THE COAL MEASURES OF THE UNITED STATES.

[PLATES XI and XII.]

BY PROF. C. H. HITCHCOCK, HANOVER, N. H.

THE observations made by American Geologists establish the fact of a fourfold division of the Carboniferous series, viz.: 1. The lowest, sandstones and conglomerates known as the Waverly sandstones of Ohio, Marshall, Napoleon, and Michigan groups of Michigan, Catskill of New York, the Vespertine of Pennsylvania, the Knobstone of Kentucky, etc. 2. Mississippi group, or Carboniferous or Mountain limestone. This is supposed to be the equivalent of the Umbral red shales of Pennsylvania and Virginia. 3. Millstone grit, or a series of sandstones and conglomerates, the Seral of Pennsylvania and Virginia, the Conglomerate of Ohio, etc. 4. The Coal Measures. It is from this upper division that the chief supply of our coal is derived. In some regions there are said to be good workable beds below the Millstone grit; and in such cases they are included in the lower division upon the map.

There is considerable diversity of opinion in respect to the minute subdivision of the Coal Measures. Hence, the map will show only a division in two parts, the upper and lower. The line of demarcation in the Appalachian basin is the Pittsburgh bed or its supposed equivalent. In the Illinois and Missouri basins the dividing line cannot be synchronized with the same horizon, but the division is a natural one.

A glance at the map shows the coal to be grouped in the following natural basins. It will be interesting to compare these Coal Measure areas with the limits of the entire Carboniferous System as given in the General Geological Map of the United States.

New England Basin.
Anthracite Basins of Pennsylvania.
Appalachian Coal Field.
Michigan Basin.
Illinois Basin.
Missouri Basin.
Texas Coal Field.

THE NEW ENGLAND BASIN.

This lies in Massachusetts and Rhode Island and is estimated to cover 750 sq. m. The coal is a plumbaginous anthracite, used to advantage in some smelting furnaces. Perhaps eleven different beds exist; and as seen at the Aquidneck Mine, Portsmouth, R. I., their maximum thickness is 23 feet. In a sketch of the Rhode Island part of the field, printed in the Proceedings of the American Association for the Advancement of Science for 1860, I estimated the whole thickness of the Coal Measures at 6,500 feet, and the Coal Measures proper at 2,500 feet. According to Lesquereux the plants from this field correspond with those of the Salem and Mammoth Anthracite and the lower Freeport Bituminous beds in Pennsylvania.

THE ANTHRACITE BASINS OF PENNSYLVANIA.

The statistics prove these to be the most important in the country, yet they occupy a very insignificant space upon the map. They are usually divided into three groups,

	Square Miles.
The first, Southern or Schuylkill Basin and Mine Hill, .	146
The second, Middle or Shamokin, 50; Mahanoy, 41; and Lehigh Basins, 37, ...	128
The third, Northern, or Wyoming and Lackawanna Basin,	198
	472

The first and second of these basins are shown upon an enlarged scale near the bottom of the map. [Plate XII.]

Originally these basins must have formed part of a single coal field, which by later elevating forces has been extensively folded, the character of the coal changed from bituminous to anthracite, and the strata broken into fragments through fractures and erosion. This is shown by the similarity in number, succession and thickness of the beds of coal in the several parts; also by the constancy of the character of the conglomerate forming the floor of the Coal Measures.

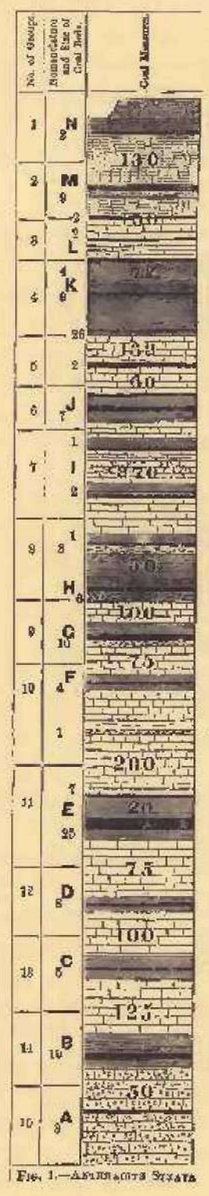

FIG. 1.—ANTHRACITE STRATA

Fig. 1 is a section of the coal strata at Pottsville, Pa., made by Daddow and Bannan. We are under obligations to D. Appleton and Co. of New York, for the privilege of copying it from their electrotype in James Macfarlane's treatise upon The Coal Regions of America. A, the lowest bed, is not worked. B, or the Buck Mountain, is a very important bed, 25 to 30 feet thick at Plymouth, and in some of the Lehigh basins. The third seam, C, is not usually workable. D, the Skidmore or Wharton, is from 6 to 12 feet thick, and valuable. E is the Mammoth, the largest and best of all the anthracite coal-beds, from 12 to 70 feet thick; but its best size is about 30 feet, as in the Lehigh basins, producing more coal than when at its maximum size. In parts of the Mahanoy basin it is 70 or 80 feet thick. This bed is said to correspond with the upper bed of the lower bituminous coal measures. F is supposed to be the equivalent of the small seams in the barren measures, and G, or the Primrose, may represent the Pittsburgh and Cumberland beds in the Appalachian Field. The upper anthracite beds above H may correspond to the Redstone, Sewickly, and Waynesburg beds in other Sections.

