long's coal, which is above the millstone grit, to the battery rock coal, acknowledged to be below it, is no more than 140 feet. In the vicinity of Mr. Wills', in Montgomery county, on the edge of the eastern coal fields, in a space of three miles, the difference in the thickness of the conglomerate is at some places, on the same line of strike, more than 100 feet.

As for the bed of limestone below the coal, it has been looked upon, by those who contradict the above opinion, as one of those thin strata of limestone which are said to occasionally run within the thickness of the millstone grit. But in that case, is the true millstone grit above or below this limestone? If below, we should have at this place the abnormal appearance of a limestone, which is not seen elsewhere. If above, we must certainly have above the limestone the sub-conglomeratic coal, equivalent to the coal 18 to 22 inches thick, resting immediately upon the limestone at McCormick's, and reduced to its true proportion by the gradual decreasing of the low coals towards the west.

A difficulty occurs in accounting for the position of a thin coal, which was seen in a boring by Mr. Sam'l Casey, 20 feet below his vein, worked near the Tradewater river, and which coal is said to be 20 inches thick. Unfortunately, when I visited the place the pit was entirely covered, and I could find around it no traces of any shales or of coal. It is possible that this coal might be a representative of our No. 1 A coal, generally placed at 25 feet below No. 1 B, and which has been developed here occasionally. If so, it would be the only place where it has been remarked in the whole extent of the western coal fields.

#### CONGLOMERATE.

Along the edge of the western coal fields, the millstone grit, a coarse sandstone, with or without pebbles, generally replaces the true conglomeratic formation. Its thickness does not appear to have been accurately measured. On the western edge, Mr. Lyon mentions it as being from

50 to 100 feet thick. The different members of the millstone grit occupy, probably, the whole space between the sub-carboniferous limestone and the lowest strata of what is generally called the base of the coal measures.

On the western edge of the eastern coal basin the formation is mostly conglomeratic. Still, often in part replaced by a coarse and ferruginous sandstone. Its thickness varies from 75 to 300 feet, attaining probably its highest point in Owsley county, where Mr. J. Lesley, jr. measures it at 300 feet, and at Rockcastle creek, where D. D. Owen found it to be 240 feet. Northward, viz. : in Greenup county, the conglomerate thins out considerably, and nearly disappears even ; as by the measurements of Mr. L. Lyon, on Tigert's creek, six miles northwest of Grayson, the distance from the top of the millstone grit to the sub-carboniferous limestone is only 30 feet. These modifications are evidently local, and cannot be considered as resulting from any general law of distribution. From Greenup county northward, in following the western edges of the eastern coal fields, after crossing the Ohio above Portsmouth, the conglomerate again thickens to 300 feet, in Hocking valley, then thins out to a few feet in Licking county, near Newark, and thus it continues in undulations to its northern terminus, where, according to the measurements of Mr. Whittlesey,\* it is from 100 to 150 feet thick.

From this, and what has been said about the unequal and local distribution of the coal below the conglomerate, it is evident that the sub-carboniferous measures were broken and much diversified in their general level by currents and other accidents, and that the super-position of the conglomerate was the true and firm basis for a uniformity of distribution, and consequently for the wide expanse of our coal fields.

Towards the eastern limits of the coal fields of America, the conglomerate attains its greatest thickness, and is generally divided in three or more members by shales, or thin strata of coal. The question, therefore, is, whether these beds of coal are not the equivalents of our western coal strata below the conglomerate, and consequently, whether the thickness of the measures contemporaneous with the deposit of the conglomerate, is not greater in the western coal fields than has been supposed. The conglomerate at Pottsville is about 1,400 feet thick ; and although it becomes thinner towards the west, it may be that the McKean coal

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\* Second Report of Geol. Survey of Ohio, by W. W. Mather, pp. 57, 58.



measures, as well as those in Kentucky, counted as sub-conglomeratic, are true conglomeratic measures, or contemporaneous to the lowest conglomerate. The only difference would be that in some parts of East Pennsylvania they are pebbly and barren, while in others they are coal bearing, and without pebbles.

From the general views of the formation of the coal, as they have been presented in our former report, we must infer that the materials composing the conglomerate were brought and rounded by the wavy movements of the sea against the shore. Such movements cannot be uniform upon a very extensive area, therefore must the materials, carried by the waves, be deposited very irregularly. Supposing these movements to have been progressive for a long period of time, as the enormous quantity of heaped materials seems to warrant, large tracts of country must have been separated from the shores, in lagoons and marshes, and covered with the growth of the coal vegetation. Thus, while the sand and pebbles were heaped around them, they have formed isolated coal banks of various dimensions. A more general depression brought over the whole formation the upper and true conglomerate, generally extended over the whole coal fields of North America. In this case, the so-called sub-conglomeratic coal banks, either covered by sandstone or intercalated in the sub-carboniferous limestone, belong, with the limestone itself, to the true conglomeratic period.

These considerations are not without practical interest; they tend to demonstrate the fallacy of limiting the coal-bearing strata to the last conglomeratic formations, and of supposing that the appearance of coal below it, being something abnormal and a local phenomenon, without direct connection with the true carboniferous epoch, it would be useless to search for coal below its series. Although the prospect for good workable coal beds below the conglomerate, or within this formation, cannot be as promising as above it, researches for coal as far down as the knob sandstone, may be rewarded with satisfactory results in all the counties bordering the coal basin of Eastern Kentucky.

#### DISTRIBUTION OF THE COAL STRATA BETWEEN THE CONGLOMERATE AND THE MAHONING SANDSTONE.

It is very difficult to exhibit satisfactorily the distribution of the coal beds in this great division of the coal measures. The veins of coal which it contains, are all more or less subject to modifications, which alter their

appearance, even at short distances. They thicken or thin out; some separate or multiply; others, which are generally found separated by sandstone, limestone, or shales of various thickness, join and become united in a single bed of coal. Modifications of this nature occur in the whole extent of the coal measures, but nowhere are they more frequent and more marked than between the conglomerate and the Mahoning sandstone.

In the western coal basin of Kentucky, the first coal above the conglomerate is the same as the one designated No. 1 B, in the 3d volume of the report of the State Geological Survey. In the eastern coal fields, No. 1 A, with its characters and subdivisions, is generally present. Here we also find a third bed, properly, perhaps, a subdivision of No. 1 B, but distinct enough in Kentucky to be separately characterized. As we cannot change the nomenclature adopted in a former report, I shall have to number the coals as follows, omitting two thin streaks which sometimes appear in Ohio, but have not been seen in Kentucky :

*Coal 1 A.* Scarcely present in the western coal basin of Kentucky; generally developed in the eastern coal fields; and sometimes divided into two members.

*Coal 1 B.* The most reliable and most extensively developed, as well as the most variable of all the coal strata. Extensively worked in both basins of Kentucky, where it is generally the depository of cannel coal.

*Coal 1 C.* Might be called the coal below the limestone; generally a thin coal of no great value; placed at a short distance from the former, with which it often unites. It is for this reason, probably, that it was not mentioned in the reports of Ohio and Pennsylvania, and is likewise unnoticed by Mr. Lesley.

*Coal 2.* Scarcely known in the western coal fields of Kentucky; generally present in the eastern coal basin; bed of medium thickness, increasing considerably towards the southeast.

*Coal 3 A.* Good, reliable coal; often cannel, (like every bed of coal formed in connection with, or overlaid by a limestone,) of workable thickness, as well in the western as in the eastern basin.

*Coal 4.* Equivalent of the Pomeroy coal; placed at the base of the Mahoning or second conglomeratic sandstone, which forms the terminating mass upwards of this division.

The above subdivision may appear arbitrary, if considered in a mathematical point of view. Topography often takes into account outcrops of coal, without much regard to the peculiar arrangement of the coal strata; but in a general, correct, stratigraphical, and palæontological examination of the distribution of the coal strata, this method is not admissible. Some beds of coal, like our No. 1 B, for instance, exposed at one point as a single stratum, may be seen at a short distance, even on the same hill, to divide in two, three, or four beds of coal, separated by shales or sandstone of variable thickness. In a palæontological point of view, I could not but refer those accidental divisions to the parent bed, and regard them as in reality one bed of coal. Often as such cases have come under my consideration, I have reported them as mere subdivisions of one bed, noting the peculiarities of each member.

#### COAL 1 A. PALÆONTOLOGY, STRATIGRAPHY, AND DISTRIBUTION.

This vein, often divided into two members, presents itself with two different characters. Sometimes it is encased in a great bank (2 to 10 feet thick) of black, rusted shales, splitting parallel to the line of stratification, in large, thin laminæ. These are often barren of fossil plants; yet by close examination, I have never failed to find, in the interlaminated surface of the shales, cones of *Lepidodendron*,\* and the *Lingula umbonata*; the only remains, with a few leaves of *Lepidodendron*, which these shales appear to contain. It is evident from this that the palæontology of coal 1 A is nearly related, if not quite identical, with that of the upper bed of coal, mentioned under the conglomerate. The only difference, indeed, appears in the scarcity of fossil remains in the shales of coal 1 A, and in the presence of *Lingula umbonata* in greater abundance. Independent of palæontology, there are some characters of the shales which help to the identification of coal 1 A: 1st. Their black, dull, rusty color. 2d. Their manner of splitting in large thin, regular slabs. 3d. The absence of small oval pebbles of carbonate of iron. It sometimes happens that the whole space separating this coal from the next above it, is occupied by black shales. In this case, when the distance is great, I have found in the slates, besides *Lingula umbonata*,† other species of fossil shells, especially a small *Leptaena*, and a fine new species of fern, and *Pecopteris velutina*, published

\* Third volume of the Report of the Geological State Survey of Kentucky, pl. 7, fig. 3.

† Third vol. of the Report of Geol. State Survey of Ky, pl. 10, fig. 4.

in the report of the Pennsylvania State Survey.\* But these species do not appear as true characteristics of this coal, being only accidentally present. Nevertheless, I found the same species of shells at Yellow creek, Ohio, and at Johnstown, Pennsylvania, distributed in the same manner, and under the same geological circumstances.

The second division of this coal is far different from the former, in its palæontology and distinctive characters. The coal is generally covered by a coarse sandstone of variable thickness, containing numerous prints of a great many plants of the largest species. The genus *Lepidodendron* furnishes one half of these prints, after which *Sigillaria* (especially *Si. Brardii*) gives the greatest number, and then the *Calamites*. This sandstone is everywhere remarkable for the abundance of its fossil remains. It contains the great *Megalodendron* and *Megaphitum*, large trunks of trees completely transformed into sandstone; even a whole forest of calamites (mostly *C. Suckowii*) and *Sigillaria* is found at Carbondale, Pennsylvania, imbedded, and standing, in its coarse material.

The coal under this sandstone generally overlies a bed of brashy or slaty coal, splitting in thin laminæ, and bearing numerous prints of crushed plants of the same species as those enumerated above, with leaves of *Neuropteris hirsuta*.†

This vein of coal, in its two divisions, thins out and disappears westward. Even in the Eastern Kentucky basin it is never very thick. Its average is no more than two feet, and, except where it comes in contact with 1 B, it is never thicker than three feet. The coal is generally good, but under the black shales especially, it contains much sulphuret, and is somewhat caking.

Its two divisions, as indicated by the palæontological characters, are hardly ever developed together, the difference being rather local; but when they are so formed, the coal covered with sandstone is the upper division, and is separated from the lower by the black shales.

The modifications of this coal are well defined, and can be easily studied in Morgan and in Breathitt counties. On the head waters of Gladly creek, branch of Red river, Morgan county, it makes its first appearance, and is worked 20 inches thick at the old Latham bank. It is there covered by one foot of black shales, with *Lingula*, and has above

\* Vol. 2, p. 866, pl. 12, fig. 3.

† Report of the Geol. State Survey of Ky., vol. 3, pl. 6, fig. 4

this a shaly sandstone, with iron ore. Its distance above the conglomerate is here about 50 feet.

At Jackson, Breathitt county, near the mines of Messrs. Jerry South & Son, this coal is seen about 8 inches thick, 20 feet below the main coal 1 B.

The following section is taken a few miles south of Jackson, near the mouth of Lick branch of Quicksand:

	Feet.	Inches
1. Gray micaceous shale, (gray metal,) and sandstone, space covered .....	20	
2. Bituminous coal .....	1	2
3. Black rusty shales, with <i>Lepidodendron</i> stems, and <i>Lingula</i> .....	9	
4. Coal, bituminous, tending to cannel .....	1	2
5. Black, hard, fire clay .....	2	4

Further up on the same creek, it has at the base 20 inches of coal, separated from a 6 inch bed above it by 4 feet 5 inches of black shales, with the same fossils.

The same vein near by, within 100 yards of Mr. Sam'l Back's house, on Quicksand creek, is not divided, and is 18 inches thick, covered by one foot of the black shales, with *Lingula* and *Lepidostrobi*. At this latter place the coal lies 25 feet lower than coal 1 B.

Divisions like those exemplified in these sections, are of less frequent occurrence in this coal than the change of its characters, viz.: the disappearance of the shales, to be replaced by sandstone, or *vice versa*. One and a half mile above the mouth of Barge fork of Troublesome river, Breathitt county, this bed has been worked under sandstone, and is 18 inches thick, bituminous, and somewhat shaly. Beyond the hill, on Tobacco branch of Charley's fork, the same vein is also 18 inches, but it is covered by 6 feet of rusty, black shales. At both places it has a clay parting. This bank can be traced across the hill by following its outcrop. Again, the same coal exposed above the mouth of South fork of Quicksand, is 16 inches thick, without clay parting, and is covered by 10 feet of its black shales, containing the characteristic fossils.

In Owsley county, No. 1 A coal is well exposed; along Jett's and Meadow creeks, one foot thick, covered by 10 to 14 feet of black shales, and in Morgan county, it crops out along Caney creek, near Judge Liken's house, where it is covered by its sandstone, and two miles below, where it has two feet of coal, overlaid by 8 feet of black shales, always with the same fossils.

In Greenup county, No. 1 A coal is rather covered with sandstone than shales. At Mr. Sam'l Bradshaw's, on Indian creek, it is three feet thick, including an eight inch clay parting, and is overlaid by black shales, while near Steam furnace, and at Caroline and Amanda furnace, etc., it is mostly overlaid by sandstone. In this county, the distance between No. 1 A and No. 1 B varies generally from 20 to 30 feet. In Johnson, Floyd, and Lawrence counties, the vein thickens somewhat, and the distance from No. 1 B becomes greater. At Paintsville, Johnson county, it is 60 feet, and the coal is here two to three feet thick, immediately overlaid by sandstone. In the thickest part of the coal measures at Warfield, on Tug river, Lawrence county, the coal worked is No. 1 A, and the distance to 1 B is about 70 feet. In Ohio and Pennsylvania there is no great difference in the distance between No. 1 A and No. 1 B. In Licking county, Ohio, near Flint ridge, it is only 40 feet. At Salineville, it is reduced to 35 feet. At Yellow creek the vein is divided in two members, separated by 20 feet of black shales, and its upper member is only at a distance of 20 feet from No. 1 B. At Johnstown, Penna., 60 feet of black shales, containing in abundance the fossils belonging to this coal, separate it from No. 1 B. And at Archibald, in the anthracite region of the same State, near the east edge of the coal measures, a section which I owe to Mr. Ed. Johns, the director of the coal mines, marks its place at 25 feet from the coal there worked, which, according to its character, is our No. 1 B.

This apparently shows a great uniformity in the general extension of this coal. Yet in the examination of No. 1 B, we will see No. 1 A coming sometimes in close proximity, or even uniting with it.

#### COAL 1 B. PALEONTOLOGY.

More than one hundred species of fossil plants, of the coal measures of America, have been found in connection with this vein of coal. Its flora is thus much varied. It nevertheless has a peculiar aspect, which cannot but be easily recognized, when its examination is made with any care.

The top shales of this vein of coal present two different characters; they are either grayish, somewhat micaceous and ferruginous, of fine texture, perfectly well adapted to the preservation of the prints of fossil plants, or else black, soft, also somewhat micaceous, very hard, bituminous, and nearly without fossils. In the first case, the vein below the

shales is a bituminous coal; in the second it is mostly cannel. It is well to remark here that plants have been but indifferently preserved in the bituminous shales of the beds of cannel coal, (except accidentally in sulphuret of iron,) having probably been destroyed by the action of marine water. On the contrary, the marine shells are generally abundant. It is also well to observe, that sometimes the shales are not present above the coal, and then the coal is covered by laminated sandstone, or *gray metal*.

The only species of shells found in the black shales of coal 1 B is *Lingula umbonata*, but in such abundance that it sometimes entirely covers the shales. Besides this, the bituminous black shales have generally preserved the leaves and cones of *Lepidodendron*, and leaves of *Flabellaria Borassifolia*. (Pl. 3, fig. 2.) In this respect, the resemblance to the black slates of No. 1 A and No. 1 B is striking, and the identification would be difficult but for the great abundance of *Stigmaria* which the black slates of No. 1 B contain, and which are not found in those of No. 1 A. Indeed, the *Stigmaria ficoides*\* appears to have been the plant living especially on the marshes of the coal, while they were covered with water, and to have been an essential constituent of the cannel coal.

The plants which, by their presence in the gray shales of this vein, are characteristic of its geological position, may be presented in three divisions. The first embraces the species common to this and other veins of coal, and which become characteristic only by the great number of their specimens; the second are the species truly, or, at least, apparently peculiar to the vein, which have not been found elsewhere, but are too scarce to be remarked as true characteristics; the third, the few species appertaining to this coal only, and which are distributed in great abundance over the whole area of the coal basin, and consequently are true characteristics of this coal.

Among those of the first class, the most abundant, is certainly the *Lepidodendron*.† Fifteen species, at least, of this genus have been found in the shales of No. 1 B; of this number, more than one half belongs to it exclusively, a few of the more common species only ascending higher in the measures. The genus *Sigillaria* is also abundantly

\* Vol. III of this Report, pl. VII, fig. 2.

† American species of this genus have been described and figured in the final Geological Report of the State Survey of Pennsylvania, vol. II, pages 673 to 675, plates XV and XVI.

represented by twelve species, some of which, *Sigillaria corrugata*, Lsqx.; (pl. 4, fig. 6;) *Sigillaria stellata*, Lsqx.; *S. Serlii*, Brgt.; *S. tessellata*, Brgt.; *S. Alverlaris*, Brgt.; *S. elongata*, Brgt.; *S. attenuata*, Lsqx.; *S. catenulata*, Brgt.; and especially *S. discoidea*, Brgt., do not appear to ascend any higher in the measures.\* *Calamites* are also well represented in a number of species, yet without predominance. Then come some of the largest ferns of the coal: *Neuropteris hirsuta*, Brgt.; in the greatest abundance, sometimes apparently filling, by the superposition of its leaflets, the entire thickness of the shales; *Sphenopteris latifolia*, Brgt., which ascends higher; *Hymenophyllites Hildreti*, Lsqx., (pl. 2, fig. 5,) found also in the shales of No. 3; *Alethopteris nervosa*, Brgt.; and *Al. Serlii*, Gopp, (pl. 1, fig. 3,) of which the range of distribution extends out of this vein.

In the second class the most prominent of the species are all the species of *Odontopteris*, except *O. Schlothimii*, Brgt.; which, perhaps, ascends higher; *Cyclopteris flabellata*, Brgt.; *Whittleseyia elegans*, Newb.; *Nepheopteris orbicularis*, Brgt.; *Neuropteris Clarksoni*, Lsqx.; *N. rarinervis*, Bunb.; *N. vermiculata*, Lsqx.; (pl. 2, fig. 7;) *Sphenopteris glandulosa*, Lsqx.; *Sp. Newberii*, Lsqx.; *Sp. Lescurii*, Newb.; *Sp. squamosa*, Lsqx.; *Hymenophyllites furcatus*, Brgt.; *Hymenophyllites artemisiæfolia*, Brgt.; (fig. 2, pl. 6;) *Callipteris Sullivantii*, Lsqx.; *Pecopteris Sillimannii*, Brgt.,† and a new *Alethopteris Coxiana*, Lsqx.; (pl. 1, fig. 2.)

The third class contains fruits of different sizes, from the smallest grain, no larger than millet seeds, to nuttlets as large, and still larger, than almonds. These fruits generally abound in coal No. 1 B, and are found in nearly every one of its outcrops; in Union mines, of Livingston county, in Bell's, Hawesville, and Breckinridge mines of the western basin, as well as in all the localities where coal 1 B is seen in the eastern coal fields. What these fruits are, (two species are figured in vol. 3 of the Report, pl. 7, fig. 8 and 9, and another very remarkable, pl. 2, fig. 4,) to what species, or eventowh at genus of plants they belong, is still an unsolved problem of the coal vegetation. Some small seeds, inclosed in large cones, have been recently ascertained to be the fruits of *Sigillaria*; a few of the nuttlets of the coal are perhaps the fruits of *Flabellaria*;

\* Ibid, vol. II, pages 871 to 873, plates XIII and XIV.

† Ibid, description of fossil plants of the coal measures of Pennsylvania, vol. 2, pages 847 to 878, with plates.



but this species, although very abundant in the No. 1 B coal, is also found in other veins above this, especially in the Pomeroy coal, yet the fruits are entirely wanting.\* The number of these fruits is without proportion to the number of species to which they could belong. This shows that the vegetation of the coal is far from being known, and that it contained some genera, of which the remains, leaves, or stems, have been destroyed, or are not preserved in the shales. Some of these fruits of large size are inclosed in a kind of leathery pericarp, or husk, enlarging at the top like a three-cornered funnel, and appear to belong to some species of palm. But, except *Flabellaria*, there is no leaf in the coal which could be related to this family of plants. Some others, generally found flattened, have a heart-shaped form, and grew around the stems of *Asterophyllites* or branches of *Calamites* as tubercles, or perhaps true seed.

The second true characteristic species of No. 1 B, found everywhere in its shales, and never till now found out of it, is *Alethopteris Lonchitica*, Brgt., (Rep. 3, pl. 6, fig. 3,) a fern which bears a great likeness to our common brake. (*Pteris aquilina* L.) Besides these, I may mention as less frequent, however, *Lycopodites carifolius*, Lsqx., (pl. 4, fig. 5,) found in Union mines, Livingston county, and at the mouth of Horse branch, one half mile below Catlettsburg, Greenup county, at both the farthest ends of the Kentucky coal fields, and *Neuropteris vermiculata*, Lsqx., (pl. 2, fig. 9,) with distant, sharply marked, though fine veinlets, especially common in Eastern Kentucky, and *Hymenophyllites artemisiæfolia*, Brgt., (pl. 2, fig. 6.)

Resuming the paleontology of the No. 1 B coal in its essential characters, we find, first, that it contains everywhere in its shales the greatest number of fossil plants; second, that its remains belong to the largest species of trees and ferns; third, that it is the depository of the fruits, and some *Alethopteris* and *Hymenophyllites* not found elsewhere. It may also be remarked, that it is deficient in the species of the true *Pecopteris*, or has but few of them.

#### COAL 1 B. STRATIGRAPHY AND GENERAL DISTRIBUTION.

This vein is apparently extended without interruption, except accidental ones, over the whole coal fields of the United States. It is the

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\* I have recently examined, in Arkansas, thick black shales of sub-conglomeratic coal, entirely covered with leaves of this species, without any remains of fruits of any kind.

most reliable of all the coal strata, as it is usually the one of the greatest thickness. In the western coal fields it is generally undivided, and is the first above the conglomerate. In the eastern coal basin it begins to show its subdivisions, its variability of forms, its increasing size. It is in both the great depository of cannel coal. In the western coal basin it has generally a clay parting from one to six inches thick, and in the eastern, two or three which thicken, disappear, or change their nature, in the most unaccountable manner. Its average thickness in Kentucky is four to six feet. Taking under consideration the whole extent of the coal fields of America, we find this thickness varying from 6 inches to 20 feet, accidentally to 40 feet. This coal is nearly always found in close connection with No. 1 C coal, the next bed above it. Thus it can sometimes be said to be in three members, each one having its peculiar characters. The upper one is covered by sandstone, (rarely by limestone,) and has the fossil plants at its base, viz.: in the top shales of the middle coal. This middle member is generally covered by the gray shales, with the plants heretofore enumerated. The lower member is overlaid by a coarse sandstone, with plants, but sometimes there is no sandstone, and the plants characteristic of No. 1 A are found in a brashy coal at its bottom.

