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FAUNA OF THE SO-CALLED BOONE CHERT

NEAR

BATESVILLE, ARKANSAS

BY

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FAUNA OF THE SO-CALLED BOONE CHERT NEAR BATESVILLE, ARKANSAS.

By GEORGE H. GIRTY.

INTRODUCTION.

The geologic section.—The rocks considered in this paper are of Mississippian age and their outcrops are found in the vicinity of Batesville, Ark., though of course their distribution extends to other and remote parts of the State.

The portion of the geologic section at Batesville to which I shall refer comprises in ascending order a series of pure limestones of unmeasured thickness, a series of fine-grained impure and cherty limestones 200 to 250 feet thick, a series of black and green shales about 225 feet thick, and a massive quartz sandstone to which a thickness varying from 30 to 200 feet has been assigned. The first two series have been referred to the Boone limestone, but the paleontologic evidence here recorded indicates rather strongly that the cherty limestone is younger than the true Boone and should really be classed as a distinct formation. In the present paper I shall refer to these two series of strata as the limestone member and the chert member, respectively.

The shale overlying the chert member is the Moorefield, which in turn is overlain by the Batesville sandstone. The Moorefield shale as at present defined contains at its base a thin and perhaps local development of impure limestone which H. S. Williams once called the Spring Creek limestone, but the name was preoccupied and probably can not be retained for this occurrence. The evidence here presented seems to show that both lithologically and faunally the "Spring Creek limestone" belongs with the underlying chert member. With the Moorefield redefined so as to exclude these calcareous beds at its base the formation would become much more uniform in lithologic and paleontologic characters.

The fossils that form the subject of this account are poorly preserved, and as a fauna they comprise little that is new, almost all the species being found in the overlying "Spring Creek limestone." Their chief interest, indeed, resides in this fact and in the fact that they come from a series of rocks which has usually, if not always, been classified as part of the Boone limestone, though the fauna of the Boone, as at

present known, is widely different from that of the "Spring Creek limestone" and that of this chert member.

The rocks that furnished these fossils have been studied and identified only in the vicinity of Batesville, the outcrops especially examined by me occurring on the hills east and west of Spring Creek and along the railroad up White River west of Spring Creek.

The south face of the hills at the debouchure of Spring Creek into the White River valley, west of Batesville, is occupied by the Moorefield shale and the Batesville sandstone. These beds dip south and east, so that the chert member may be found by going northward up Spring Creek or westward up White River. The contact of the chert with the black shale and limestone of the Moorefield is at Ruddells Mill, on Spring Creek one-half mile from White River junction, and also along the railroad three-fourths of a mile west of the same point in the White River bluffs. Possibly the same contact occurs 1 mile north of Sharps Crossroads (7 miles northeast of Batesville in the Batesville quadrangle), where a hillside is covered with fragments of light-gray, hard, earthy limestone and chert, weathered reddish and yellowish on the outside, which seem to belong to the chert member, although the country adjacent to the south is occupied by the Moorefield shale. The attitude of some thin sandstones apparently belonging to the Batesville, which outcrop one-half mile to the southwest, suggests the possibility of an intervening fault in this direction.

Presumably if the outcrops were followed northward up Spring Creek or westward up White River from the points where the top of the chert member was shown, its basal contact would also be found. In fact, the axis of a low anticline does bring to the surface about 1½ miles west of White River junction a whitish limestone which may be the limestone member; if it is, then along White River the chert occupies a position stratigraphically and geographically intermediate between the limestone member and the Moorefield shale. Although I did not follow these cherty beds up Spring Creek to their basal contact with the underlying limestone, I did determine their relations along the road to Bethesda Church. This road crosses Spring Creek at Ruddells Mill at about the top of the chert member, which also composes most of the high Tallow Hill on the west side of the stream. Chert is indicated by fragments or poor outcrops farther northwest along this road down the gradual descent to Mill Creek, but about 2 miles from Ruddells Mill these cherty beds are replaced by good outcrops of whitish crinoidal limestone, apparently very pure, and massive to slabby in structure. The actual contact was not here seen. The contact is well shown, however, in a quarry about 2 miles north of Batesville on the road to Blowing Cave. The quarry is in a massive, fine-grained, pure, light-gray limestone, which is called an oolite in the trade, but is entirely without oolitic structure. The limestone

of the quarry contains no chert beds, but it is overlain by thin-bedded cherts which are warped by subsidence into irregularities in the limestone surface produced by solution, or so it appeared. In so far as my notes describe the occurrence, however, the irregular upper surface of the limestone might be erosional.

I have not anywhere obtained a good measurement of the thickness of the chert member, but a fairly satisfactory estimate places it at 200 to 250 feet.

Lithology.—The lithologic character of the chert member may be described from the different outcrops where it has been observed. About a mile west of White River Junction it forms a high bluff along the north bank of White River, and is cut into here and there to make room for the track of the White River division of the St. Louis, Iron Mountain & Southern Railway. The bluffs rise about 80 feet and consist of a solid outcrop of limestone and chert. The limestone is fine grained and light gray and is interspersed with heavy layers of cherty beds. The general effect is thin bedded in weathered exposures and massive in the cuts. Similarly, the cherty character is brought out by weathering, the beds appearing more like a normal limestone where blasted. Toward the top the strata become less massive and also more earthy, weathering full of small vermicular cavities. Fragments of similar vermicular cherts and limestones occur for 50 feet higher up on the hillside.

The 130 feet of strata thus exposed or indicated comprises neither the top nor the bottom of the chert member. To the west occurs a limestone which is presumably the limestone member, and about 575 feet to the east another outcrop presents the higher beds of the series, consisting of 20 feet of finely crystalline, light to dark gray limestone, apparently nearly pure, overlain by thin, black, sandy shale, black calcareous sandstone resembling chert, black calcareous shale in thin sheets, and black limestone. I am unable to say definitely whether this outcrop represents the poorly exposed upper portion of the one farther west or a slightly higher horizon. In the field I was inclined to the latter opinion. Still farther east and apparently somewhat higher stratigraphically there are exposed in still another cut 10 feet of fine, fissile, greenish and black shale, 2 feet of sandy black calcareous shale, and 2 feet of thin black shale. Half a mile farther east, at White River Junction, is the main mass of the Moorefield shale, topped by the Batesville sandstone. The last cut, I judge, represents the base of the Moorefield shale; the one to the west represents the "Spring Creek limestone"; and the extensive one first described represents the chert member.

The railroad that runs along Spring Creek up to Cushman makes a series of cuts on the east bank of the stream, one of them being the typical exposure of the "Spring Creek limestone." As the beds

have a southward inclination, the chert member is well shown along the railroad north of the Spring Creek outcrops. My own observations cover somewhat less than one-fourth of a mile above the contact, so I use Weller's notes, which describe 68 feet of strata as follows:

Section of the chert member along Spring Creek.

	Ft.	in.
4. Hard gray limestone with chert	8	0
3. Chert like No. 1, but more uniform in color and nearly white	25	0
2. Black chert with much iron		3
1. Very hard mottled gray and black chert with numerous horizontal seams from 2 to 6 feet apart	35	0

A series of hand specimens accompanies this section, the numbers given to the specimens corresponding to the numbers of the beds. Specimen 1 shows a fine, dense, flinty-looking rock of mottled light and dark gray color. Specimen 2 is very similar but darker in general tone. Specimen 3 is fine, dense, and flinty looking and of a uniform light gray. It may be compared with No. 1 but lacks the darker mottling, the entire tint being that of the lighter portion of that specimen. Specimen 4 is a thinly and unevenly bedded rock with finely sparkling fracture surface. It is an impure limestone with small irregular light-gray segregations of chert. The limestone is somewhat darker, about the same shade as specimen 3. Specimen 4 is obviously calcareous, and the three other lots, in spite of their flinty look, effervesce briskly when dipped in hydrochloric acid, showing that they contain a considerable percentage of lime.

H. S. Williams also collected a series of hand specimens at this locality. The lowest collection, which is designated on the label "Cushman chert," consists of fine, dense, flinty-looking rock like Weller's Nos. 1 and 3, and like them effervescing in acid. The mottled specimen has less dark gray than Weller's No. 1. There is also a small piece consisting in part of fine whitish calcareous rock and in part of dark granular limestone with a sharp and irregular line of demarcation. The next bed in Williams's collection is limestone (No. 2), a fine, rather light gray, somewhat impure rock, either uniform in tint or with fine bands of stratification. A part of the material also shows light to rather dark gray limestone with chert layers of somewhat lighter color but weathering yellowish or reddish and finely porous. This is comparable to Weller's No. 4. Williams's No. 3 (top of cherty layers) consists of weathered cherts, yellowish gray to brown in color, evidently derived from a very impure limestone. One type is honeycombed by irregular tortuous pores. The other is more massive but still shows irregular excavations, and it is also fossiliferous, containing molds of zaphrentoid corals. The rock mass of these specimens is finely porous, so that it can be cut by a chisel without difficulty. The vermicular type

I suspect to be a weathered form of the mottled flinty rock such as is shown by Weller's No. 1.

Weller also obtained two specimens from the chert member in a ravine close to his other collection. One is a fine, dense, flinty rock very similar to some of the specimens already described (Weller's Nos. 1 and 3, and Williams's No. 1), but of a slightly brownish tint and a rather more siliceous look. In fact, it seems to be a true flint and shows no effervescence in acid. The other exhibits in a single specimen another rock in its weathered and unweathered phases. A sharp and rather even line divides the two. The unaltered material is a fine, dense, nearly black impure limestone, so hard that it can be scratched only slightly with a knife. The weathered rock is light gray or slightly brownish and is finely porous, with a sandy fracture which contrasts with the smooth surface of the unaltered portion. It is also relatively soft and can be cut with a knife. The specimen shows weathering to the depth of about 1½ inches or 32 millimeters.

Some distance above the locality at which these specimens were obtained, about a mile from Ruddells Mill, where the contact of the Moorefield shale with the chert member occurs, there is a high bluff on the east bank of Spring Creek, the same side as the outcrops of which I have been speaking. Here I measured 170 feet of rock in place, consisting mostly of chert but including some siliceous limestone that weathers light gray or reddish and yellowish. Toward the top the cherts are porous, so that they suggest certain varieties of tufa. Above the outcrop the hillside is covered with blocks of chert for 70 feet to the top, which is also strewn with chert fragments, some of them fossiliferous. Here a collection of fossils was made. (See lot 388, p. 10.) On descending the same bluff at a point rather less than one-half mile farther south I came upon 30 feet of black calcareous shale and shaly limestone underlain by 10 feet of cherty beds, which were partly massive, light brownish, finely porous, and siliceous (an impure weathered limestone probably), and partly very porous and vermicular. These black shaly beds must come about midway in the mass of the cherts, which in the section farther north apparently continue above them, either as outcrops or as fragments, for about 120 feet. Their apparent absence might be ascribed either to a wedging out of the beds themselves or to imperfect exposure, there being gaps in the other outcrop in which these beds may belong. Apparently, then, the chert member must be described as containing occasional lenses of black shale and limestone.