The obtaining of exact information respecting the amount of coal in any basin is at present impracticable. If we know the area in square miles and the thickness of the beds along a given section, the multiplication of the area by the thickness should give the precise number of cubic feet in the field; but the beds vary so much that all such estimates must be regarded only as approximate. The estimates that follow are those based upon the best attainable information.

Prof. H. D. Rogers reports that the first Coal Field contains an average thickness of 100 feet of coal, and that the second and third carry about 60 feet; the general average of all three coming to about 70 feet. Daddow and Bannan enumerate 14 beds at Pottsville, having the maximum thickness of 205 and the minimum of 60 feet; while the accompanying strata vary from 2,175 to 820 feet in thickness. There is no end to the details respecting the anthracite basins which are contained in the Geology of Pennsylvania, by H. D. Rogers, 1858; Coal, Wood, and Oil, by S. H. Daddow and Benj. Bannan, 1866; and the Coal Regions of America, by James Macfarlane, 1873.

APPALACHIAN COAL FIELD.

This basin comprises 59,105 sq. m. and is situated in the States of Pennsylvania, Maryland, Ohio, West Virginia, Virginia, Kentucky, Tennessee, Georgia, and Alabama. Reckoning by States, the areas are distributed as follows:

	Square Miles.
Pennsylvania (H. D. Rogers), ...	12,302
Maryland (P. T. Tyson), ...	550
Ohio (J. S. Newberry), ...	10,000
West Virginia and Virginia (W. B. Rogers), ...	16,000
Kentucky (Joseph Lesley), ...	8,983
Tennessee (James M. Safford), ...	5,100
Georgia (H. D. Rogers), ...	170
Alabama, rough estimate from map, ...	6,000

Several peculiarities in the structure of this basin are suggested by an inspection of the map. 1. It is much broader over its northern area, contracts through Tennessee and Northern Alabama, but expands considerably at its termination in Alabama, though by no means to such an extent as in West Virginia and Ohio. 2. The peculiar basin structure is best seen in the northern half; while the upper measures are wholly wanting south of West Virginia, save a minute portion in Alabama. 3. Considered in connection with its elevation above the sea, nearly the whole of the Appalachian Coal area is an elevated plateau, 2,000 feet above the sea in Tennessee, the principal depression lying along the Ohio River below Pittsburgh. 4. The northern and western edges have suffered greatly from denudation. The smallness of the scale prevents the perfect representation of this outline, but the numerous isolated patches in Northern Pennsylvania, which were once connected together, indicate forcibly the immense amount of loss this basin has sustained. The absence of much of this ruggedness along the eastern border illustrates the fact of the operation of different forces in that region. There have been extensive upthrows and downthrows along the eastern border, shown on the map in the narrow band of older rocks in southeastern Kentucky. Perhaps on account of these oscillations of level the coal has disappeared from immense areas in Virginia, Tennessee, Georgia, and Alabama. The narrow lines of lower Carboniferous rocks in Virginia, on the General Geological Map [Plate XI], may indicate the former eastern extent of the coal there. 5. The basin is subdivided by minor undulations which are of the greatest consequence in the location of mines. Much remains to be done in tracing out these folds; but I will mention those that are well known. They are the most marked in Pennsylvania, where they are eight in number. First is the small Broad Top basin. The extent of this and the other sub-basins can be best comprehended by referring to the General Geological Map, where the lower Carboniferous rocks are not separated from the Coal Measures. The second is the Cumberland basin of Maryland. Though connected directly with a projection from the great basin to the west, it is not quite certain that the connection is through the upper division. But there is a distinct anticlinal axis along the angle of the bend, separating the second from the third basin. The third basin, commonly called the First in Geological treatises, commences with the small area east of Williamsport, known as Mahoopeny mountain passes somewhat south of west toward Snowshoe and then southwesterly into Maryland, being divided again by the ridge lying partly in Pennsylvania and partly in Maryland. The fourth basin begins with the Barclay and McIntyre regions, passes to the small patches in the great bend of the north branch of the Susquehanna and continues up the west branch. This basin may be traced southwesterly to the east of the long pink ridge called Laurel Hill, and upon it are situated the figures 244 in Pennsylvania, and 90 in West Virginia. The fifth basin commences at Blossburgh, may be traced by undulations of the lower strata to connect with a much shorter spur from the main basin and passes down to the southwest side of the Laurel Hill Range into West Virginia. The sixth basin cannot be traced by names upon our map, but it commences on the Tioga River in New York, crosses the P. and E. R. R. three miles above Emporium, and terminates at the Kiskimineras River two and one half miles from its mouth. The seventh basin commences with the Smethport outlier, passes to Ridgway and crosses the Alleghany just above the great bend between the large letters E and N on the map, pointing towards Pittsburgh. The eighth basin is said to occupy the rest of the Coal Measures lying to the west of those enumerated. These undulations have not yet been identified in West Virginia and Kentucky. Possibly the anticlinal axis at the Kanawha salines may correspond with the Laurel Hill ridge spoken of above. Their distinctness in the north may be explained by the seemingly greater exposure there to the plicating forces.