In the western coal basin of Kentucky it has everywhere preserved its normal appearance. The shales above are sometimes absent, but, as is the case at Bell's mine, they appear in some part of the mines, and, in their absence, the sandstone forming the top of the coal is full of remains of *Stigmaria*. At Caseyville, Hawesville, and Breckinridge, it has only the black shales, formed under marine influence, with an abundance of *Lingula*, and scarcely any plants but *Lepidodendron*; but at Union mines, Livingston county, as also in the vein opened by Dr. Long, opposite Caseyville, it has both kinds of shales in close proximity; the black shales, with the *Lingula*, and the gray ones, full of fruits and plants. Along the northern edges of the same basin this coal appears to be lost, or, at least, if it is anywhere below the coal which crops out along the margin, it has not yet been discovered.

In the eastern coal fields of Kentucky, especially in Greenup, Breathitt, and Morgan counties, the changes to which this coal is subject may sometimes be traced on the same exposure of rocks, and distinctly show

its extension. On a branch of Stillwater, five miles from Hazlegreen, Morgan county, the coal is exposed along the creek as follows:

	Feet.	Inches.
Top sandstone.....	4	-----
Gray shales, with the lower part soft, full of beautiful specimens of plants.....	4	-----
Coal, with four inch clay parting.....	1	2
Fire clay.....	4	-----

At a short distance the same coal is just below the sandstone, and the shales at its base bear the plants of the gray shales, covering the coal of the former section. It is not that the coal has changed places, but that here the feather edges of two divisions of coal 1 B draw near each other, viz: the one just below the sandstone, and the lower one below the shales. The three divisions are seen together three miles above Jackson, Breathitt county, on the Kentucky river, on the property of Mr. Thos. Sewell, where the section is as follows:

	Feet.	Inches.
Hard sandstone.....	6	-----
Bituminous coal.....	1	10
Fine clay, with Stigmaria.....	1	9
Bituminous coal.....		6
Black brittle shales, with the plants.....	1	7
Bituminous coal.....		7

On main left fork of Cane creek the coal is exposed in the following manner:

	Feet.	Inches.
Compact sandstone.....	10	-----
Bituminous coal.....	2	-----
Clay parting.....	1	6
Bituminous coal.....		6
Fire clay.....	1	6
Gray metal and shaly sandstone.....	8	-----

And near by, up the same branch of the same creek, it is:

	Feet.	Inches.
Hard sandstone.....	6	-----
Gray soft shales, with plants.....	20	-----
Bituminous coal.....	1	-----

At Clinton furnace, in Greenup county, this coal is 16 inches thick, covered either by the sandstone or by an eight inch bed of carbonate of iron, and at a short distance up the ravine it takes the following form :

	Feet.	Inches.
Sandstone and shales .....	10	-----
Bituminous coal.....	1	-----
Shale parting, with plants .....	1	-----
Cannel coal .....	1	-----

It is generally the lowest division of this coal which is changed into cannel coal, while the upper member, separated by shales, or shale parting, preserves its bituminous composition. Near Mordecai creek, in Morgan county, two sections of the same coal, on the property of J. Schoolfield, show this difference :

	Feet.	Inches.
Shaly sandstone, hardening at the upper part.....	6	-----
Brashy coal, or shales with Stigmaria .....		10
Cannel coal.....	3	-----

And on the other side of the hill :

	Feet.	Inches.
Hard sandstone shales .....	6	-----
Bituminous coal.....		4
Black shales, with Stigmaria .....	2	-----
Cannel coal.....	3	-----

Near Chinch creek, two miles south of the old Fulton forge, in Greenup county, on the land of the Maysville Oil Company, the cannel coal is found in the upper bed :

	Feet.	Inches.
Dark shales, full of Stigmaria.....	1	-----
Cannel coal, in block .....	4	4
Shales, with plants.....		10
Bituminous coal.....		3

And at the mines of the Ashland Oil Company, near Greenup furnace, the cannel coal is between two strata of bituminous coal :

	Feet.	Inches.
Shaly sandstone, space covered.....	15	
Bituminous coal.....	1	
Clay parting.....		4
Bituminous coal.....		4
Soft clay parting.....		4
Bastard cannel coal.....		10
Hard block cannel coal.....	3	6
Fire clay.....		6
Bituminous coal.....	1	
Sandy or shaly fire clay.....	2	

In its union with the limestone coal, or coal No. 1 C, along the railroad from Ashland to Grayson, same county, our coal No. 1 B presents some other modifications. In the cut behind the bridge of Williams creek, one mile south of the tunnel, it has :

	Feet.	Inches.
Shaly sandstone.....	6	
Lime-stone ore.....		2
Shaly coal, full of stems, with oxide of iron (C. 1 C).....	2	
Fire clay.....	4	
Soft shales, with plants.....	4	
Bituminous coal (C. 1 B).....	1	
Clay parting (C. 1 B).....		6
Cannel coal (C. 1 B).....		4
Fire clay to the road.....		

Three miles from Kilgore's, up Williams creek, the section is as follows :

	Feet.	Inches.
Black shales, with <i>Lingula</i> and other shells.....	15	
Bituminous coal.....		6
Soft fire clay.....	1	6
Bastard or shaly cannel coal.....	1	

On Louisa river, six miles below Louisa, and nearly opposite Gavet's mines, our No. 1 B is distributed thus :

	Feet.	Inches.
Base of covered sandstone, 50 feet above low water :		
Shales and gray metal .....	5	
Bituminous coal.....	1	6
Cannel coal, without parting .....		6
Clay parting .....		6
Bituminous coal.....		2
Fire clay and shales .....		
Gray coarse shales .....		
Bituminous coal.....		
Hard laminated fire clay.....		
Gray micaceous sandstone, with broken plants .....	1	
Soft gray shales .....	2	
Shaly cannel coal .....		9
Black shales and <i>Lepidodendron</i> .....		6
Bituminous coal.....	1	
Gray soft shales, with plants of coal 1 B .....	4	

In this case both 1 A and 1 B are united probably with coal No. 1 C, and we have thus more than 30 feet of measures occupied by four divisions of this coal and its shales.

At Peach Orchard, on Louisa river, and in the same county, No. 1 A and 1 B, in connection with No. 1 C above them, occupy 100 feet of measures, with five veins of coal from one to two feet in thickness; and at Paintsville, Johnson county, the main coal 1 B, worked at Mr. J. Wheeler's, is four feet thick, with a four inch clay parting, and is covered by its soft gray shales, full of the characteristic plants, while behind the same hill it is divided in three members, each separated by 10 feet of shales and sandstone.

If we continue to follow this coal in its geological distribution eastward, out of Kentucky, we find it gradually becoming thicker, and taking its greatest development in the anthracite basins of Pennsylvania, beyond the Allegheny mountains, where, by its divisions, and the thickness of its different members, it becomes truly a "*mammoth vein*," or, as it is generally termed there, the *big vein*.

At Nelsonville, Ohio, the greatest coal mining district of the Hocking valley, coals 1 A, 1 B, and 1 C, are superposed in the following order :

	Feet.	Inches.
Sandstone and shales.....	70	
No. 1 C. Bituminous coal .....	4	
Black shales .....	20	
No. 1 B. Bituminous coal .....	1	10
Cannel coal.....	1	8
Bituminous coal.....		6
Shales, with abundance of fruits .....	12	
Bituminous coal.....	6	
Fire clay and shales below.....	27	
No. 1 A. Bituminous coal .....	2	6
Sandstone .....		

The 12 feet black shales, separating the upper member of No. 1 B from the lower, is in some places reduced to a one foot, or even six inches, shale parting. The characters of No. 1 C and No. 1 A are well marked in each of these coals.

At Zanesville, Ohio, coal 1 B is said to be six feet thick, mostly cannel, in the bed of the river. I have only seen its top shales, and thus ascertained its identity. At Salineville, Ohio, it is seven feet, mostly bituminous, and with a clay parting. At Wilkesbarre, Pennsylvania, it forms the *big vein*, varying from 7 to 20 feet. At Carbondale it has 12 feet of coal, divided into five sections by four clay partings. The true member, viz: the one covered by shales, containing the characteristic plants, is six feet thick.

The celebrated bed of summit Lehigh, measuring in its whole thickness about 50 feet of strata, of which nearly 30 feet is coal, and the balance, a number of slates and clay partings, is also referable, by its plants, to our No. 1 B, connected with both 1 A and 1 C; all these coals divided and considerably thickened by a geological phenomenon. Its medial part, covered with the shales and plants of this coal, is six feet thick.\*

It would be easy to give a greater number of sections, but these will suffice to show the remarkable distribution of this vein of coal; the other variations worth mentioning in Kentucky will be reported in the enumeration of the coal beds of each county.

#### COAL NO. 1 C. PALEONTOLOGY AND GENERAL DISTRIBUTION.

If this bed of coal had not some palæontological characters entirely at variance with those of the former, it would be better, perhaps, to take it in connection with them.

In its separate form, it generally appears covered with a kind of ochreous, laminated, and rolled clay, breaking into small irregular pieces, like pieces of decayed wood. It is rarely covered with shales, but when they are present, they appear as if formed by a superposition of stems, especially stems of ferns of undeterminable species. This shale has above it either a bed of sandstone, limestone, or limestone ore. In this

\* To prevent a new accusation of plagiarism, I may mention that all the sections, given without reference, were made by myself, and that for every one of them I ascertained, by palæontological evidence, the place of the coals reported. For the purpose of comparing the palæontological characters of the coal strata, I spent, in 1857, a few months in explorations through Ohio and Pennsylvania, re-visiting again most of the localities which I had explored as assistant in the Geological Survey of Pennsylvania. These explorations were made at my own expense, and cannot be claimed as the property of the Director of the Geological Survey of Pennsylvania.

latter case, the ochreous clay, which covers it, is, like the limestone, abundantly fossiliferous. But when the limestone is not formed, the yellow clay shales of the roof bear no traces of fossils of any kind. The coal of this vein has a peculiar appearance, which may help to identify it: It looks, as the shales, like a compound of broken stems, of which the forms are obscurely preserved by charcoal, or sulphuret or oxide of iron. This coal is, therefore, of inferior quality, yet it is worked sometimes, and proves a good coal for blacksmiths. Its thickness varies from one to three feet, and rarely attains four feet.

This vein is called limestone coal, because of its position below a limestone, or limestone ore, of variable thickness and inconsistent distribution. It would, perhaps, be better to say that this coal occupies the place of a bed of limestone; for, generally speaking, when the limestone is fully developed, the coal is scarcely formed. Its distance from No. 1 B is from one to fifty feet.

There is nothing in the western coal basin of Kentucky which, within the present range of my observations, could be referred to this vein, except, perhaps, the vein mentioned as having been found about 60 feet above Bell's coal, in Crittenden county, and the top bed of coal at Hawesville. (The former of these veins has not as yet been examined.) Our No. 1 C was not crossed in Holloway boring, where its place is filled by black shales; at Greenville it is apparently replaced by limestone.

In the eastern coal fields this coal is not often developed, but its place is marked by large boulders of septaria, or yellow ferruginous limestone, seen at from 10 to 45 feet above coal 1 B. On Quicksand creek, near Jackson, Breathitt county, the cannel coal, at Mr. J. Roark's, is overlaid at 15 feet distance by a bed of black, polished, very bituminous shales, filled with stems and *Stigmara*, which probably indicate its place.

Eight miles above the mouth of Blackwater creek, in Morgan county, on the property of Mrs. Dennis, the limestone is formed, but the coal is not present, or is connected with No. 1 B; the section is as follows:



	Feet.	Inches.
Shaly sandstone .....	20	
Limestone in layer .....		2
Micaceous shales .....		4
Hard sandstone, resembling whetstone .....		6
Gray micaceous soft shales .....		2
Bituminous coal .....	1	3
Gray soft shale parting, with plants of No. 1 B .....		3
Bituminous coal .....		4
Brashy coal, with plants .....		2
Bituminous coal .....		2
Fire clay and covered space .....	2	

In Greenup county this coal takes a distinct position, with its proper characters, and it is in this same county that we see the first appearance of the buhrstone, a peculiar formation, largely developed along Flint ridge, and some localities of Ohio, above this coal. This buhrstone is, in Greenup county, a compound of large pieces of blue and greenish flint, mixed with charcoal, or woody fibres, hardened by sulphuret and oxide of iron. It is often covered by large, apparently multiple layers of bark of *Sigillaria*, badly preserved, and transformed into flint. This kind of stone is seen along the railroad from Ashland to Mr. Welsh's store, at the foot of the Stinson hills, overlaying either No. 1 C, or the limestone above it; it generally breaks in great regular cuboidal pieces.

Near the Buena Vista furnace, coal No. 1 C is 20 feet above cannel coal 1 B, and just below the limestone ore. At Greenup mines, on the land of the Kentucky Coal Oil Company, of Ashland, the same coal is also 20 feet above the main cannel, and is here two feet thick, rusty, and full of stems. The rusty color of this coal appears to be general. In this last locality it has no limestone above it; but around Buena Vista furnace both limestone and ore are sometimes found with it, in which case the coal is very thin. This vein attains its greatest thickness on Brush creek, on the land of the Buena Vista furnace, where, under the guidance of Mr. John Means, the proprietor, I saw it in three places, from three to four and a half feet thick, below the ochreous shales heretofore described. As in the other openings examined, the coal is here also a compound of rusty stems transformed into charcoal, with abundance of sulphuret and oxide of iron.

To the southwest, its geological horizon is marked at Mt. Savage furnace, Carter county, by a bank of black, very bituminous, shales, below limestone ore; and in the same county, at Mr. Jas. Graham's, on Blane

river, a vein of coal two feet thick, referable to 1 B, is overlaid, at about 40 feet distance, by a kind of flinty iron ore. But farther south and westward, every trace of limestone disappears, and the coal loses its characteristics, preserving, however, its place, and being then covered by a sandstone. At Warfield, Lawrence county, judging from palæontological evidence, a bed of coal three feet thick, and one hundred and seventy (170) feet above No. 1 A, is its equivalent. At Paintsville, Johnson county, it is marked by two thin coals, six and eight inches thick, separated by 10 feet of shales, and placed at 40 feet distance from No. 1 B.

Towards the northwest, in Ohio and Pennsylvania, this coal is apparently parted, sometimes by the buhrstone, into two thin beds, one in the middle of this flint formation, and the other between it and the limestone, while the normal branch below the limestone unites with No. 1 B. At Flint ridge, Licking county, Ohio, this branch is only a bed of black slate, charged with so much bitumen that it is used with the coal in the oil manufactories of Newark. The shale mentioned at Mt. Savage possesses the same property; it burns without consuming; containing a great proportion of oil.

I give below, on account of its general interest, the whole section of Flint ridge, made with the assistance of the director of the coal oil factory at Newark, Dr. H. I. Salisbury, with whom I lately visited the mines:

	Inches.	Feet.
Translucent white flint and buhrstone .....		8
Bituminous coal at the base .....	3	
Fire clay .....		2
Sandstone .....		50
Carbonate of iron, with thin coal .....	6	
Black shales .....		25
Blue hard limestone, with soft ochreous fossiliferous clay below .....		6
C. 1 C. Rich oil-producing cannel slates .....		1
Fire clay and shales .....		4
C. 1 B. Cannel coal .....	2	4
Black shales, with <i>Flabellaria</i> , <i>Lingula</i> , &c. ....	9	
Cannel coal .....	9	
Fire clay and shales .....		2
Sandstone, with large <i>Lepidodendron</i> , &c. ....		31
C. 1 A. Bituminous coal .....	6	2
Black shales .....		20
Block iron ore .....	8	
Sandstone shales .....		20
Bituminous coal .....	6	1
Conglomerate at base of the hills.		

The block ore here occupies the same geological level as in Greenup county, Kentucky.

At Yellow creek, on the limits of Ohio and Pennsylvania, our No. 1 C coal is the *Rogers* vein, perfectly well characterized by its shales, which are but a compound of stems, and by the nature of its coal. It is three feet thick, separated from No. 1 B by fifty feet of shales, mixed with iron ore. Further west it probably disappears, or is united to 1 B in the formation of a member of the *big vein*.

#### COAL 2. PALÆONTOLOGY, STRATIGRAPHY, AND GENERAL DISTRIBUTION

The flora of this coal has no peculiar species of its own, as yet discovered—indeed, nothing remarkable, except, perhaps, a greater abundance of specimens of different species of *Calamites*, and of the *Neuropteris hirsuta*, Brgt., and *N. flexuosa*, Brgt., described and figured in the third volume of the Report, plate 6, figures 2 and 4. It also occasionally contains some *Lepidodendron* and their leaves. As the two above-mentioned *Neuropteris* are generally found in all the strata of the coal measures, at least between the conglomerate and the Anvil Rock Sandstone, this flora would, apparently, not warrant a separation of coal 2 from No. 1 B coal. There is, nevertheless, an appreciable difference, first, in the general distribution of the flora, and, secondly, in the nature and position of the stratum of shales bearing plants. Coal No. 2 is ordinarily divided by a clay parting of about six inches, (sometimes thicker,) which contains the plants. As the shales of the parting (of light gray color) are generally soft, brittle, exfoliating easily, sometimes like a brash coal, the plants are mostly found in a bad state of preservation, and can scarcely be satisfactorily examined. The number of species is thus apparently limited: *Asterophyllites*, plate IV, figure 1, and the above named species, forming the essential part of the flora. In a single case, viz: at Ironton, I have seen this parting shale becoming black and bituminous, and containing some leaves of *Lepidodendron*. Generally speaking, therefore, the palæontological characters of this vein may be indicated by the absence of *Lingula umbonata*; of remains of large trees, *Sigillaria* and *Lepidodendron*, and of well preserved specimens of ferns.

The roof shales of coal No. 2 offer another reliable character in their total absence of palæontological remains; they are coarse and micaceous; sometimes passing into black shaly sandstone, splitting irregularly across

the plane of stratification, and crumbling in small pieces under prolonged atmospheric influence. They contain no traces of fossils of any kind, neither vegetable nor animal. The coal itself has a peculiar aspect. In the mines it is very black, of good appearance; but when exposed to atmospheric influence it becomes whitish, by efflorescence of sulphate of iron. In its horizontal sections charcoal also appears in greater proportion than in No. 1 B coal. Nevertheless, in some localities, this coal is of good quality, and much used for the forge, as it has a disposition to cake. The fire clay below the coal is soft, white, and suitable for pottery and fire brick.

The division of this coal into two members is not always well defined, and shows some occasional differences, which may lead to errors. It is proper, also, to mention some of these variations of distribution. At Ironton, Ohio, on the property of Colonel El. Nigh, the apparently true shale parting of this vein is three inches thick; but there is above the coal another small vein, separated by a four feet sandstone, which presents a division much resembling some of the partings of coal No. 1 B. In this case the likeness is rendered still more striking by the appearance in the cannel coal, or rather shaly cannel, of leaves of *Lepidodendron*. It looks as if No. 1 B had ascended to No. 2, and was only separated from it by four feet of sandstone. The great, and generally uniform distance between those coal beds militates against such a supposition. It is more likely that a local vein of coal has been formed above No. 2; or, perhaps, that the cannel coal is formed by the increasing thickness of the shale parting, and forms, with the four feet sandstone, the true parting of this coal.

At Gavet's mines, six miles below Louisa, Lawrence county, the distribution is still different. The upper coal has become very thin, and the clay parting shales look like top shales. Then the analogy of the plants with those of No. 1 B might also lead to wrong conclusions. On the opposite side of the river the coal has again taken its natural appearance; has a thin parting clay and the true characters, as before indicated.

The distance of this coal from No. 1 C, either when it is united to 1 B or ascends above it, is, on an average, 100 feet. At Warfield, where the measures increase in an extraordinary degree, it is 280 feet from 1 A. At Paintsville, about 190 feet from 1 B, or 250 feet from 1 A.

I know of no coal in the western coal fields of Kentucky which, by

position or palæontological characters, could be compared with No. 2, except the Ice-house coal, marked 2 feet 6 inches on the 1st diagram of the 1st Report of the Survey, at just 100 feet above the horizon assigned to the limestone coal 1 C. I have reported, volume 3, page 534, all that I know about this vein, which was but just opened on my first tour in Union county, and was covered with water when I visited the place the second time.

Our coal No. 2 is generally well developed in the eastern coal fields of Kentucky, especially in Greenup county, where it forms the Amanda, Ashland, Killgore, Star furnace coal beds, etc. Its average thickness in this county, including the clay parting, is about four feet. In Morgan county it is worked two and a half feet thick, at Hazlerig's mines, opposite to West Liberty; in Breathitt county its place is about 80 feet above No. 1 B, and its thickness is only 20 inches. It attains its greatest dimensions in Lawrence county, where, at Peach Orchard, it is four to five and a half feet, including the parting. Although this coal sometimes has a layer of cannel in it, it is mostly bituminous. Two sections taken from the mines of Peach Orchard, where it has been extensively worked, will show its distribution and its changes in that place:

	Feet.	Inches.
Top sandstone, about .....	50	
Bituminous coal .....		2
Brash coal, with broken plants, (shale parting) .....	1	4
Bituminous coal, with sometimes a band of one inch of pyritiferous shales .....	4	
White fire clay below.		

Back in the hills, about three miles from the above section, it is:

	Feet.	Inches.
Sandstone .....	70	
Cannel coal .....		4
Black shales and iron shales, (parting) .....	5	
Bituminous coal .....	3	8
Shales and sulphuret of iron .....	2	
Bituminous coal .....		10
White fire clay below.		

At Whetstone creek, Greenup county, on the land of Mr. John Stewart, where this vein has been opened in many places, its thickness, with a clay parting, is from eighteen inches to two and a half feet. At one

of the openings the two members of this coal are separated by 8 to 10 feet black micaceous shales, without fossils, apparently as if another bed of coal had been formed above this one.

Its peculiar distribution at Colonel El. Nigh's, of Ironton, has already been mentioned. The section is as follows :

	Feet.	Inches.
Thick sandstone above.		
Bituminous coal.....	2	
Hard sandstone.....	4	
Fine block cannel shales, or cannel coal, with leaves of <i>Stigmara</i> and <i>Lepi-</i> <i>dodendron</i> .....	1	6
Bituminous coal.....	1	6
Fire clay and shales.....		3
Bituminous coal.....		8

At Pinegrove, two and a half miles northeast of Hanging Rock, Ohio, where this vein is extensively worked, it measures four to four and a half feet, including a clay parting of three to six inches.

The only place, further east, where I had an opportunity to examine it, is at Yellow creek, where it forms the *big vein*. It is there from six to eight feet thick, including a clay parting, having at its base a shaly cannel coal, full of remains of fishes. At Yellow creek it has the same distribution and general appearance as at Peach Orchard, and is also covered by a great thickness of hard sandstone.

It is mentioned by Mr. J. P. Lesley in his manual under the appellation of coal C, or Kittanning bed; the first coal above the buhrstone, as generally developed in the northern part of the bituminous coal fields of Pennsylvania. Its average thickness there is from  $3\frac{1}{2}$  to 4 feet. Mr. Lesley makes this coal the great depository of the cannel coal of Pennsylvania, while Prof. M. D. Rogers indicates the coal above it, viz: the lower Freeport coal, as the bed most generally becoming cannel. Not being acquainted with the localities where these geologists took their observations, I cannot decide the question for Pennsylvania. But in the eastern Kentucky coal fields it is our No. 3 coal (consequently a coal higher than the Kittanning) which becomes the main repository of cannel coal.

