ART. XXX.—*Thickness of the Paleozoic Sediments in Arkansas;* by JOHN C. BRANNER. With a Map (Plate III).

THE general divisions of the rocks of Arkansas are shown on the accompanying geological map. There are no Archæan rocks in the state, and the bottom of the Paleozoic beds is, therefore, not exposed. The syenites of the state, formerly supposed to be Archæan, are eruptives, probably of Tertiary age; whether the "red granite" said to occur at the mouth of Spavina Creek in the Indian Territory, near the northwest corner of the state,* is Archæan, is not known at present.

The total thickness of the oldest sediments cannot, therefore, be determined from direct observations within the state, and the total given in the present paper is, for that region, less than it should be.

On the other hand, the method of giving maximum thicknesses and of obtaining the total thickness of any one series of beds by adding together outcrops observed at many different localities, is liable to give an exaggerated idea of the total thickness of sediments, for in all probability no such total exists at any one place.

The lowest rocks—the Lower Silurian—are exposed in Arkansas in two separate regions: the first in the region of the Ouachita uplifts, running west from Little Rock past Mt. Ida to the Indian Territory; the second north of the Boston Mountains along the Missouri line.

In the former area the rocks are exposed by erosion in a region of sharp folds; in the latter they are horizontal or nearly so, are faulted in a few places, and are exposed for the most part by the trenching of the streams and the exposure of perpendicular bluffs, where the character and thickness of the beds may readily be inspected.

In the region of the Ouachita uplift no attempt has been made to subdivide the Silurian beds, further than to locate the novaculites. Very few fossils have ever been found in this area and no correlation of the rocks with those of other Silurian area of the state is possible at present, further than that made by Dr. R. R. Gurley, based upon a study of the graptolites found there. He says that a Trenton horizon and a Calciferous horizon are represented.† Mr. Griswold, who has studied this area more thoroughly than any one else, says that the shales, limestones, and quartzose sandstones below the novaculite have a thickness of about 1300 feet, while the

* Second report of a geological reconnoissance of Arkansas, by D. D. Owen, Philadelphia, 1860, pp. 17 and 408.

† Ann. Rep. Geol. Surv. Ark. for 1890, vol. iii, p. 401.

novaculites are about 1260 feet thick, making a total thickness of 2560 feet of Silurian sediment exposed in the Ouachita uplift.*

The lower Carboniferous beds are not represented, so far as we know, in the Ouachita uplift, but the Lower Coal Measures (Pennsylvanian) rocks seem to rest directly upon the Silurian novaculites.

In the Silurian area north of the Boston Mountains the rocks are sandstones, cherts, magnesian limestones and a few beds of shale. The lowest rocks in the Boston Mountain region of which we have any knowledge are those penetrated by the deep well bored near Cushman, Independence County. This well gives a thickness of 1750 feet below the Izard limestone.†

Overlying this unclassified (in Arkansas) group of sediments is a bed I have called the Izard limestone, from its development in the southeastern part of Izard county; according to Penrose this limestone has a maximum thickness of 285 feet‡ at Penter's Bluff on the White River. From the manganese region in Independence and Izard counties it thins out east, west, north and south.

Next above the Izard limestone is the St. Clair marble with a maximum thickness of 155 feet at Penter's Bluff; it also thins out on all sides and is not known in the western part of the state.

According to Dr. H. S. Williams, who has carefully studied the paleontology of these rocks, the lower part of the St. Clair bed of Penrose is "about equivalent to that of the Nashville group of Tennessee or the Cincinnati group of Ohio,"§ while the upper part of it contains fossils "equivalent to the Waldron fauna of Indiana or to the Clinton-Niagara fauna of New York," and the middle is of "early Niagara." The last two divisions are Upper Silurian.

Next above the St. Clair marble is what I have called the Eureka shale with a maximum thickness in Washington County of 50 feet.‖ The age of this shale has not been definitely settled. In Tennessee, Safford calls it the "Black shale" and refers it provisionally to the Devonian; Hershey thinks it is the equivalent of shales of Devonian age in Iowa and Illinois.¶

* Ann. Rep. Geol. Survey of Ark., for 1890, p. 206, and plate III, p. 209.

† Op. cit., vol. i, Manganese, by R. A. F. Penrose, Jr., pp. 117–118.