The Ohio River runs through the most depressed portion of the whole basin. It may be remarked that a very narrow exposure of the lower measures follows the Ohio both at the northern and southern limits of the upper group. This is occasioned by the river erosion.

In Tennessee an anticlinal axis divides the area into two basins. Its course is indicated by the extension northeasterly from Alabama of the narrow white strip west of the Tennessee River.

In Alabama there are four basins. First is the *Coosa* field, the long narrow strip crossing the Coosa River, with the small area nearly reaching to the Georgia line. Second, the *Cahawba*, a narrow club-shaped area, extending farthest south of any. This is supposed to be on the same line with the long trough terminating at Chattanooga. Third, is the eastern border of the great expanse to the northwest known as the *Black Warrior* field, and connecting with the eastern basin in Tennessee. Fourth, the balance of the coal in Alabama may be comprised in one basin. The dips are highly inclined to the east in the first basin, but show less evidences of elevation and disturbance in proceeding northwesterly. These facts are compiled from statements furnished by R. P. Rothwell and J. M. Safford.

A few details concerning the character of the Coal Measures in different parts of the Appalachian Field now to be presented, will illustrate their subdivision minutely, as well as the amount of coal present.

H. D. Rogers' System of Coal Measures of Pennsylvania from Mercer to Greene Counties.

ALLEGHANY RIVER.

I.—Lower Coal Measures.

No.		Feet.
1	Conglomerate and Tionesta sandstone	50 to 60
2	Slate and shale	5 " 15
3	*Coal A, Brookville*	1 " 2
4	Slate and shale	25
5	*Coal B, Clarion, Blossburg, etc.*	3 " 4
6	Slate and shale	30
7	Ferriferous limestone	15
8	*Buhrstone and Iron ore*	½ " 6
9	Shale and sandstone	30
10	*Coal C, Kittanning*	3 " 4
11	Slate and shale	75
12	Freeport, Dunbar or Contorted sandstone	50 " 60
13	*Coal D, Lower Freeport*	3
14	Shale and sandstone	30 " 40
15	Limestone	4 " 7
16	Fire-clay and shale	1 " 10
17	*Coal E, Upper Freeport*	3 " 6
		392

PITTSBURGH REGION.

II.—Barren Measures.

No.		Feet.
18	Shale	50
19	Mahoning sandstone	75
20	*Coal F, Elk Lick*	1 to 2
21	Thick shale	..
22	Slaty sandstone	30
23	Red and blue shale, Pittsburgh	20
24	*Coal G*	1
25	Limestone	2
26	Olive slate and buff shale	100
27	Ligonier sandstone	70
28	Red marly shale	12
29	Shale and slaty sandstone	10
30	Limestone	3
31	Red and blue shales	4
32	Buff shales	18
33	Yellow and purple shale	10
34	Limestone	2
35	Red and yellow shale	12
36	Limestone	3 to 5
37	Shale and sandstone	30
38	Limestone	25
	Total feet, 873	481

MONONGAHELA RIVER.

III.—Upper Coal Measures.

No.		Feet.
39	*Coal H, Pittsburgh*	5 to 8
40	Brown shale	30
41	Gray slaty sandstone	25
42	Shales	20
43	Limestone (the best)	16
44	Black calcareous shale, sometimes 2½ feet coal	8
45	Slaty sandstone	18
46	Black slate	5
47	Limestone	18
48	Shale	10
49	Flaggy sandstone	20
50	Shale	10
51	Upper Limestone	8
52	Sandstone and shale	35
53	Soft shale	5
54	*Coal I, Waynesburg*	6
	Total feet, 1,115	242

WASHINGTON AND GREENE COUNTIES.

IV.—Upper Barren Group.