#### COAL 3. PALEONTOLOGY, STRATIGRAPHY, AND GENERAL DISTRIBUTION.

From observations made in former years in Pennsylvania, I had supposed that the plants of the genus *Lepidodendron*, which appear to have

had their greatest development at the time of the formation of coal No. 1 B, had gradually diminished, and, eventually, totally disappeared; so that at the epoch of the formation of the Pomeroy coal there was scarcely any representation of this genus. As yet there is no evidence that this conclusion is erroneous for the Pomeroy coal, (No. 4 coal,) but it is certain now that species of *Lepidodendron*, with their leaves and cones, are found in our No. 3 vein, which is generally formed but a short distance below No. 4. Although specimens of these species of plants have been found in but few of the localities where the bed has been examined, it is sufficient to prove that this beautiful genus had not entirely disappeared from the flora of the coal marshes when this coal (No. 3) was in process of formation.

The shales covering our third vein are generally yellowish gray, or blueish, very soft, and so fine in texture that they are easily divided transversely with the knife. This softness of texture is the cause of the beautiful and distinct preservation of the fossil plants of this coal. Not only have the outlines of numerous fern leaves and stems been preserved in their most delicate details, but the substance of the plants has been transformed into thin lamellæ of coal, so that the roof itself looks like a drawing made on stone by a skillful lithographer. A singular phenomenon often remarked, but still unexplained, is the persistence of the coaly matter of the fossil plants in remaining attached to the lower part of the roof shales, so that pieces detached from the roof have, generally, one side imprinted with the forms of the leaves only, while the other preserves the carbonized vegetable matter.

There have been but few opportunities for a favorable study of the palæontology of this coal. In the western coal fields it is generally connected with a calcareous black band, and its shales becoming bituminous and black, have preserved only the most durable parts of the fossils. In the eastern coal fields of Kentucky this vein is placed too high in the hills to be easily worked; and though its outcrops are numerous enough, it has been nowhere extensively worked, except, perhaps, at Stinson hills, Greenup county, at Grayson, Carter county, and at Haddock's mines, in Breathitt county.

The most abundant of the fossil remains at Stinson's belong to *Dictyopteris obliqua*, (pl. 1, fig. 1;) to *Sphenophyllum Schlotheimii*, Brgt., (pl. 4 fig. 2,) to *Annularia fertilis*, Stern., (pl. 4, fig. 4,) and especially to

*Asterophyllites tuberculata* S., (pl. 3, fig. 3;) *Neuropteris hirsuta*, and *Pinnularia*. On the roof shales there are a few specimens of *Lepidodendron elegans*, Brgt.; the long *Lepidostrobus*, which Mr. Brongniart has named *Lepidostrobus ornatissimus*, from its great size; branches of *Pecopteris*, apparently *P. oveopteridius*, Brgt., and *Sphenopteris latifolia*. At Haddock's there is an abundance of *Calamites*, especially *Calamites decoratus*, Brgt., (pl. 3, fig. 4,) which is also found in Pennsylvania in connection with the same vein, and may belong to it exclusively. Then *Hymenophyllites Hildreti*, Lsqx., (pl. 2, fig. 5,) a plant abundant also in the shales of No. 1 B. *Alethopteris Serlii*, Brgt., (pl. 1, fig. 3,) common at Zanesville, Ohio, in coal No. 3, and at Room run mines, Pennsylvania, and *Pecopteris unita*, Brgt., (pl. 2, fig. 2,) probably particular to this vein, or, perhaps, ascending to the Pomeroy coal. I have seen in this coal no traces of *Sigillaria*, nor of fruits of any kind, except the long cones of the *Asterophyllites* and *Lepidostrobi*. Some species, apparently new, were found at Stinson hill, but the shales were too soft to be transported. Moreover, this vein is not worked now; the tunnels were full of water, and it was with difficulty that I could detach from the roof a few pieces for a too hurried and unsatisfactory examination.

Besides the nature of the shales, the perfect preservation of the fossil plants, and the predominance of the named species, there is yet another character which may help to identify this vein. It is generally overlaid by a bed of limestone, separated from the shales of the coal by a space of 5 to 20 feet. The thickness of this limestone, which is somewhat more consistent than any other limestone of the coal measures, varies from one to eight feet. The nearer the limestone lies to the coal, the more black, and more bituminous, the shales become. When it comes in contact with, or in close superposition to the coal, as in Muhlenburg and Christian counties, this limestone is often replaced by a very productive black band iron ore, whose remarkable color (an alternation of red, or chocolate, and black stripes) prevents its being mistaken for any other black band of our coal fields. The limestone above this coal is generally present in the western coal basin, as well as in Greenup county. It caps the Stinson hills; it is found at Catlettsburg, and at the top of some of the highest hills, forming sometimes a bastard, or rather porous and somewhat cherty limestone. In the southeastern part of the east coal



basin it entirely disappears, as well as all other beds of limestone, and is replaced by thick strata of sandstone, with some iron ore.

This difference in the intermediate strata renders the distance of this coal from No. 2 somewhat variable. On Stinson hill and at Grayson, where, as before said, the thickness of the coal measures is considerably reduced, the distance between these veins is about 85 feet. At West Liberty, Morgan county, (Cox's vein,) it is 110 feet. At Haddock's, on the Kentucky river, No. 2 is not formed (at least is not visible) on the same hills where No. 3 is worked, and its distance from No. 1 is 275 feet. Below Louisa, in Lawrence county, No. 2 and No. 3 coals are, apparently, 100 feet apart. At Warfield, 140 feet. At Paintsville, about the same distance. It is unnecessary to state that the distances here indicated, like all others in my Report, are approximative; *i. e.*, as accurate as a measurement with the pocket level can make them.

In the western coal basin of Kentucky, along the Ohio river, this coal, near Caseyville, is represented below the Curlew limestone by a thin streak of coal. At Hawesville it is 20 to 30 inches thick, and along the southern edges of the same basin, in Muhlenburg and Christian counties, it varies from 6 to 30 inches, its greatest thickness being, probably, at Mr. Larkin Campbell's, 2 feet 10 inches.

The Hawesville upper coal has been the subject of much discussion, and its place is still uncertain. In the fourth diagram of the first volume of the Reports, it is marked 205 feet above the main coal, which, from palæontological evidence, I consider as the equivalent of No. 1 B. This would be just the place of No. 3. Still, the general characters of the Hawesville upper coal are not the same as those usually indicated by this vein. The coal is bituminous, much charged with pyrites, like the top coal of the Raccoon furnace, and is separated from a 9 feet stratum of fossiliferous limestone by a brown ochreous clay, resembling that which sometimes covers No. 1 C. This brown clay, like the limestone, contains an abundance of fossil shells, especially *Terebratulæ* and *Encrinia* *es.*, just like the Curlew limestone. The absence of the intermediate sandstone, separating at other localities coal No. 3 from the limestone, has, perhaps, caused the difference in the nature of the shales, and, consequently, substituted shells in the place of plants, which cannot exist where the marine influence has had full sway. At any rate, the upper coal at Hawesville,

so far as can be judged from the present observations, belongs, in all probability, to the coal horizon of No. 3.

Here I would take occasion to remark that we cannot expect to be able to refer every one of our coal beds to one of the divisions indicated by the distribution of the greatest number of them. There are, without doubt, local strata which cannot be referred to any of the geological horizons of our sections. At Mr. John Steward's a coal, 70 feet above No. 2, 18 inches thick, covered with *gray metal* and very soft polished shales, cannot be referred either to No. 2 or No. 3, by its palæontological and external characters, nor by its position. I have not seen this coal anywhere, except at the top of a great bluff of gray metal, near the mouth of Whetstone creek, a tributary of Little Sandy. It was but little exposed at either place. Some similar cases of peculiar distribution may be mentioned in the examination of the counties.

In the eastern coal fields of Kentucky No. 3 is mostly cannel coal of good quality and of workable thickness. At Stinson hill, on the land of Mt. Savage furnace, Greenup county, it has about four feet of coal, distributed as follows:

	Feet.	Inches.
Gray yellowish shales, with plants .....	6	-----
Bituminous coal, with one inch clay parting .....	2	-----
Black bituminous slates, (bastard cannel) .....		4
Cannel coal.....	2	-----

On the top of the hills above Grayson it has, under a bed of the same shales, with the plants:

	Feet.	Inches.
Bituminous coal.....		8
Bastard cannel coal.....		4
Cannel coal.....	1	6

At Haddock's mines, on the Kentucky river, Breathitt county, its yellow or blue soft shales are covered by sandstone, and underlaid by

	Feet.	Inches.
Shaly or brash coal .....		4
Bituminous coal .....	1	2
Cannel coal, (no parting).....	3	-----

This coal is the finest grained cannel of Kentucky. To this No. 3 I refer also a vein of coal, opened at Raccoon furnace, 300 feet above the creek, and about 260 feet above No. 1 B. From measurement, it is thus at the very place which No. 3 should occupy. But, although the shales which cover it are soft, and of the same color as those of coal 3, I could find in them no traces of fossil plants, and, therefore, could not identify it from palæontological data. Its identity, nevertheless, is rendered more probable from the presence of a ferruginous limestone placed at a short distance above it. It is probably the equivalent of the Curlew limestone of the west, and of the Stinson limestone of Greenup county. On Stinson hill, the equivalent of the cannel coal, opened near the tunnel, is bituminous, and has also the yellow soft shales, apparently without fossils. The coal at Raccoon furnace is bituminous, and separated into two members by a parting of gray, soft, brittle, easily decomposed clay.

It is certain that, even in close proximity, the nature of the coal, as cannel or bituminous, cannot be a guide for identification. We have already seen the Stinson cannel coal becoming bituminous at a short distance. At Warfield, coal No. 2 is opened on three successive hills along the river, precisely at the same level. On the middle hill half the bed of coal is cannel; on the two others it is entirely bituminous. At and around Ironton, the same vein is always bituminous, except at Col. El. Nigh's vein, where it is mostly cannel.

On Mr. John Steward's property, on Whetstone creek, Greenup county, there is also a coal, occupying the same horizon as No. 3, and of which the shales are yellowish, soft, and without fossils. It is 130 feet from No. 2, appears in two members, and is said to be cannel. I could see nothing of this bed except the yellow shales, and very small pieces of that. Above this vein, separated from it by 10 to 15 feet of shaly sandstone, or shales, the Mahoning Sandstone sets in and caps the hills, in a thick, hard, conglomeratic stratum. As from the double stains, this coal appears in two beds; it might be possible that coal 3d and coal 4th are here in near proximity; but no trace of limestone is to be seen above it, and our coal 3d is sometimes separated in two beds, like this one.

## COAL 4. PALEONTOLOGY, STRATIGRAPHY, AND GENERAL CHARACTERS AND DISTRIBUTION.

The characteristic plants of the roof shales of this vein are especially small species of ferns. Among the *Neuropteris*, it has *N. flexuosa*, Brgt., in the greatest abundance; *N. Loschii*, Brgt.; *N. dentata*, Lsqx.; *N. heterophylla*, Brgt., and the remarkable *Cyclopteris fimbriata*, Lsqx., a beautiful, large, nearly round, fringed leaf of fern. The genus *Sphenopteris* is represented by *Sphenopteris Gravenhorstii*, Brgt.; *S. Dubuissonis*, Brgt.; *S. abbreviata*, Lsqx.; *S. intermedia*, Lsqx.; and *S. plicata*, Lsqx.; all species rarely found, and seen only in the anthracite basins of Pennsylvania. This vein has all the representatives of a peculiar genus, (*Schizopteris* of the authors,) published in the final Report of Pennsylvania Survey, under the name of *Pachyphyllum*, Lsqx.\* The plants of this genus are thick, with leaves irregularly divided, sometimes quite smooth, sometimes covered with hair. This vein, No. 4, has scarcely any *Alethopteris*, but the greatest abundance of *Pecopteris*, viz: *Pecopteris polymorpha*, Brgt.; *P. notata*, Lsqx.; *P. oreopteridis*, Brgt.; (this last found also with No. 3;) *P. pusilla*, Lsqx., especially *P. arborescens*, Brgt., (pl. 2, fig. 1;) *P. cyathæa*, Brgt., (perhaps a variety of the former;) and *P. arguta*, Brgt., (pl. 2, fig. 3.) These last three species appear to be the true characteristic plants of this vein, and not found elsewhere. It also, like the former coal, contains a great abundance of *Asterophyllites*, *Sphenophyllum*, and their fruits, with *Pinnularia*, apparently a kind of root, dividing itself in innumerable threads, like branches. It covers sometimes, by itself alone, great surfaces of the roof of the mines. This vein does not appear to have any remains of *Lepidodendron* in its shales, at least none has been found till now. But it has still some *Sigillaria*, especially those of the section of the *Leioderma*, which are not marked with longitudinal furrows: *Sigillaria sculpta*, Lsqx.; *S. obliqua*, Brgt.; *S. fissa*, Lsqx., and some *Calamites*; *C. cruciatus*, Brgt.; *C. ramosus*, Brgt., which, perhaps, belong to the same species, and exclusively to this coal. Thus, this vein is well marked in its peculiar flora by the abundance of small ferns, and the deficiency of large trees, of stems of *Lepidodendron*, and of fruits. It has, like No. 1 B, *Flabellaria* in abundance.

In his excellent Report on the Geology of Ohio, Dr. Hildreth, of

\* Fossil flora, of the final Report of the Pennsylvania Geological State Survey, vol. II, p. 868, pl. 8.

Marietta, has thus briefly characterized this flora: "*In the shales twenty species of plants, Equisetaceæ, Filices numerous, Lycopodiaceæ rare.*" The *Calamites* belong to the *Equisetaceæ*, the *Lepidodendra* to *Lycopodiaceæ*; the *Filices* are the ferns.

Lithologically, this vein, No. 4 is easily distinguished from No. 3 by the hard, micaceous texture of its gray shales, and by its position at the base of a great, hard, mostly conglomeratic sandstone, 20 to 100 feet thick, which overlays it sometimes without the intermediate shales and plants. In this case coal 4 resembles C. 1 A; the more so as the Mahoning Sandstone, like the sandstone above 1 A, contains large pieces of fossil woods. But there is a great difference in the consistence and thickness of the sandstones. Moreover, the fossil remains of the Mahoning Sandstone are not merely prints, but pieces of wood transformed into charcoal, or silicified trunks, belonging, a few of them, to *Calamites*, and mostly to *Sigillaria* and *Psaronius*, or fern trees.

Among thousands of specimens examined in Ohio, Athens county, I have not found a single *Lepidodendron*. This Mahoning Sandstone, often a conglomeratic or pebbly sandstone in its upper part, attains a great development near Pomeroy, Ohio, where it measures more than 100 feet. In the S. E. part of the eastern coal fields of Kentucky, viz: at Warfield, its thickness is 200 feet. It does not appear to thin much toward the west, since in the western basin, in Muhlenburg county, it is 75 feet thick, and even more.

The coal of this 4th vein is of excellent quality; indeed, for domestic use and generation of steam, it is one of the best of the coal measures. It and the best Pittsburg coal are the only coals, I believe, of which the coke has been used in the west for smelting iron in place of charcoal. The old Pennsylvania furnace, in Muhlenburg county, used it profitably for a long time. The vein is generally compact, sometimes divided in two by a thick shale parting, and its average thickness is from 3 to 5 feet. Near Pomeroy, Ohio, it is 6 feet thick. In the southern part of the western coal basin of Kentucky, where it has been opened in many places and considerably worked, it is generally 3 to 3½ feet. At G. Terry's, near the county line of Hopkins and Christian counties, the coal is 4½ feet thick, &c.

The distance of this vein from No. 3 is short and not very variable. Under the Waugham coal No. 3 is found 25, at the most 30, feet lower

in the creek. In the vicinity of the old Pennsylvania furnace there is generally 25 feet of measures between both veins. In Greenup county coal No. 4 has not been seen; its place is marked by black shales, placed above the limestone. At Iron-ton, opposite Amanda furnace, where the section is easily followed on the same hill, its place is still occupied by shales, and coal No. 3 is 30 to 40 feet below the base of the pebbly Mahoning Sandstone. In Lawrence, Johnson, and Floyd, the place of this coal is not positively ascertained. It is too high in the hills; and, though some outcrops have been seen, which, by position, might be referred to it, it was not possible to have any of them either opened or exposed, to satisfactorily study the characters of the shales. In the anthracite coal fields of Pennsylvania this vein, like the former, is generally well developed, distinctly marked by the fossils of the shales. It furnishes to the trade the kind of mineral coal named *red ash*, from the color of its ashes.

THIRD DIVISION. COAL MEASURES BETWEEN THE MAHONING AND ANVIL  
ROCK SANDSTONES.

While between the conglomerate and the Anvil Rock Sandstones the characters of each vein of coal are taken especially from the fossil plants preserved in the shales, in this higher division of the coal measures we cannot find in Kentucky any reliable guide in the vegetable kingdom, at least from the distribution of peculiar species.

Generally, the plants found in connection with the coal strata of this division are much broken, or rather obliterated, mostly replaced by marine shells, or even intermixed with them. This shows a predominance of marine influence in the formation of the shales. Either the water covering the coal marshes, after the formation of the combustible matter, became too deep to permit the continuation of an abundant vegetation on their surface, or the remains of the plants have been too much decomposed in the water, and hence obliterated in the shales. It is, nevertheless, evident that the same vegetation, which caused the formation of the coal strata of the former division, had the same action in the formation of the coal beds of this section. Some roof shales, like those of our coal No. 9, contain well preserved remains of *Pecopteris*, *Sigillaria*, and *Calamites*, with numerous remains of shells. In the sandstone strata of this division, also, are imbedded remains of broken plants, pieces of wood, trunks of trees, all belonging to the same genera of plants as those of the former

section. These vegetable fragments in the sandstone are generally thrown into confusion, or without any apparent order, either of direction or of stratification. It shows that they have been carried and transported by waves, or currents, and irregularly deposited on shores. But the nature itself of the shales, and the shells and the plants which they contain, is evidence that these shales have been deposited, like those of the former division, in a quiet and shallow body of water.

In the eastern coal fields of Kentucky, the upper division of the coal measures has been entirely washed away, and no trace of it left. On the contrary, in the western coal basin, the true coal-bearing formations the most easily attainable, and those which contain the best and thickest coal strata, have their place above the Mahoning Sandstone. This part of our examination, therefore, is exclusively confined to the western coal basin.

Though the first geological reconnoissance made in the western coal basin was too short and hurried, it, nevertheless, afforded important results, since a more careful revision of most of the localities previously examined, has not changed my views about the general characters of the veins of coal and their distribution. It has not, therefore, caused any modification in the determination of the coal strata, or in the place assigned to them in my Report and that of Mr. C. T. Cox. But since a greater number of coal banks have been examined, and their peculiar appearance compared at many places, it will be necessary to make now a short review of their general characters, to mention additional facts which have been ascertained by the examination of the new localities.

*Coal 5th.* This had not been seen in the first tour of exploration. It is characterized by a thick bed of black, polished, hard shales, sometimes a little micaceous, splitting horizontally in large slabs, entirely barren of any traces of fossil remains, either animal or vegetable. This coal is locally of good workable thickness. On Richland creek, Hopkins county, it is 5 feet, and its roof of black slates 12 feet thick. In the upper part of the bank the shales are somewhat whitish, spotted like those of No. 9; but they have no trace of fossils. At Mr. Robertson's bank, near Greenville, Muhlenburg county, the coal is 18 inches thick, underlaid by 18 inches of brash coal, and covered by 6 feet of black slates. The thickness of the bed of Richland creek is given as it appears in the outcrop. Perhaps it is somewhat overrated, for generally

in Hopkins county this vein is no more than 2 to 3 feet thick. At Mulford's, and along the Ohio river, it is reported 4 feet, and known as the *Four-foot coal*.

Though this coal belongs to what has been generally called the barren measures, of the Pennsylvania Report, it is found of workable thickness in Ohio, and even in Pennsylvania. Dr. Hildreth has reported it as being 4 feet thick, and 120 feet above No. 4. He calls it appropriately the limestone coal; for it is generally covered by a stratum of this material. In Pennsylvania this vein is marked by Mr. J. P. Lesley as coal G, one foot thick, placed below a limestone, at 125 feet from No. 4. And in the final report of the Survey of Pennsylvania, vol. 2, p. 656, it is reported as placed below calcareous shales, at about the same distance (125 feet) from the Pomeroy coal. In western Kentucky the distance of this coal from No. 4 varies according to the thickness of the Mahoning Sandstone. It averages 100 feet.

*Coal 6th.* The characters reported, vol. 3, p. 537, are, apparently, constant. This vein, like the former, is locally formed and of variable thickness. At Mr. E. L. Johnes', near the old Buttermilk road, Hopkins county, it is 4 feet thick, and the coal is of fine appearance and of very good quality. It is hardly as thick elsewhere. At Greenville, Mublenburg county, it lies just at the top of the great limestone and 70 feet above No. 5. In the Airdrie shaft, on Green river, it is placed at the same distance, and is also a thin coal. In Union county it has been seen only at Mulford's. Except what has been reported, p. 538 of the 3d volume of this Survey, I have no data by which I could ascertain its position in Pennsylvania and Ohio.

*Coal 7th.* I formerly referred to this number the following vein No. 8. Our coal 7th is the Well coal of Mulford's shaft. It has peculiar characters distinct enough from those of No. 8. I had an opportunity of seeing it partially opened at Curlew, Union county, the last time I visited the mines. At this place the coal is about 2 feet thick, overlaid by very black, soft, polished shales, resembling those of No. 5, with the exception that they do not split in large slabs, but in small pieces, and that they contain teeth and scales of fishes. The teeth are very small, scarcely an eighth of an inch long. There may be other fossil remains in the shales, but I did not find any. The most reliable and evident character is the great abundance of pebbles of carbonate of iron in the shales over-



laying the black slates. This vein never was seen of any great thickness, so far as I know.

To this 7th coal may be probably referred a bed, 13 inches thick, crossed in digging a well on the property of Mr. I. Short, at Greenville, Muhlenburg county. It was reached at 25 feet from the surface. A short distance above this coal the shales, from the statement of Mr. Short, contained fine specimens of fern leaves. Unhappily none of the specimens could be found and examined. In the blue shales of the barren coal measures, near Athens, as also in the red shales of the Grotto of Flowers, near Marietta, there is an abundance of leaves of a peculiar species of fern—*Asplenites rubra*, Lsqx.—which is, perhaps, identical with the plant found at Mr. Short's. This would be the more remarkable, as, at both places, the shales contain carbonate of iron and traces of coal. Thus the identity of the plants would show the place of our coal 8th in the barren measures, where it has not been formed. From stratigraphical observations the place occupied by those fern-bearing shales in the "*barren measures*" of Ohio, would correspond with the place of the Well coal. The Isinglass Lick coal, of Hopkins county, reported vol. 2, p. 326, has also the characters of this vein, and evidently is its equivalent.

If any part of the space comprised between coals No. 5th and 9th, properly deserves in Kentucky the name of barren coal measures, it is the 250 feet, including the above named 6th and 7th coals, which, not being persistent, are not altogether reliable beds, and have been but little worked anywhere. The characters of their shales are still somewhat obscure, and not perfectly reliable, and require to be verified by further comparisons.

*Coal 8th.* The appearance of this vein is so attractive, although fallacious, that it has been opened for examination at a great number of its outcrops. It is improperly called the *Black-band*, of Hopkins county, and is a compound of black, heavy, compact limestone, resembling a fine iron black band, and of black, hard, compact, bituminous slates, resembling cannel coal. Its palæontology is mostly remains of animals. It has, among many species of large shells, an extraordinary quantity of a very small species, scarcely visible to the naked eye, and which is strewn over the shales like innumerable grains of sand. It also contains abundant remains of fishes, especially the double teeth, mentioned with coal

No. 12, vol. 3, p. 548. Two species of plants were found in the shales of this coal, both apparently of marine origin. The one, *Calamites gracilis*, Lsqx., (pl. 3, fig. 5,) a long, narrow *Calamites*, a quarter of an inch in thickness, bearing obscure sheets, like the *Horsetail*, (*Equisetum*), and thus, if the appearance is not fallacious, a true *Equisetites*. I only found one specimen of this plant. The other, a long blade, or leaf, enlarging toward the top, and resembling a *Flabellaria* without the striae or longitudinal grooves. Both are undistinctly marked on the black shales.