‡ Annual report of the Geol. Survey of Ark. for 1890, vol. i, Manganese, by R. A. F. Penrose, Jr., Little Rock, 1891, pp. 121–122. Also marbles and other limestones, vol. iv, by T. C. Hopkins, p. 108.

§ On the age of the Manganese beds of the Batesville region of Arkansas, by Henry S. Williams, this Journal, III, 1894, xlviii, 326.

‖ Ann. Rep. Geol. Survey of Ark. for 1888, vol. iv, Washington County, p. xiii.

¶ The Devonian series in southwestern Missouri, by Oscar H. Hershey, Amer. Geologist, 1895, xvi, 294–300.

The fossils found in the Eureka shale in Arkansas are mostly *Discinas* and *Lingulas* and are of but little use in correlation, but inasmuch as crinoid stems are abundant in places, and as the shale merges gradually into the overlying Carboniferous limestones, I am inclined to believe that it belongs with the Carboniferous rocks.

The Sylamore sandstone (one of the phosphate beds of Arkansas) has a maximum thickness of 40 feet on Sylamore Creek in Stone County; it sometimes replaces the Eureka shale; often it is entirely wanting. At St. Joe a thin bed (4″) overlies the shale, and a thicker one (2–4 feet) underlies it.*

Thus far but few recognizable fossils have been found in this formation.

Above the Sylamore sandstone and Eureka shale is the chert-bearing limestones (sometimes containing sandstones also) which I have called the Boone chert on account of its wide occurrence and development in Boone County. It is found throughout the entire Paleozoic area of North Arkansas north of the Boston Mountains, and has a maximum thickness of 370 feet.

The next horizon, named by Prof. F. W. Simonds the "Wyman sandstone," has a thickness of only 10 feet.† Above it the Fayetteville shale (Simonds), a widespread formation north of the Boston Mountains, has a maximum thickness of 300 feet near Batesville.

Next, the Batesville sandstone has a thickness of 200 feet in the western part of the state. The Batesville sandstone lies at the top of the Arkansas equivalent of the Keokuk and Burlington. Then follows what I have called the Boston group, a series of shales, sandstones and limestones, which form the upper portion of the Lower Carboniferous or Mississippian: these taken together have a maximum thickness of 780 feet. This brings the section to the base of the Coal Measures or Pennsylvanian.

In the Boston Mountain region the lowest member of the Pennsylvanian series, the Millstone Grit, has a thickness, in places, of 500 feet.‡ With the exception of some of the sandstones and shales that have been extensively eroded in that region, this is the highest member of the series exposed along the north side of the Boston Mountains, and the remainder of the group must therefore be measured in the Arkansas Valley.

* In Tennessee, Safford reports a similar sandstone below the shale (Geology of Tenn., p. 330); Meadows and Brown speak of it both above and below (Trans. Am. Inst. M. E., xxiv, 189, 585, 589); Hayes represents it as below (Sixteenth Ann. Rep. U. S. G. S., pt. iv, pl. vi).

† Ann. Rep. Geol Surv. of Ark. for 1891, vol. iv; Geology of Benton County, by F. W. Simonds and T. C. Hopkins, p. 27.

‡ Ann. Rep. Geol. Surv. of Ark., 1888, vol. iv, p. 137; 1890, vol. i, p. 140.

Beginning at the base of the Lower Coal Measures rocks southwest of Little Rock where they rest directly upon the Silurian novaculites, and going across the strike, nearly due north, to the Big Rock syncline whose axis crosses the Arkansas River two miles above Little Rock, we have a series of sandstones and clay shales, the latter predominating. The rocks all have very steep, almost vertical north dips except near the axis of the syncline; this belt is from three to four and a half miles wide. If they are not faulted or overturned, these beds have a thickness of something more than 16,000 feet. It is not improbable that they are faulted, however, for they are mostly clay shales, with an abundance of large quartz veins, and the beds exposed at the "little rock" on the river bank at Little Rock are much crushed and distorted; faulting in this case must have tended to conceal a part of the true thickness of the rocks.