No.		Feet.
55	Yellow and brown shale	10
56	Gray and brown sandstone	35
57	Blue friable shale	7
58	*Coal*	2
59	Soft blue shale	3
60	Limestone	4
61	Soft blue shale	4
62	Limestone, three layers	4
63	Blue and yellow shale	10
64	Sandstone, in three layers	20
65	Brown and blue shale	10
66	*Coal*	1
67	Brown and blue shale	4
68	Sandstone	20
69	*Coal*	1
70	Buff shale	20
71	Limestone	3½
72	Buff shale	50
73	Gray micaceous sandstone	11 to 14
74	Buff shale	17 " 20
75	Gray micaceous sandstone	14
76	Yellow micaceous shale	15
77	Shales and sandstone	62
78	Flaggy sandstones	13
79	Blue and buff shales, thin	..
80	*Coal ten inches*	1
81	Blue shales and sandstones	42
82	Limestone	3
83	Thin bedded sandstone	15 to 25
84	Shale and limestone	10
85	*Coal*	1
86	Dark gray shale	13
87	Limestone	2
88	Shale and laminated sandstone	15
89	Limestone	3
90	*Coal ten inches*	1
91	Limestone	½
92	Gray sandstone and shale	42
93	Yellow, blue, and brown shale	27
94	Limestone, thin	..
95	Green micaceous sandstone	44
96	Dark gray sandstone	18
97	Blue, buff, and olive shale	56
98	Limestone	5
99	Dark calcareous slate	5
100	Gray and buff sandstone	110
101	Blank	200
	Total feet, 2,089	974

Section of the Coal Measures in Ohio, by J. S. Newberry.

I.—Lower Coal Measures.

No.		Feet.
1	Waverly	..
2	Conglomerate	100
3	Shale	20
4	Fire-clay	3
5	*Coal No. 1* (A), Briar Hill or Block Coal	4
6	Shale	5 to 40
7	Sandstone	20 " 70
8	Shale	20
9	*Coal No. 2*, generally thin	1 " 6
10	Shale and sandstone	75
11	Fire-clay	6 " 12
12	*Coal No. 3* (B)	2 " 4
13	Blue or ferriferous limestone	4
14	Shale and sandstone	10 " 50
15	Fire-clay	3
16	*Coal No. 3a*, local	2 " 3
17	Shale and sandstone	20
18	Fire-clay	3
19	*Coal No. 4* (C, Kittanning)	2 " 6
20	Gray limestone	3 " 6
21	Shale and sandstone	20 " 60
22	Fire-clay, locally hard clay	4
23	*Coal No. 5* (D, Lower Freeport)	2 " 4
24	Shale	50
25	Limestone	0 " 8
26	Fire-clay	3
27	*Coal No. 6* (E, Upper Freeport)	4 " 7
28	Gray shale	5 " 20
29	Mahoning sandstone	30 " 80
	Total feet, 685	

Barren Measures.

No.		Feet.
1	Limestone	2 " 10
2	Fire-clay	3
3	*Coal No. 7*	0 " 5
4	Sandstone and shale	50
5	Fire-clay	1
6	*Coal No. 7a* (F)	1 to 6
7	Shale	2 " 10
8	Shale and sandstone	50 " 100
9	Fire-clay	2
10	*Coal No. 7b* (G)	½ " 4
11	Shale	1 " 17
12	Crinoidal limestone	2 " 8
13	Shale	5 " 10
14	Shale and sandstone	110
15	Limestone	4 " 30
16	Fire-clay	3
	Total feet, 1,044	359

Upper Coal Measures.

No.		Feet.
17	*Coal No. 8* (H, Pittsburgh)	4 to 8
18	Black shale	2 " 10
19	Limestone	30 " 70
20	Fire-clay	½
21	*Coal No. 9*	2½
22	Sandstone	35 " 40
23	Fire-clay	3
24	*Coal No. 10*	3 " 6
25	Sandstone	45
26	Limestone	6
27	Sandstone and shale	50
28	Fire-clay	1
29	*Coal No. 11*	1½ " 4
30	Sandstone and shale	20 " 40
31	*Coal No. 12*	1 " 6
32	Sandstone and shale	70
33	*Coal No. 13*	1 " 2
34	Sandstone	40
35	Limestone	7
	Total feet, 1,455	411

West Virginia Section, by W. B. Rogers. Abridged.

Lower Coal Group.

No.		Feet.
1 to 5	Shales and sandstones	46 to 64
6	*Coal A*, friable	1½ " 2½
7	Sandstone and shale	30
8	*Coal B*	1
9 to 13	Sandstones, shale, limestone, iron ore	17 " 67
14	*Coal C*	1 " 2
15	Shale	12
16	*Coal D*, friable	3½ " 4
17	Shale	30 " 40
18	*Coal E*, thin	1
19	Shale	5 " 6
20	Mahoning sandstone	60 " 70
	Total feet	299

Barren Measures.

No.		Feet.
21 to 29	Shale, sandstone, limestone	144
30	*Coal F*, poor	1 " 1½
31 to 33	Shales and sandstone	53
34	*Coal G*, slaty	2½ to 3
35 to 58	Shales, conglomerates, sandstones, limestones	201
59	*Coal g*	2
40, 41	Limestone and shales	16
	Total feet, 719	420

Upper Coal Group.