The coal of this vein is thin. Indeed, it can be called a barren vein, since the black shales, though very bituminous, and sometimes inflammable, do not consume like coal. In a few openings the coal has been found to be one to one and a half foot thick, but no more. The following section illustrates the most general distribution of this vein. It is taken at the Black-band, of Michel's heirs, Hopkins county, near Mr. A. Towns' property :

	Feet.	Inches.
Shales and sandstone, covered space .....	10	-----
Black slates, spotted and splitting .....	1	-----
Soft crumbling shales, with shells .....	1	3
Hard bituminous cannel slates .....		6
Black heavy limestone, (black-band) .....	1	-----
Gray, hard fire clay, with boulders of sulphate of lime .....		6
Yellow ferruginous clay, with boulders of limestone .....	3	-----
Dark, gray, hard fire clay .....	1	6

The black limestone and the hard bituminous slates vary in thickness from a few inches to two feet, yet preserving their color and appearance.

The distance of this No. 8th from No. 7th is not known to me in a positive manner, as No. 8th was not seen in the area occupied by this vein; but it is generally from 20 to 25 feet from No. 9th.

Its distribution is limited to the southwestern part of Hopkins county, where it occupies a basin traversed by the Henderson and Nashville railroad. It is mostly seen on the waters of Richland, Steward, and Clear creeks, and their branches. It extends, probably, in a narrow spur in Muhlenburg county, where it crops out at Mr. E. R. Veirs', two miles north of Greenville.

*Coal 9th.* This fine bed of coal has been examined in a number of openings, and its characters closely compared, without eliciting any change from the description given in the former Report, pp. 541-2. Neverthe-

less it must be remarked, first, that the shales bearing fossils contain well preserved branches of ferns, (especially *Pecopteris Miltoni*, Brgt.,) and of trees, (especially *Sigillaria*,) together with specimens of shells, (especially *Avicula rectelateraria*, Cox, and *Productus muricatus*,) sometimes all together, plants and shells on the same piece of shale; secondly, that the fossil shells and the remains of fishes are sometimes rare in the shales, and that they must be looked for carefully. The peculiar hardness of its fire clay and its striped dark color is a persistent character.

The distribution of this vein in Pennsylvania is now ascertained, though its place is not marked in Lesley's manual of coal, and it has not been mentioned in Ohio. It was first identified by its palæontological characters at the base of the great cut, near the tunnel, about two miles east of Greensburg, Pennsylvania, with its hard fire clay and about 18 inches of coal. It is there covered with black shales of the same character as in western Kentucky. And, recently, my excellent friend, Prof. W. D. Moore, of Oxford College, Miss., being on a tour of exploration around Pittsburg, collected and forwarded to me, for examination, a box of specimens of shales covered with *Avicula rectelararia* and *Pecopteris Miltoni*. These shales, from the observation of the learned Professor, overlay a bed of coal 1 foot thick, exposed close to the track of the Allegheny Valley railroad, fifteen miles above Pittsburg. From the nature of the shales and the species of fossils which they contain, this vein is evidently identical with our No. 9.

In the final Report of the State Geological Survey of Pennsylvania, the only coal which, by position, may be referred to No. 9, is the Elk Lick creek coal, marked about 60 feet lower than the Pittsburg coal. It varies in thickness, from one foot at Elk Lick creek to three feet at Ligonier.

In Kentucky the thickness of this vein does not vary much. It averages 5 feet of good bituminous coal, scarcely, if ever, cannel coal, generally without a clay or shale parting. It is the most extensively worked bed of the western coal basin, and its coal is of excellent quality. Its distance from No. 11 varies from 60 to 100 feet.

From a note received from Mr. Patterson, director of the Airdrie iron furnace and coal mines, it appears that, in the shaft at that place, coal No. 9 is underlaid by a bank of gray, hard, compact limestone,  $3\frac{1}{2}$  feet thick, abundantly fossiliferous. It is separated from the coal by only 3

feet of clay and shales. This limestone cannot be supposed to be the equivalent of the false black band of Hopkins county. It is quite different in texture, color, fossils, &c. It is remarkable that no limestone has been observed before on the same geological horizon, and that the Airdrie shaft section has already been twice reported, on apparently good authority, without this limestone being mentioned.

*Coal 10th.* This vein has been only seen on the hill at Mulford's coal mines company, with the same characters as those indicated, vol 3, p. 544. It is, probably, a separated member of No. 11. It has not been seen in Hopkins county, although the space between No. 9 and No. 11 is often exposed for exploration. At Airdrie, and along Green river, the shafts and numerous borings between No. 11 and No. 9 have not found it anywhere. It would thus appear to be developed only along the Ohio river, in the vicinity of Shawneetown and Mulford's.

*Coals 11th and 12th.* Like No. 9th, they have been examined at many new openings, and appear to preserve exactly the characters formerly reported. The vein No. 12th is so often in such close proximity to, or in connection with No. 11th, that it may be regarded as one of its members. Both these beds of coal stand in nearly the same relation as the three divisions of our coal No. 1.

The extension of these veins is finely exemplified near Clark's mill, Pond river, on the limits of Muhlenburg and Hopkins counties. The section of the cliffs, as reported in the first volume of the Survey, page 136, is:

	Feet.
Covered space, shales and clay iron stone.....	6 to 10
Coal, (No. 12,) bituminous.....	2
Yellow, somewhat coarse shales.....	10
Limestone.....	2
Coal, with clay parting.....	5

Thus both veins, 11th and 12th, are here separated by 12 feet of measures, of which two feet are limestone. Since the above section was made, the coal has been entered by a tunnel, cutting through both beds of coal and the intermediate strata. Only 14 feet from the entry, within the tunnel, the appearance of the measures is already totally changed. The limestone, which, from the outside, looks like a continuous bank, has entirely disappeared; first thinning, then changing into a yellow ferruginous clay, soon lost with the shales. Now, at the place mentioned, 14 feet from the entry, the fire clay of No. 12th has become the roof of No. 11th, and the distance between the base of No. 12 coal and the top of

No. 11th is only two feet. Somewhat further, both coals appear united, only separated by six inches of black shale parting, containing the fossils of No. 11th, and the bed is 7 feet thick. The limestone which covers the entry has an horizontal breadth of but 7 feet 3 inches.

Such divisions in the veins No. 11th and 12th have given rise to a great deal of discussion among the geologists; some being led to the conclusion that several strata of coal do exist, where really but one is found. It is, therefore, important to follow those changes in good authenticated sections. On this matter none are more instructive than the borings carefully recorded by Mr. Achison, and made at and around Uniontown, Union county, in searching for a thick bed of No. 11 coal. At the first boring, mouth of first branch of Dry Fork of Highland, the Anvil Rock Sandstone is in three members 53 feet thick, and at its base, 111 feet from the surface, a three inch coal is found running into it. From this down for 60 feet the section is :

	Feet.	Inches.
Hard green sandstone.....	2	
Coal.....	1	10
Fire clay.....		6
Hard gray sandstone, slaty sandstone, and shales.....	22	3
Coal No. 12th.....	2	3
Brown slate.....	1	10
Limestone, in three beds.....	15	10
Slates.....	7	2
Sandstone.....	5	
Coal No. 11th.....	5	

On Main and Second streets, in Uniontown, the base of the Anvil Rock Sandstone (18 feet thick) is marked at 90 feet from the surface, and overlies a coal 20 inches thick. The section then continues :

	Feet.	Inches.
White rock, mixed with clay and blue shales.....	16	2
Coal No. 12 at 112 feet from surface.....	2	3
Fire clay.....	2	1
Limestone clay.....	5	1
Hard white limestone.....	2	10
Blue shales, with limestone.....	12	8
Hard limestone.....		5
Bituminous shales, limestone, and clay.....	4	
Hard limestone.....	4	
Soft white, blue, and black clay.....		3
Coal, 146 feet from surface, No. 11th.....	5	

On the other side of the river, opposite Uniontown, the base of the Anvil Rock is at 131 feet 4 inches from the surface, and there are below :

	Feet.	Inches.
Black shales, with a little coal, (No. 12th).....	2	
Fire clay.....	2	4
Gray limestone.....		6
Hard fire clay.....	4	8
Gray limestone.....	1	
Hard fire clay, with limestone.....	6	3
Dark blue shales, with traces of coal, (No. 11th).....	4	

This is just the place of No. 11th. The boring was continued to 168 feet, through blue shale and limestone, without reaching any coal.

At the boring of Mr. Geo. Payne's, to whom I owe the communication of the records, the place of both No 11th and 12th is normal. Under the Anvil Rock Sandstone, (55 feet thick,) the base of which is at 199 feet from the surface, there are :

	Feet.	Inches.
Blue shales.....	6	
Black shales, with coal No. 12.....	1	
Dark gray limestone.....	1	3
Hard limestone.....	3	4
Black slates.....		4
Coal No. 11.....	5	

The distance between the first three borings is short, not more than half a mile. The boring of Mr. Payne's was made at his house, in the hills, four miles south of Uniontown. In the first boring, there is between No. 11th and 12th coals 30 feet of strata, of which about 16 feet is limestone. On the second boring, the same thickness of measures contains about 22 feet limestone. At Mr. Payne's, the separation of the coals is about the same as reported (vol. 3, p. 547) for the McNary's coal bank, and the limestone is only four and a half feet thick. These differences of distribution, if exposed to view by outcrops, and not ascertained by borings, could not fail to mislead the observer whose researches are not directed by palæontological evidence.

Coal 11th is locally underlaid by a yellow, drab-colored limestone, without or with but few fossils. Like the other banks of this kind, it takes, at some places, a considerable development, and at others, disappears entirely. Under the Llwellyn's and Watson's mines, Hopkins

county, it is 12 feet thick. At Providence it is absent. At Buffalo Mt. its greatest thickness is apparently four feet. It does not appear to be formed any where in Muhlenburg county and along Green river, but is marked in the Holloway boring, at Henderson. Both the limestones above and below No. 11th are locally replaced by limonite iron ore, or by a kind of ochreous soft iron ore, widely distributed in Hopkins county, where it can be traced from Buffalo Mt. to Montezuma, on the Trade-water river. It is sometimes in beds of one to three feet thick, and contains as much as 40 to 45 per cent. of iron.

Before concluding these general remarks, it is necessary to correct an important error of my former Report. From comparison of fossil shells found at the great vein near the tunnel of the railroad, three miles east of Greensburg, Pennsylvania, with those of our No. 11th coal, the identity of both veins had been ascertained. I had also identified, in the cut of the railroad near the same place, the fire clay of a vein of coal 70 feet lower than the great vein, as being the equivalent of No. 9th, (vol. 3, p. 541.) From the position of the big coal of Greensburg, between two thick banks of limestone, I had supposed that it was the coal of the great limestone of Pennsylvania, and, consequently, admitted a lower coal, viz: No. 8th, as the equivalent of the Pittsburg vein. Now, from the final Report of the Geological Survey of Pennsylvania, which has just been published, it is evident that the great vein of Greensburg is the equivalent of the Pittsburg coal, and, consequently, that this celebrated vein finds, in the western coal basin of Kentucky, its representative in our Nos. 11th and 12th coals. This is truly remarkable, and fills up the measure of analogy in the distribution of the veins of coal on both the basins of Pennsylvania and of western Kentucky.

Independent of the fossils and other characters indicated above, the identity of our No. 11th coal with the Pittsburg may be sustained by the following considerations:

1st. In Pennsylvania, the Pittsburg coal is generally separated into two seams, either by a shaly parting or by thick layers of shales, or even by sandstone. We have seen our No. 11th and 12th veins connected, or divided, in the same manner. Only the separating member between our coals is generally a limestone, and the distance of separation is sometimes greater.

2d. The Pittsburg coal often appears between two strata of limestone,

It is the same with our No. 11th, which, in Hopkins county, is casually underlaid by 3 to 12 feet of limestone.

3d. The Report of the Pennsylvania Survey says, (vol. 2, p. 505 :) "*The characteristic rock above the Pittsburg coal is a massive sandstone, irregularly stratified, weathering with roundish holes, 30 to 50 feet thick.*" This is just the description of the Anvil Rock Sandstone covering the third division of the coal measures of Kentucky. I may add that, above the tunnel of Greensburg, Pennsylvania, this sandstone contains large trunks of fossil trees of a new genus, and that in Indiana, Posey county, within the area of the western coal basin, Dr. D. D. Owen has found standing trees of the same species in a bank of shaly sandstone and clay, which, from stratigraphical observations, he refers to the same horizon as the Anvil Rock Sandstone.

4th. The great limestone of Pennsylvania, laying about 100 feet above the Pittsburg coal, is sometimes 50 to 70 feet thick, and has below, or within its members, a bed of coal, occasionally thick enough to be workable. In Western Kentucky, one hundred feet above No. 12th, we have a thin coal, No. 13th, and above it two great banks of limestone, separated by shales. The thickness of both banks vary from 15 to 30 feet.

6th. Another coal in Pennsylvania shows itself 200 feet above the Pittsburg coal, and our No. 14th coal, one foot thick, is 180 feet above No. 12.

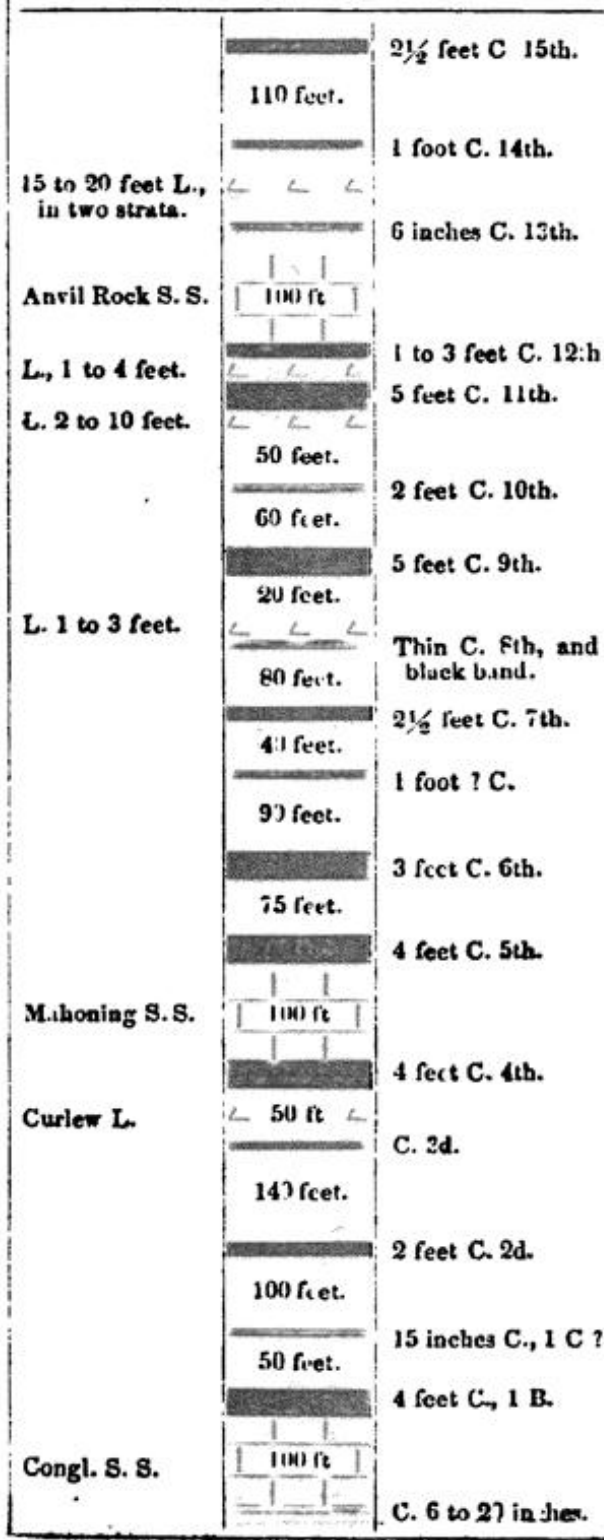
7th. The Waynesburg coal, in Pennsylvania, 300 feet above the Pittsburg vein, is sometimes a workable bed of three feet. On the connected section of the Kentucky measures, (vol. 3, p. 19,) our No. 15th coal is marked 2 feet 6 inches, and placed just 300 feet from No. 12th.

8th. Above the Waynesburg coal, the Pennsylvania Report mention about 600 feet of measures, with three thin beds of coal; and the same connected section mentioned above marks in Kentucky 200 feet more of upper measures above coal No. 15th, with still three thin beds of coal. The comparative sections at the end of this report will further elucidate this remarkable coincidence.

The detailed characters of the different coal strata above the Anvil Rock Sandstone in Western Kentucky, would, probably, render more evident the identity of the measures. But, till now, there has been no opportunity of studying satisfactorily these upper coal beds, either in



GENERAL SECTION OF UNION COUNTY.—  
1 INCH FOR 200 FEET.



Kentucky or in Pennsylvania. In Illinois, near Shawneetown, there is, above the Mahoning Sandstone, two veins of coal, one to two feet thick, in close proximity to each other, overlaid at some distance by a thick bed of limestone. The shales of the lower are apparently *gray melol*, or a chaly sandstone blackened with broken, undiscernible plants, nearly like the shales of No. 6th; the upper coal is covered with black slates and limestone shales, full of shells of peculiar species. As these upper coals are generally too thin to be worked with profit, they are rarely opened.

GENERAL SECTION, SHOWING DISTRIBUTION OF STRATA IN LIVINGSTON, CRITTENDEN, UNION, PART OF HOPKINS, DAVIESS, HANCOCK, OHIO, AND BRECKINRIDGE.

The general sections given here for reference exhibit approximately the place of the coal beds of each county. The distance between the veins of coal is of course somewhat variable in each locality, at least for a few feet. When they differ much from those marked in the section, they are mentioned or given in local sections. The abbreviations, C. for coal, S. S. for sandstone, L.

for limestone, will be easily understood.

## LIVINGSTON COUNTY.

An upheaval of the lower measures has separated in this county a spur of the western coal basin. Coal 1 B is the only vein found in this isolated basin. It is worked at Union mines 3 to 4 feet thick. The palæontological description of this coal bank was given, (vol. 3, p. 531.)

## UNION COUNTY, AND PART OF CRITTENDEN.

*Coal 1 B.* The various openings of this vein were lately re-examined along the Tradewater river, on the edges of the measures. At Bell's mines, Crittenden county, it is five feet thick. At Casey's mines, on the west side of Tradewater river, Union county, five feet. Above Caseyville, near the old distillery, two to three feet. It is of the same thickness on the land of the Kentucky Coal Company, one mile and a half north of Caseyville. This review confirms the palæontological characters exposed in the former Report.

Another bed of coal, in the vicinity of Caseyville, was mentioned to me by Dr. B. M. Long, as the Trapnel coal bank, three feet thick at the entry, and supposed to be lower than coal 1 B, from this fact: *that it is underlaid by a single stratum of sandstone about 40 feet thick, at the base of which the sub-carboniferous limestone is exposed.\** I was prevented, by too high water, from approaching this coal. But from Mr. Long's description, I believe it to be the equivalent of Bell's, viz: No. 1 B.

About 50 feet above Bell's mine, a vein of coal two feet thick has been reported before, referable, with doubt, to No. 1 C.

*Coal 2d.* Has not been seen in Union county.

*Coal 3d.* Is marked only by a streak of coal, below the Curlew limestone, near Curlew mines.

*Coal 4th.* Through the kindness of Mr. Wilwerth, one of the directors of the Mulford mines, I was enabled to examine the vein named Curlew coal, of which the geological horizon was still uncertain in the former Report. Although this vein, partly opened under a great bank of coarse, hard sandstone, was not accessible in its whole thickness; the shales and their characteristic fossil plants showed conclusively the identity of this coal with No. 4th. The sandstone overlaying this coal at Curlew is about 50 feet high, and has the structure and the composition of the Mahoning Sandstone. By its own weight, it breaks, as at Pome-

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\* Dr. B. M. Long, in letter.

roy, in immense blocks, strewn, like picturesque towers, along the base of the hills. The coal, of which the upper part (18 inches thick) only was exposed, has a roof of 4 to 5 feet of gray, micaceous, hard shales, bearing the prints of *Asterophyllites*, *Pecopteris arborescens*, *Neuropteris flexuosa*, and other species characteristic of No. 4th.

The examination of the Curlew coal has proved that the Geiger's vein, described vol. 3, p. 535, is its geological equivalent, and was rightly referred to it.

The Curlew limestone, about 20 feet below the coal at Curlew, is two to three feet thick, full of fossil shells, especially *Encrinites* and *Terebratulæ*.

*Coals 5th, 6th, 7th.* Nothing more has been observed in regard to these coals than what has been already reported.

*Coal 8th.* Is not formed in Union county.

*Coal 9th.* Nothing new was elicited by re-examination of the openings of this vein.

*Coal 10th.* Has been recently opened near Mulford three feet thick, rusted by oxide of iron. It has a large proportion of sulphuret of iron, which causes it to decompose under atmospheric influences. Its local characters are exactly the same as described in the former Report.

*Coal 11th.* This vein has been again examined.

1st. On the land of the Curlew company, where it is finely opened, it is separated from the Anvil Rock Sandstone only by six feet of black slates, abundantly filled with the shells of this coal, and a black band six inches thick, which indicates the place of No. 12th. The coal is two feet and a half thick, of fine, bird-eye cannel, and at the bottom six inches of bituminous coal, separated by a clay parting.

2d. At Uniontown, in the Highland mines, where the coal is worked by a shaft 150 feet deep, the black roof slates are like those of the former coal, covered with a great number of the characteristic shells. The coal is five to five and a half feet thick, with a parting of a few inches. In some part of the mines it is covered by six inches to one foot of cannel.

3d. One mile and a half northwest of Morgansfield, on Mr. Thier's property, there are two unopened outcrops of the same coal, covered at both places with flinty limestone.

Though Union county is rich in coal, it derives the greatest advan-

tage from its mines by their proximity to the Ohio river. Along the Tradewater river coal 1 B is already extensively worked. Other outcrops of the same vein will probably soon be discovered in the neighborhood. Above Caseyville, No 9th and 11th have, for a long time, furnished to the trade of Ohio a large quantity of excellent coal. At Uniontown, coal 11th is worked close to the Ohio river, and from the indications of the borings, the same coal, five feet thick, can be found all around that part of the country. Should the combustible mineral become scarce and more valuable, shafts, sunk from 80 to 100 feet deeper, will descend to No. 9th, which is generally thicker, and has a coal of better quality. Moreover, the detailed Geological Survey of Union county shows, in the interior of the county, numerous outcrops of coal banks, which will be opened and worked as soon as the value of the combustible is equal to the cost of the transportation.

#### HOPKINS COUNTY.

This county has in store for the future by far the greatest provision of coal of the western basin. Its wealth in this mineral is truly beyond computation. All the veins, from No. 3d to No. 12th, generally well developed, extend nearly over the whole area of this county, and all the outcrops are of easy access. No. 9th and 11th especially, crops out on the slopes of the hills, or descend, by gentle undulations, to the bottom of the valleys, where they are sometimes exposed for long distances in the cuts of the creeks. The town of Providence lies at the top of one of those hills, around which three veins of coal, each from five to six feet thick, are exposed in scarcely 125 feet of measures. In the southeastern part of the county, the waters of Clear, Lamb, Richland, Steward, Caney, Pond creeks, and their numerous tributaries, seem to run for no other purpose than to expose thick coal banks along their course, and to prepare gentle and easy slopes for the mining and transportation of the mineral. In the same vicinity there is an agglomeration of small mountains. Dozier's and Buffalo mountains, Wright's ridge, Bear Wallow, &c., which, from the base to the top, look like a succession of coal, iron, and limestone strata, heaped there as an inducement to labor and industry.

The Henderson and Nashville railroad is traced across the richest part of this coal region. And another projected railroad, to unite Greenville with Caseyville, passes through Mitchel's old field, the sulphur springs

of Mr. Town, and Providence. This road, if ever opened, will run between nearly continuous coal banks. It is a pity, that speculation can not be directed at will to constructions which are of so much importance to the country. Until these railroads are built, a mineral wealth of more real value than all the gold of California must lie dormant in the heart of a fertile county, from want of easy communications.