The foregoing data are all that I have of importance pertaining to the lithologic character of the cherty rocks in question in the vicinity of Batesville.

Faunal character of the rocks.—The faunal character of these rocks next demand consideration. As a rule they are scantily fossiliferous. I have searched outcrops in vain for fossils but have found loose fragments fairly crowded with them. From this it would appear that they are apt to occur in pockets. As a rule the fossils are unsatisfactory. They are preserved mostly as cavities formed by the leaching out of the shells themselves and are consequently represented by internal and external molds. The surfaces of the molds are liable to be obscured by siliceous incrustations. Specimens in the dense, hard cherts are of course difficult or impossible to uncover so as to determine their outline and those in more porous and softer matrices have lost their original shape by compression. Some of the shells appear to have been broken prior to fossilization. Almost all of my collections were obtained from loose material, but the facts of their occurrence were such that their origin in the chert member is beyond reasonable doubt.

In the bed of Spring Creek, at the foot of the bluff about a mile above Ruddells Mill, I found a loose bowlder full of fossils (preserved as cavities), among which the following species are represented (lot 387):

Productella hirsutiformis.
Productus pileiformis.
Liorhynchus carboniferum.
Spirifer martiniiformis.
Reticularia setigera.
Martinia? pilosa.
Conocardium meekanum var. magnum?
Conocardium sp. *a*.
Bembexia nodimarginata.

Another loose piece found near by yielded the following species (lot 387a):

Triplophyllum? sp.
Lingulidiscina newberryi var. moorefieldana.
Camarotœchia purduei var. agrestis?
Spirifer martiniiformis.
Spirifer arkansanus.
Reticularia setigera?
Martinia? pilosa.
Conocardium meekanum var. magnum?
Bembexia nodimarginata.
Pleurotomaria sp.

No fossils were seen in place in climbing the bluff above, but from loose pieces of chert on top of the hill and probably about in place a collection was made. Unlike the foregoing, these fossils occur scantily and a large number of fragments were examined before the collection was obtained (lot 388):

Triplophyllum sp. *a*.
Productella hirsutiformis.
Productella hirsutiformis var. batesvillensis?
Rhipidomella arkansana.
Liorhynchus carboniferum?
Liorhynchus carboniferum var. polypleurum?
Spirifer martiniiformis.
Reticularia setigera.
Conocardium sp. *b*.

The lower part of the black calcareous shale observed in descending the bluff one-half mile southeast of the last-named locality is, as already mentioned, slightly fossiliferous. Only two species were obtained (lot 390):

Rhipidomella arkansana.
Bembexia sp.

In addition there were some small, roundish fossils, very badly crushed, suggesting Martinias.

From some loose cherts near by, 150 feet above the foregoing collection and 120 feet above the top of the black shale outcrop, I collected (lot 389):

Triplophyllum sp. *a*.
Lingula albapinensis.
Lingulidiscina newberryi var. moorefieldana.
Productella hirsutiformis.
Productus pileiformis.
Liorhynchus carboniferum.
Spirifer martiniiformis.
Reticularia setigera.
Martinia? pilosa.
Conocardium meekanum var. magnum.
Parallelodon multiliratus.
Pleurotomaria aff. P. carbonaria.
Euomphalus planidorsatus.
Sphærodoma? sp.
Primitia moorefieldana?
Bairdia aff. B. cestriensis.

This horizon I take to be about the same as that of lot 388 and close to the top of the chert member.

From the outcrop at Ruddells Mill a single fossil was obtained which has been identified as Bembexia sp. (station 1248W).

The last collection which I have included here was made by J. C. Branner in the NW. ¼ NE. ¼ sec. 21, T. 13 N., R. 7 W. The locality appears to be 6 or 7 miles southwest of Batesville and the fauna and lithology are those of the chert member. The following species were obtained at this locality (1237B):

Batostomella sp.
Stenopora sp.
Rhombopora? sp.
Derbya? sp.
Productella hirsutiformis.
Productus inflatus var. coloradoensis?
Productus pileiformis.
Productus sp. *a*.
Productus sp. *b*.
Liorhynchus carboniferum.
Liorhynchus carboniferum var. polypleurum?
Moorefieldella eurekensis.
Spirifer arkansanus.
Reticularia setigera.
Martinia? pilosa.
Bembexia nodimarginata?

The following table shows the relation of these collections to each other and to the fauna of the Moorefield shale:

Table showing the species of the so-called Boone chert and their relation to the fauna of the Moorefield shale (chiefly the "Spring Creek limestone").[a]

	387	387a.	388	389	390	1237B.	1248W.	Moorefield shale.
Triplophyllum sp. a			×	×				
Triplophyllum? sp		×						
Batostomella sp						×		
Stenopora sp						×		
Rhombopora? sp						×		
Lingula albapinensis				×				×
Lingulidiscina newberryi var. moorefieldana		×		×				×
Derbya? sp						×		
Productella hirsutiformis	×		×	×		×		×
Productella hirsutiformis var. batesvillensis?			×					?
Productus inflatus var. coloradoensis?						×		×
Productus pileiformis	×			×		×		×
Productus sp. *a*						×		
Productus sp. *b*						×		
Rhipidomella arkansana			×		×			×
Liorhynchus carboniferum	×		?	×		×		×
Liorhynchus carboniferum var. polypleurum?			×			×		?
Camarotœchia purduei var. agrestis?		×						?
Moorefieldella eurekensis						×		×
Spirifer martiniiformis	×	×	×	×				×
Spirifer arkansanus		×				×		×
Reticularia setigera	×	?	×	×		×		×
Martinia? pilosa	?	×		×		×		×
Conocardium meekanum var. magnum	?	?		×				
Conocardium sp. *a*	×							
Conocardium sp. *b*			×					
Parallelodon multiliratus				×				×
Bembexia nodimarginata	×	×				?		×
Bembexia sp					×		×	
Pleurotomaria aff. carbonaria				×				
Pleurotomaria sp		×						
Euomphalus planidorsatus				×				
Sphærodoma? sp				×				
Primitia moorefieldana?				×				?
Bairdia aff. cestriensis				×				

[1] See pp. 10–11 for a description of the localities designated by numbers in this table.

It will be seen at once that a large part of the fauna, including all the abundant species, occurs also in the Moorefield shale, and so close is the agreement that I am justified in saying that this is substantially the Moorefield fauna and no other. Though not found in place, the different collections agree so well with one another and with Moorefield collections which were found in place, that it seems safe to speak of them as coming from one formation and constituting one fauna. Furthermore, though not found in place, it is also safe to conclude that these collections had their source in the chert member whose stratigraphic position is below the Moorefield shale and above the limestone member. Such cherts are not known in the Moorefield shale itself and the circumstances which surround the occurrence of these collections would almost preclude their having come from a bed higher than the chert member. On the other hand, the same reasons almost preclude their having come from the limestone member.

Classification of the "Spring Creek limestone."—As intimated in my report on the fauna of the Moorefield shale,[1] the thin limy beds which occur at the base of the formation and which have been called the "Spring Creek limestone" contain a fauna considerably different in

[1] Girty, G. H., Fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey Buli. 439, 1911.

facies from that of the purer shales which constitute the bulk of the formation. Here are segregated most of the brachiopods, while the more scantily fossiliferous shales above contain most of the cephalopods and the more peculiar types of pelecypods. It is the facies of the "Spring Creek limestone" particularly which is presented in the so-called Boone chert, and this fact raises the question whether the "Spring Creek limestone" would not more properly be classified with the Boone chert than with the Moorefield shale, as heretofore. I am inclined to think that it should be so classified, for lithologically the "Spring Creek limestone" constitutes merely a thin transitional zone from the earthy limestone of the one to the shale of the other. It unites the massive calcareous character of the Boone with the black color of the Moorefield, although the chert member is not without some nearly black beds also.

Stratigraphically such a change in definition would make little practical difference, but paleontologically the difference would be considerable, for it would remove from the Moorefield the larger part of the fauna heretofore ascribed to it, and its revised fauna would be limited largely to the Caneyellas among the pelecypods and to the cephalopods. It is desirable to be more explicit upon this point, but some difficulty attends the reference to their proper horizon of the fossils collected. This arises from the fact that some of the collections were not obtained in place and that others lie close to the critical line. In determining collections of the latter sort I propose to employ paleontologic criteria; if the collections came within a foot or two of the dividing plane between the two formations, which itself is not a definite boundary, I shall include them with the "Spring Creek limestone" if their faunas conspicuously resemble the "Spring Creek" fauna as determined by species found in place. I propose to proceed in the same way also with the collections not found in place (whose occurrence, however, gives some suggestion as to their original stratigraphic position), only in this case the paleontologic evidence must necessarily have additional weight.

The only collection mentioned in my report on the fauna of the Moorefield shale [1] that obviously came from the shaly beds of the formation in the Spring Creek region is the one which bears the locality number 2052. This collection contained only *Caneyella percostata* and *Gastrioceras caneyanum*, but I am inclined to think that the Goniatites cited by Smith as from the Moorefield shale at Batesville (*Goniatites newsomi*, *G. striatus* [=*G. choctawensis*], and *G. subcircularis*) were from this horizon.

At Moorefield the fauna listed in my report under the locality number 2051A is probably to be considered as representing the

[1] Op. cit., pp. 16–18.

"Spring Creek limestone." Station 2051B clearly represents a higher horizon, one which must be considered as being in the true Moorefield (exclusive of the "Spring Creek limestone"). Here I obtained *Liorhynchus carboniferum*, *Caneyella vaughani*, and *Deltopecten batesvillensis*. Station 2051 must also be considered as well up in the Moorefield, and here I found *Lingulidiscina newberryi* var. *caneyana*, Strophostylus aff. *S. carleyanus?*, Orthoceras sp. *b*, *Bactrites? carbonarius*, and *Goniatites choctawensis*.