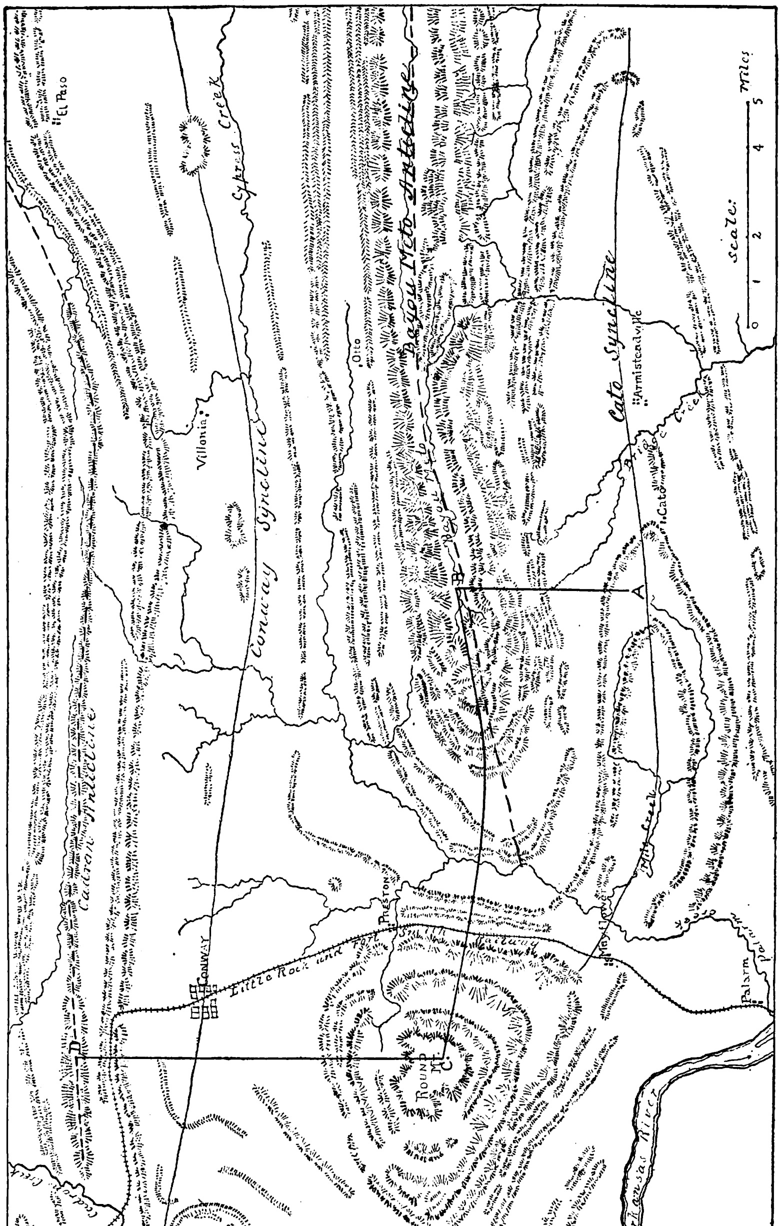
About four and a half miles north of the Big Rock axis is another syncline whose uppermost beds are at about the same horizon as those at Big Rock. The same beds are again exposed in a third syncline—the Cato syncline—fourteen miles north of Little Rock. The Cato synclinal axis is shown on the accompanying plate (p. 233). It lies east-west, and at its western extremity turns northward and ends in the Round Mountain. The rocks exposed at the axis of this syncline are at or very near the same horizon as those at the axis of the Big Rock syncline, so that we are here apparently no higher geologically than at Big Rock. Fortunately the geology hereabout and especially from Cato north to the Bayou Meto anticline, west to Round Mountain and thence to the Cadron anticline, north of Conway, is so plain that there can be no serious doubt about the thickness calculated for the several beds. An examination of the accompanying figure will, I believe, make this evident.*

The rocks are alternate beds of sandstone and shale, and erosion has developed a striking system of sandstone ridges and shale valleys: in some places these valleys and ridges may be traced for fifty miles, doubling back and forth upon themselves. The directions and continuity of the many sandstone ridges show that there can be no considerable faults or overturns.

From the top rocks of the Cato syncline (A on map, p. 233) to the bottom rocks of the Bayou Meto anticline (B on map) the rocks exposed have a total thickness of 14,900 feet.

But the top of the syncline at the starting point has been

* The details of the geology in the region represented on the figure were worked out by Mr. John H. Means and the figure was taken from his valuable map. Mr. Means has prepared a report upon the Lower Coal Measures area of Arkansas, but thus far the State has not published it.