My first exploration in Hopkins county being hurried, I only had an opportunity of seeing a few outcrops, or openings, of its coal banks. The last one was made under more favorable circumstances, with better opportunity for a methodical examination.\*

*Coal 4th.* Its northern outcrops, in Hopkins county, is on the middle prong of Richland creek, on the land of Mr. Ed. Wright; coal two to three feet thick, roofed with a few inches of shales and 12 feet of Mahoning Sandstone. Both shales and sandstone show the characters enumerated before. The same coal is seen in a well at Mr. Rich. Wright's, half a mile west of Wright's ridge. The openings into this vein, south of this place, in Hopkins county, are reported with the Muhlenburg section.

*Coal 5th.* On Richland creek, middle fork, about half a mile above the former bank, on the same property, coal five feet thick, roofed by 12 feet of black shales, without fossils.

*Coal 6th.* The coal bank of Mr. Saml. Williams, near the line of Christian county, is referable to this. The coal was covered when I examined it. Its shales have the broken plants which characterize this vein.

*Coal 7th* has been seen—

At Isinglass glade one foot thick, covered with black, soft, brittle shales, overlaid by a thick stratum of rich carbonate of iron, mixed or alternating with the shales. (Section, by Mr. Lyon, vol. 2, p. 326.)

At Mr. Jas. Skinner's, six miles west of Providence, the vein is three feet thick, about five feet from the surface, 70 feet from No. 9, opened near by. The few shales seen have the characters of this vein. On the same property, coal has been reached 15 feet from the surface; thickness

\* Mr. John Wilson had the kindness to show me, around Providence, the openings of coal, in a circuit of from six to ten miles. From Providence to the southern edges of the coal fields in Christian county, my explorations were made in the company of Mr. A. Town, the best informed gentleman on coal localities in the county. From him I received valuable information, constant assistance, and generous hospitality. I am glad to find an opportunity of acknowledging the obligations that the Geological Survey of Hopkins county has received from him.

not reported. It was covered when I visited the place. This is probably the equivalent of the former.

At Squire Waugham's, in a well 15 feet below the surface, and 75 feet from No. 9th, opened in the hills, there is a coal said to be three feet thick.

*Coal 8th.* The false black band, of Hopkins county, has already been mentioned many times in the Reports, (vol. 1, p. 125, vol. 2, pp. 339 and 344, &c.) It is omitted in the connected section of vol. 3, p. 20; it has been examined:

In three openings on Mitchel's heirs property, on Flat creek, where it has only black bituminous slates and thin limestone.

At Mrs. Bradley's, on the same creek, where it is exposed at three places. It has here the black slates only; no black limestone.

On a branch of Steward's creek, on the land of the Hopkins and Mastodon company, it is also opened in three different places, associated with limestone, and very black and very bituminous slates.

About 700 yards from Mr. Town's black band, on Pleasant run, and at Town and Kirkwood, on Sugar creek, it is finely developed with a thin coal.

On the head waters of Richland creek, same property, it has four feet of black limestone, separated by two feet of bituminous slate from another bank of limestone two feet thick.

On Steward creek, same property, three fourths of a mile northwest of Mr. A. Town's house, at two openings of it, limestone and black slates are exposed.

On Cane run, on the land of Mr. John Davis, very bituminous shales, approaching cannel coal, are seen, with thin layers of pyritiferous shales, alternating with bituminous coal. These beds have the general appearance of No. 11th.

On the head waters of Richland creek, a fine bed, apparently cannel, is seen in the creek, on the land of Mr. John Davis. By its palæontology, it is referable to this vein; but the top shales only are visible, and I am not certain of its place.

*Coal 9th.* It is in Hopkins county, as in Union county, the best and the thickest coal, and the one having the greatest area in this country. Some of its outcrops, or openings, are already reported, vol. 3. Its short distance from the surface (70 to 75 feet in Hopkins) renders it

accessible by shafts at a number of localities where No. 11th is placed at the middle, or the base of the hills. It has been examined:

In a well at Mr. John Wilson's, two and a half miles from Providence, three feet thick. This is probably the coal marked, on the map of Hopkins, as 'Squire Little's coal.

At Mr. Jas. Skinner's it is well exposed; coal five feet thick, very fine, without parting, but with a roof of six feet of black shales.

At 'Squire Waugham's it is four feet thick, without any parting, covered by three feet of black shales. Both this and the former have the characteristic fossils in abundance. Mr. Waugham has many openings of this coal, of the same thickness, in the hills around.

At Wynn's entry, southwest of Providence, near Montezuma, this coal is four feet thick, with 10 to 12 feet of black shales above it, and exhibits the same characters as the former. This coal has been referred to a low coal; but the presence of remains of fishes, and of shells of identical species with those of No. 9th, is at variance with this conclusion. The sandstone capping the hills near Montezuma is the Anvil Rock Sandstone.

At Hunter's bank, one mile south of Providence, on Owen's creek, coal is reported in the section given vol. 3, p. 120.

Montgomery's coal bank, one mile southwest of Providence, is reported with the former. Both are well characterized by their shales and fossils.

South of Providence, coal 9th is opened at Mr. John Davis', near his residence, five feet thick, without any clay parting. It also crops out half a mile further, near the base of the hills, in a position somewhat lower than the former. The bank appears to have been displaced by a slide of the underlying fire clay, softened by a running spring. The coal is covered.

At Mr. Jas. Kirkwood's, one mile from the former, it is four feet thick.

At Mr. Henson's, one fourth of a mile from Lamb creek, there are two outcrops of coal, said to be six feet thick, without a parting. They are referred, with doubt, to No. 9th. I could see only a few pieces of shales, the coal being covered up from view.

Mr. Wm. Davis' coal, in a well on Lamb creek, judging from the shales found around the well, is evidently coal No. 9th.

At Woodson and Godwin's coal bank, head waters of Richland creek, it is beautifully exposed, five and a half feet thick, without clay parting, and is covered by a thick stratum of black shales.

At Butt's gap, this coal is five feet eight inches thick, on the property of Mr. A. Town. It has some pyritiferous limestone in the fire clay at its bottom.

On the land of the Hopkins Mastodon company, south of the railroad tunnel, near the base of the hills, the same coal is five feet thick without any parting.

The coal in a well at Mr. John A. Exell's, 17 feet from the surface, between Pleasant run and Crab Orchard, head waters of Caney, belongs probably to No. 9th; but I could not see the shales.

On the property of Mr. A. Town, peak of Otter, this coal is five feet four inches, without a parting.

On the same property, Box mountain, it is six feet thick, without a parting.

At the foot of Dozier's mountain, near Fox run, Mrs. Nancy Morgan's coal bank is four feet thick, without a parting.

On the waters of the Caney, at Mr. R. Woodruff's, this coal is now covered; it has been previously worked, and is reported four feet thick. I have only seen the shales.

On the same creek, at Mr. Harrell's, it is beautifully exposed, (8 feet thick.) It has here, as at both the above mentioned places, a fine bed of carbonate of iron, in blue shales, overlaying its roof slates, and a fine mineral spring issues from the bottom of the coal. This carbonate of iron is generally found at the same horizon in Hopkins county. It is especially rich and abundant at Wright's ridge and Buffalo Mount, on the land of Messrs. Town and Kirkwood.

On Steward's creek, near the natural bridge of Mr. A. Town, coal 9th is seen at two openings, and is  $6\frac{1}{2}$  feet thick. Although these banks are nearer to the base of the Anvil Rock Sandstone than usual, viz: distant only from 40 to 50 feet, they are referable to No. 9th by their shales. The coal has no clay parting.

It is hardly necessary to mention other obscure outcrops of this vein, which could not be satisfactorily examined.

*Coal 10th.* On the Hopkins and Mastodon company's land, south of the tunnel, this coal is said to be 4 feet thick. I could not see it.



Neither could I find a single well ascertained outcrop of it in the numerous localities where Nos. 9th and 11th were exposed on the same hills. If it exists in Hopkins county, it is probably a thin coal, hardly recognized in a country where such extensive veins as No. 9th and No. 11th are everywhere found.

*Coal 11th.* Was examined again at Watson's and Llwellyn's coal banks, reported, with section, vol. 2, pp. 316-7, and vol. 1, p. 398. From palæontological evidence both banks belong evidently to this vein. In the 7 feet 8 inches space of the section, below the limestone, there may be a streak of coal No. 10th; but I could see nothing of it. In the Holloway's boring such a streak, 10 inches thick, is found at the same place. The limestone above No. 11th is, at Watson's, as generally, in irregular, loose pieces; sometimes of a great size, or in a continuous bank; sometimes in loose blocks, no larger than a man's head.

At and around Providence, coal 11th was examined—

At Hunter's bank, half a mile north of Providence. Here, however, it is half concealed from view by debris. It has limestone above it.

At E. Dorris', three miles north of the town, it is 5 feet thick, with 2 inches of clay parting, and with limestone above it.

At Mr. James Johnson's, 3 miles northwest of Providence, this coal is also 5 feet thick, with 3 to 5 inches of clay parting, and with limestone above it. The fire clay of the bottom is here full of crystals of gypsum. The iron sandstone, or base of the Anvil Rock, is 20 feet above the coal.

Lofland's coal bank, opened just behind the hill of Providence, is covered with a limestone only for a short distance within the entry, like the Clark's Mill coal. At the entry the section is:

	Feet.	Inches.
Shaly sandstone, (covered space) .....	10	-----
Limestone in irregular banks .....	1	3
Black bituminous shales .....	2	3
Brashy bituminous coal .....	-----	9
Clay parting.....	-----	1
Bituminous coal, with 3 inches clay parting.....	4	8
Fire clay to level of creek.....	2	-----

Mr. Lyon's section of this bank, (vol. 2, p. 319,) was taken at some other point.

At Dorris bank, coal 11th has the same irregular limestone, and the same distribution of coal and shales. Some pieces of the limestone are imbedded in a soft, grayish fire clay, and insensibly pass to a continuous bank. Where the limestone is not present, there is above the argillaceous clay a streak of 3 inches of black shales, probably of No. 12th.

Close to the Madisonville road, at Providence, it is worked at three different openings, with this association :

	Feet.
Covered space, shales and sandstone .....	20
Limestone in bank.....	2
Coal, with 3 inches clay parting .....	6
Fire clay.....	3

Below this fire clay, which is sometimes 4 feet thick, there is no trace of yellow limestone. The limestone of the roof of these banks can be followed in its irregularities to Lofland's and Dorris' banks. That those coal banks at Providence are the equivalents of Llwellyn's and Watson's banks, is put beyond question by the remarkable identity of fossil remains and the nature and composition of the shales.

At Bruce's Mill, three and a half miles east of Providence, a coal is worked, 18 to 20 inches thick, 7 feet below the surface. Near by, it has been struck 6 feet thick. It is entirely covered, and therefore I refer it with doubt to No. 11th.

At Mr. Hiram Kirkwood's, one half mile west of Mr. John Davis', are two outcrops of the same No. 11. The limestone above it is 6 to 8 feet thick. The coal is not seen; but near by, on the level with the outcrops, a bed of ochreous iron ore identifies the place. The top of the hills, at Mr. John Davis', is formed by 15 feet limestone overlaid at a short distance by 6 to 10 feet of shales, and then by 25 to 40 feet of the Anvil Rock Sandstone. This sandstone is here hard, coarse, weathered near the base in irregular holes and protruding bands, hardened by oxide of iron, just like the millstone grit at Caseyville, and the Mahoning Sandstone at Curlew and Pomeroy. Indeed, these three great sandstones have generally the same external appearance, and could scarcely be distinguished, if it was not from the nature and the place of the coal banks which they overlay.

At Mr. Randal Davis', about 500 yards northeast of Lamb creek, and one half mile south of Richland creek, this coal is 5 to 6 feet thick, with 9 inches clay parting, and no limestone above it. The base of the Anvil Rock Sandstone is 50 feet above the coal.

At Mr. John Davis', head waters of Lamb creek, one half mile south-east of the former, this coal is reported covered; the bed is now concealed from view. The shales have the fossils of this vein, and it has above it, also, the ochreous iron ore which generally overlays No. 11th in this part of the county. No. 12th is here 6 feet higher.

At Mr. B. Lafoon's, the red ochreous iron ore of No. 11th is 2 to 3 feet thick, and very rich; the coal appears to be absent here.

At Butts' gap, Davis' branch, on the land of the Hopkins and Mastodon company, this coal is 4 feet thick, and only 20 feet below the base of the Anvil Rock Sandstone. It has ochreous iron ore above it here also.

On the property of Henderson Seminary, at Barney's ridge, No. 11th coal crops out in close proximity to No. 12th, 25 feet below the base of the Anvil Rock Sandstone. Both veins are separated by 10 feet of the black shales of No. 11. No limestone is present in the hill; but the ochreous iron ore occupies its place.

On Price's and Johnson's land, near Rocky gap, No. 11th and 12th veins are in connection, 10 to 11 feet thick, with two clay partings. Behind the hill, the upper clay parting thickens to 6 feet, and thus both coal beds are distinct.

At a short distance from this bank, on the same property, there is a bed of cannel coal, said to be 4 feet thick, overlaid by 2 feet 9 inches of bituminous coal. It is referable to No. 11th by the fossil shells of its slates. It has above it some black band or ferruginous limestone. The appearance of this bank is different from the former and much like the cannel coal No. 11th, at Curlew. The bituminous roof shales are full of the same shells. Around Providence this vein has sometimes a few inches of cannel and the same appearance. The identification of this coal with No. 11th is from palæontological evidence more certain than that of the former, which has scarcely any fossils, and which might belong to No. 12th, in an abnormal state of development.

Arnold's bank, east fork of Steward creek, has been reported, and is mentioned only because, in examining it again, the limestone was found above it. It has generally two clay partings, and is now worked 8 feet thick. It is opened also at Mr. Bart Sisk's.

On Gamblin's land, on branch of Steward creek, this coal is scarcely opened so as to be seen, but has the drab-colored limestone below.

On northwest spur of Wright's ridge it shows itself, and all around the same hill, as well as on Buffalo Mount, on the property of Messrs. Town and Kirkwood, with yellow limestone below; but the exposure is only partial.

On the same land, at the head waters of Richland, this coal is 5 feet thick, with drab-colored limestone below and ochreous limestone above. It lies here 80 feet above the false black band.

On Box Mount, near Copperas Springs, Town's and Kirkwood's property, it is 6 feet thick, with ochreous iron ore above it.

Other expositions of this vein, so abundantly distributed in Hopkins county, are reported, vol. 3, pp. 546-7. Many more could have been mentioned, but for the impossibility of examining the shales, and thus identifying their palæontological characters.

*Coal 12th.* In its separate state from No. 11th, and with its proper characters, has been seen :

At Hunter's so-called black band, one mile north of Providence, where it is separated from Dorris' bank by limestone and shales; the coal is 3 feet thick, shaly, overlaid by some black band iron ore and bituminous cannel shales, full of *stigmaria*.

At Herrin's, half mile east of Providence, this coal is said to be 6 feet thick, mostly shales, with some poor coal, covered in part.

On the head waters of Lamb creek, at Mr. John Davis', it is not opened. This and the outcrop on Henderson Seminary land are mentioned with No. 11th.

At Burk Earl's bank, between Rocky Gap and Caney creek, coal brashy, roof shales very bituminous, full of *stigmaria* and stems.

At Town's and Kirkwood's, top of Buffalo Mount, said to be 30 feet above No. 11th, it is scarcely opened.

The Box Mount upper coal, and the upper coal near the Copperas Springs, on the property of Messrs. Town and Kirkwood, belong, from their position above No. 11th, to this vein. But they are, as yet, unopened.

#### DAVISS, HANCOCK, OHIO, AND BRECKINRIDGE COUNTIES.

Except the coal banks along Green river, which are reported with the Muhlenburg section, no other coal banks have been examined in these counties but those reported in the 3d volume. A few have been again visited without eliciting any new facts worth recording. Only at Bon

Harbor the re-examination showed, above the vein of coal, an irregular bed of limestone, underlying a streak of 12th coal. The hills around are topped by the Mahoning Sandstone.

GENERAL SECTION OF MUHLENBURG CO.

Anvil Rock S. S.	40 f.	
	15 f.	3 feet C. 12th.
3 f. L. irregular.	75 f.	5½ feet C. 11th.
	70 f.	4½ feet C. 9th, pl. of C. 8th.
	40 f.	13 inches C. 7th.
20 f. L.	20 f.	10 inches C. 6th
	70 f.	
3 f. L.		3 feet C. 5th.
Mahoning S. S.	100 f.	
	25 f.	4 to 5 feet C. 4th.
6 f. bl. ba. & L.	10 f.	
	30 f.	1 to 3½ feet C. 3d.
35 f. L. in 5 or 6 strata.	35 f.	1 inch C.
Gray metal or shales.	200 f.	
Millstone grit.	30 f.	

MUHLENBURG, PART OF HOPKINS, CHRISTIAN, AND BUTLER COUNTIES.

This section presents a remarkable difference from the former. The lowest coal, No. 1, with its divisions, and No. 2, are entirely wanting. Coal 3d is formed under a limestone sometimes containing a rich black band iron ore. Thirty feet below it, there is one inch coal, and then 6 or 8 feet of strata of limestone, in layers of from 3 to 4 feet thick, underlaid by about 200 feet of gray micaceous shales or *gray metal*, to the top of the conglomerate or *millstone grit*.

Though our veins Nos. 3 and 4 have such a peculiar palæontology, that it was not possible to mistake their characters, I would not admit as positive the total disappearance of both the lower coal beds, until I had followed the distribution of the measures along their southern edges, in Christian county, and especially spent in careful ex-

amination of south Hopkins county and Muhlenburg county, as much time as was necessary to elucidate the question by stratigraphical evidence. This evidence confirmed the conclusions drawn from palæontology, proving: that from the mouth of Caney creek, in the Tradewater river, along the southern edge of the basin, across Christian, Muhlenburg, and Butler

counties, as far as Morgantown, the only two workable coal strata are No. 3d and No. 4th, in close proximity.

Both the coal banks of Mr. Drue Wooldridge and of Mr. Larkin Campbell are acknowledged to be, in Christian county, the lowest beds, except, perhaps, a streak of coal reported by Mr. Campbell as cropping out in Casselbury creek, one mile south of his house. These two beds of coal are separated at both places by about 20 feet of measures, containing a limestone which varies in thickness from a few inches to 4 feet. At Mrs. E. Brasher's coal bank, on the same horizon as the lowest coal of Mr. Campbell, the limestone is partly replaced by a ferruginous chocolate-colored black band iron ore, identical with the Black-band of the old Pennsylvania furnace, in Muhlenburg county. The color, nature, composition, palæontology of that *band* is so peculiar, that it is not possible to mistake it for any other stratum. Moreover, it can be traced all along from Christian county to Muhlenburg county, where it is now opened in many places. At the old Pennsylvania furnace the distribution of the measures below the black band can be very easily followed on the back of an anticlinal structure, which has brought up the sub-carboniferous members, and exposed the lower measures down from the Mahoning Sandstone. From No. 3d, except a streak of a few inches, there is no trace of coal to the conglomerate.

If more conclusive evidence was wanted, numerous borings were made in the vicinity by Mr. Alex. Hendrie, when the furnace was in activity, and recently further west, on the land of Mr. Alexander. By these borings the nature of the measures has been ascertained for more than 300 feet below the black band. It is only limestone and gray metal to the millstone grit; and no trace of coal has ever been found in the space but the one inch vein already mentioned. It is probably the equivalent of the thin vein of coal seen in Casselbury creek by Mr. Campbell.

The first coal above the black band, or the upper Wooldridge coal, is covered by a bank of hard, somewhat conglomeratic, coarse sandstone, containing plants transformed into charcoal, (the Mahoning Sandstone.) This sandstone is thin at Mr. Wooldridge's, but increases in thickness to the north, along the old Buttermilk road. At Mr. G. Terry's, on branch of Buffalo creek, it is already 30 feet. At Mr. Roland Williams' it forms, above the coal, a bluff of about 40 feet. It is seen, as reported before, with the same characters, near the foot of Wright's ridge, over-

laying 3 feet of coal, and upon it are piled up the measures of the ridge, which can be followed to the Anvil Rock Sandstone, which caps the ridge.

On Mr. Alexander's land, near the old Pennsylvania furnace, borings were made from the top of the Mahoning Sandstone to the black band, which was reached 20 to 25 feet below No. 4th coal, just underlying the Mahoning Sandstone, which is here 76 feet thick; and the measures, from the boring, or even from the base of the sandstone, can likewise be followed in exposed stratification, at and around Greenville, up to the Anvil Rock. Though it is probable that at Messrs. Wooldridge and Campbell's, coals No. 3d and No. 4th come nearer to the sub-carboniferous measures than at the old Pennsylvania furnace, yet these coals, even if they were not so positively identified by palæontology and stratigraphy, could not be mistaken for any of the lowest veins, which are never accompanied by such strata as the limestone above the 3d vein, and the hard, thick, conglomeratic sandstone above the 4th.

The upper division of the measures, as marked in the section, is, like the lower, elicited by a series of borings and of stratigraphical observations. It gives thus a true representation of the upper coal measures in the southwestern part of the western coal basin. Except that the strata are somewhat reduced, and that two banks of shales and sandstone are replaced by limestone, the distribution is about the same as marked on the section of Union county. The two banks of limestone placed in Muhlenburg county, between 5th and 6th coals, are very variable in their distribution. The upper one attains its greatest development at Greenville, thins to the northwest, being at Airdrie 4 feet only. At Vallandingham's it is in two parts, one and two feet thick, separated by 5 feet of fire clay. The lower limestone, marked on the section just above coal 5th, is generally replaced south of Greenville by a bed of carbonate of iron. But it is formed at Airdrie  $1\frac{1}{2}$  foot thick.

Muhlenburg county shows in its geological distribution some analogy to Greenup county, viz: a thinning out of the measures by the appearance of limestone beds and iron ore, which take the place of great banks of sandstone developed elsewhere. As this metamorphosis is still more marked and defined in Greenup, it will be examined in discussing the general section of that county.

*Coal 3d.* In its last exposure to the south, it is so near the surface

that it is worked by stripping. The roof shales, grayish, soft, easily broken, contain at Mr. Larkin Campbell's and at Mr. Woolridge's a great quantity of the stems and leaves of this vein. The upper part of the shales is chocolate colored, very hard, and shows the first appearance of the black band.

It was examined also: At Mrs. Aquila Brasher's, where it comes to 2 feet from the surface, and is 2½ feet thick. The gray shales are pulverized by infiltration and atmospheric influence.

At Mr. G. Terry's, half a mile southwest of Mr. Waugham's entry, on Buffalo branch, the partially opened coal is 2 feet thick. It is also in the creek 25 feet lower than Mr. Waugham's coal bank.

It is probable that the coal bank of Mr. Archibald Bourland belongs to this vein; but it is covered, and could not be examined.

Near the old Pennsylvania furnace this coal is only 1 to 2 feet thick. At one place it ascends by a curve to No. 4th, and near the point of junction both beds of coal disappear, and are replaced by a bed of carbonate of iron.

Coal 3d has been found many times by borings on the land of Mr. Alexander, always from 20 to 30 feet lower than No. 4th. About one mile southwest of the old furnace, it is beautifully exposed with the black band, as follows:

	Feet.	Inches.
Sandstone passing into gray metal.....	8	7
Carbonate of iron and soft shales.....	3	
Black, soft, brittle shales, with <i>Lepidodendron</i> .....		8
Black band iron ore.....		10
Black, soft shales, with plants.....	6	
Coal, (bituminous).....	2	6

At Williams' landing, on Green river, the black band, says Mr. A. Hendric, is below 2 feet 6 inches of black slates, and a bed of coal is placed 33 feet lower. On the Williams section, vol 1, p. 143 of the Reports, the coal brash, 2 feet 6 inches, is placed below the black band, and, following the same authority, it ought to be placed above.