In the same fauna must be included Pleurotomaria ? sp., Orthoceras sp. *a*, *Endolobus ornatus*, and *Goniatites choctawensis*, collected by Mr. Siebenthal, and *Bactrites? carbonarius*, *Glyphioceras calyx* (= *Gastrioceras richardsonianum*), and *Goniatites crenistria*, cited by J. P. Smith.[1] Lastly the fossils from Howards Wells (locality 1245A) must be referred to the Moorefield above the "Spring Creek limestone"; they are *Goniatites choctawensis*, *Gastrioceras caneyanum*, *Eumorphoceras bisulcatum*, and *Adelphoceras meslerianum?*

In the Batesville quadrangle, then, the fauna of the Moorefield shale, after eliminating the collections which appear to belong to the "Spring Creek limestone," consists of 19 species as follows:

Lingulidiscina newberryi var. caneyana.
Liorhynchus carboniferum.
Caneyella vaughani.
Caneyella percostata.
Deltopecten batesvillensis.
Pleurotomaria? sp.
Strophostylus aff. S. carleyanus.
Orthoceras sp. *a*.
Orthoceras sp. *b*.
Endolobus ornatus.
Bactrites? carbonarius.
Goniatites choctawensis.
Goniatites crenistria.
Goniatites subcircularis.
Goniatites newsomi.
Gastrioceras richardsonianum?
Gastrioceras caneyanum.
Eumorphoceras bisulcatum.
Adelphoceras meslerianum?

Of these only four (*Lingulidiscina newberryi* var. *caneyana*, *Liorhynchus carboniferum*, *Deltopecten batesvillensis*, and Strophostylus aff. *S. carleyanus*) are known in the "Spring Creek limestone"; or, of the 71 species of the "Spring Creek" fauna but 4 are known in the shales above. These same facts might be stated in another way to bring out more clearly the relationship between these three faunas. Of the 71 species at present constituting the fauna of the "Spring Creek limestone," 18 occur among the 33 species known from the underlying chert member and only 4 occur among the 19 species known from the Moorefield shale.

That these figures do not give an entirely truthful representation of the faunal conditions of this epoch is indicated by the reappearance at higher horizons than the Moorefield of some species not yet known from the Moorefield itself. Furthermore, when we come to consider the faunas from Marshall, described in my Moorefield shale report,

[1] Op. cit., p. 19.

the truth of this becomes perplexingly apparent, for at Marshall there seems to be no sedimentary phase which can be compared with the "Spring Creek limestone," and on the other hand there is no faunal development which can be compared with that of the Moorefield shale proper. The faunas from Marshall are much less varied than those from the Batesville quadrangle. They contain some species peculiar to Marshall, but generally the facies is more like that of the "Spring Creek limestone" than that of the shaly beds above. From the fossils themselves one might infer that the beds at Marshall represent only the "Spring Creek" portion of the Moorefield, or the "Spring Creek" plus the chert member of the Boone, for it is not known at present, at least so far as I am aware, whether there is at Marshall anything to compare lithologically and faunally with the chert member of the Batesville quadrangle.

Relations of the chert member to the typical Boone.—The chert beds in the vicinity of Batesville have usually, perhaps always, been regarded as part of the Boone limestone. Penrose[1] so called them in 1891 and Hopkins[2] in 1893. Adams and Ulrich[3] used the same name in 1904 and I[4] myself in 1911. The peculiar fauna which they contain, however, brings into question both the relation of the chert member to the Boone limestone and the classification of the Boone itself.

The term "Boone" as a geologic name was introduced in the literature by Penrose[5] and by Simonds[6] in two reports published in the same year, 1891. Penrose mentions particularly the outcrops near Batesville, but says that the formation received its name from its development in Boone County, Ark. The beds have, however, been so carefully studied in southwestern Missouri that the Joplin region vicariously has almost become the standard section of the Boone.

Boone County has very nearly the same boundaries as the Harrison quadrangle, and from that quadrangle and the one just west of it, the Eureka Springs quadrangle, there has recently come under my observation a series of nearly 40 collections, obtained from the base to the top of the Boone. These collections indicate that the formation ranges in age from Kinderhook (Fern Glen) to Keokuk. I find nothing in the Boone indicating an age younger than the Keokuk. The St. Joe limestone member, which forms the base of the Boone, I would correlate as above stated with the Fern Glen limestone, a correlation which was originally made by Weller and which my own observations confirm. Of the rest of the Boone, the lower moiety seems to represent Burlington and the upper Keokuk

[1] Penrose, R. A. F., jr., Arkansas Geol. Survey Ann. Rept., 1890, vol. 1, pp. 115, 213, 1891.
[2] Hopkins, T. C., Arkansas Geol. Survey Ann. Rept., 1890, vol. 4, p. 103, 1893.
[3] Adams, G. I., and Ulrich, E. O., U. S. Geol. Survey Prof. Paper 24, pp. 26 and 102, 1904.
[4] Girty, G. H., op. cit., pp. 5, 11, et seq., 1911.
[5] Op. cit.
[6] Simonds, F. W., Arkansas Geol. Survey Ann. Rept., 1888, vol. 4, pp. 27-37, 1891.

time. There do not appear to be any sharp faunal breaks, that between the St. Joe and the rest of the Boone being perhaps the most recognizable. As might be expected, these faunas are not typical Burlington nor typical Keokuk faunas, since they lack some of the features found in the typical ones and, on the other hand, present features not possessed by them, but I see no reason for doubting the general equivalence.

In passing it may be of interest to record that a notable feature of the faunal sequence of the Joplin district is not found in the Boone at its typical outcrops. I mean the *Productus magnus* fauna, which occupies the upper part of the Boone limestone at Joplin. This fact raises the question whether there may not be present in the Joplin region in beds classified as Boone strata which are younger than the typical Boone and which should be assigned to a geologic period later than the Keokuk. For a variety of reasons I have reached the conclusion that such is not the case. It is, of course, true that one can never be sure of the equivalence of formations foot for foot, even in areas not very widely separated. But that any considerable part of the Boone near Joplin is younger than the typical Boone and of a different geologic age I do not believe. The abundant *Productus magnus* fauna of the Joplin region consists almost entirely of recognized Keokuk species, even the crinoids and fish teeth being Keokuk types. There are, it is true, associated with these a very few species which have not elsewhere been found below the Warsaw, but I see no justification on this account for calling the upper part of the Boone at Joplin Warsaw, except with the following proviso. Although there is little evidence to support it, I would be willing to admit another possible interpretation of the conditions found in the Joplin region. The Warsaw fauna, which at Warsaw itself has not a little in common with the Keokuk fauna, may in its extension to the southward lose most of its distinctive features and become one with the Keokuk fauna in its facies as in the lithology of the rocks which contain it, but in that event I could hardly admit the validity of the Warsaw as a unit in the time scale. The Warsaw should then be classed as upper Keokuk. In point of the equivalence of the Boone in the Joplin and Harrison quadrangles I may note that the *Productus magnus* fauna, or at least that *Productus magnus* itself, has been found as near to the Harrison quadrangle as St. Joe, Ark., and that stratigraphic tracing has as yet shown no quantitative discordance in the rocks contained in the Boone at the localities in question. Indeed, at a number of points in and probably over much of the Harrison-Eureka Springs area there is an oolitic band near the top of the Boone which occupies a position similar to the Short Creek oolite of the Joplin region and is believed to be that formation.

But to return to the fauna of the so-called Boone cherts at Batesville and its bearing on the Boone problem. This fauna, especially when supplemented by forms from the "Spring Creek" limestone, not only differs entirely from anything in the typical Boone (or in the Boone at Joplin), probably not more than a species or two existing in common, but it also contains intrinsic evidence, if our present knowledge of the range of species and genera is correct, of being distinctly younger than the Keokuk. If we consider these facts alone, it would appear that the chert member[1] at Batesville ought not to be classified with the Boone limestone, but should be regarded as a separate and distinct formation, intermediate between the Boone limestone and the Moorefield shale. Indeed, we have as yet no real evidence as to the age and correlation of the limestone below the chert member itself, although it is assumed to represent the Boone limestone.

Evidence from other areas.—The fauna under consideration is so unlike any of the typical Mississippian faunas that it is difficult to find even one or two species in the one by whose range in the other its geologic age can be tested. Of such, *Diaphragmus elegans* is in my view by far the most important, for in the typical faunas of the Mississippian I have never found it below the Chester. In the Arkansas area, where conditions were obviously much different, it is quite possible that this type may have appeared earlier. A few other species indicate post-Keokuk age,[2] but aside from these few forms the peculiar Spring Creek fauna need not necessarily be placed above the Keokuk in the time scale. Its almost complete unlikeness to the typical Keokuk fauna need be no bar, for the Spring Creek fauna must correspond to some member of the typical Mississippian sequence, if all the successive facies are known to us, and yet it is equally different from any of them. Thus, so far as the fauna is concerned, the chert member may be only a remarkable variant of the Boone limestone of the Harrison and Joplin areas. There is still further evidence that this may be the case.

To present this evidence it will be necessary to consider briefly two geologic sections in western Tennessee, one at Ridgetop, near Nashville, and the other in the Waynesboro quadrangle, southwest of Nashville. The Carboniferous sections in these two areas are in many respects very similar. The rocks between the Chattanooga black

[1] This conclusion assumes that the chert member is a unit, although nearly all the paleontologic evidence, upon which the conclusion chiefly rests, was obtained near the top of the series. The assumption is supported by the uniform character of the lithology and by the very meager fauna obtained from the black shaly beds near the middle of the series, which, so far as it goes, has a "Spring Creek" and not a Boone facies.

[2] Girty, G. H., op. cit., p. 23, 1911.

shale [1] and the St. Louis limestone constitute the Tullahoma formation as formerly recognized in those areas. In general the Tullahoma is a highly siliceous formation consisting of flinty and cherty limestone,[2] often in heavy layers. In the Ridgetop section, however, it is composed of green and dark-gray shales in the lower half and of heavier and more calcareous beds in the upper half, and R. S. Bassler has there broken it up into two formations, calling the lower one the Ridgetop shale and correlating the upper one with the Fort Payne chert. H. D. Miser has followed the same plan in mapping the rocks of the Waynesboro quadrangle. Bassler gives the geologic age of the Fort Payne as Keokuk and that of the Ridgetop as Kinderhook, the latter chiefly on the strength of Winchell's correlation made 50 years ago.

At Whites Creek Spring, also near Nashville, Bassler found the beds above the Chattanooga to consist (1) of the Ridgetop shale, similar to the typical Ridgetop in fauna and lithology, but much thinner; (2) above this some coarsely crystalline crinoidal limestones; and (3) the Fort Payne chert. He found in the limestone below the Fort Payne a fauna which differed from the typical Ridgetop fauna and proved to be like that of the New Providence formation of Indiana and Kentucky, and he distinguishes this as a separate formation, calling it by the imported name, New Providence. In harmonizing this with the section at Ridgetop, it was of course necessary to provide an unconformity between the Ridgetop shale and the Fort Payne chert in which the New Providence formation might be intercalated. The New Providence formation, it will be remembered, has been correlated by Weller with the Fern Glen formation, and to this correlation Bassler assents.

