THE FAUNA OF THE MIDDLE BOONE NEAR BATESVILLE, ARKANSAS

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INTRODUCTION

The geologic section at Batesville, Ark., so far as it is of present concern, comprises the Batesville sandstone, the Moorefield shale, and the Boone chert. The formations are cited in descending order, and the Boone is underlain at different places by rocks of different ages ranging from Ordovician to Devonian.

The faunas of the Batesville sandstone and Moorefield shale are already known. The Batesville fauna was first described by Weller [1] and somewhat later was reviewed by me [2] on collections more extensive inasmuch as they comprised material from Marshall as well as from Batesville. I also described the fauna of the Moorefield shale,[3] using the same two localities as sources for my collections. On the other hand, my contacts with the Boone fauna of that region have been few and more or less in the nature of afterthoughts. The faunas of the Moorefield and Batesville, then little known, were of chief interest, whereas the fauna of the Boone was naturally supposed to be the same as other Boone faunas, with which I was fairly familiar.

I had already observed, as I thought, that lithologically the Boone exposures near Batesville were somewhat different from the more typical exposures farther west. Near Batesville the formation seemed to consist of a darker, finer-grained, and more siliceous rock, lacking in beds of a crystalline or crinoidal nature, and conspicuously poor in fossil remains. It was divisible into a lower calcareous member and an upper cherty member. The cherty member, which was thought to be about 250 feet thick, even included near the middle some 20 feet of beds comprising calcareous shale, limestone, and calcareous sandstone, mostly black or dark gray. This feature is of course quite foreign to the Boone in its typical aspects. Finally, a small fauna collected in the upper part of the chert member [4] proved to be closely related to the fauna of the Moorefield shale and widely different from the typical Boone faunas. These facts, which were brought out in Bulletin 595, might provisionally be interpreted in three ways: (1) The Boone at Batesville is not the true Boone but a different formation and, if different, younger; (2) it is equivalent to the typical Boone but is more or less transformed in lithologic character and in fauna; (3) it is a more extensive formation, the lower part equivalent to the Boone but the upper part younger. The problem thus seemed to focus upon the lower part of the formation. If the fauna of the limestone member proved to be of the normal Boone type, and consequently different from the higher fauna, the inference would naturally follow that the limestone member represents the true Boone, and that the chert member is a later formation. If the fauna could be assigned to some definite part of the Boone, the inference would be modified to suit, but further progress along any but speculative paths seemed barred until something was known of the lower fauna.

Unfortunately, when I had an opportunity to examine the lower part of the Boone section near Batesville, I had little idea that the Boone of that region presented such a problem; my observations were hasty, and no collections were made. Under some circumstances one has recourse to one's friends, and as Mr. H. D. Miser was about to visit the Batesville region on an economic behest, I asked him to collect some fossils from the limestone member in the hope that its relations to the typical Boone might thus be determined. My request was graciously fulfilled, and Mr. Miser made the two collections upon which this report is based. This evidence, however, does not solve the problem but rather complicates it, for the fauna of the middle Boone, though conspicuously different from the upper fauna, is also conspicuously different from the faunas of the typical Boone. The purpose of the present paper, then, is to place these facts on record and to discuss certain relations which they suggest.

Mr. Miser has kindly furnished the following description of the stratigraphic relations and occurrence of the rocks from which these fossils came:

The fossils described in the present report were obtained by me from a bed of limestone near the middle of the Boone chert at two localities on Spring Creek 5 miles northwest of Bates-

[1] Weller, Stuart, The Batesville sandstone of Arkansas: New York Acad. Sci. Trans., vol. 16, pp. 251–282, pls. 19–21, 1897.

[2] Girty, G. H., The fauna of the Batesville sandstone, northern Arkansas: U. S. Geol. Survey Bull. 593, 1915.

[3] Girty, G. H., The fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey Bull. 439, 1911.

[4] Girty, G. H., Fauna of the so-called Boone chert near Batesville, Ark.: U. S. Geol. Survey Bull. 595, 1915.

ville, one in an abandoned limestone quarry on the east side of the Spring Creek valley about a quarter of a mile northeast of Denieville and the other on the east side of the valley about a mile southeast of Big Spring.