El Paso
Cypress Creek
Bayou Meto Anticline
Cato Syncline
Armistead
Otto
Villonia
Conway Syncline
Cadron Anticline
Conway
Little Rock and Fort Smith Railway
Preston
Round Mt.
Arkansas River
Palarm
Scale:
Miles
A
B
C
D

removed by erosion. If one turns nearly due east, from the Bayou Meto anticline, crosses the Little Rock and Fort Smith railway a mile or two south of Preston, and goes to the top of Round Mountain in 4 N. 14 W. (C on the map), he will cross over the same series of rocks, plus the beds forming Round Mountain. All the way the dip is toward the west, and the total thickness of the exposed rocks is 18,480 feet.

Another series of observations made along a line run north from the top of Round Mountain to the axis of an anticline three miles north of Conway (D on the map), and deducting for the gentle fold near Conway, gives a thickness of 17,730 feet.

I lay particular stress upon these three measurements because they involve the greater part of the thickness of the Lower Coal Measures rocks, and because, judging from the manner in which these three sections agree, there seems to be no possibility of any serious mistake in estimating their thickness.

It ought to be noted here that in 1889 I authorized Mr. Griswold to say that the rocks of the Coal Measures in Arkansas had a total thickness of four miles.* This statement was based upon a section examined and measured between the Petit Jean Mountain and the Silurian novaculites of the Ouachita uplift. But there was no certainty that the rocks along this section were not repeated by folds or faults, and the thickness seemed so unusual that I afterwards sent assistant J. F. Newsom (now Professor of Geology in the University of Indiana) over another part of the same beds with a view to checking my results. The three measurements here given from the Cato syncline to the Bayou Meto anticline, thence to Round Mountain, and from Round Mountain to the Cadron anticline, are the results of Professor Newsom's work.†

So far as I can make out, the sandstones in the top of Round Mountain are at the same geological horizon as those in the tops of Carrion Crow Mountain, Petit Jean Mountain and Mount Nebo, and these sandstones lie only a short distance below the Ouita coal bed near Russellville.

From the base of the productive Coal Measures (beginning at the top of Carrion Crow Mountain) to the top of the Poteau Mountain at the Indian Territory line, there is a maximum thickness of 5300 feet, of which 3500 feet belong to the upper series, which Mr. Winslow proposes to call the Poteau group.

* Ann. Rep. Geol. Sur. for 1890, vol. iii, Whetstones and the Novaculites of Ark.; by L. S. Griswold, p. 206.

† In his report to me Professor Newsom notes the fact that the measurement on the south side of Bayou Meto anticline gives a thickness of 14,900 feet, and that the measurement on the west side, or down its nose to the ridge corresponding to that at the synclinal trough on the south, gives 14,520 feet—a difference of only 380 feet.

In the Lower Coal Measures area lying south of the Ouachita uplift Dr. George H. Ashley, who worked out the details of the geology of that region, found 5200 feet of sediments above the Silurian on West Saline River, and on the Rolling Fork of Little River he found 6800 feet, with the bottom still concealed.

These sediments are overlapped by the Cretaceous rocks to the south, so that the total thickness of the beds on that side of the Ouachita uplift is not visible.

Table of Thickness of the Paleozoic Sediments of Arkansas.

			Bost. Mts. feet.	Ark. Valley. feet.
Coal Measures or Pennsylvanian	Upper Coal M.	Poteau beds		3500
		Productive beds		1800
	Lower Coal M.	Barren beds		18480
	"Millstone grit"		500	
Lower Carboniferous or Mississippian	"Chester, St. Louis" / "Warsaw"	Bost. group	780	
	"Keokuk" / "Burlington"	Batesville sandstone	200	
		Fayetteville shale	300	
		Wyman sandstone	10	
		Boone chert	370	
Devonian (?)		Sylamore sandstone	40	
		Eureka shale	50	
Upper Silurian		St. Clair Marble	155	
Lower Silurian		Izard limestone	285	
		Underlying beds	1750	
			+	+
			4440	23,780+
Total thickness of known Paleozoic sediments			28,220 feet.	

There is, of course, nothing remarkable about the thickness of any of the Arkansas sediments except in the case of the Lower Coal Measures. So far as I can learn, the thickness of the Carboniferous rocks in this section is greater than that of sediments of the same age in other parts of the country or of the world.