As has already been stated, Miser [3] recognized the Ridgetop shale, with the Maury Green shale at its base and the Fort Payne chert above, included between the Chattanooga shale and the St. Louis chert, in the Waynesboro quadrangle, just as at Ridgetop. In the southeastern part of his area, however, he found the Ridgetop shale replaced in part by beds of crinoidal limestone. These apparently have much the same character as Bassler's New Providence formation at Whites Creek Spring, but they are not confined to the upper part of the interval, being in fact very variable both in amount and in position, and Miser interprets them, not as being a distinct formation from the Ridgetop (as Bassler interpreted the apparently similar occurrence at Whites Creek Spring), but rather as being contemporaneous with it, the constituents being crinoidal material in the one

[1] The Maury Green shale, 1 to 2 feet thick, was formerly included in and is now excluded from the Chattanooga, but that is of minor importance.

[2] Safford, J. M., and Killebrew, J. B., The elements of the geology of Tennessee, Nashville [1900], p. 144.

[3] I take this opportunity to state that all of my information about the Waynesboro quadrangle and part of that about the Ridgetop section I owe to my colleague Mr. H. D. Miser.

area and a dark clastic in the other. I am rather inclined to believe that Bassler's New Providence formation would better be so interpreted.

The fauna of the Ridgetop shale, which is copious, is not a Kinderhook fauna at all, as Bassler has stated following Winchell; at least it is widely unlike either the Kinderhook or any other fauna of the typical Mississippian series. It is also widely unlike any of the Waverly faunas of which I have cognizance, and I believe that all of them are known to me. In fact, it strongly and obviously resembles the fauna of the Moorefield shale. . I am speaking now of the Ridgetop shale at Ridgetop, where the fossils in it are abundant. The Fort Payne chert of the same section is scantily fossiliferous, but the few species obtained from it are common to the Ridgetop below.

The same is true of the Waynesboro quadrangle. The Ridgetop shale is here not very fossiliferous, but so far as its fauna is known it agrees with the typical Ridgetop fauna. A thin stratum near the base of the Fort Payne in this area proved to be rich in fossils, and the fauna from this, as well as from such higher horizons as contained them, was closely like the more restricted fauna of the underlying Ridgetop. In other words, in both areas the fauna of the lower beds seemed to extend into the upper without important change, and, whether considered severally or combined, the faunas of the two areas appeared to be in essential agreement.

To this agreement, however, two marked exceptions must be noted. The fauna obtained from the New Providence formation at Whites Creek Spring, as listed by Bassler, is very different from the Ridgetop fauna, and the fossiliferous crinoidal limestone already mentioned as occurring in the southeastern part of the Waynesboro quadrangle likewise contains a fauna that is almost totally different from the fauna of the Ridgetop. In many respects the Waynesboro fauna presents a typical Burlington facies, but after canvassing the question rather widely I am provisionally correlating it with the Fern Glen (which I suspect is really of lower Burlington instead of Kinderhook age). Furthermore, this fauna has little in common with that listed by Bassler from the New Providence formation, though it appears to belong to the same period in the time scale as that to which Bassler refers the New Providence, namely, the Fern Glen.

If we accept this evidence at its face value and place the crinoidal limestones [1] of southeast Waynesboro at the same horizon as Bassler's New Providence formation, complications would ensue which are obvious and need not be discussed here; and the composite section resulting would be contrary to observed facts of stratigraphy. Indeed, almost any correlation of these sections which makes the limestones

[1] As already stated, these calcareous beds vary much in different sections both as to amount and position; the collections of fossils, however, were obtained from the middle of the interval or below.

of the Whites Creek Spring and Waynesboro sections either younger or older than the Ridgetop shale of the Ridgetop section raises difficulties which are hard to adjust. The most simple and rational explanation of these phenomena may be found, I believe, in the supposition that the strata included between the Maury Green shale and the Fort Payne chert are essentially equivalent in all three sections, and that several faunal facies, whose character was determined by different conditions of environment, were coexisting in areas not far removed from one another. Thus, I am supposing that dark muddy sediments were collecting in the Ridgetop region and in part of the Waynesboro quadrangle during the whole of Ridgetop shale time, affording a habitat favorable to a fauna of the Moorefield type; that throughout the same period this environment was intermittently replaced, where now is the southeastern portion of the Waynesboro quadrangle, by conditions of limestone deposition favoring the growth of crinoids and other forms which made up a quite different type of fauna; and lastly that the faunas and sediments which persisted fairly uniformly in the Ridgetop region and extended now and again into southeastern Waynesboro extended also into the Whites Creek Spring region, but only during the earlier half of Ridgetop shale time, being later succeeded by crinoid colonies among which lived a fauna conspicuously different from that of the Ridgetop shale but somewhat, though not by any means completely in accord with the faunas of the calcareous deposits of the Waynesboro quadrangle. This hypothesis—for such only it is, of course—would make the New Providence formation of the Whites Creek Spring section not younger than the typical Ridgetop shale, but equivalent to its upper part, just as the similar beds in the Waynesboro quadrangle are supposed to be equivalent to it, and it would do away with the unconformity in the middle of the Tullahoma between the Fort Payne chert and Ridgetop shale, or at least give to it a different significance. I may say here that the irregularity mentioned by Bassler in the Ridgetop section has been seen by other observers and has not by them been considered of special significance. This hypothesis also would make the New Providence fauna of Whites Creek Spring and the crinoidal limestone fauna of southeast Waynesboro, both of which appear to correlate with the Fern Glen formation, represent different parts of the same geologic period and would not of necessity ascribe any chronologic significance to their different facies.

If we may tentatively explain in this way the phenomena in western Tennessee, there is no reason why we should not extend the same hypothesis to northern Arkansas, other things being equal.

If the crinoidal limestones of southeastern Waynesboro are in fact of Fern Glen age, and if, on the other hand, they are merely a different lithologic and faunal phase of the lower part of the Ridgetop

shale, there must have flourished in Tennessee a fauna which was at the same time contemporaneous with the lower Boone (St. Joe) and which yet possessed a facies conspicuously resembling that of the Moorefield shale. Indeed, this fauna must have survived until a still later period, changing with changed conditions, but retaining more or less of its original character; for we find some of the peculiar Moorefield types, such as *Liorhynchus carboniferum*, near the top of the Fayetteville shale. If such a fauna existed and endured so long, there can be no doubt that it spread wherever and whenever the conditions were favorable to it. Such may have been the Batesville region during the later part of Boone time.

These considerations only remove or weaken certain a priori objections against considering it even possible that the chert member with its peculiar fauna was contemporaneous with any part of the Boone. They do not adduce evidence, and in fact little evidence can be adduced, for concluding that it actually was contemporaneous. It is not probable that this fauna persisted so long without undergoing important changes through the extinction of old species and the introduction of new ones. If such modifications were known and recorded one might determine what stage in the progress of this fauna the chert member represented. As it is, the differences between the fauna of the chert member at Batesville and the similar faunas of the Fort Payne chert and Ridgetop shale of Tennessee might be interpreted as regional or as chronologic with almost equal propriety. Among the differences most worthy of note are the presence of *Moorefieldella eurekensis* in the fauna at Batesville and the abundance of *Chonetes planumbonus* var. *choctawensis* in the Tennessee faunas, though there are of course many other less important differences.

The faunas, then, do not furnish conclusive evidence as to whether these chert beds on Spring Creek are younger than the typical Boone or are equivalent to part of it. The geology of the area between Batesville and the Harrison quadrangle is pretty well known, yet to none of the geologists who have traversed this region has it suggested itself that the cherts below the Spring Creek limestone were anything else than the upper part of the Boone limestone. These facts seem to me presumptive evidence that the cherts really belong to the Boone. Miser informs me that in the Harrison-Eureka Springs region three members can usually be recognized in the Boone above the basal St. Joe limestone member, an upper and a lower chert divided by a limestone. The upper chert and underlying limestone of the typical Boone are thus suggestive of the chert member and the limestone member near Batesville. However, the Boone varies so much from point to point that such speculations without close stratigraphic work have little value.

The character of the fauna of the chert beds on Spring Creek has suggested two conclusions: That the "Spring Creek limestone" should be classified with the underlying cherts rather than with the overlying Moorefield shale; and that the formation thus constituted was younger than the Boone instead of equivalent to the upper part of it. The bearing of the phenomena observed in Tennessee on only one of these propositions has been considered. They also have a bearing upon the question whether the "Spring Creek limestone" should be classified with the chert member or with the Moorefield shale. If the Moorefield fauna actually did persist as long as the facts discussed above seem to suggest, it must nevertheless have undergone changes with the passage of time, but the changes were probably not fundamental, the groundmass of the fauna remaining the same. This consideration would tend to enhance the importance of the introduction of new and critical species. A number of forms have been recorded from the Spring Creek limestone that have not yet been found in the underlying chert. One of these is *Diaphragmus elegans*, a species already mentioned as not known in the typical Mississippian below the Chester. Of the identification of these fossils there is little doubt, but of their origin in the Spring Creek limestone I have never been entirely satisfied. The introduction of *D. elegans*, together with other changes, may obscurely mark a transition from one geologic period to another in a fauna so long-lived and persistent as this is supposed to be.

Of possible importance in this connection is the fact that Siebenthal has found in the Wyandotte quadrangle and in other parts of Oklahoma, between a limestone correlated with the Boone and a sandstone correlated with the Batesville, some 30 feet of calcareous strata which are separated from the Boone by an erosional unconformity and which contain a fauna allied to that found in the "Spring Creek limestone" and in the chert member near Batesville. This fauna, furthermore, shows strong Chester affinities.

The significance of the fauna of the so-called Boone chert near Batesville can not be properly estimated without further evidence, especially stratigraphic evidence as to the relations between the beds themselves and the typical Boone limestone. In spite of the great dissimilarity existing between the fauna of these chert beds and any of the Boone faunas, it is credible that the cherts may have been synchronous with part of the Boone, presumably with the upper part. However, in view especially of the related fauna which comes in above the Boone in northwestern Arkansas and northeastern Oklahoma it seems rather more probable that the chert member near Batesville is younger than the Keokuk and not properly part of the Boone. Provisionally, also, I would classify the Spring Creek lime-

stone with the chert member, withdrawing it from the Moorefield shale. Nevertheless, it may be found that the chert member is contemporaneous with part of the Boone and that only the Spring Creek limestone is equivalent to the limestones of the Wyandotte quadrangle which occur between the Boone and the Batesville sandstone. In any event, the chert member at Batesville differs so strongly both in fauna and lithology from the typical Boone of Boone County that it deserves to be regarded as a distinct formation, in the Batesville region at least.

DESCRIPTION OF SPECIES.

CŒLENTERATA.

TRIPLOPHYLLUM sp. *a*.