No.		Feet.
42	*Coal H* (Pittsburgh)	6½ to 9½
43, 44	Shale and limestone	22
45	*Coal I*, Redstone	3 " 4
46 to 52	Shale, limestone, and sandstone	31
53	*Coal J*, Sewickly	3½
54 to 65	Shales, sandstones, and limestones	211
66	*Coal K*, Waynesburg, and two smaller seams	7½
67, 68	Shales and sandstones	20
	Total feet, 1,029	310

Comparison of Upper Coals, by J. J. Stevenson.

OHIO.	PENNSYLVANIA.	WEST VIRGINIA.
Coal XIII.	Top at Waynesburg.	?
Coal XII.	Middle at Waynesburg.	?
Coal XI.	Waynesburg.	Waynesburg.
Coal X.	Uniontown. ?	Not present.
Coal IX.	Not present.	" "
Coal VIIIc.	" "	" " east side of basin.
Coal VIIIb.	Sewickly.	Sewickly.
Coal VIIIa.	Redstone.	Redstone.
Coal VIII.	Pittsburgh.	Pittsburgh.

Tennessee Coals.

Through the kindness of Prof. J. M. Safford we are enabled to present further details of the distribution of the coal-beds in Tennessee in the small map annexed.

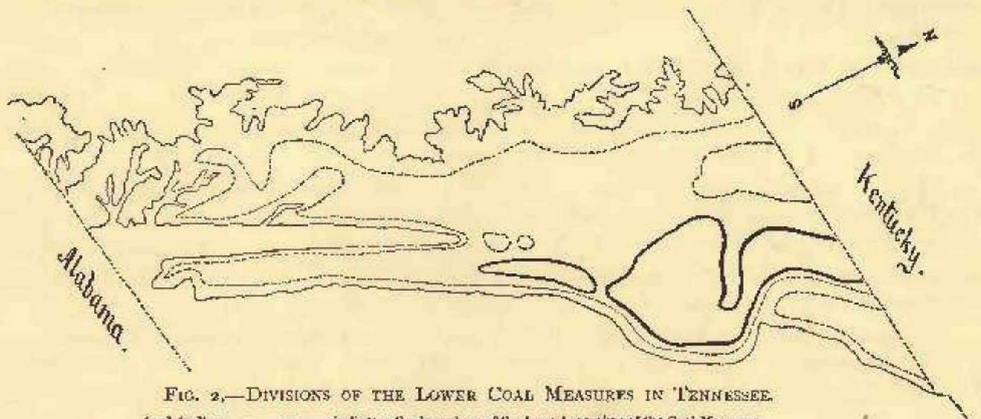

Fig. 2.—Divisions of the Lower Coal Measures in Tennessee.

A plain line ——— indicates the boundary of the lowest member of the Coal Measures.
A dotted line ····· " " outcrop of the Main Sewanee Coal, supposed to be Lesley's bed B of Pennsylvania.
A broad line ━━━ " " upper part of the Lower Coal Measures.

The outline of the Coal Measures is indicated by a simple line, and it will be found to correspond essentially with the delineation upon our map. Within this is a dotted line agreeing with the outcrop of the main Sewanee coal. This is regarded as the equivalent of Lesley's bed B in Pennsylvania; and the area between the dotted and outer border lines is placed under the conglomerate underlying the usual Coal Measures. These lower beds are not developed so extensively in the States farther north.

The Michigan Basin.

The Michigan Basin has an area of 6,700 square miles, with 123 feet of measures, and eleven feet (maximum) of coal. In the center the coal is thickest, thinning out to nearly the thickness of paper around the edges. The facts are derived from the reports of Prof. A. Winchell, and the map from a geological sketch of Michigan in the recently published Topographical Atlas of that State.

The Illinois Basin.

The Coal Measures of the Illinois Basin occupy about 47,188 square miles, in the States of Illinois, Indiana, and Kentucky. Some authors think the beds of coal in this basin are the equivalents of corresponding ones in the Appalachian field. It is claimed by some that the two fields were connected together at the time of their formation, their subsequent separation being due to erosion. Our small map shows that the lower part of the Carboniferous is continuous from one basin into the other, but the delineation of the Coal Measures themselves indicates a wide gap between the two areas, even where they approach nearest to each other in Kentucky.

Dr. J. S. Newberry shows conclusively that the Silurian rocks in Southern Ohio constituted a mountainous ridge long before the Carboniferous era, and thinks it clear that the coals could never have been united in Ohio. Mr. Lesquereux endeavors to show by a thorough comparison of plants that several beds can be identified in both basins by their organic remains. Drs. Newberry and Dawson dissent from his conclusions, on paleontological grounds.