Hitherto the Carboniferous sediments of Nova Scotia have been looked upon as the thickest on the Continent—between 10,000 and 16,000 feet.*

* There has been some disagreement about the thickness of these beds. Sir Wm. Logan reported 14,570 feet; later Sir Wm. Dawson gave 10,000 feet for the Coal Measures proper (Proc. Am. Phil. Soc. 1862, ix, 101; 1863, ix, 208;

In the Wahsatch section of Utah and Eastern Nevada the Weber quartzite and its overlying Coal Measures and Permian beds have a thickness of 10,650 and possibly of 16,650 feet.*

In the Indian Territory Chance reports a thickness of 8500 to 10,000 feet in the Carboniferous rocks, but that is simply another part of the Arkansas valley basin.†

Thickness of Coal Measures (Pennsylvanian) Sediments in North America.

Arkansas	23,780
Nova Scotia	16,000
Utah and Nevada	16,650 (?)
Indian Territory	10,000

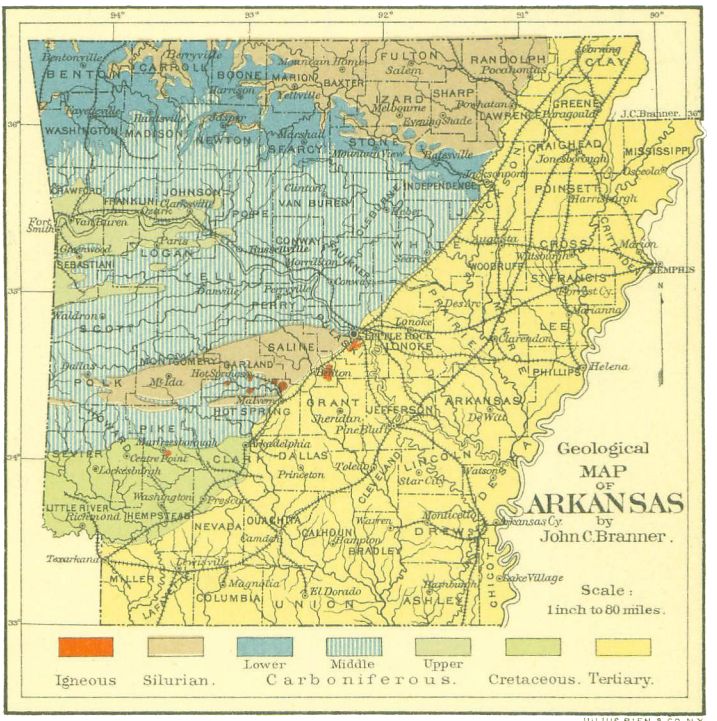
In other parts of the Mississippi basin containing Coal Measures rocks the beds are generally less than 5000 feet thick, the thicker portions lying along the eastern border of the Appalachian coal fields from Pennsylvania to Alabama, where they are 5500 feet thick.

If we inquire into the reason for the great thickness of Coal Measures sediment in the Arkansas Valley, I believe it is to be found in the drainage of the continent during Carboniferous times. The rocks of this series in Arkansas contain occasional marine fossils, and these marine beds alternate with brackish or freshwater beds whose fossils are mostly ferns and such like land or marsh plants. This part of the continent was, therefore, probably not much above tide level. The drainage from near the Catskill Mountains in New York flowed south and west. The eastern limit of the basin was somewhere near the Archæan belt extending from New England to Central Alabama. This Appalachian watershed crossed the present channel of the Mississippi from Central Alabama to the Ouachita uplift, or to a watershed still farther south and now entirely obliterated and buried in Northern Louisiana. In any case the drainage flowed westward through what is now the Arkansas valley between the Ozark Island on the north and the Arkansas Island on the south.

Acadian Geology, 2d ed., 1868, 149, 146, and 151), and still later 14,000 and 16,000 feet (Quar. Jour. Geol. Soc., xxx, 210). Mr. Gilpin says that H. Fletcher of the Canadian Survey gives a total thickness of 21,960 feet for all the Carboniferous of Cape Breton. This, however, includes the Lower Carboniferous (Quar. Jour. Geol. Soc., xlii, 1886. p. 524).

* U. S. Geol. Expl. 40th Parallel, I, Systematic Geology, by Clarence King, pp 240, 248.

† Trans. Amer. Inst. Mining Engineers, 1889–90, xviii, p. 655.


Geological
MAP
OF
ARKANSAS
by
John C. Branner.
Scale:
1 inch to 80 miles.
Igneous
Silurian.
Lower
Middle
Upper
Carboniferous.
Cretaceous.
Tertiary.
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