*Coal 4th.* Has been examined—

At Drue Wooldridge's and Larkin Campbell's upper coal banks. The excellent quality of this 4th coal is remarked every where it has been worked. At both the openings it is three feet thick:



At T. and T. W. Waugham's, 1 mile west of Terry's entry, on Buffalo creek, where the coal is  $4\frac{1}{2}$  feet thick. The shales above it are covered with the characteristic plants of this vein :

At G. Terry's coal bank, near the Buttermilk road, 1 mile from his house, on Buffalo creek, the coal is  $4\frac{1}{2}$  feet thick at two openings, covered with shales and sandstone :

At Mr. Roland Williams', half a mile west of the former, the same coal is opened under a high bank of sandstone. It is roofed by the shales with plants :

At Widow Humphrey's, 3 miles southeast of Greenville, this coal is not well exposed, and said to be  $3\frac{1}{2}$  feet thick. It is referable to this vein from the Mahoning Sandstone seen above it.

On Mr. Alexander's land, about 4 miles southwest of Greenville, some four to six openings of this coal, 4 to 5 feet thick, mostly without shales, are overlaid by the Mahoning Sandstone. The Eade's coal, 2 miles distant, has above it the fossiliferous shales, like Terry's and Williams' coal banks. At Mr. W. Evans', it is 4 feet thick, just under sandstone. It has been reported above as the coal worked for coke for the old Pennsylvania furnace.

This vein is crossed in Williams' boring, on Green river, under 36 feet of sandstone. In the Airdrie shaft, it is probably only a coal streak below a sandstone 23 feet thick, and in this case the black band would be marked by black slate and iron stone, with two thin coals, at  $130\frac{1}{2}$  feet of the boring. This boring completing the section, vol. 3, p. 24, from the base of the shaft, is as follows :

	Feet.	Inches.
Shales, blaes,* and sand rock .....	9	9 $\frac{1}{2}$
Gray micaceous shales, gray metal, &c. ....	17	5 $\frac{1}{4}$
Hard rock .....	5	7
Soft sandstone rock .....	2	5
Sandstone .....	18	9
Gray micaceous shales, (fakey and blaes) .....	11	10 $\frac{3}{4}$
Sandstone .....	3	8 $\frac{3}{4}$
Gray shales .....	1	5 $\frac{1}{4}$
Sand rock and shaly sandstone .....	17	8 $\frac{3}{4}$
Hard rib .....		3
Coal streak .....		1 $\frac{1}{2}$
Sandstone .....	5	4 $\frac{3}{4}$
Shales, gray metal, and blaes .....	31	10 $\frac{1}{4}$
Black slate, black band? .....	3	4 $\frac{3}{8}$
Iron stone, black band? .....		5 $\frac{3}{4}$
Coal, divided by a streak of sulphuret of iron .....	1	6
Sandstone and shales .....	9	
Balls .....		9
Gray metal and shaly sandstone .....	27	10 $\frac{1}{4}$
Alternating iron balls and shales .....	19	7 $\frac{3}{4}$
Coal .....		5
Gray metal and shales .....	26	10

From base of shaft, 216 feet.

\* Term used by the English miners. Like fakey, it indicates a schistose clay, or clay shales.

*Coal 5th.* Is placed at Greenville, near the top of the Mahoning Sandstone, at the base of the great limestone. It is seen 1 mile from the town, on the Hopkinsville road, where the shales only are exposed.

At Mr. Robertson's coal bank, 3 miles south of Greenville, it is 18 inches thick, with 5 to 6 feet black shales above it.

*Coal 6th.* It crops out at Greenville, just at the top of the limestone, with its peculiar micaceous gray shales, blackened with broken plants. It was found also in Mr. Short's well, at 45 feet from the surface. Near the old Pennsylvania furnace, it is exposed 6 to 10 inches thick in the same gray metal.

From the nature of the shales and broken plants, I refer to this vein Mr. E. S. John's coal, near the Buttermilk road, Hopkins county. The coal is about 4 feet thick, very good for blacksmithing, and is opened at two places on the same property. It is probably the coal cropping out in the bed of Caney creek, one mile northwest of Greenville, where it is 13 inches thick. The bed of coal at the Vallandigham boring, 3 feet 6 inches thick, below black shales, at 50 feet from the surface, is also referable to No. 6th.

*Coal 7th.* Was passed at Greenville, in Mr. Short's boring, about

25 feet above the former. It crops out also near the old Pennsylvania furnace, 40 feet above the limestone, but is only a few inches thick.

*Coal 8th.* Or false black band, was seen only in Muhlenburg county, as reported before, at Mr. E. B. Veirs', where it has only black shales and a few septaria. There is an abundance of shells and fish remains in the shales.

*Coal 9th.* About 3 miles northwest of Greenville, it is finely exposed on Messrs. Veirs & Rickett's land, 60 feet below No. 11th coal,  $4\frac{1}{2}$  to 5 feet thick, without clay parting. No trace of No. 10th was seen above this vein, nor has it been observed in Muhlenburg county. This 9th coal is also found in the hills, 20 feet above No. 8th, at Mr. E. R. Veirs'.

At Vallandigham's, on Green river, it is only one foot thick, 50 feet below 11th.

At Lewisport boring, it is found six feet ten inches thick.

At and around South Carrollton, it is not formed.

At Taylor's mines, below Cromwell, it is 50 feet below the main coal No. 11, with its characteristic shales well developed. Coal 3 feet thick.

At Mr. Cook's mines, above Livermore, Ohio county, the same No. 9 is found 50 feet below No. 11, where it has been reached by a shaft, and is 5 feet thick.

*Coals 11th and 12th.* Outcrop on Veirs and Rickett's, with 15 feet of distance between both. Some boulders of limestone appear above No. 11th.

Coal 11th is worked near by at Mr. Hugh H. Martin's, 3 miles northwest of Greenville,  $5\frac{1}{2}$  feet thick, with two clay partings. It is roofed with a limestone 2 to 3 feet thick. Coal 12th is seen in the hills above No. 11th, but thin.

At Mr. Th. Withers' outcrops, and at Mr. Andrew Glenn's, on the road from Greenville to Paradise, coal No. 11th is 4 feet thick. At Mr. Glenn's it is opened and has above it some boulders of limestone, with abundance of shells. Near by, the limestone is replaced by the ochreous iron ore of Hopkins county. In Mr. Glenn's well coal No. 9th was reached 50 feet below No. 11th.

Both 11th and 12th veins have already been reported at Airdrie, where the ochreous iron ore is also found, sometimes at the place of the limestone above No. 11th; and also at Clark's mill.

At Vallandigham's coal 12th is seen near the top of the hills, with its black band, and No. 11th is opened 15 feet below it, and has a roof of limestone.

At South Carrollton, No. 12th is also formed 2 feet thick, with iron stone above it, and No. 11th is 30 feet lower, apparently cannel.

At Taylor's mines No. 11th is  $4\frac{1}{2}$  feet thick, just at the base of the Anvil Rock Sandstone. It is covered by two feet of its black, crumbling shales, with abundance of shells. No. 12th is marked in the sandstone by a streak of coal 6 feet above No. 11th.

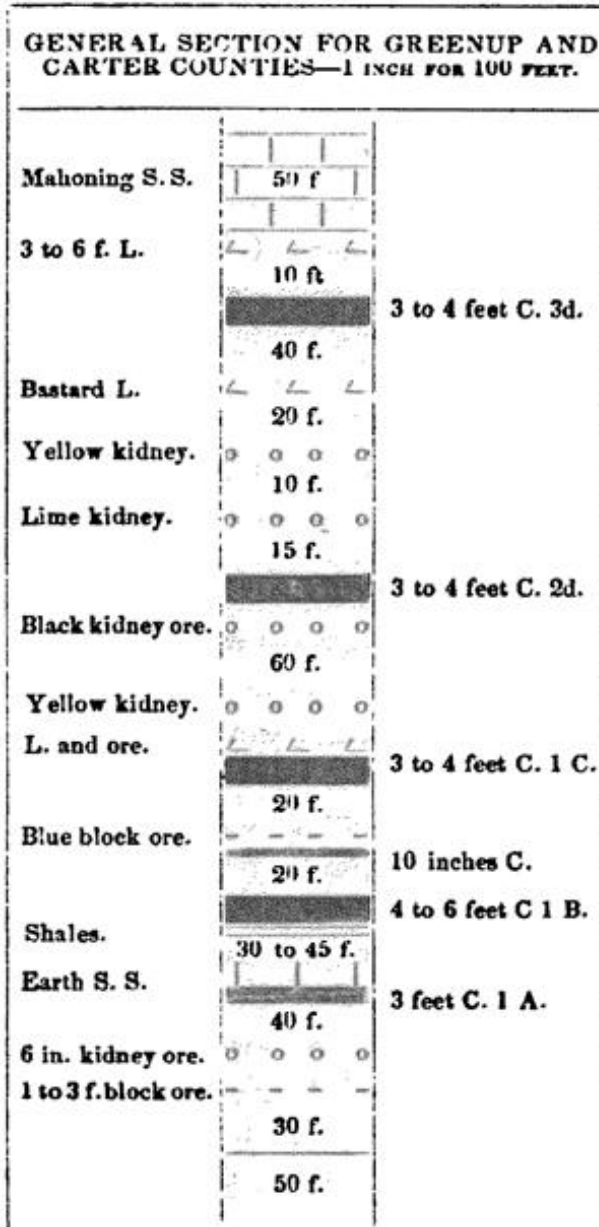
The Rough creek coal mines of Mr. Cook, as also the Eberly coal mines in the ridge on the other side of Green river, belong to No. 11. At Mr. Cook's the coal is about 35 feet below the Anvil Rock Sandstone, and at Eberly's ridge this sandstone covers the shale of the coal as at Taylor's mines.

At Cook's mines the coal is  $4\frac{1}{2}$  to 5 feet thick, overlaid by a roof of cannel shales, and some small boulders of limestone, or rather of septaria. On both sides of the river the shales have abundance of their characteristic fossils, and the coal has a tendency to cannel. Mr. Cook has opened his vein at three different places, and found it of the same quality and thickness. The top of the Anvil Rock Sandstone, near one of the openings, is covered by a fossiliferous gray limestone.

It is not possible to make a just appreciation of the mineral wealth of Muhlenburg, Daviess, and Ohio counties. The difficulty of profitably using or transporting the rough material dampens the interest of the proprietors, and prevents careful researches. It is only along Green river that the coal has been worked with some activity, and the great amount of coal and iron ores recorded in the shaft and boring of Airdrie is a fair indication of what may be found in the interior of those counties.

#### GREENUP AND CARTER COUNTIES.

Greenup county deserves the first place in the whole State of Kentucky for its mineral wealth. It has, in abundance, beds of iron ore of excellent quality, thick veins of fat cannel coal; and, with this, a most favorable position along the Ohio river, which facilitates the transportation of the produces of its mines, already transformed by its numerous furnaces and oil factories. It would be pleasant to dwell on the prospects of future prosperity offered to such a county by the increase of an industrious population. But the task of the Geologist is to find out, to



examine, not to follow those springs of wealth, which industry only knows how to guide and to regulate for the best advantage of a country.

The formation of the numerous veins of iron ore which cover the whole extent of Greenup county, the northern part of Carter, in Kentucky, with the south of Scioto county, in Ohio, is a geological problem of the greatest interest. It has been supposed that those deposits of iron ore are due to the agency of marine currents, acting along a shore, and transporting the materials from a distance. But all the veins of iron of Greenup county indicate a quiet deposit, and do not show any trace of disturbance. Numbers of these veins, placed at different horizons, are covered with soft black shales stratified, and, consequently, were deposited in a quiet body of water. Even some of the richest ores are locally inter-

mixed with a quantity of roots of *stigmara*, of which the leaves are extended in their natural position—a proof that they have never been disturbed by any movement of the water. At the epoch of the formation of the coal, all the country now under examination must have been a lake, an inland lagoon, full of low islands, covered with the vegetation of the coal marshes. As it happens now in the formation of the bog iron ore around the peat bogs of our formations, the iron was in a process of constant chemical formation and agglomeration around the marshes of the coal epoch, in such places where the water was too deep for the growth

of the plants. In following the distribution of some of the coal beds of Greenup, they are found to run into or lose themselves in beds of iron ore, generally placed somewhat lower than the coal. It is especially the case with coal 1 C.

If the peculiar distribution of the ores and coal strata of Greenup county was general all along the edges of the eastern coal fields of Kentucky and Ohio, it would be perhaps reasonable to draw the conclusion that these shallow marshes or low islands did form the true limits of the eastern coal basin, and consequently that the great Silurian ridge, which separates both coal fields of Illinois and Ohio, was already formed at the coal epoch. But there is no similar formation any where along the edges of the coal basins of Kentucky, (except perhaps a small area in Muhlenburg county,) neither to the south in Morgan, Breathitt, Owsley, nor in Ohio, except adjacent to the Ohio river, opposite Greenup county. On the contrary, iron deposits of the same nature are found in abundance in the centre of the great Apalachian coal basin, where the coal formations are continuous. This is, therefore, a local formation, which has nothing to do with the laws of distribution which have governed the whole.

Contrary to assertions, I find in Greenup county more evidence of the upraising of the coal measures against the Silurian ridge, and consequently a proof of the separation of the great basin by an upheaval posterior to the formation of the coal. Six miles west of Greenupsburg, the sub-carboniferous limestone is exposed at the top of a high hill, about 400 feet above the Ohio river. A strong dip to the east soon brings it at the level of Tygert's creek, where it disappears. At White Oak creek, coal 1 A makes its first appearance in the hills, and crops out at Coal creek, nearly at the high water level of the Ohio river, 2 miles west of Greenupsburg. Henceforth the general dip to the east discontinues, as far at least as the mouth of Big Sandy, and is replaced by gentle undulations, of which the highest point is no more than thirty feet above the general water level of the country.

Greenup county has been, till lately, considered as especially abounding in productive iron ores, but deprived of valuable deposits of coal. The opening of the railroad traversing the county from Ashland to Grayson, and the impetus given to the search for cannel coal, by its use for the fabrication of oil, have caused the discovery of so many new coal banks, that now this county may be regarded not only as possessing

a number of workable coal beds, but as having probably the thickest strata of cannel coal in Kentucky. It is, therefore, convenient to correct a few of the sections formerly given by the addition of the new opened coal banks.

The section at Amanda furnace is one of the most interesting in Greenup county, from the beautiful display of mineral strata, veins of coal, beds of iron ore, of limestone, and of fire clay, which are exposed on the same vertical plan on the hill facing the river behind the furnace. The section is :

	Feet.	Inches.
Top of the hills, covered space.....	20	
Coarse, soft, ochreous iron ore.....		10
Coal not opened, C. 3?.....	3	
Covered space, shales and sandstone.....	26	
Small vein of kidney ore.....		2
Shales and shaly sandstone.....	25	
Yellow kidney iron ore.....		6
Covered space, shales and sandstone.....	5	
Lime, kidney iron ore.....		10
Sandstone and yellow shales.....	17	
Main Amanda coal bank, with clay parting, C. 2.....	4	
Shales and shaly sandstone.....	30	
Hard compact sandstone.....	13	
Gray soft shales.....	4	
Black soft shales without fossils.....	2	
Fire clay.....	2	
Kidney iron ore.....		3
Alum fire clay.....	5	5
Limestone ore.....	3	
Limestone.....	4	
Slates and shales.....	20	
Clay.....	2	6
Slate or kidney ore, with black soft shales.....		10
Cannel coal, with clay parting, 3 to 4 inches 1 B.....	5	
Covered space, shales, &c.....	18	
Earth, sandstone, and plants.....	15	
Black shales and Lepidodendron.....	4	
Bituminous coal, 1 A.....	2	8
Fire clay.....	2	
Shales.....	18	
Black shales, with 2 inches kidney iron ore.....	18	
Fire clay.....	2	
Block ore.....	1	

Space covered to low water of the river about 50 feet.

The section at Chinch creek, between Steam furnace and the Old Fulton forge, shows the distribution of the coal strata in a still more favorable light. It marks the place of the more important strata of Steam furnace, and is as follows :

	Feet.	Inches.
Top of hills, space covered, sandstone and shales.....	50 to 75	-----
Sandstone and shales.....	8	-----
Coal, bituminous.....	1	3
Fire clay.....	2	-----
Iron ore.....	1	-----
Lime-stone, irregular, often absent.....	1	-----
Shales and sandstone.....	40	-----
Kidney slate or top ore of Steam furnace.....	1	-----
Space covered.....	10	-----
Coal, No. 2d.....	2	-----
Shales and slates, No. 2.....	4	-----
Coal, No. 2d.....	2 to 3	-----
Shales and sandstone.....	75	-----
Bituminous slate, No. 1 C.....	1	-----
Shales and sandstone.....	15	-----
Black slates with Flabellaria, &c., No. 1 B Chinch coal.....		10
Cannel coal in blocks, No. 1 B Chinch coal.....	4	4
Black shales and plants, No. 1 B Chinch coal.....		8
Bituminous coal, No. 1 B Chinch coal.....		3
Black slate parting, No. 1 B Chinch coal.....		4
Bituminous coal, No. 1 B Chinch coal.....		10
Block ore at Steam furnace, where coal B is absent.....	1	-----
Sandstone, shales, and gray metal.....	38	-----
Coal No. 1 A, 3 feet coal, 1 foot shales above.....	4	-----
Covered space, shales, sandstone, and gray metal.....	60	-----
Coal or cannel shales.....		4

At Steam furnace, this last streak of coal is 20 feet below the surface in a well. At Chinch creek, it is just at the level of the creek. Here the distance to the base of No. 1 B is just 100 feet. At Steam furnace, where the coal 1 B is not formed, the distance from this streak of coal to the block ore, or place of No. 1 B, is also 100 feet. Where this block ore is found, the coal is generally absent.

No trace of coal has been seen in Greenup county below the millstone grit or conglomerate. The examination of the coal banks of the county begins, therefore, with No. 1 A.

Coal 1 A seen opened at—

Mr. S. Bradshaw's, near the bed of Indian creek, 3 feet thick, with 6 inches clay parting, and a roof of shales.

At Chinch branch, on the land of the Maysville Coal and Oil Company, where it is 3 feet thick and bituminous, overlaid with sandstone.

Near Steam furnace, at Mr. G. Davidson's, coal 4 feet thick, with one foot clay parting, and a roof of black shales above it.

At Ulin's branch, one and a half miles below Steam furnace, and near by at the head waters of Ramsey hollow. Here the coal, under black shales 2 to 3 feet thick, is now hid by a slide of the bank.



Dr. Spalding's coal, 8 inches thick, covered with the black shales, has the characteristic *Lingula* and *Lepidophylla*. It is exposed on the road from Greenupsburg to Raccoon furnace.

At Raccoon furnace, in the bed of the creek, coal 8 inches thick.

At Coal creek, one mile above its mouth, at Mr. Richards', coal 18 inches thick. The roof is a thick stratum of black shales overlaid by a sandstone, full of plants.

At Mr. W. England's coal bank, on Slash branch, same thickness and characters as the former.

At Caroline furnace, coal 15 feet above the creek, mostly roofed by sandstone, sometimes with one foot of shales. It varies in thickness from 1 foot to 18 inches.

On branch of Oak creek, on the road to Amanda furnace, Hammer's coal, 18 to 24 inches thick, under its sandstone. At this place the coal looks better than at Caroline furnace.

At Amanda furnace, coal 10 to 18 inches, under black shales. It has some coal brash at its bottom.

Around Buena Vista and Greenup furnaces this coal, 8 to 14 inches thick, is seen at some of its outcrops, near the branch of the creek, mostly overlaid by sandstone. At Bush creek it is 2 feet thick.

At Catlettsburg, 25 feet below 1 B, a coal is exposed in a deep ravine, about half a mile east of the town, and, from its position, is referable to this 1st A vein. It appears roofed by fire clay and iron ore, and 6 to 8 inches thick.

From Catlettsburg to Grayson, along the railroad, this coal is not seen; but at Grayson it is exposed on Dr. Lansdown's property, near his house, coal 1 foot thick, 50 feet above low water of Little Sandy, where the top of the millstone grit is exposed. This is the only place where this coal was examined in Carter county.

*Coal 1 B.* In Greenup and Carter counties it was examined:

At Chinch creek, Maysville Coal Oil Company, where four openings have been made into the cannel coal, which is 4 to 4½ feet thick, as reported on the section.

At Indian creek, where the bank is now concealed by debris, but seems to have the same characters as the former. The section is given by Mr. Lyon, vol. 3, p. 456.

On Col. Bradford's and Geo. Wurtz's land, two miles south of Fulton

furnace, where two entries have been made into the same cannel coal as the former. The coal is there  $3\frac{1}{2}$  feet thick.

In the bed of Whetstone creek, near Mr. John Steward's house, where it is 6 to 10 inches thick, half cannel, half bituminous, with abundance of fossil plants in the shales.

One and a half miles south of Raccoon furnace, where the cannel coal is 18 to 20 inches thick, and its shales are full of *Flabellaria* and *Lingula*. Here are two openings in the bank. On the land of Raccoon furnace the section is:

	Feet.	Inches.
Hard sandstone .....	6	
Bituminous coal .....		6
Black, bituminous, and micaceous shales, with plants and <i>Lingula</i> .....	3	
Cannel coal .....	1	6

Half a mile from this place, on the land of Buffalo furnace, it is:

	Feet.	Inches.
Gray micaceous shales .....	1	
Bituminous coal .....		2
Gray shales, with plants .....	2	
Cannel coal .....	1	
Bituminous coal .....		2

Near Raccoon furnace, 40 feet above No. 1 A, it has the same characters, and is 8 inches thick.

At Amanda furnace, on the hills facing the river, coal 1 B is represented only by the black bituminous shales bearing plants, especially *Flabellaria*. But back in the hills it is finely developed. 1st. At White Oak branch, 3 feet thick. It is here cannel coal, with a roof of soft shales, entirely covered with *Flabellaria*. 2d. At head waters of Pond run and Indian run, with the same characters. 3d. At Davidson's hollow, 4 miles west of the furnace, coal 4 feet thick, hard cannel, appearing entirely formed of *Flabellaria* and *Stigmaria*, visible in the coal; roofed with coarse micaceous gray shales. 4th. At Salisbury's hollow, 6 miles from Ashland,  $2\frac{1}{2}$  miles from railroad, coal  $4\frac{1}{2}$  feet thick. One foot of it is bituminous, separated by four inches clay parting from  $3\frac{1}{2}$  feet fine compact cannel. 5th. Below Mr. Wm. Morrow's house, on east fork of Little Sandy, where it is half bituminous, very shaly, about

5 feet thick, covered by black slates and overlaid by 12 feet of gray micaceous shales. The same vein crops out in the hills around in various stages of development.

Along the railroad from Ashland to Grayson, it is seen in near proximity with C. 1 C, (sections, p. 43, and Rep. 2, p. 355.) At Star furnace and Kilgore's, it is near the base of the hills connected with 1 C.

Around Buena Vista, on the land of Mr. Means, it is under gray micaceous shales, mostly in two members. The upper part, 8 to 14 inches, is coarse cannel coal or cannel shales; the lower part is bituminous coal, 1 foot thick. On Bush creek the cannel coal is fine, but only 6 inches thick. On Williams' creek, near Mr. Green's house, it has also fine cannel coal, ten inches thick.

At and around Greenup furnace, this coal takes a great development. It is opened at many places, and now worked for its cannel, rich in oil, and of excellent quality, (sect. p. 42.)

Near Hood's creek, on the land of the Bellfonte furnace, coal 1 B is worked 2½ feet thick, bituminous. It is roofed by brashy coal and gray shales, and placed 20 feet above earthy sandstone. It has above it three different coal stains, separated by fire clay and iron ore in a space of 21 feet.