Corals appear but rarely in this fauna so far as it is exhibited by my collections, and the only types observed belong to the Zaphrentidæ. Possibly two species are present. The more common of these comprises small, rather rapidly expanding and strongly curved coralla averaging about 25 millimeters in length and 15 millimeters in diameter. Not only are these fossils few in number, but their characters are imperfectly retained. The exterior appears to be marked by rather numerous, strong, transverse striæ and rather faint longitudinal striæ. No spines or stolons are developed. The internal structures are not shown, but the calice, as exhibited by the molds of the interior, is moderately deep and is provided with a large fossula, on either side of which at 90° of arc occur other points of asymmetry, probably representing smaller fossulæ. The primary septa number 33 and reach nearly to the center. There are also an equal number of secondary septa which are short and confined to the calice.

The arrangement of the septa indicates that this form belongs with Simpson's genus Triplophyllum, to which also all the forms which I have cited under the European genus Menophyllum probably belong. I do not regard it as certain, however, that Triplophyllum is not a synonym of Menophyllum.

The specific relations of this form have not been definitely determined. At present the only species appearing under Triplophyllum is *T. centrale*, the type species, but other forms at present cited under the genus Zaphrentis doubtless belong here. The specimens under consideration are rather smaller and have fewer septa than those on which *T. centrale* was founded, and are much smaller than specimens subsequently referred to that species. They show similar but somewhat greater differences when compared with the form from the "Spring Creek limestone" which I cited under Menophyllum sp. All the septa in these other species appear to be primary, in which case the present one has rather fewer—otherwise it has many more. Of

the two, the "Spring Creek limestone" species appears to agree with *T. centrale* rather more closely than this, but more complete information may show all three to be the same.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 388, 389).

TRIPLOPHYLLUM? sp.

This form is represented by a single very poor specimen, which differs from those cited as Triplophyllum sp. *a* by having apparently fewer and more widely spaced septa without secondary septa. The whole number of these structures can not be determined, but in this form there are four primary septa in 5 millimeters and in the other about five. The reference to the genus Triplophyllum is purely hypothetical.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 387a).

BRYOZOA.

BATOSTOMELLA sp.

Small ramose Bryozoa are not rare in the collections studied, but they are poorly preserved. They occur as molds, or are silicified and united with the matrix in a solid cherty mass. There may be two species among them. The branches averaged about 5 millimeters in diameter and probably divide rather freely. The zooecia are round and have more or less strong constrictions. Mesopores are present but are not abundant. Diaphragms appear to be developed here and there toward the surface and to have the central perforation characteristic of the family. This form is too imperfectly known for identification, but it appears to be distinct from any species yet found in the Moorefield shale (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

STENOPORA sp.

This is a thin explanate form represented by only a small fragment preserved as a mold, so that some of the characters are imperfectly known. The thickness of the zoarium is only about 1 millimeter, and, perhaps owing to the consequent shortness of the individual cells, diaphragms are scantily developed if at all. The cell walls appear to be moderately thick and not strongly constricted.

The specific relations of this form can not be determined, but it is probably distinct from the species found in the "Spring Creek limestone," which has a ramose mode of growth.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

RHOMBOPORA? sp.

This type depends chiefly on one specimen preserved as a mold in chert. It differs conspicuously from Batostomella sp. in the slenderness of the branches, which are less than 1½ millimeters in diameter, and in the smaller, more regularly arranged, and more widely spaced zooecia. Nothing comparable with this has yet been found in the Moorefield shale (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

BRACHIOPODA.

LINGULA ALBAPINENSIS Walcott.

Plate I, figure 10.

1884. *Lingula albapinensis.* Walcott, U. S. Geol. Survey Mon. 8, p. 108, pl. 2, fig. 1.
Upper Devonian: White Pine district, Nev.

1909. *Lingula albapinensis.* Girty, U. S. Geol. Survey Bull. 377, p. 17, pl. 1, figs. 6, 6a, 7, 8(?).
Caney shale: Atoka, Antlers, and Ardmore quadrangles, Okla.

1911. *Lingula albapinensis.* Girty, U. S. Geol. Survey Bull. 439, p. 36, pl. 1, fig. 11.
Moorefield shale: Batesville quadrangle, Spring Creek, Ark.

This species is represented by a single specimen characterized by its small size and rather elongate, regularly ovate shape, with narrow and nearly symmetrically rounded ends. The length is 6 millimeters and the width 3 millimeters.

This is closely similar to the shells from the "Spring Creek limestone" and Caney shale to which I have given the same identification. In size it is more like the Caney specimens, but in shape it is rather more like those from the "Spring Creek limestone." That is, it is more symmetrical and has the greatest width about midway instead of near the posterior end. The latter shape, however, is not found in all the Caney specimens.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

LINGULIDISCINA NEWBERRYI var. MOOREFIELDANA Girty.

1911. *Lingulidiscina newberryi* var. *moorefieldana.* Girty, U. S. Geol. Survey Bull. 439, p. 38, pl. 2, figs. 6, 7.
Moorefield shale: Batesville quadrangle; Marshall quadrangle, Ark.

This species is inadequately represented by five imperfect specimens, three ventral and two dorsal valves, the latter not definitely known to be conspecific with the others. In so far as their characters can be made out these specimens may be referred to the species named above.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387a and 389).

DERBYA? sp.

The specimen representing this species is a mere fragment, apparently part of a gently convex dorsal valve. It evidently belongs to one of the Strophomenoid types common in the Mississippian, but whether to Derbya, Orthotetes, Schuchertella, or some cognate genus is beyond determination. This type of shell seems to be lacking in the Moorefield fauna (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

PRODUCTELLA HIRSUTIFORMIS Walcott.

1884. *Productella hirsutiformis.* Walcott, U. S. Geol. Survey Mon. 8, p. 133, pl. 2, fig. 10.
Upper Devonian: Eureka and White Pine districts, Nev.

1909. *Productella hirsutiformis.* Girty, U. S. Geol. Survey Bull. 377, p. 24, pl. 2, figs. 4–6.
Caney shale: Ardmore, Atoka, and Tishomingo quadrangles, Okla.

1911. *Productella hirsutiformis.* Girty, U. S. Geol. Survey Bull. 439, p. 50, pl. 3, figs. 1–4.
Moorefield shale: Batesville quadrangle, Spring Creek; Moorefield, Ark.

This species is represented by about 10 more or less fragmentary specimens. They have a smooth surface marked only by concentric growth lines and striæ of varying distinctness, and by small spines some of whose bases are prolonged as slender irregular evanescent ridges. The specimens evidently belong to a type or types closely related to *P. hirsutiformis*, which is undoubtedly represented among them. I am not sure that *Productus subsulcatus* var. *janus* is not also present, definite determination on this point being prevented by the crushed and fragmentary condition of some of the fossils.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 388, 389, and 1237B).

PRODUCTELLA HIRSUTIFORMIS var. BATESVILLENSIS Girty?

Plate I, figure 1.

1911. *Productella hirsutiformis* var. *batesvillensis.* Girty, U. S. Geol. Survey Bull. 439, p. 51, pl. 3, fig. 5.
Moorefield shale: Batesville quadrangle, Ark.

This species is represented primarily by an external mold of a dorsal valve which also retains part of the cardinal area of the ventral valve. The dorsal valve itself has a low area and a smooth surface. Its shape is strongly transverse, much the widest at the hinge line. It is moderately concave, and somewhat elevated along the middle and flattened at the ears.

That this is a species related to *P. hirsutiformis* seems almost certain, but it differs in the transverse shape, in the projecting ears, and in the inflated mesial portion. Though this specimen is a dorsal

valve and the type specimen of *P. hirsutiformis* var. *batesvillensis* is a ventral valve, it seems to show very much the characters which the complementary valve of the variety *batesvillensis* would have, and its identification as such is regarded as highly probable.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 388).

PRODUCTUS INFLATUS var. COLORADOENSIS Girty?

?1890. *Productus boliviensis* (non d'Orbigny). Nikitin, Com. géol. [Russia] Mém., vol. 5, No. 5, pp. 57, 158, pl. 1, figs. 4a, 4b, 4c.
Gschelstufe: Near Moscow, Russia.

?1902. *Productus inflatus* (non McChesney). Tschernyschew, idem, vol. 16, No. 2, pp. 261, 612, pl. 28, figs. 1–6.
Gschelstufe: Ural and Timan mountains, Russia.

1903. *Productus inflatus* (non McChesney). Girty, U. S. Geol. Survey Prof. Paper 16, p. 359, pl. 3, figs. 1–1b, 2, 2a, 3.
Hermosa formation: San Juan region and Ouray, Colo.
Weber limestone: Crested Butte and Leadville districts, Colo.
Pennsylvanian: Glenwood Springs, Colo.

1904. *Productus inflatus?* (non McChesney). Girty, U. S. Geol. Survey Prof. Paper 21, p. 52, pl. 11, figs. 5, 6.
Pennsylvanian (Naco limestone): Bisbee quadrangle, Ariz.

1910. *Productus inflatus* var. *coloradoensis*. Girty, New York Acad. Sci. Annals, vol. 20, No. 3, pt. 2, p. 215.
Basal Fayetteville shale: Fayetteville quadrangle, Ark.

1911. *Productus inflatus* var. *coloradoensis?* Girty, U. S. Geol. Survey Bull. 439, p. 42, pl. 4, figs. 3, 3a.
Moorefield shale: Batesville quadrangle, Spring Creek, Ark.

The fossils included here evidently represent a species which occurs in the "Spring Creek limestone," and which I identified from that formation as *P. inflatus* var. *coloradoensis?*. The specimens are fragmentary but indicate a typical semireticulate Productus of medium size with strongly arched ventral valve terminating laterally in small depressed ears and having a distinct mesial sinus, the surface being crossed by fine, well-developed, continuous costæ and the visceral region by fine, regular, concentric wrinkles. This species has been obtained at only one locality where, however, it seems to be rather abundant.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

PRODUCTUS PILEIFORMIS McChesney.

This seems to be a common species in the fauna under consideration. Ten or more specimens, some very fragmentary, have come to hand. They attain a rather large size, 40 millimeters or more in width; have rather fine liræ, 21 to 25 or even 40 in 10 millimeters; and have rather small and infrequent spines which cause hardly any appreciable irregularity in the striation.

These shells are in very close accord with those from the Moorefield shale which are referred to the same species. Although a separation

of specimens is not easy, owing to imperfect preservation, I may have included two distinct species among specimens of *P. pileiformis* from the "Spring Creek limestone"; one form, with thin shell and high convexity, being true *P. pileiformis*, and the other, with thick shell, less strong convexity, and more spreading shape, representing a distinct species, one possibly related to *P. giganteus*.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 389, and 1237B).

Productus sp. *a*.

The imperfect specimen here referred to is a ventral valve resembling in a general way *P. subsulcatus* var. *janus*, but having the spine bases prolonged into regular, almost continuous costæ. It lacks the regular, strong, transverse wrinkles of the *semireticulati* and can scarcely be reckoned an aberrant or fragmentary example of *P. inflatus* var. *coloradoensis?*. It is thus probably distinct from any of the associated Producti and appears to represent a type which is absent from the fauna of the Moorefield shale (including the "Spring Creek limestone"). At all events it has not yet been found there.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

Productus sp. *b*.