Mr. Lesquereux made use of the stratigraphical facts collected by Major S. S. Lyon, assistant of Prof. D. D. Owen, State Geologist of Kentucky, and drew a comparative section of the measures in Pennsylvania, Ohio, Kentucky, etc., pointing out the beds that seemed to be equivalent in both fields. There were difficulties in the matching of the paleontological and stratigraphical work which lead to a new investigation, and a fault was discovered in Major Lyon's section. It is to the credit of Lesquereux's theory that it suggested the existence of errors which had not been suspected by the field geologists, while the first announcement of the equivalency was compelled to assume the correctness of the stratigraphical work. Nevertheless, the theory is rather unpopular with American Geologists.

In this field the beds of coal are not so thick as in the Appalachian, though their number is about the same. The thickness of the measures is also greatly reduced, while the limestones are more abundant, thus giving evidence of different conditions of formation. These differences are intensified in the Missouri field, save that the measures are almost as thick as in the east. The coals themselves are also more apt to be impure, while there is an abundance of good workable beds, as shown by the statistics of production.

Indiana.—The measures in this State occupy 6,500 square miles, contain twelve beds of coal with an aggregate thickness of 40 feet above the millstone grit, according to Prof. Cox's Section. The division of lower and upper corresponds to the "eastern and western zones" of the reports. The former occupies about 450 square miles. The coals are non-coking or free-burning, and are generally known as the "block coal" because it comes out in square pieces, the bed being traversed by a multitude of joints or seams. It is found to be very valuable in the smelting of iron, and is largely used for this purpose.

The western zone is by far the most extensive, and the coals are of good quality and considerable thickness. The irregular outlines of these divisions were specially furnished us for our map by Prof. Cox. The following is his Section, taken from the Report for 1870:

CONNECTED SECTION OF THE COAL MEASURES IN INDIANA, BY E. T. COX.

LOWER PART.

	ft.	in.
Shales and thin Coal		
Measures	47	
Coal A	3	
Measures	20	
Coal B	2	
Millstone Grit	265	3
Coal F, third block	4	
Measures	23	6
Coal G, second block	4	
Measures	17	
Coal H	1	6
Measures	13	
Coal I, main block	4	4
Measures	16	

UPPER PART.

	ft.	in.
Coal J	2	
Measures	17	7
Coal K	5	
Measures	40	
Coal X	4	
Measures	40	
Coal L	8	
Measures	41	
Coal M		6
Measures	31	3
Coal N	4	6
Measures	45	
Total feet	659	5

Illinois.—The measures in this State occupy 36,800 square miles, are 600 feet thick, and contain ten beds of coal with an aggregate thickness of 38 feet. The workable coals belong to the lower division. In the section the beds are numbered from below upward.

LOWER SERIES.

No. 1 ranges from two to three feet in thickness.

No. 2 ranges from two to five.

No. 3 ranges from three to four feet, and is local in its development.

No. 4 has been seen only at Cuba, where it is four and one-half feet thick.

No. 5 is almost universally developed, and is extensively worked. It varies from three to nine feet in thickness.

No. 6 is much like 5 in its development and valuable qualities, varying from three to seven feet in thickness.

The five seams of the upper series range from a few inches to two feet in thickness, and are of scarcely any practical value. The limits of the upper part were furnished specially for the map by A. H. Worthen, State Geologist.

Usually a coal basin displays its lowest beds upon all sides, and the lower measures extend beneath the upper, with greater thickness in the middle. The Illinois basin shows certain peculiarities in its structure varying from the normal type. It may be seen partly by reference to the smaller general map. At the south end the underlying strata are of Carboniferous age, just older than the Coal Measures to the north in Illinois; these are outcrops of the Devonian and Silurian, the lower members of the latter system adjoining the Carboniferous on the north side of the field. The upper Coal Measures rest upon Silurian rocks in Northern Illinois instead of the lower Coal series. It would appear, therefore, that there must have been a gradual sinking of the land to the north during the age of the Coal Measures, and the newer beds have been brought successively into direct contact with much older formations. Our map exhibits the lower division upon the east and west sides of the upper, but not on the north. There is a somewhat similar state of things in Western Kentucky.

Kentucky.—In Western Kentucky this field occupies 3,888 square miles, according to Major S. S. Lyon's survey. A revision of the vertical column, by E. T. Cox, makes the measures 612 feet thick, including the millstone grit. There seem to be nine beds of coal in this area, having the following thicknesses respectively, commencing with the lowest, two, four, three, two-and-a-half, five, two-and-a-half, five, two, and three feet; making 29 feet in all. The reports of Kentucky need to be studied with great care, since they were prepared before the discovery of serious errors in their sections. Several of the beds are repeated in consequence of the presence of a fault on the Ohio River near Henderson, and hence the number of beds are given in the reports as twice their proper number. Our map shows the boundaries of the lower division, as given by S. S. Lyon expressly for us, while the line of the upper measures has been drawn by a comparison of the statements in the reports with the facts sent in for Illinois and Indiana. We shall soon have reliable maps of this State from the Survey now in progress under the direction of Prof. N. S. Shaler.