The limestone yielding the fossils is 22 feet thick in the quarry near Denieville and appears to be only a few feet thick at the locality a mile southeast of Big Spring. It is light gray, ranges from fine to coarse grained, occurs in layers attaining a thickness of 6 feet, and contains a few layers and nodules of flint. In addition to the brachiopods and the other fossils described by Mr. Girty, the limestone contains numerous crinoid stems, which are in fact abundant enough for the rock to be called a crinoidal limestone. Similar limestone of apparently the same age is exposed at other places in the Batesville region, though no fossils have been observed or obtained except at the two localities on Spring Creek. At Pfeiffer, 5 miles northeast of Batesville, there is an even-bedded fine-grained light-gray limestone 40 feet thick, which is being quarried, dressed, and marketed for use as a high-grade building stone. Similar though cross-bedded limestone has been quarried on the Blowing Cave road 2 miles north-northeast of Batesville.

The fossil-bearing limestone on Spring Creek and the limestone at the two localities just mentioned are near the middle of the Boone chert, a formation whose thickness is estimated to be between 300 and 400 feet. The full thickness of the Boone is revealed on Spring Creek. The base is exposed in a small area beginning at Big Spring and extending down the creek for almost half a mile. Here the Boone is underlain by the St. Clair limestone, of Silurian age. The topmost beds of the formation are exposed near Ruddells Mill, 2½ miles southeast of Denieville, where the Boone is overlain by the Moorefield shale.

The base of the limestone at the quarry near Denieville stands 50 feet above the bottom of Spring Creek, but no rock exposures were observed in the steep slope below the quarry. The chert underneath the limestone is thus not revealed there. It is, however, exposed farther upstream, especially along the Batesville-Cushman road, which follows Spring Creek past Big Spring. A large fresh exposure of the chert has been blasted recently in the construction of the highway three-quarters of a mile southeast of the spring. It shows the unweathered rock to consist of gray to blue flint in thin and thick layers, parts of which are limy. The flint on weathering loses its small quantity of calcium carbonate, becomes slightly porous, and breaks into hard, angular gray fragments that cover the steep slopes, with no admixture of clay. The flint as revealed in a fresh exposure on the highway and also in exposures to the north toward the outcrops of the St. Clair limestone has a southerly dip of a few degrees. On a hill half a mile southeast of Big Spring flinty chert that is below the fossil-bearing limestone of the Boone extends from the base to the top of the hill, which is 150 feet high. The chert below the limestone bed of the Boone is thus more than 150 feet thick but perhaps does not exceed 160 feet.

The upper chert member of the Boone along and near Spring Creek—the part of the formation lying above the fossil-bearing limestone—has been described by Mr. Girty in Bulletin 595 of the United States Geological Survey. He says that a fairly satisfactory estimate of the thickness is 200 to 250 feet. At the Denieville quarry the upper chert continues up the slope to the crest of the hill, 165 feet above the top of the limestone. The chert as revealed on the slopes occurs in part as soft, knotty, thin ledges but mostly as loose slabs and fragments of porous gray to brown vermicular chert, in some of which there are sparse casts of fossil remains.

The following beds are exposed along Spring Creek:

Section on Spring Creek between Big Spring and Ruddells Mill

	Feet
Moorefield shale, including at the base a limestone facies several feet thick that has been called "Spring Creek limestone."	
Boone chert:	
Chert weathering to porous vermicular slabs and fragments, sparsely fossiliferous; fauna described in Bulletin 595	200–250
Fossiliferous gray limestone; fauna described in present report	22
Flint weathering to hard angular fragments	150–160
St. Clair limestone; base not exposed	50+

For the purpose of recording a fauna the bare list of species is often highly unsatisfactory. It is not so always, because in a region where a fauna is well known certain undesirable features of a bare list are by that fact correspondingly minimized. Even then such a list makes somewhat trying demands upon the knowledge and imagination of the reader. If the fauna is new, however, or if, though not new, it comes from a new and remote area, the disadvantages inherent in a bare list become serious, and one feels the need of supplementing it by descriptions and figures. A list presents not facts but interpretations of facts, and it affords no opportunity for qualifying or discussing the interpretations which it presents—namely, the identifications of species.