On the land of the Pennsylvania furnace, this coal is apparently connected with No. 1 C. Its palæontology is obscure. At least, I did not find characters evident enough to place its different members with certainty. The section is :

	Feet.	Inches.
Yellow shales and sandstone, covered space.....	10	
Black bituminous soft shales.....		6
Bituminous coal.....	1	
Slate parting with few plants.....		6
Bituminous coal.....		6
Fire clay parting.....	1	
Bituminous coal.....	1	
Cannel coal.....		6
Fire clay.....	2	
Black shales.....	15	
Bituminous coal in bed of creek.....	1	

Near Catlettsburg, coal 1 B is opened on Horse branch, near the Ohio river, where its roof of gray shales is covered with beautiful specimens of its plants. Along Catlett's creek there are two other openings into

this vein. At the three openings the coal is bituminous. (Vide sections in Mr. Lyon's report, vol. 2, pp. 357-8.)

At Clinton furnace it is only a thin coal, half cannel.

At Grayson, Carter county, it has been worked in the hills for the salt works of Dr. Lansdown. It is there 3 feet 9 inches thick, with 3 to 4 inches clay parting. It appears to be covered with black bituminous cannel shales. The bank is now covered by a slide, and could not be fully examined. Along Little Sandy, above Grayson, this coal crops out at many places, and is said to be always cannel.

At Mt. Savage furnace coal 1 B is seen covered with gray shales, full of plants, near the bed of Pritchard's creek, half mile from the furnace. On the same hill, above this bank, the main coal is not formed. Behind the furnace, coal 1 B keeps its place by its shales and plants only, but it has no trace of coal; and the main coal makes its appearance 20 feet higher, separated from the shales of No. 1 B by a bank of sandstone. Both Pritchard's coal in creek and main coal must be referred to two divisions of No. 1 B. The main coal has at its bottom a brash coal, with abundance of plants. This is exactly, though in a larger scale, the same position as that of the veins of Stillwater, mentioned above, (page 40.)

*Coal 1 C.* As a separate vein, it has already been reported around Buena Vista and Greenup furnaces, generally 20 feet above 1 B. It is seen also, but unopened, on the land of Bellfonte furnace, and especially along the railroad from Ashland, at a variable distance from 1 B. It is worked 3 feet thick, just above the railroad, at Mr. Rouse's.

All along the Ohio river its place is occupied by a limestone, and the coal is not formed, or is thin. In the hills behind Ironton, in Ohio, it has black cannel shales and 10 inches coal.

I refer also to this vein a thin coal at Catlettsburg, 45 feet above 1 B, and the main coal of Clinton furnace, 30 feet above the cannel coal 1 B exposed in the creek. The black bituminous shales of Mt. Savage furnace, evidently belonging to C. 1 C, have already been mentioned.

*Coal 2d.* Is probably the vein badly opened at the head waters of Chinch creek, separated in two parts by 4 feet of shales, with plants. Each part of the coal is 15 inches to 2 feet.

On Whetstone creek, at Mr. John Steward's, it is opened 1 to 3 feet thick, at six different places, sometimes half cannel.

At Raccoon furnace its place is marked 100 feet above the creek by a streak of coal and a bank of shales.

This vein is worked as the main Amanda, the main Ironton, and the main Ashland coal, up in the hills, generally 4 feet thick, including a clay parting.

At Buena Vista furnace, it is opened above the church, 3 feet 8 inches thick, with a 3 inch hard shale parting.

At Catlettsburg its place is not marked, unless it be by a replacing limestone.

At Star furnace and Kilgore's, it varies in thickness from  $3\frac{1}{2}$  to 5 feet, including clay parting, and is 90 feet above coal 1 C.

At Stinson's hills, and at Mt. Savage furnace, it is marked by a stain of coal or a bed of shales, about 75 feet above coal 1 C.

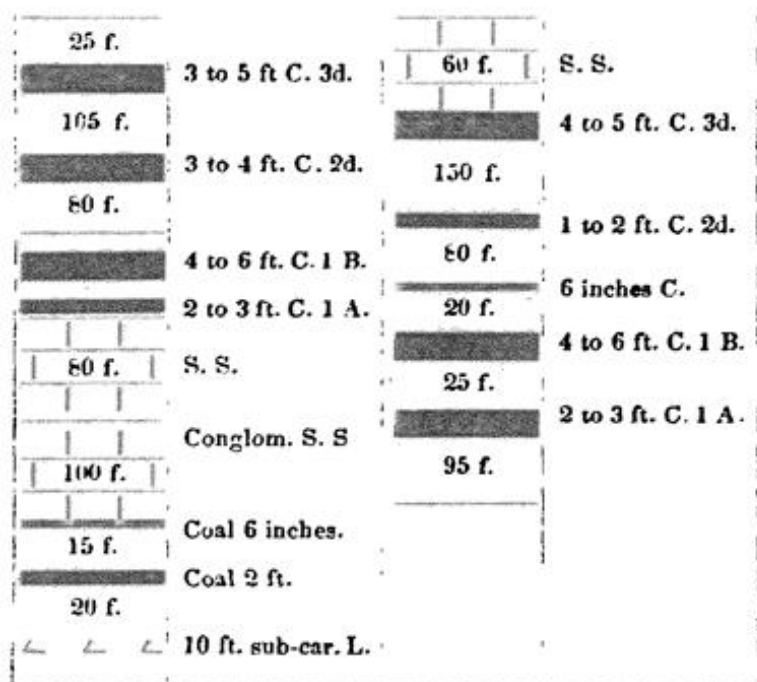
*Coal 3d.* Except at Stinson's hills and above Grayson, both places already reported, this vein is not worked any where in Greenup and Carter counties. The general remarks contain all that can be said about these banks. The beds of coal marked three feet and unopened, both at the top of the Amanda and Buena Vista sections, are referred to it, as well as the top coal banks of Raccoon furnace, and of Mr. J. Steward, at Whetstone creek.

*Coal 4th.* It has not been identified in Greenup and Carter counties, where the hills are generally too low to contain it. It may be also that it has not been formed in that part of the country. In Ohio, opposite Ashland, the Mahoning Sandstone tops the hills without any coal at its base.

## MORGAN, BREATHITT, AND PART OF OWSLEY.

The disposition of the coal strata in these counties is not materially different. The section of Morgan county begins lower, and shows two

GENERAL SECTIONS OF MORGAN AND BREATHITT COUNTIES.—1 INCH FOR 200 FEET.



beds of coal below the conglomerate. The section of Breathitt begins above the conglomerate, and its upper coal No. 3 is at a somewhat greater distance from No. 2. It shows already the increasing development of the coal measures to the southwest.

Morgan and Breathitt counties have certainly a great abundance of coal. Most of the creeks, in these counties, are strewn

with pieces of coal, detached from unopened, mostly unknown, strata buried in the hills.

What was said of Muhlenburg, Ohio, and Daviess counties of the western basin, is also true for this part of the eastern coal fields. A few mines are worked near Jackson, for the trade of the Kentucky river, navigable for barges in the winter months; a few entries have been made also around West Liberty for an occasional transportation on the Licking river. But except this, there is at present very little trade in the coals of these counties. Their inexhaustible deposits of combustible mineral will, at some future time, become of great value, at least for home industry. The numerous outcrops reported below are only a specimen of this mineral wealth.

The coal strata below the conglomerate have already been reported. Our examination, therefore, begins with:

*Coal 1 A.* In Morgan county it has been seen—

At Old Latham coal bank, head waters of Glady creek.

On the road from Hazlegreen to West Liberty, in the bed of Grassy creek, with black shales above it, but still unopened.

On Little Caney, coal 8 to 12 inches thick, overlaid by 15 feet of black shales.

On waters of Caney, near Judge W. Lykins' house, coal 3 feet 2 inches under sandstone.

On the same creek, and two miles below the former, coal 2 feet thick under 8 feet of black shales.

One mile southeast of West Liberty, near the guide post, on the road to Louisa, coal 18 inches thick, with black shales above it.

In Breathitt county coal 1 A is, at Jackson, 18 inches thick, or more. The bank has been worked, but is now covered.

On Quicksand river, three outcrops of this vein have been reported with the sections. Another outcrop is seen on South's and Breck's claim; coal 14 inches thick, roof of black slates.

On Troublesome river, two outcrops of the same coal have been mentioned. There is still another, near the mouth of the river, in connection with No. 1 B.

On Cane creek, No. 1 A is only 4 to 6 inches thick.

On Puncheon Camp fork, it is 15 inches, and on Middle fork of Kentucky river, 1 foot, still covered with black shales.

In Owsley county, this coal crops out at Jett's and Meadow's creeks, as reported; coal 1 foot thick.

I could not ascertain if both the coal banks, the one at Booneville and the other on Back creek, three miles from the town, belong to this vein. At Booneville, the coal is said to be 20 inches, bituminous. It is covered with 3 feet of micaceous shales, without plants, overlaid by 8 feet of hard sandstone, with plants; very probably the sandstone of No. 1 A. Both coal banks were under water.

Coal 1 B, and its divisions, was seen in Morgan county, two miles south of Hazlegreen, where the gray shales only, with abundance of their characteristic plants and fruits, are exposed in the bed of a branch of Red river. Probably there is a coal under the shales. Among the plants examined, there was an abundance of *Sphenopteris artemisiæfolia*, Brgt., very rare in the American coal fields, though common in Europe, and a new *Odontopteris*, found also in Illinois, near St. Louis, on the same geological horizon.

On a branch of Stillwater, this coal has been reported before, as well as the opening on Blackwater creek.

On Nicholas' fork of Grassy creek, coal 6 inches.

On Little Caney it is of the same thickness, and separated from coal 1 C, 3 feet thick, by 30 feet of shales. This last coal is full of stems and poor. Many other outcrops of coal 1 B are seen along Little Caney; but they are generally thin.

On Elk creek, half a mile southeast of West Liberty, coal 1 B is connected with coal 1 A, about 18 inches thick, in two beds. On the same creek, at Mr. Robert Casca's, a vein of coal 1 foot thick, and another at Mr. Harrison Cole's, entirely cannel, and said to be 4 feet 8 inches, were covered, and could not be fully examined. They are referred to this vein with doubt.

At low water of the Licking, near West Liberty, the upper part of 1 B is 6 inches thick. It has above it the shales with the plants.

On Mordecai creek, at Mr. S. Schoolfield's, No. 1 B is finely developed, and mostly cannel coal, three to four and a half feet thick, at 6 different openings. No. 1 A is placed there 20 feet lower, as reported in the section of that coal.

At Mr. Wm. Davis', 3 miles southeast of West Liberty, on the waters of Caney, this vein has 2 feet of bituminous coal, and further up, at Mr. Allen Cassidy's, 15 inches.

On the land of Judge Lykens, waters of Caney, it is beautifully exposed at seven or eight different openings, mostly cannel coal. The distribution is generally thus:

	Feet.	Inches.
Micaceous shales or shaly sandstone of various thickness.		
Bituminous coal and black shales.....		10
Gray shales with the plants.....		6
Cannel coal.....	3	
Bituminous coal.....		8

At one of the openings, the coal is all bituminous, though in two parts, and only two feet thick; and at a short distance on the same level, the coal is cannel and 4 feet 3 inches thick. Down the creek it is seen near the road much divided, as follows:



	Feet.	Inches.
Gray metal and shales, with some plants.....	30	
Hard micaceous shaly sandstone, without fossils.....		3
Bituminous coal.....		2
Clay parting.....		2
Bituminous coal.....		4
Black soft shales, with plants.....		2
Bituminous coal.....		9
Soft fire clay, with stigmaria.....		8
Bituminous coal.....		6

Divisions like this are interesting for explaining the multiplication of the beds of this coal; whereas, in the east they become thicker, and form peculiar and separate strata.

On big branch of Lick fork, coal 1 B is 4 inches thick.

In Breathitt county, coal 1 B is seen :

On the waters of Frozen creek, near the road to Jackson, where the coal crops out all along the creek, half cannel, half bituminous. No. 2 is about 75 feet above it, and No. 3 is, perhaps, the bank formerly worked at Saml. Holmes', and said to be 3 feet thick. I found there some soft yellow shales, with plants. But the coal has been covered, and could not be seen. Another outcrop of coal in the same vicinity, at Mr. Day's, is also covered.

At Jackson, coal 1 B is worked 4 feet thick, at Mr. T. W. Cardwell's mines, and at Messrs. Jerry South & Sons. It is here a good bituminous coal, with a tendency to cannel.

On Quicksand creek, on Mr. Strong's land, where it is said to be 7 feet thick, and all cannel. The bank is covered.

At Meat Scaffold, branch of Quicksand creek, where it crops out about 8 feet above the level of the creek. This branch is full of pieces of cannel coal.

At Isaac Risner's, where it was reported to be 13 feet thick, I found it as follows :

	Feet.	Inches.
Covered space, apparently black shales.....	2	
Black fire clay and stigmaria.....	2	
Bituminous coal.....	1	6
Black bituminous cannel slates, with two thin streaks of poor coal.....	4	
Gray fire clay and shales.....	1	
Good bituminous coal.....	2	
Fire clay below.....		

At Mr. Isaac Back's, 3 miles from Jackson, 6 inches, bituminous coal and 21 inches cannel; and near by at Mr. Roark's, where it has the same thickness.

The lower part of this vein, covered with the gray shales and plants, crops out 2 feet thick. One hundred yards above the mill of Quicksand, and just opposite the mill, its upper part, 2 feet thick, underlaid by the same shales and plants, is roofed by sandstone.

At Judge Alfred Combs', on Barge fork of Troublesome creek, where it is 2½ feet thick, half cannel.

On the Kentucky river, at Thos. Swells' bank, reported before.

On main left fork of Cane, coal 20 inches thick, with shales and plants at the bottom and sandstone above. Two of the outcrops on the same creek are reported.

*Coal 2d.* Is not much worked in the counties under examination. On head waters of Buck creek of Kentucky river, Morgan county, it is 3 feet 4 inches thick, with a 4 inch clay parting. It is there named Brown's coal. The coal is good, but whitish, with efflorescence of sulphates.

On branch of Lacey's, near Hazlegreen, where it is the Swango's coal, it has the same thickness, and same quality of coal, as the former.

At West Liberty, it is the Hazlerig's coal, 3 feet thick, separated into three members by two clay partings. It is there 75 feet from the upper member of No. 1 B exposed at low water of the river.

At Judge Lykins' it is not opened, but has been found in the hills between his upper and lower cannel coal banks.

In Breathitt county, its place is marked on Bone creek by 21 inches of bituminous coal.

About one hundred feet above the cannel coal of Mr. Roark, it is also marked by a streak, as well as below Haddocks' mine; but it is unopened at both places.

Coal No. 3d is better developed than the former; but its place in the hills is too high for convenience. At Jackson, 250 feet above No. 1 B, there is a streak of cannel coal marking its place, and it may be found to be a good coal in the hills around. It is extensively worked at Haddock's mines, and is probably Mr. Jno. Wells' coal bank, near the top of a high hill, between the Kentucky and Troublesome rivers. The coal is said to be 4 feet thick, and half cannel. It has been opened before, but

is now caved in. This coal will be found in thick strata, near the top of the highest hills of Quicksand and Troublesome river.

Its distribution in Morgan county is the same as in Breathitt. It has been opened near West Liberty, where it is the Cox's coal, and tops the highest hills of Caney creek, on the land of Judge Lyken.

LAWRENCE, JOHNSON, AND FLOYD COUNTIES.

In Lawrence, Johnson, and Floyd counties, No. 1 B is, as in Greenup county, generally at the water level;\* but the measures increase in thick-

GENERAL SECTION OF LAWRENCE, JOHNSON, & FLOYD COUNTIES.—1 IN. FOR 100 FT.	
50 f.	Top of hills.
	5 feet C. 3d
150 f.	
	2½ to 4 feet C. 2d.
140 f.	
	8 inches coal.
20 f.	
	6 inches coal.
10 f.	
	4 to 6 feet C. 1 B.
55 f.	
	2 to 3 feet C. 1 A.
100 f.	
	13 inches coal.
25 f.	
	Creek.

ness, the coal strata are placed at a greater distance, separated by thick beds of sandstone; the country is deeper cut and the hills higher. The coal strata appear to follow the same rate of progression, and are generally more developed.

The observation formerly made for Breathitt and Morgan counties, about the great amount of coal still unknown, remains true for these counties. The exportation is made only by the Louisa and Tug rivers; and as long as these rivers are not slacked, the navigation is too precarious to admit of active operations in the exportation of the coal.

A lower coal, 1 foot thick, is generally formed in these counties, just at the top of the conglomerate. It is exposed in Paints creek, near Paintsville, in Johnson county, and at some places along Blane river. In the boring of Warfield it is recorded 6 feet thick; but, like the coal below the conglomerate, the thickness is evidently overrated by counting with it the whole thickness of the black slates forming the roof of the coal.

Coal 1 A is apparently connected with 1 B in Lawrence county, at Gavit's and Peach Orchard mines. At Warfield, it is the main coal, worked 5½ feet thick, 70 feet below 1 B.

\* Along the railroad from Grayson to Ashland, the geological horizon does not vary more than 20 to 30 feet in the whole length of the track.

In Johnson county, at and around Paintsville, it is generally 3 feet thick, covered with sandstone and overlaying a brash coal with plants. It is opened near Paintsville, at Messrs. Stafford & Hammond's. Its place is generally 40 to 50 feet below 1 B. In Floyd county it is of the same thickness and in the same position. Opposite Prestonburg it is 3½ feet thick and lies 35 feet below 1 B.

Coal 1 B was seen in Lawrence county, at Mr. Robert Eastham's, where it is 3 feet thick, bituminous coal and the top cannel. Near by, on Blane river, it is two feet thick, and is all cannel.

On Louisa river, at Calhoun mines, and at Peach Orchard, it is much divided, and thus its working is rendered troublesome and expensive.

On Tug river, opposite Louisa, it crops out under sandstone, and is there a thin coal, roofed by cannel shales, and is seen also two miles above, where it is in three members, with only 8 inches of good coal.

At Warfield it is apparently only 6 inches thick. But it is not certain that this streak is the only representative of the vein in the vicinity. A few miles down the river, the dip of No. 1 A being somewhat stronger than the slope of the river, it disappears, and No. 1 B makes its appearance near high water level, and is seen in a great bank of black shales, 25 to 30 feet thick, where it is divided into three veins of 6 inches to 1 foot each. Though coal 1 B is not opened at Warfield, its place is evidently marked by its position above 1 A, and by the presence of 1 C, 100 feet above it, and perfectly well characterized by its shales full of stems and the brashy nature of its coal.

This coal 1 B is exposed along the road from Warfield to Peach Orchard, especially on Rockcastle creek, always thin.

Near the road, about half way up the river from Peach Orchard to Paintsville, in Johnson county, it is opened under a bank of gray micaceous shales, with prints of *Lepidodendron*, *Flabellaria*, &c. The coal is half bituminous, and is two feet thick to the level of the creek; but its lower part is uncovered.

Seven miles below Paintsville, on Louisa river, it is 4 to 5 feet thick, mostly coarse cannel coal.

At and around Prestonburg it is the main coal, averaging 4 feet. Some of its outcrops are exposed along the river for 15 miles above Prestonburg.

At Paintsville, it is worked at Mr. Moses Preston's, on Muddy

branch, where it is of a bituminous character, with some cannel coal at the bottom, in all 4 feet 2 inches thick. Its roof is a gray shale, marked with numerous impressions of plants. It has been opened also at a short distance just above Louisa river,  $1\frac{1}{2}$  mile below Paintsville, 160 feet above low water, where it is bituminous coal, thirty inches thick.

On the land of Dr. H. F. Strong, 1 mile west of Paintsville, No. 1 A and 1 B are seen at their respective places, but not opened.

As reported before, Mr. Jesse Wheeler works this coal 4 feet thick in the same vicinity.

*Coal No. 1 C.* The coal banks referable to this vein have been all mentioned.

*Coal No. 2.* Reported at Gavit's and Calhoun's mines, on Louisa river, 3 to 4 feet thick, mixed with clay partings. At Peach Orchard, where it is the main and only workable bed. At Paintsville it has been opened, but never worked, and at Prestonburg it is perhaps a coal said to be 2 to 3 feet thick, 130 feet above main. I could not see it. At Warfield it is 4 feet thick, and is sometimes half cannel.

*Coal 3d.* On account of its high position in these counties it has not been examined to any extent. It is opened near the top of the hills, above the falls of Blane river, Lawrence county, where it is all cannel. At Warfield it is said to be 7 feet, and at Paintsville 5 feet, where it is also cannel. The openings in these three last coal banks are very partial, and so that I could see only the top shales. At Calhoun mines, on Louisa river, it is 100 feet above No. 2, and said to be 6 feet thick. The top layers exposed are a true cannel coal.

#### COMPARATIVE SECTIONS.

This report is concluded by a sectional table, showing the comparative position of the most important coal strata in different parts of the American coal fields. The number of the sections could have been much increased; but I have deemed it best to record only in this table those which I consider as perfectly reliable, and of which I have been able to compare the palæontological characters, at least at some of their principal horizons.\*

The remarkable analogy of distribution of the coal strata, as indicated

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\* All the coal beds, the position of which has been ascertained by such palæontological evidence, are marked by a (\*).

by those sections, is thus put in evidence, and cannot be ascribed to any ideal system. The order of superposition of the different sections is established on lithological and palæontological characters. But it is only by palæontology that the equivalency of the coal strata has been, and can be, established in distant parts of the same basin, and especially in separate coal fields. Therefore palæontology, as applied to the identification of coal beds, can no longer be considered as a chimerical notion. Its practical advantage is at once evident. And I have no doubt that, as soon as it is generally received as a guide in the examination of our coal fields, the harmony of distribution of the coal strata will become more and more striking.

The sections made in Kentucky indicate a remarkable increase in the thickness of the measures, especially of the sandstone strata towards the southeast. It would have been interesting to compare sections made in the coal fields of Virginia, south of Charlestown, and to ascertain how far this progression of thickness is continued. It was impossible to get reliable data on the distribution of the coal in that country. From what I have seen myself, many years ago, and especially from sections on Coal river, kindly communicated by Dr. I. H. Salisbury, it appears that coal No. 1, with its members B and C, and perhaps No. 2, multiply and form as many as eight different strata. A similar development is seen in the north anthracite basin, of which Wilkesbarre is the center. And in the same basin we find another analogy in the constant decreasing of the measures from Wilkesbarre to the eastern edges of the basin at Carbondale.

It was also impossible to get any well ascertained data from the other basins of the Anthracite coal fields. The disturbances of the strata are so marked in innumerable flexures that dynamical geology has failed, till now, to give any indication about the general distribution of the veins. From palæontological evidence I am satisfied that the highest coal of the Pottsville and Tamaqua basin is the equivalent of our No. 4th, and that the measures do not ascend higher in that part of Pennsylvania. It is certain also that the *big* or *mammoth vein*, so generally worked in the same basin, is the equivalent of No. 1 B.

The 1st section represents the distribution of the coal strata in Union county, Kentucky, and is perfectly correct. It was made by Dr. D. Dale Owen, from borings and repeated measurements.

Section 2 is the record of the Holloway boring at Henderson, and is also perfectly reliable for the place of the coal strata in this part of Kentucky.

Section 3d belongs to Mr. J. P. Lesley's Manual of Coal. It was condensed from such numerous and authentic records as the best geologist can obtain.

Section 4th is another general section of Pennsylvania copied from the State geological final report of Pennsylvania. In comparing these four general sections, it becomes evident that the essential coal strata, viz: coal 1 B, C 4th, and C 11th, come just under the same horizon. The difference in the intermediate strata is not of material importance. In the section of the Pennsylvania survey there is a distance of 480 feet marked as barren of coal, contradictory to local sections of the same Report, which show generally one workable bed, the *Elklick coal*, and sometimes two, above the Mahoning Sandstone. Mr. Lesley's section has marked the place of these strata. In the same section of the report, there is a group of veins, called the Mercer coal, which has no equivalent in the other sections, or which is represented only by a thin coal. Palæontology only could decide if this Mercer coal is not the equivalent of No. 1 B and its subdivisions, as it appears to be.

From all the local sections of the Pennsylvania Survey, two ascertained data are especially worth mentioning. 1st. The reliability of our Curlew limestone, which, in Pennsylvania, is called Freeport limestone, and is generally placed 6 to 15 feet above our No. 3d coal. 2d. The consistency of the *ferriferous* limestone between No. 1 B and No. 2 in the place occupied by our coal 1 C. It lies, as in Kentucky, 10 to 40 feet above No. 1 B, and is generally accompanied by calcareous iron ores.