THE MISSOURI BASIN.

This is the largest of all the Coal Fields of the country in territorial expanse, amounting to 84,343 square miles, though thinner and with fewer beds of coal than the Appalachian. The lower division occupies all the eastern border, while the higher portions are situated upon the western side and pass beneath Permo-Carboniferous, and Cretaceous strata. The territory has been very little studied.

Iowa.—The Coal Measures of Iowa are divided by Prof. C. A. White, State Geologist, into three parts, each about 200 feet in thickness. The area of the lowest division is 6,100 square miles, of the middle, 3,400, and of the upper, 8,500, in all 18,000. The lowest is the most important for producing coal, and occupies the eastern border of the tract, as shown upon our map. The middle and lower divisions are grouped together as the lower member upon our map.

Nos.		Thickness. ft.	in.
	LOWER DIVISION.		
	Sandstones and shales, two or three workable beds, about	200	
	MIDDLE DIVISION.		
1–3	Shales, limestones, etc.	43	
4	*Coal*, Lacona		20
5–7	Sandstones and shales	40	
8	*Coal*, Panora	1	
9–18	Shales, etc.	26	8
16	*Coal*, Wheeler		15
17–32	Shales, sandstones, limestones	152	
33	*Coal*, Marshall		20
34–41	Shales, etc.	55	
42	*Coal*, Lyonsdale		2
43, 44	Shales	14	
	UPPER DIVISION, WINTERSET SECTION.		
2–5	Limestone, etc.	84	
6	*Coal*		18
7–16	Limestones, clays, carbonaceous shales, etc.	94	

As the lower divisions extend beneath the higher, it is probable that the whole 18,000 square miles are to be regarded as workable territory.

Missouri.—According to G. C. Brodhead, State Geologist, the Coal Measures cover an area of about 23,100 square miles in Missouri. He divides the series into three parts, as in Iowa—the upper, or barren measures, occupying 8,406, the middle 2,000, and the lower 12,420 square miles. Upon our map the middle and lower divisions of Brodhead are called the lower member, and upon the map the attempt has been made to make others correspond in distribution with the corresponding members in Iowa.

The aggregate thickness of the upper division is 137 feet, including about four feet of coal in two seams of one foot each, and a few streaks. The middle division is 324 feet thick with seven feet of coal, including two workable seams of 21 and 24 inches, a third of one foot worked under favorable circumstances, besides six seams of extreme thinness. The lower division is from 250 to 300 feet thick, embracing five workable beds, varying from one-and-one-half to four-and-one-half feet each in thickness, and thin seams between six and eleven inches, besides unimportant streaks—in all, 13 ft. 6 in. The total thickness is therefore near 1900 feet of Coal Measures and 24 ft. 6 in. of coal.

The following is a condensed vertical section of the Coal Measures, as drawn up by the State Geologist, only the numbers of the strata are reversed so as to make this conform to the list already given for other States.

No.		Thickness.	Locality.
	LOWER DIVISION.		
1 (32)	*Coal*, clay 10 inches at base	2 ft.	Ralls, Audrain, St. Louis, St. Charles and Montgomery, Henry and Johnson.
2	Measures	13 "	
3	*Coal*	11 in.	Macon, Henry, and Johnson.
4	Measures	11 ft.	Macon.
5	*Coal*	2½–4 ft. 5 in.	Randolph, Boone, Callaway, Johnson, Henry, Vernon, Bates,
6	Measures	48 ft.	Adair, Sullivan, Putnam, Audrain, and Macon.
7	*Coal*	2 "	Henry.
8	Measures	4 "	
9	*Coal*	8 in.	Johnson.
10	Measures	18 ft.	
11	*Coal*	1 ft. 8 in.	Johnson.
12	Measures	18 ft.	
13	*Coal*	7 in.	Johnson.
14	Measures	52 ft.	
15	*Coal*	1½ ft. (Warrensburgh.)	Johnson, Henry, Chariton.
	MIDDLE DIVISION.		
16	Measures	50 to 90 ft.	
17	*Coal*	21 in.	Lafayette, Johnson, Carroll, and Livingston.
18	Measures	14 ft.	
19	*Coal*	7 in.	Lafayette and Ray.
20	Measures	36 ft.	
21	*Coal*	2 ft. (Lexington.)	Lafayette, Johnson, and Ray.
22	Measures	70 ft.	
23	*Coal*	1 foot.	Cass, Johnson, Lafayette, Livingston, Grundy.
24	Measures	164 ft.	
25	*Coal*	3 in.	Pleasant Hill, Missouri City, and Princeton, Mercer County.
26 (7)	Measures	379 ft.	
	UPPER DIVISION.		
27	*Coal*	10 in.	Platte County.
28	Measures	207 ft.	
29	*Coal*	12 in.	Andrew, Buchanan, DeKalb, Gentry, Platte.
30	Measures	392 ft.	
31	*Coal*	12 in.	Holt, W. part of Nodaway and northwardly.
32 (1)	Measures	339 ft.	