Like species *a*, this type is represented by a single ventral valve preserved as an internal mold and more or less imperfect. In its intrinsic characters also it resembles species *a*, but it is considerably smaller and has larger and more persistent costæ. It probably represents a related, though I believe a distinct, species. It suggests the Kinderhook *Productella concentrica* and *P. arcuata*, and in some respects it appears to be intermediate between them. No species closely related to it has as yet been found in the Moorefield fauna (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

Rhipidomella arkansana Girty.

Plate I, figures 11, 12.

1911. *Rhipidomella arkansana.* Girty, U. S. Geol. Survey Bull. 439, p. 53, pl. 2, figs. 14–16.

Moorefield shale: Batesville quadrangle, Ark.

Two specimens represent this species, an internal mold of a dorsal valve and a bivalved specimen deeply exfoliated over most of the surface. The identification with the species from the "Spring Creek limestone" hardly admits of doubt.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 388 and 390).

LIORHYNCHUS CARBONIFERUM Girty.

Plate II, figure 11.

1877. *Leiorhynchus quadricostatus*? Meek, U. S. Geol. Expl. 40th Par. Rept., vol. 4, p. 79, pl. 3, figs. 9–9b.
Carboniferous: White Pine Mountains, Nev.

1909. Liorhynchus aff. *L. mesicostale*. Girty, U. S. Geol. Survey Bull. 377, p. 26, pl. 2, figs. 11, 12.
Caney shale: Atoka quadrangle, Okla.

1911. *Liorhynchus carboniferum* (n. sp.). Girty, U. S. Geol. Survey Bull. 439, p. 54, pl. 6, figs. 1–10, pl. 7, figs. 13–16.
Moorefield shale: Batesville quadrangle, Spring Creek, Moorefield; Marshall quadrangle, Marshall, Ark.

This species appears to be abundant and comprises large shells with a few coarse ribs in the fold and sinus, but with the sides more or less completely unplicated. There are also specimens in which the mesial portion, too, is unplicated, and when preserved as external molds it is impossible to determine whether they are an extreme form of this species or are a species of Composita. As the general expression is rather rhynchonelloid and as no Compositas are known in this fauna I have included them here. Similar shells occur in the Moorefield fauna[1] (including the "Spring Creek limestone") and in that of the Caney shale (Pl. II, fig. 10, p. 44).

The more common varieties of this interesting form are in close agreement with *L. carboniferum* as it occurs in the Moorefield and Caney shales.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 389, 1237B, and 388?).

LIORHYNCHUS CARBONIFERUM var. POLYPLEURUM Girty?

Plate I, figure 5.

1909. Liorhynchus aff. *L. laura*. Girty, U. S. Geol. Survey Bull. 372, p. 27, pl. 2, figs. 13–15.
Caney shale: Antlers and Tishomingo quadrangles, Okla.

1911. *Liorhynchus carboniferum* var. *polypleurum*. Girty, U. S. Geol. Survey Bull. 439, p. 59, pl. 7, figs. 7–12.
Moorefield shale: Batesville and Marshall quadrangles, Ark.

I am including here a single specimen of doubtful affinities, a more or less flattened ventral (?) valve preserved as an internal mold. It has much the appearance of a large coarsely plicated Eumetria (*E. marcyi* var. *costata*), but it has a sinus (which, however, might be accounted for as due to distortion from crushing); its exterior shows striæ of growth, a character rare in Eumetria; and it is without evidence of punctation, a structure which would probably be indicated in the fine cherts even on the external mold. The specimen is therefore probably a rhynchonelloid, and it suggests both *Liorhynchus carboniferum* var. *polypleurum* and *Moorefieldella eurekensis* var.

[1] Fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey Bull. 439, p. 124, pl. 6, fig. 4, 1911.

cuboides. The real specific relations can not be determined from the material in hand. The specimen may be compared with figure 11 of Plate VII of my report on the Moorefield fauna,[1] but it has rather stronger and more persistent costæ.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 388 and 1237B).

CAMAROTŒCHIA PURDUEI var. AGRESTIS Girty?

1911. *Camarotœchia purduei* var. *agrestis*. Girty, U. S. Geol. Survey Bull. 439, p. 60, pl. 5, figs. 1–4a.
Moorefield shale: Batesville quadrangle, Ark.

A fragmentary dorsal valve occurs in the collection which seems to agree very well with this species, but its characters are so incompletely known that an unqualified identification can not be made.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 387a).

MOOREFIELDELLA EUREKENSIS Walcott.

1884. *Rhynchonella Eurekensis*. Walcott, U. S. Geol. Survey Mon. 8, p. 223, pl. 18, figs. 8–8c.
Lower Carboniferous: Eureka district, Nev.
1911. *Moorefieldella eurekensis*. Girty, U. S. Geol. Survey Bull. 439, p. 63, pl. 5, figs. 12–17a.
Moorefield shale: Batesville quadrangle, Ark.

To this species is referred a single ventral valve, and though it is imperfect the characters shown place its identity beyond reasonable doubt.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 1237B).

SPIRIFER MARTINIIFORMIS n. sp.

Plate I, figures 2–4.

1911. *Martinia glabra?* Girty, U. S. Geol. Survey Bull. 439, p. 70, pl. 9, figs. 9–11.
Moorefield shale: Batesville quadrangle, Spring Creek, Ark.

This is the most abundant species of the fauna under investigation, but though numerously represented in the collection its relationships are nevertheless incompletely known. The specimens are preserved as molds in chert, and rarely can an external mold be correlated with the internal mold of the same specimen. Most of the specimens also are more or less crushed, and many are broken around the margins back to where the secondary thickening gives strength to the umbonal portion, which is, on this account, alone preserved.

In spite of these disadvantages, however, it seems clear that we have a large oval shell varying somewhat in proportions but invariably wider than long, even in the case of the ventral valve, and having its greatest width a little in advance of the long hinge line. The ventral

[1] Fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey Bull. 439, p. 126, p. 6, fig. 4, 1911.

valve is rather strongly convex and has its apical portion prominent and incurved over a somewhat ill-defined (?) cardinal area which is divided by the usual triangular foramen. The sinus is relatively narrow and strong above, but broad, shallow, and undefined toward the front. The shell is considerably thickened over the posterior parts so that internal molds appear less convex than external ones. These testaceous deposits tend to obscure, though they by no means completely obscure, two well-defined dental plates.

The dorsal valve corresponds in a general way to the ventral, but it is less convex, and, as it lacks the projecting umbo, it is relatively much more transverse. A low but distinct fold is developed, broadening sharply toward the front.

The exterior is marked by a few regularly arranged lamellose growth lines but is otherwise smooth. It should be noted, however, that some specimens seem to show a few hardly perceptible radial costæ near the fold, asymmetrically developed on one side and not on the other.

This is undoubtedly the species which in the Moorefield shale I identified as *Martinia glabra?* and the specimens from that formation may be considered cotypes with those figured here. All the anomalous characters are shown which made it doubtful whether to place the species in the genus Martinia, or in Martiniopsis, or in Spirifer.

After examining many more specimens than I was able to obtain from the "Spring Creek limestone," preserved in such manner as to show the critical characters clearly, I am now able to state that dental plates are a persistent character of these shells. A continued reference to the genus Martinia seems therefore hardly justified. I also hesitate to cite them under Martiniopsis, a genus which seems to be developed in a widely different and much younger fauna. I am therefore citing them under the genus Spirifer, to which the presence of radial costæ, though only as traces and perhaps somewhat doubtful ones, also suggests an affinity. The character of the surface, smooth instead of bristling with fimbriæ of spines, forbids a reference to Reticularia, besides which this form has no septum in the ventral valve.

This form is readily distinguished from others known to me by reason of the dental plates and the essential absence of radial costæ.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 387a, 388, and 389).

SPIRIFER ARKANSANUS Girty.

1911. *Spirifer arkansanus.* Girty, U. S. Geol. Survey Bull. 439, p. 66, pl. 8, figs. 2–4. Moorefield shale: Batesville quadrangle, Ark.

This form is abundant at locality 1237B, though rare elsewhere, and the specimens seen are fragmentary and ill preserved. There

is, nevertheless, hardly room for doubt that some of them at least belong to the species named. Some specimens (for instance, internal molds which show neither the shape nor the costate surface clearly) can not be satisfactorily distinguished from certain associated types, so that it is possible that the distribution in the collections is wider than I have indicated, and also that some of the specimens included here may belong elsewhere.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387a and 1237B).

RETICULARIA SETIGERA Hall.

Plate I, figures 6, 7.

1858. *Spirifer setigerus.* Hall, Iowa Geol. Survey Rept., vol. 1, pt. 2, p. 705, pl. 27, figs. 4a, 4b.
Kaskaskia limestone: Kaskaskia and Chester, Ill.

1877. *Spirifera setigera.* Hall and Whitfield, U. S. Geol. Expl. 40th Par. Rept., vol. 4, p. 270, pl. 5, figs. 17, 18.
Lower Carboniferous limestone: North of Snowstorm Hill, Dry Canyon, Oquirrh Mountains, Utah.

1883. *Reticularia setigera.* Waagen, India Geol. Survey Mem., Palæontologica Indica, ser. 13, vol. 1, p. 542.

1883. *Spirifera setigera.* Hall, New York State Geologist Rept. for 1882, pl. (36) 61, figs. 26, 27.
Chester limestone: Chester, Ill.

1893. *Spirifer setigerus.* Hall and Clarke, New York Geol. Survey, Paleontology, vol. 8, pt. 2, pp. 21, 37. (Advance distribution in fascicles.)

1895. *Spirifer setigerus.* Hall and Clarke, idem, pp. 21, 37, pl. 36, figs. 26, 27. (Date of imprint, 1894.)
Chester limestone: Chester, Ill.

1895. *Spirifera setigera.* Keyes, Missouri Geol. Survey, vol. 5, p. 83. (Date of imprint, 1894.)
Kaskaskia limestone: St. Marys, Mo.

1906. *Reticularia setigerus.* Beede, Indiana Dept. Geology and Nat. Res. Thirtieth Ann. Rept. (for 1905), p. 1318, pl. 21, figs. 1, 1a.
Salem limestone: Lanesville and Bedford, Ind.

1911. *Reticularia setigera.* Girty, U. S. Geol. Survey Bull. 439, p. 69, pl. 8, figs. 6, 6a.
Moorefield shale: Batesville quadrangle, Spring Creek, Ark.

The stratigraphic position in which these specimens occur makes it important to determine whether they belong to the upper Mississippian species *R. setigera* or to the lower Mississippian species *R. pseudolineata*. *R. setigera* and *R. pseudolineata* are more similar than Hall's figures would lead one to suppose, because his figure of *R. pseudolineata* represents an abnormal specimen. At least, many of the specimens which I have seen from the Keokuk and from the Burlington, and the species is not rare at either horizon, are larger and especially have neither so transverse a shape nor so well developed a fold and sinus.