Section 5th, at Yellow creek, is given from measurements of Dr. Newberry, in his railroad survey, and from my own palæontological examination. The distances between the coal strata are said to be too great.

Section 6th was made at Buena Vista and Greenup furnaces from my own measurements, compared with five different sections, kindly furnished by Mr. John Means.

Section 7th, made at Mount Savage, is exact, as far as measurements by pocket level can be relied upon.

Section 8th was taken at West Liberty, first by Dr. D. D. Owen, and afterwards by myself. The upper part of No. 1 B crops out in the bed of the river, and it was impossible to ascertain at what distance this member, one foot thick, is placed from the main 1 B. The distance, 71 feet, to No. 2, is too short by, probably, 20 to 30 feet.

Section 9th, at Jackson, only shows No. 3d coal as a streak of coal 6 inches thick. The section was followed along a steep ravine, from the bed of the river to the top of the highest hill. Though this coal was covered, and its palæontology was not ascertained, I have no doubt of its identity with the Haddock's coal, our No. 3d, which is worked in the vicinity, 275 feet above No. 1 A.

Section 10th, at Peach Orchard, was ascertained from measurements and palæontological data. Coal 3d is only marked by a hard bed of fire clay, nearly limestone, or bastard limestone, and a streak of coal, and coal 4th is replaced by fire clay and iron ore, just at the base of the Mahoning Sandstone, which tops the hills, 520 feet above low water of Louisa river, and is conglomeratic at its top.

Section 11th, at Warfield, is made from No. 1 A coal, at the top of the boring to the highest hill, 740 feet, where all the coal strata are opened, nearly on the same vertical line. I refer the cannel coal vein, said to be 8 feet thick, to No. 3, and not to No. 4, because it is not placed just below the Mahoning Sandstone, but separated from it by about 90 feet of measures, apparently shales and iron stone. I could find no trace of coal 4th; but the top of the hill, except where the Mahoning Sandstone appears in perpendicular cliffs, is covered with a nearly impenetrable thicket of brambles, which rendered close researches impossible.

Section 12th was taken at Wilkesbarre, in the center of the north anthracite basin. This and the following sections were copied from the report of the Pennsylvania survey, and were especially compiled from borings and observations made by the directors of coal mines. They are certainly reliable. For Wilkesbarre, there is an upper section containing two beds of coal, which would correspond with No. 5th and 6th coals of Kentucky. As this section was not taken from the same place as the lower part, and as I could not see any of the reported coal beds so as to ascertain their palæontology, it is omitted. Some coal beds of unworkable thickness are marked in the section of the Pennsylvania report. But they are not reported by Mr. Lesley, nor were they marked in a section which I obtained of the foreman of the mines.



Section 13th, at Pittston, is remarkable by the separation of coal 2d and C. 3d, each into two beds, separated by 10 feet of shales. We have seen the same disjunction of these veins at Chinch creek, and at Whetstone creek, in Greenup county.

Section 14th, at Scranton, is also reported in Mr. Lesley's Manual, with some difference.

Section 15th, at Carbondale, was obtained from Mr. Ed. Johnes, director of the mines of Archibald. At Carbondale the hills are too low, and contain only the coal 2d. The 3d coal is added from the Archibald's section, which is about the same. In this last place, the distance between C. 1 B and 2d is 92, and at Carbondale 95 feet.

TABLE OF SECTIONS.

1. UNION CO., WESTERN KENTUCKY, BY D. D. OWEN.		2. HOLLOWAY'S BORING, HENDERSON, WEST. KY.		3. PENN. SECTION, BY J. P. LESLEY, JR.	
50 f.	Thin C. 18th.				
60 f.	8 in. C. 17th.				
35 f.	Thin C. 16th.				
102 f.	2½ f. C. 15th.				
115 f.	1 f. C. 14th.				
77 f.	6 in. C. 13th.				
100 f.	3 f. C. 12th.	40 f.	Shales and An. Rock S. S.		
10 f.	5 f. C. 11th.	7 f.	3½ f. C. 12th.		
40 f.	3 f. C. 10th.	10 f.	4½ f. C. 11th.		Pittsburg coal 8 f. C. 11th.
60 f.	5 f. C. 9th.	45 f.	10 in. C.	290 f.	
20 f.	6 in. C. 8th.	20 f.	3 f. 2 i. C. 10th.		1 f. C. 6th.
70 f.	2½ f. C. 7th.	98 f.	4 f. 3 i. C. 9th.	50 f.	1 f. C. 5th.
110 f.	3 f. C. 6th.		2½ f. C. 7th.	125 f.	
65 f.	4 f. C. 5th.	196 f.	5 f. C. 5th.		6 f. C. 4th.
95 f.	3 f. C. 4th.	106 f.	1 f. 8 i. C. 4th.	50 f.	3 f. C. 3d.
25 f.	Curlew L. and thin C. 3d.			170 f.	
130 f.	2 f. 6 in. C. 2d.	300 f.			3 f. C. 2d.
100 f.	20 in. C. 1 C.		6 f. C. 1 B.	80 f.	
55 f.	5 f. C. 1 B.	150 f.	S. S.		3½ f. G. 1 B.
110 f.	Conglomerate.			40 f.	Thin C. 1 A.
	20 in. C.				Cong. S. S.

TABLE OF SECTIONS.

4. PENN. SECTION, BY H. D. ROGERS.		5. YELLOW CREEK SECTION, OHIO, BY D. NEWSBERRY.		6. BUENA VISTA, GREENUP COUNTY, KY.	
40 f.	10 in. C.				
	1 f. C.				
65 f.					
	10 in. C.				
200 f.					
	10 in. C.				
20 f.					
	1 f. C.				
40 f.					
	2 f. C.				
45 f.					
	4 f. C. Waynesburg.				
115 f.					
	2 f. C. Red St.				
100 f.					
	4 f. C. Sewickly.				
85 f.					
	Pitts. C. 14 f. 11th & 12th.				
480 f.			4 f. C. 4th.		
		60 f.			
			Limestone.		
	4 f. C. 4th. Limestone.		4 f. C. 3d.		
60 f.	3 f. C. 3d.				
140 f.		105 f.			
	4 f. C. 2d.		7 f. C. 2d.		Limestone.
75 f.				15 f.	
	4 f. C. 1 B.				3 f. C. 3d.
25 f.		110 f.		75 f.	
	2 f. C. 1 A.		3 f. C. 1 C.		4 f. C. 2d.
60 f.					
	4 f. C. Merc. C.	50 f.		70 f.	
15 f.			4 f. C. 1 B.		3 f. C. 1 C.
	1 f. C. Merc. C.				
15 f.		20 f.	Shales.	35 f.	
	1 f. C. Merc. C.				5 f. C. 1 B.
15 f.			3 f. C. 1 B.		
	1 f. C. Merc. C.				
	Conglomerate.	25 f.		40 f.	
			1 f. C. 1 A.		1 f. C. 1 A.

TABLE OF SECTIONS.

7. MT. SAVAGE FURNACE, CARTER COUNTY, KY.		8. WEST LIBERTY, MORGAN COUNTY, KY.		9. JACKSON, BREATHITT CO., KENTUCKY.	
20 f.	Limestone.			165 f.	6 in. C. 3d.
90 f.	3½ C. 3d.			70 f.	6 in. C. 2 f. C. 2d.
70 f.	2 f. C. 2d.	3 f. C. 3d.		4 f. C. 1 B.	
30 f.	3 f. C. 1 C.	110 f.		20 f.	2 f. C. 1 A.
	3 f. C. 1 B.	71 f.		80 f.	Coal streak.
		1 f. C. 1 B.			

TABLE OF SECTIONS.

10. PEACH ORCHARD, LAWRENCE COUNTY, KY.	11. WARFIELD, ON TUG RIVER, EAST KENTUCKY.	12. WILKESBARRE, PENN. REPORT 2, P. 220.
	100 f. Mahoning S. S.	
	90 f. S. S.	
	8 f. C. 3d.	
	230 f.	4 f. C. 4th.
	4 f. C. 2d.	60 f. Ball ore.
	100 f.	10 f. C. 3d, Baltimore vein.
	3 f. C. 1 C.	182 f.
50 f. Mahoning S. S.	110 f.	17 f. C. 2d. 3 partings.
C. 4th.	60 f.	
C. 3d.	5½ f. C. 1 A.	155 f.
190 f.	85 f.	19 f. 1 B.
5½ f. C. 2d.	6 f. C & shales.	
100 f.	90 f. Cong. S. S.	20 f.
6 in C. 6 in. C. 1 C.?	525 f. Strong brine.	12 f. C. 1 A.
50 f.		50 f.
1 f. C. 1 B.		
22 f.		
6 in. C. 1 f. C 1 A.	125 f. 1st brine.	190 f. Conglomerate.

TABLE OF SECTIONS.

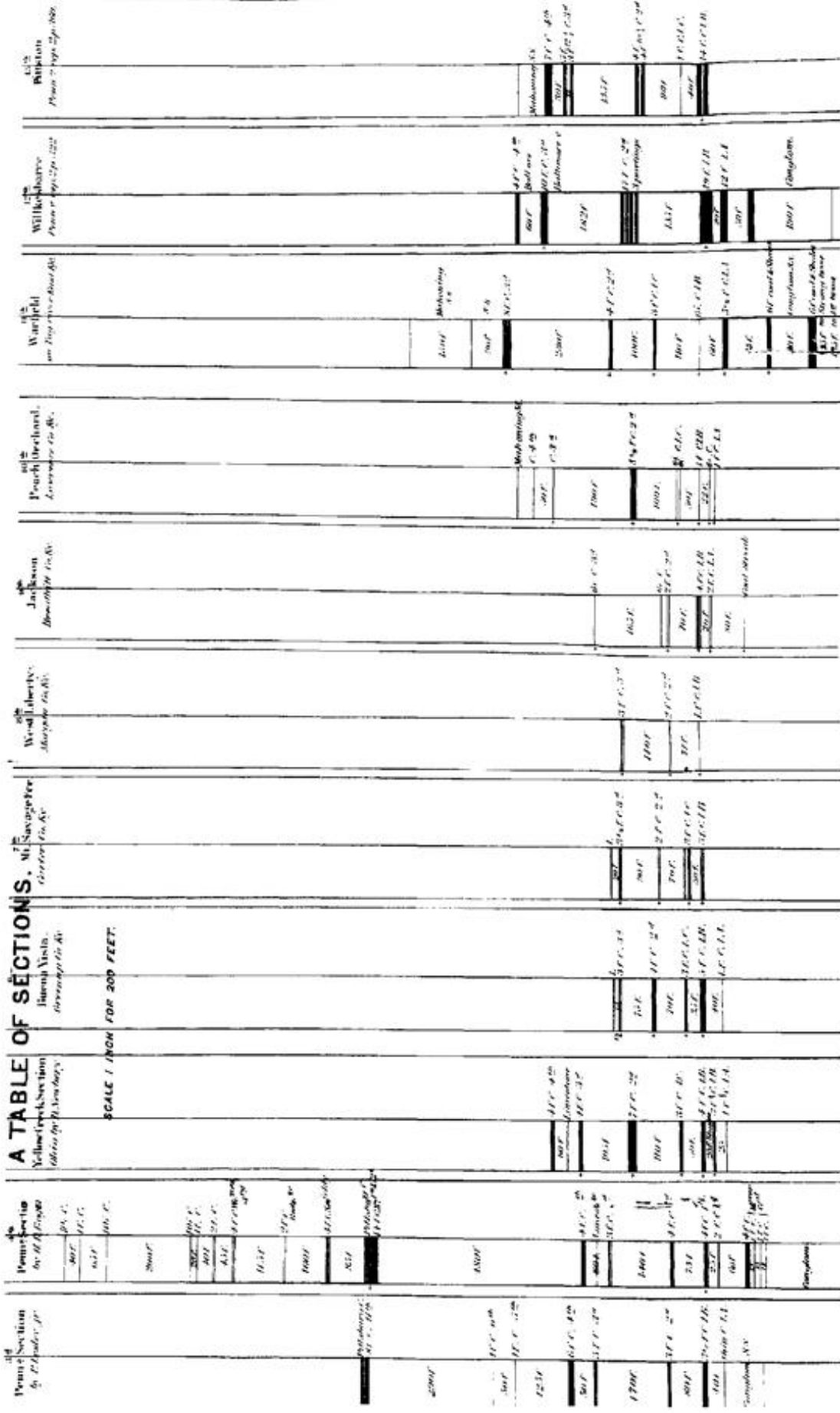
13. PITTSBURGH, PENN. REP. 2, P. 360.		14. SCRANTON, PENN. REP. 2, P. 339.		15. CARBONDALE, BY MR. E. JOHNS.	
			10 f.	1½ f. C. 4th.	
				4½ f. C. 4th.	
			20 f.		
				6 f. C. 3d.	
			100 f.		
				10 f. C. 2d.	
			40 f.		
				6 f. C. 1 C?	
	Mahoning S.S.		50 f.		
	7 f. C. 4th.			12 f. C. 1 B.	
	30 f.				
	3 f. C. 3d.		25 f.	4 f. C. 1 A.	
	12 f.			8 f. C. 1 A.	
	3 f. C. 3d.				7 f. at Archibald, C. 3d.
	155 f.		80 f.		60 f.
	4 f. C. 2d.			1 f. 10 in. C.	
	10 f.		30 f.	Conglomerate.	
	4 f. C. 2d.			4½ f. C.	
	90 f.				25 f.
	1 f. C. 1 C.		35 f.	Conglomerate.	
	40 f.			6 in. C.	
	14 f. C. 1 B.		160 f.	Conglomerate.	
					30 f.
					17 f. C. 1 B.
					1 f. C. 1 B.
					3½ f. C. 1 A.

# A TABLE OF SECTIONS.

Yellow Rock Section  
Address for Publications  
General Mailing  
Address for Authors  
Savage Free  
Library  
Jackson  
Peach Orchard  
Wardfield  
Willsborough  
Berkton  
Scranton  
Circulating  
Library

SCALE 1/1600 FOR 200 FEET.

Penn's Section by P. A. Schuchert, Jr.  
Penn's Section by H. C. Frisvold  
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# A TABLE OF SECTIONS.

SCALE 1 INCH FOR 200 FEET.

Union, W. Va. By H. B. Pappas	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
Yellow Springs, Burmingham, R. Va.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
Penn's Section By P. H. Pappas	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
Penn's Section By H. B. Pappas	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.

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W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.

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W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
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W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
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W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.
W. Va. Sec.	2000 F.	1000 F.	500 F.	250 F.	100 F.	50 F.	25 F.	10 F.	5 F.	2 F.	1 F.	500 F.	1000 F.	2000 F.





# EXPLANATION OF THE PLATES

AND

## DESCRIPTION OF THE SPECIES.

### PLATE I.

Fig. 1 and 1 a. *Dictyopteris obliqua*, Bunby. . Species easily known by the peculiar reticulation of its nervules or veinlets. Fig. 1 a is somewhat enlarged, and more distinctly elucidates the nervation. This species is sometimes found in coal No. 1 B, but mostly in No. 3d.

Fig. 2 and 2 a. *Alethropteris Coxiana*, Lsqx. This fine species, found by Prof. E. T. Cox and myself, at the Union mines, Livingston county, has the leaflets obliquely decurring on the rachis, united near the base, oval-lanceolate in outline, and irregularly sinuate. The medial nerve is thin, or scarcely marked; secondary nerves thin, obliquely arched, generally twice forked. Fig. 2 a, enlarged size. This species is related to *Alethropteris sinuata*, Brgt., but is evidently distinct: by its *more oblique* nervules, sometimes *nearly perpendicular* on the medial nerve; by the form of the *distant* leaflets, which *are more pointed, united above the base*, and by a *plane* (not undulate) surface. The figured specimen is the best which was found, though the species is abundant on the shales of Union mines.

Fig. 3 and 3 a. *Alethropteris Serlii*, Brgt. Easily distinguished from its relative, *Alethropteris lonchitica*, Brgt., by its shorter, broader leaflets; by the broad, flattened medial nerve of the leaflets; by the more divided and thinner veinlets, and by its narrow rachis. It is especially found in the shales of coal No. 3d, while *Alethropteris lonchitica* is a characteristic plant of coal No. 1 B.

### PLATE II.

Fig. 1 and 1 a. *Pecopteris arborescens*, Brgt. Rachis thick, often dotted with irregular points, which show the base of obliterated scales. Leaflets half round, irregular in size, united near the base; nervules simple, as marked in fig. 1 a, which is enlarged. This species is very

Fig. 2 and 2 a. *Pecopteris unita*, Brgt. It takes its name from the position of the leaflets, generally united nearly to the top. The distant, thin, and peculiar nervation of this species is marked in fig. 2 a, enlarged. It has been found till now only in connection with coal No. 3d.

Fig. 3 and 3 a. *Pecopteris arguta*, Sternb. Frond bi or perhaps tripinnate. Pinnæ long, about half a foot, perpendicular to the rachis; pinnules alternate, long, narrow, lanceolate oval, obtusely pointed, united nearly from the middle. Nervules thick, flat, oblique to the thick medial nerve, straight, running to the margin. The cellular tissue of the leaflets of this species being soft and easily decomposed, the natural outline, either entirely or partially destroyed, is sometimes changed, and the leaflets appear thus, either serrulate by the protruding veinlets, or as a bundle of threadlike parallel nervules, which have been described as a peculiar species. It is found in the shales of No. 4th coal.

Fig. 4. *Rhabdocarpus arcuatus*, Lsqx. This peculiar fruit is, in its outline, somewhat like a pea-nut. It appears to have been covered with a woody envelop or shell about as thick as a common nut-shell. This outer envelop is now transformed into coal, and narrowly striated. Under it, the fruit is parallelly ribbed, dotted on the surface with small holes. It is borne on a pedicel about one half inch long. I found three specimens of this beautiful species on Burnt branch of Caney, near West Liberty, Morgan county, in the shales of coal No. 1 B.

Fig. 5 and 5 a. *Hymenophyllites Hildrethi*, Lsqx. The frond of this species appears much divided, alternately forking. The leaflets are either simple, linear-oval, or enlarged and bi or tri-lobed. Each division is marked by a single nerve descending to the branch of the stem, which is somewhat inflated in the middle, or marked by a strong nerve. This species is commonly found in the shales of coal No. 1 B and No. 3d.

Fig. 6 and 6 a. *Hymenophyllites artemisiacifolia*, Brgt. The frond is apparently bi-pinnately divided. The leaflets are wedge-shaped, roundish, or eroded at the top, obliquely decurring on the rachis, joined together near the base, and marked with thin parallel veinlets. This species appears to be rare in the American coal fields, though common in Europe. I found it in a bed of the shales of coal No. 1 B in a branch of Red river, two miles south of Hazlegreen, Morgan county.

Fig. 7. *Neuropteris vermicularis*, Lsqx. This species, by the form of its leaflets, is exactly like *Neuropteris flexuosa*, Brgt., only the base

of the leaflets is round, and not expanded on one side. The nervation is very different. The veinlets are thinner, more deeply or strongly marked, and more distant. They are generally so sharply exposed that they can be detached from the leaflets like bits of hair, or like small pieces of rain worms. This species was found at many places, only in the shales of coal No. 1 B. Generally the leaflets are detached from the stem.

## PLATE III.

Fig. 1. *Cordaites borassifolia*, Ung. By its broad, long leaves, narrowed at the base and embracing the stem, generally cut, sometimes rounded at the top, with the surface narrowly striated, this species is related to the family of the palm trees. It is very common in the shales of most of the coal strata, from the sub-conglomeratic coal of Arkansas to No. 1 B, No. 3d, No. 4th, and even No. 8th, of the coal strata of Kentucky.

Fig. 2 and 2 a. Leaves of *Lepidodendron*, with an enlarged cross section at fig. 2 a. These leaves, most common with the shales of the sub-conglomeratic coal, have been sometimes described as blades of grass, or as leaves of *Sigillaria*, or with some peculiar names. They are variable in length, but the form is generally the same. When they are found entirely flattened in the shales, they appear as marked by two parallel nerves in the middle.

Fig. 3. *Asterophyllites tuberculata*, Brgt. I have figured, as well as possible, this kind of ear, composed of parallel rows of appressed, apparently oval-obtuse scales. These ears are very abundant in the shales of coal No. 3d, but always broken, and never attached to any stem. They do not appear to contain, within or under the scales, any seeds or granules. Though they are generally found mixed with stems and leaves of *Asterophyllites*, they cannot belong to this genus, unless *Asterophyllites* are considered as branches of *Calamites*, and *Asterophyllites tuberculata* as a kind of male flower or cone, bearing pollen, attached immediately to the trunk of *Calamites*, where it leaves, in falling from it, those large, round scars, observed on some species of *Calamites*. The true fruit, or cones, of *Asterophyllites* are much smaller, or appear to be tubercles or nutlets attached around the stem in the axil of the leaves.

Fig. 4. *Calamites decoratus*, Brgt. This fine species has been considered by some authors as a variety of *Calamites approximatus*, Brgt.

But it appears truly different—by its well marked, very thinly striated ribs; by its double range of tubercles around the transversal line of separation, and by a thin, but well marked, line at each side of the ribs. It is commonly found in the shales of coal No. 3d, and has not been seen elsewhere till now, while *Calamites approximatus* abounds with coal No. 1 B.

Fig. 5. *Calamites gracilis*, Lsqx. This species, without any trace of leaves, has just the appearance of a horse-tail or *Equisetum*, and thus may belong to the genus *Equisetites*. But the sheaths are not well marked and replaced by a thin coat of coaly matter; the true genus of the plant cannot, therefore, be ascertained. It appears to have lived in water, being found in the coal shales of No. 8th coal, in connection with marine shells and a black band limestone.

PLATE IV.

Fig. 1 and 1 a. *Asterophyllites equisetiformis*, Brgt. It has the leaves in rows of 8 to 14 leaflets, which are linear acute, from half an inch to one inch long, marked in the middle by a broad nerve. Fig. 1 a is enlarged. The rachis is generally somewhat and irregularly striated. Though this species is considered by some authors as belonging to a *Calamites*, it has never been found attached to the stem of a true *Calamites*. It is common from No. 1 B to No. 4th coal beds, most generally with coal No. 3d.

Fig. 2 and 2 a. *Sphenophyllum Schlotheimii*, Brgt. Leaves in a row of six cuneate, enlarged leaflets, which are truncate and crenulate at the top. Veinlets forking twice, nearly parallel, and running to each of the notches of the crenules. The number of the veinlets is thus just the same as that of the notches, viz: about ten. This species, like the following, lived on the surface of the water, where its leaflets were expanded. It has the same stratigraphical distribution as the former. Fig. 2 a is a leaflet enlarged to show the nervation.

Fig. 3. *Annularia fertilis*, Sternb. Leaves in rows of 16 to 20, oblanceolate, narrow, notched leaflets, apparently recurved along the margins, and perhaps fruit-bearing under their surface like the ferns. All the European specimens figured of this species have pointed leaflets. But I do not think that this difference has a specific value. Another species of this genus, *Annularia sphenophylloides*, Ung.; very common in the shales of coal No. 3d and 4th; has both pointed and notched

leaflets, sometimes on the same specimen. It differs only from the one figured here, by its much smaller size and fewer leaflets. Same range of distribution as both the former species.

Fig. 4 and 4 a. *Lycopodites cavifolius*, Lsqx. Stem apparently slender, forking; leaflets imbricated, lanceolate-oval, acute, half embracing the stem at the base, concave, with an obsolete nerve in the middle. The form of the leaflet enlarged and figured at 4 a, is taken from very concave impressions on the stone. It cannot be compared with any of the *Lycopodites* published till now. Found in the shales of coal No. 1 B.

Fig. 5. *Sigillaria corrugata*, Lsqx. A species somewhat related to *Sigillaria dilatata*, Lsqx., (Penn. Rep., p. 871, pl. 13,) but separated from it by its transversally wrinkled surface and its broader scars. Shales of No. 1 B coal.