Nebraska.—The area marked Carboniferous in this State, upon Dr. Hayden's map, measures about 3,600 square miles. The outcrops belong entirely to the upper of the three divisions of Iowa and Missouri; all geologists agree that it is not likely to afford any good workable beds of coal. Beds of the thickness of six, eleven, fifteen, and twenty-two inches, are reported from different counties. The coal is usually inferior, but may be used in the neighborhood to some advantage in the absence of all other fuel, but good workable coals are yet to be discovered in Nebraska. They may yet be found at considerable depths.

Kansas.—Prof. Swallow estimates the area occupied by the Coal Measures in Kansas at 17,000 square miles. The same three divisions occur here as in Iowa and Missouri, but we have not the means of separating them upon the map. The rocks dip slightly to the northeast, and consequently the upper unproductive division is the one most largely developed.

The elaborate section of the Coal Measures given by Prof. Swallow shows 22 different seams of coal, varying from a few inches to seven feet in thickness. Ten are over a foot thick. The measures amount to 2000 feet in thickness, being made up of more than 80 different seams of limestone.

SUMMARY OF SWALLOW'S SECTION IN ASCENDING ORDER.

No.		Thickness.
1	*Lower Carboniferous Formation*	120 feet.
2	*Lower Coal series*, contains 24 layers, five beds coal. (1) 6 to 10 inches. (2) 3 feet. (3) 2 to 4 inches. (4) 2 to 6 inches. (5) 5 to 7 feet.	353 "
3	*Fort Scott Marble series*, 7 layers, coal bed 2 ft. 6 in.	23 "
4	*Fort Scott series*, 12 layers, two coal seams, 6 in. and 16 in.	142 "
5	*Pawnee limestone series*, 9 layers, 6 inches coal	112 "
6	*Marais de Cygnes coal series*, 25 layers, 4 seams coal. (1) 2 to 3 feet. (2) 1 foot to 2 ft. 6 in. (3) 1 ft. 8 in. to 2 ft. 9 in. (4) 2 inches.	303 "
7	*Well rock series*, 11 layers, coal 1 to 5 inches	238 "
8	*Spring rock series*, 9 layers, two seams coal, 6 in. to 1 foot, and 4 to 8 inches	88 "
9	*Cave rock series*	75 "
10	*Stanton limestone series*, 5 layers, coal 12 to 30 inches	74 "
11	*Chocolate limestone series*, 10 layers	79 "
12	*Upper Coal Measures*, 56 layers, 3 seams coal, 1 to 3 and 4 to 10 inches	391 "

Indian Territory.—The Coal Measures are made to cover as much as 13,600 square miles upon the map. Little is known of the coal outcrops. The officers of the Missouri, Kansas, and Texas R. R. Company find good banks of coal at several places along their line several feet thick.

Arkansas.—There are two beds of coal in Arkansas beneath the millstone grit, according to D. D. Owen and Lesquereux. They are each four or five feet in thickness. Owen estimates the area occupied by the coal-bearing rocks in this State at 12,000 square miles. Macfarlane states it to be 9,043 square miles.

TEXAS BASIN.

According to A. R. Roessler in the "Almanac," the measures occupy 6,000 square miles in this State. Our map is copied from one furnished by him. B. F. Shumard estimates the thickness of the measures at 300 feet. S. B. Buckley says there are from two to four seams of coal at Fort Belknap, and six miles further north another five feet thick. This field may be the continuation of the Missouri, as the space between them, along the valley of Red River, is occupied by newer and overlying formations.

Arizona.—Near Camp Apache, Mr. G. K. Gilbert of the expedition under the direction of Lieut. G. M. Wheeler, reports a bed of coal belonging to the true Carboniferous series. Two other examples are mentioned by Prof. Blake.

TRIASSIC COAL.

The map does not extend far enough west to allow of the delineation of Rocky Mountain areas underlaid by beds of lignite. The outcrops of a later coal are shown in Virginia and North Carolina. The best known is the Chesterfield County field near Richmond, Va., estimated at 185 square miles. Coal was mined here before the opening of collieries in any other part of the country. The thickness of the beds vary, the largest being at the Creek Pit, where 52 feet of clear coal are contained in a thickness of 58 feet. The two other Triassic areas in Virginia are not known to contain beds of coal. The most southern one in North Carolina is known as the Deep River Basin, containing 5 beds, having a thickness of three, one, three, two, and four feet respectively. It is known to be 30 miles in length with a width of 12 to 14 miles. The other is the Dan River field, about 40 miles in length and from four to seven miles wide. The coals are less promising than in the other field.

There are other Triassic areas in the field of the map, but they are not represented, as no coal of any consequence is known to occur in them.