Comparing the two species Hall says of *R. setigera* that the area is much shorter and the mesial fold and sinus more strongly defined. According to my observations *R. setigera* is also a much smaller species.

In size the specimens under discussion suggest *R. setigera* much more than *R. pseudolineata*, for they are less than 27 millimeters in width. On the other hand, since the fold and sinus are very imperfectly developed, the agreement in this particular is rather with *R. pseudolineata*. I am not sure that the outline and sculpture present any features which aid the identification. The internal structures, however, are dissimilar to those of *R. pseudolineata*, in which the septum of the ventral valve is thin and high and is continued far into the cavity of the beak and in which the dorsal valve also has a well-developed median septum. In these specimens the ventral septum is thick and not very high and it does not extend far into the beak, whereas in the dorsal valve internal structures are more or less completely obsolete. If these differences are constant, and I have no evidence to the contrary, and if youthful conditions of *R. pseudolineata* do not exhibit similar phases, the internal structures of the present specimens indicate that they belong to a different species. They do not necessarily indicate the same species as *R. setigera*, however, as the internal peculiarities of *R. setigera* are not known to me.

So far as can be told this is the same form which occurs in the "Spring Creek limestone" and which I identified from it as *R. setigera*. For the reasons given above I believe that it is a different species from *R. pseudolineata* but am not sure that it actually belongs to *R. setigera*. If it does not, it apparently represents a species undescribed.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 387a?, 388, 389, and 1237B).

MARTINIA? PILOSA n. sp.

Plate I, figures 8, 9.

1911. Martinia sp. Girty, U. S. Geol. Survey Bull. 439, p. 72, pl. 9, fig. 8. Moorefield shale: Batesville quadrangle, Ark.

This is the species which in the "Spring Creek limestone" I described as Martinia sp. The most characteristic specimens in the present collection were found at locality 1237B and are in the form of internal and externals molds. The external molds show the surface to be marked by very fine concentric striæ and by numerous fine hairlike spines which tend to an arrangement in concentric rows. With one of the external molds belongs an internal mold showing both valves in conjunction but having the posterior portion missing. In this specimen the dorsal valve is nearly flat and the size and shape are, so far as determined, like those of the specimen from the "Spring Creek limestone" represented by my illustration. According to

observations made on the form from the "Spring Creek limestone" the ventral valve should be without dental plates, and such appears to be the condition of a few specimens from station 389 included in this species. These, however, do not show the superficial characters.

As the specimens are presented for study it is difficult, perhaps impossible, to separate *M.? pilosa* from several other species in this fauna, even from species only remotely related to this, though with well-preserved material there should be no difficulty. The associated type which is really most closely related is *Spirifer martiniiformis*, but though the two forms are apparently much alike in general configuration they may be distinguished, when these characters can be determined, by the one being small, without dental plates, and with a finely spinose surface, and by the other being large, with dental plates, and with smooth surface. I do not see how these differences can be ascribed merely to age, and I am led even to refer the two forms to different genera. What genus is really proper to receive the present one especially is doubtful. In my Moorefield paper the three genera Martinia, Reticularia (Squamularia), and Ambocœlia were discussed, but *M.? pilosa* would appear to possess anomalous features for either genus.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387 ?, 387a, 389, 1237B).

PELECYPODA.

CONOCARDIUM MEEKANUM var. MAGNUM n. var.

Plate II, figures 3, 4.

Conocardiums occur in the collections with some frequency and at least three species seem to be represented, only one of which can be described with reasonable completeness, because as usual the material is fragmentary or otherwise imperfect. The best specimen, a left valve, has a subtriangular shape and appears to be without a tube-like anterior projection. The width along the hinge line is 12 millimeters, the length along the umbonal ridge is about the same, and the extreme length (obliquely from the posterior-superior to the anterior-inferior angle) is about 16 millimeters. The anterior outline is slightly oblique downward to the projecting rounded anterior-inferior angle. The convexity is high, but the posterior parts are compressed, and the umbonal ridge is angular and prominent.

The surface is marked by slender, sharp, radial liræ which are more crowded over the umbonal region (where they stand about their own width apart) and are more widely spaced posteriorly. The anterior sculpture as usual is discrepant with the rest. In front of the umbonal ridge the costæ abruptly stand at wide intervals and are gradually more and more crowded toward the anterior extremity. The ribs are

alternating. On the outside these markings appear as narrow ridges and wide striæ, but on the internal mold they appear just the reverse, as wide ridges and narrow striæ, the internal markings, however, being on a much larger scale than the external. In addition to the costæ there are fine, regular, concentric lamellæ.

This form resembles *C. meekanum* and *C. cuneatum* of the Spergen fauna. It is of course much larger, and the sculpture, though of the same general character, differs in proportions. It is probable that the present form should be considered as a distinct variety, if nothing more. There seems to be no other species of similar age or faunal association with which an equally close relationship exists.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 387a, 388 ?, and 389).

CONOCARDIUM sp. *a*.

Plate II, figures 5, 6.

This title is used for a specimen partly concealed in chert which, so far as known, has the general configuration of *C. meekanum* var. *magnum*, but differs chiefly in its smaller size and coarser sculpture. This is a testiferous specimen and shows strong sharp costæ much more than their own diameter apart, but becoming finer and more closely arranged toward the posterior extremity, and finer and much more closely arranged anterior to the umbonal ridge, which is prominent and narrowly rounded. The ribs are crossed by rather coarse crenulating concentric lamellæ.

This may be a young specimen of the larger form named above, which has retained the primary costæ without developing interstitial ones, but for the present it seems inadvisable to refer both to the same species.

CONOCARDIUM sp. *b*.

This type is represented by a single specimen much resembling species *a*, like it, testiferous and, like it, partly buried in chert. The configuration also appears to be similar, but the sculpture is markedly different. In species *b* the costæ are broad and rounded instead of narrow and sharp, and they are separated by intervals about equal to their own width or less. They are coarse and widely separated on the posterior wing and are much finer and rather crowded at and near the umbonal ridge. The concentric liræ are very fine, even, and closely arranged, though toward the margin they are replaced by heavy striæ due to intermittent growth.

This species is certainly distinct from both *C. meekanum* and Conocardium sp. *a*, unless the difference in sculpture is an abnormality.

PARALLELODON MULTILIRATUS Girty.

Plate II, figures 8, 9.

1909. *Parallelodon multiliratus.* Girty, U. S. Geol. Survey Bull. 377, p. 39, pl. 3, figs. 4, 5.
Caney shale: Atoka and Tishomingo quadrangles, Okla.
1911. *Parallelodon multiliratus.* Girty, U. S. Geol. Survey Bull. 439, p. 85, pl. 12, figs. 3–4.
Moorefield shale: Batesville quadrangle, Ark.

Two specimens, agreeing in every particular with specimens from the "Spring Creek limestone," represent this species. One of them is especially perfect and shows the dentition. It is a left valve and possesses at least five small oblique anterior teeth and about four parallel posterior teeth. These are strong and large toward the posterior superior angle, but toward the umbo they are replaced by five or six much finer lamellæ, which do not conform entirely to those farther back.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

GASTROPODA.

BEMBEXIA NODIMARGINATA McChesney.

Plate II, figure 7.

1860. *Pleurotomaria nodomarginata.* McChesney, Desc. New Species Pal. Foss., p. 70. (Date of imprint, 1859.)
Hamilton group: Near Batesville, Ark.
1865. *Pleurotomaria nodomarginata.* McChesney, Illustrations New Species Foss., pl. 7, figs. 1a–c.
1868. *Pleurotomaria nodomarginata.* McChesney, Chicago Acad. Sci. Trans., vol. 1, p. 47, pl. 7, figs. 1a–c. (Date of imprint, 1867–1869.)
Hamilton group: Near Batesville, Ark.
1884. *Pleurotomaria nodomarginata.* Walcott, U. S. Geol. Survey Mon. 8, p. 259, pl. 18, fig. 15.
Lower Carboniferous: Eureka district, Nev.
1911. *Bembexia nodimarginata.* Girty, U. S. Geol. Survey Bull. 439, p. 91, pl. 7, figs. 1–5.
Moorefield shale: Batesville quadrangle, Ark.

This type is abundant in collection 387a, and the specimens show a wide range of variation. Part of this variation is in the shape, some specimens having a narrower, others a broader spiral angle. Rather more marked is the variation in sculpture, and although this is probably in part ascribable to preservation I am inclined to think that several valid varieties might be discriminated with good material.

In some specimens the transverse markings are fine and faint so that the surface appears almost smooth. In others, however, they are strong and coarse, so that the surface looks transversely corrugated. These varieties are without conspicuous nodose swellings below the suture, but another type has the strong transverse costæ alternately large and small, the smaller ones not continued quite to

the suture and the larger ones persistent and expanded into nodes of different sizes in different specimens. Some of the smaller costæ appear to branch from the larger; and, again, the nodes may be large and prominent close to the suture, but may have the costæ with which they are connected and also the intermediate costæ only partly developed. All these modifications are more or less closely connected in series, and most of them appear to be indicated in McChesney's original description and figures. Some of my specimens show more prominent nodes than are represented by him, and on the other hand my figure of a Moorefield shale specimen scarcely shows this character at all. The specimen, however, is an internal mold or nearly so and does not retain the nodes in the degree in which I believe they were originally present.

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 387, 387a, and 1237B?).

Bembexia sp.

This type is known from two very imperfect specimens. It is a large shell, in a general way suggesting Pleurotomaria aff. *P. carbonaria*, but perhaps with a somewhat higher spire. The greatest diameter may be 35 millimeters or even more. The volutions are more or less regularly rounded, only slightly embracing, and with deep sutures. The surface is crossed by strong, regular, transverse liræ which apparently subside to more or less inconspicuous growth lines on the under side. A broad, sharply defined slit band is developed on the periphery.

In sculpture this form resembles *B. nodimarginata* but is perhaps without the nodes close to the suture. It appears to be readily distinguished also by its much larger size, more rounded whorls, and deeper sutures. This type is not known in the Moorefield fauna (including that of the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (stations 390 and 1248W).

Pleurotomaria aff. carbonaria Norwood and Pratten.

Five specimens from station 389 show a type of shell apparently belonging to the group of *Pleurotomaria carbonaria*. They are all either fragmentary or very much crushed and some of their characters are not definitely known.

The size is large (about 17 millimeters in greatest width) and the spire moderately high. The volutions, which were about six in number, appear to have been rather regularly rounded and are not strongly embracing, so that the sutures are deeply impressed. There is some evidence of a slight flattening of the upper surface and an attendant angulation where it gives onto the curved sides.

The sculpture consists of numerous angular revolving liræ separated by somewhat wider striæ. The liræ are not absolutely equal and one distinctly larger than the rest apparently occurs at the junction of the upper and the lateral surfaces. There are also numerous fine lamellose transverse liræ, which produce crenulations on the revolving ones. Their course can not be described in detail, but it is sinuous, with a broad rounded sinus across the periphery. The presence of a slit or a slit band has not been ascertained.

If a slit and slit band are absent, the reference to Pleurotomaria is of course not correct, although these structures are not well shown in *P. carbonaria*, which is certainly one of the Pleurotomarias. Perhaps the generic relationship will prove to be rather with Cyclonema.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

Pleurotomaria sp.

This is a single specimen and a mere fragment. It is an ornate type marked above and below by strong, sharp, revolving liræ. The rather broad slit band is situated on the peripheral line and is traversed a little above the middle by a double row of small nodes connected by two slender ridges. This type also has no analogue in the Moorefield shale (including the "Spring Creek limestone") so far as known.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 387a).

Euomphalus planidorsatus Meek and Worthen?

Plate II, figures 1, 2.

1860. *Euomphalus planodorsatus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 462.
Chester limestone: Thompson's quarry, Randolph County, Ill.

1863. *Euomphalus perspectivus.* Swallow, St. Louis Acad. Sci. Trans., vol. 2, p. 98.
Kaskaskia limestone.

1866. *Straparollus planidorsatus.* Meek and Worthen, Illinois Geol. Survey, vol. 2, p. 302, pl. 24, figs. 2a–c.
Chester group: Thompson's quarry, Randolph County, Ill.

1894. *Straparollus planidorsatus.* Keyes, Missouri Geol. Survey, vol. 5, p. 160.
Kaskaskia limestone: St. Marys, Mo.

This type is represented by a single specimen preserved as an external mold of the upper surface. The shell is small, 13 millimeters across, and thus it is intermediate in size between *E. planidorsatus* and the related *E. similis*. The spire is low and the upper surface of the volutions flattened. An indistinct carina is developed toward the outer margin, but its obscurity, together with the absence of data regarding the under side of the shell, brings the identification into considerable doubt. This type also is not known in the Moorefield shale (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

SPHÆRODOMA? sp.

This is a single imperfect specimen and is mentioned only because it belongs to a type not yet found in the Moorefield shale (including the "Spring Creek limestone").

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

OSTRACODA.

PRIMITIA MOOREFIELDANA Girty?

1911. *Primitia moorefieldana.* Girty, U. S. Geol. Survey Bull. 439, p. 106, pl. 9, figs. 6–7a.

Moorefield shale: Batesville quadrangle, Ark.

Ostracods are fairly abundant at station 389, but though some of the cherts in which they occur are soft enough to permit one to uncover their outlines they are nevertheless preserved as molds, chiefly as molds of the interior, and the study which I have devoted to them does not warrant definite conclusions as to their specific and generic relations. Two genera are present, Bairdia and another type which appears to be Primitia, both of which genera are found also in the "Spring Creek limestone." That the third genus from the "Spring Creek limestone," Paraparchites, does not also occur among these specimens I am not able to affirm. At least no specimens can be positively identified as Paraparchites. The Primitia-like type is more common than the other, but its generic position is open to question. The general appearance is suggestive of *P. moorefieldana*, but the median pit is indistinct, as might perhaps be expected in internal molds.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

BAIRDIA aff. B. CESTRIENSIS Ulrich.

Plate II, figure 10.

Three or four specimens only are included here. Their shape reveals their generic position with some certainty, but their specific relations are less clearly indicated. They appear to be less elongate than *B. attenuata* of the "Spring Creek limestone," their proportions being more like those of *B. cestriensis*. In fact, the most perfect of my specimens closely resembles one of Ulrich's figures.[1] It differs chiefly in being rather larger and in having its posterior extremity so shaped that the pointed termination is more central and the outline below more strongly curved upward, an appearance which might to some extent be produced by a slightly different posing of the specimen. It seems rather improbable that this is really *B. cestriensis*, though it appears to be a related species.

Locality.—Batesville quadrangle, Ark., Spring Creek (station 389).

[1] Cincinnati Soc. Nat. Hist. Jour., vol. 13, pl. 17, fig. 6a, 1891.

REGISTER OF LOCALITIES.

Station 387. Batesville quadrangle. Loose piece of chert in the bed of Spring Creek, a mile or two above Ruddells Mill.

Station 387a. Another loose piece found near by.

Station 388. Batesville quadrangle. Spring Creek, 1 mile above the trestle near Ruddells Mill. Loose pieces of chert from the top of the hill, probably about in place.

Station 389. Batesville quadrangle. Loose blocks of chert, probably about in place on the hillside just south of station 390, but about 150 feet higher in section.

Station 390. Batesville quadrangle. Hillside along Spring Creek, one-half mile north of Ruddells Mill, near Batesville, Ark. Lower part of black calcareous shale near the middle of the chert member.

Station 1237B. Batesville quadrangle. Probably in the NW. ¼ NE. ¼ sec. 21, T. 13 N., R. 7 W. The point thus designated is 6 or 7 miles southwest of Batesville, Ark.

Station 1248W. Batesville quadrangle. Found loose on the railroad embankment along Spring Creek, near Batesville, Ark.

PLATE I.

PLATE I.

PRODUCTELLA HIRSUTIFORMIS var. BATESVILLENSIS? (p. 26).

FIGURE 1. External mold of a dorsal valve, with an impression of the area of the corresponding ventral valve.

SPIRIFER MARTINIIFORMIS (p. 30).

FIGURE 2. Internal mold of a ventral valve, showing the impressions of the dental plates.

3. Squeeze made from an external mold of a crushed ventral valve. These molds, when best preserved, are smooth save for obscure incremental lines.

4. Internal mold of a dorsal valve.

LIORHYNCHUS CARBONIFERUM var. POLYPLEURUM? (p. 29).

FIGURE 5. Squeeze of an external mold of a ventral valve.

RETICULARIA SETIGERA (p. 31).

FIGURE 6. Internal mold of a ventral valve.

7. Internal mold of a compressed dorsal valve.

MARTINIA? PILOSA (p. 33).

FIGURE 8. Internal mold of a ventral valve.

9. Part of the external mold of a dorsal valve, × 10. This shows the fine incremental lamellæ surmounted by hairlike spines which in the impression are represented by tiny holes.

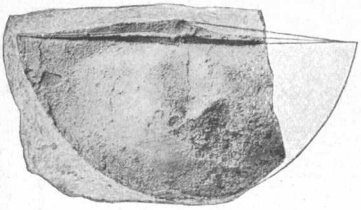
LINGULA ALBAPINENSIS (p. 25).

FIGURE 10. A dorsal? valve, the only specimen seen.

RHIPIDOMELLA ARKANSANA (p. 28).

FIGURE 11. Ventral view of a bivalve specimen from the black shale occurring midway in the chert series.

12. Dorsal view of same.



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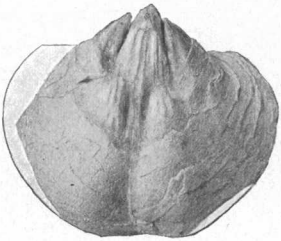

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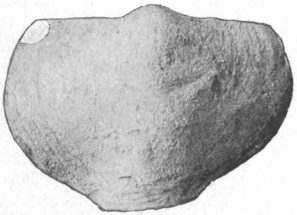

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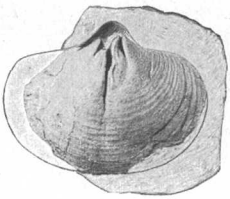

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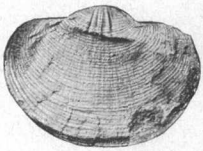

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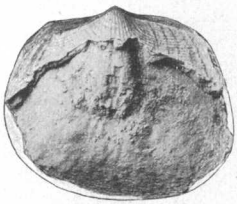

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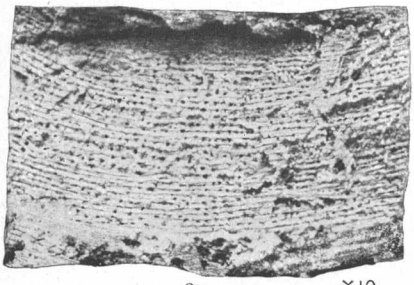

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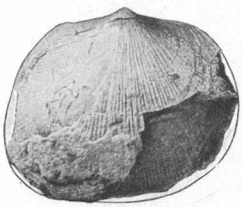


12

BRACHIOPODA.

PLATE II.

PLATE II.

EUOMPHALUS PLANIDORSATUS? (p. 38).

FIGURE 1. A squeeze from a mold of the upper surface.
2. Side view in outline.

CONOCARDIUM MEEKANUM var. MAGNUM (p. 34).

FIGURE 3. Internal mold of a medium-sized specimen.
4. Squeeze from a part of the external mold of same, × 2. The exterior of this specimen is marked by fine sharp costæ, while the mold of the inner surface seems to be marked by coarse flat ones. The markings, of course, represent shallow, widely spaced grooves on the inside of the shell.

CONOCARDIUM sp. *a*. (p. 35).

FIGURE 5. A testiferous specimen preserved in chert, × 2.
6. Same, natural size, in outline.

BEMBEXIA NODIMARGINATA (p. 36).

FIGURE 7. A fragment of chert with three specimens embedded in it, × 3.

PARALLELODON MULTILIRATUS (p. 35).

FIGURE 8. Internal mold of a left valve.
9. Same, × 2, showing the impression of the hinge teeth.

BAIRDIA aff. B. CESTRIENSIS (p. 39).

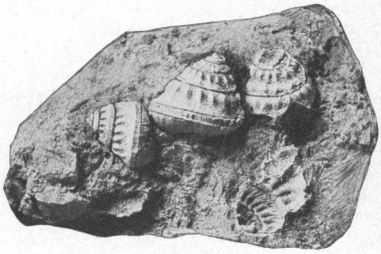
FIGURE 10. An internal mold, × 10.

LIORHYNCHUS CARBONIFERUM (p. 28).

FIGURE 11. A slab containing impressions of a number of specimens.

1

2



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X10

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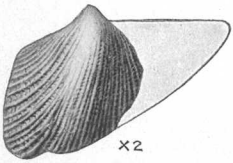

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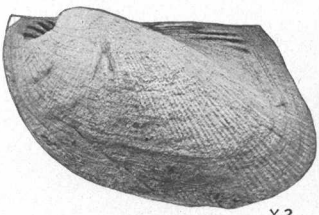

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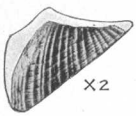

X2

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6

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BRACHIOPODA, PELECYPODA, GASTROPODA, AND OSTRACODA.

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