In attempting to record the character of the middle Boone fauna of the Batesville region I have been prevented from giving discussions and illustrations of the different species, such as I would like, by the unsatisfactory character of the fossils. They are, to be sure, abundant, but at the same time they are rather poorly preserved. The matrix seems to consist of thin irregular plates of granular or crinoidal limestone alternating with fine-grained impure calcareous material that has been more or less converted into chert. The same process of alteration which gave a cherty character to the rock has perhaps caused it to adhere tightly to the shells. At all events, most of the shells are seriously exfoliated and, where they are partly concealed by matrix, sometimes very hard to uncover. Of many species only the larger features could be determined, and specimens that were suitable for illustration, that exhibited at one time all the significant characters shown singly by the others, were indeed few. Under these circumstances it has not been found practicable to illustrate all the species or to describe some of them in any but a large way. Nevertheless, the general aspect of the fauna, I believe, will be presented to others almost as well as the collections themselves presented it to me.

The subjoined table shows the representation of the middle Boone fauna of the Batesville region in the two collections by which it is at present known. The species marked with an asterisk are to be compared with species in the meager fauna of the upper Boone, which as here considered is that obtained from the

cherty beds, to the exclusion of the richer fauna obtained from the overlying "Spring Creek limestone." Species are thus marked that may prove to be the same, though they are not now known to be so, as *Triplophyllum?* sp. or *Rhombopora?* sp. It is rather doubtful whether subsequent knowledge will show these forms to be identical; on the other hand, some of the Producti that are not marked as identical may prove to be so. On the whole, although but six species are marked as common to the two faunas, this probably overstates the relationship indicated by the facts at hand. As at present known (and it would be useless to speculate what future discoveries will reveal) the middle fauna is very different from the upper, and the difference is even more impressive in the collections than in the lists, because of the numerical representation of the species. Regarding the fauna of the "Spring Creek limestone," as that fauna is more extensive than the upper fauna of the Boone, by so much the more does it differ from the present one.

Distribution of the middle Boone fauna from localities 3203 and 3204 [a]

	3203	3204
Cladochonus beecheri	×	
Cladochonus aff. C. longi	×	
Cyathaxonia? n. sp		×
*Triplophyllum? sp		×
*Rhombopora? sp	×	
Cystodictya pustulosa?	×	×
Rhipidomella aff. R. jerseyensis	×	
Schizophoria compacta	×	×
*Orthotetes? sp	×	
Chonetes miseri	×	×
Chonetes miseri var	×	
Chonetes aff. C. shumardianus	×	×
Chonetes batesvillensis	×	×
*Productella hirsutiformis?		×
Productus magnus	×	
Productus crawfordsvillensis?		×
Productus mesialis?		×
Productus burlingtonensis	×	
Productus aff. P. gallatinensis	×	
*Productus ovatus var. minor	×	
Avonia arkansana var. multilirata?	×	
Pustula aff. P. gradata		
Pustula incrassata		
Rhynchopora palmeri?		×
Rhynchopora sp		×
Spirifer floydensis?	×	×
Spirifer incertiformis	×	×
Spirifer washingtonensis var. incomptus	×	
*Spirifer martiniiformis	×	×
Spirifer sp		×
Syringothyris subcuspidatus	×	×
Pseudosyrinx gigas	×	×
Brachythyris suborbicularis	×	×
Reticularia setigera var. internascens	×	×
Spiriferina subelliptica var. fayettevillensis	×	×
Spiriferina sp	×	×
Hustedia circularis	×	
Bembexia magna?		×
Orthonychia ungula	×	×
Orthonychia undata	×	×
Orthonychia sp	×	
Platyceras oxynotum	×	×
Platyceras latum	×	×
Proetus sp. aff. P. roundyi var. alternatus	×	
Cytherella sp		×

[a] For a description of these localities see p. 97.

As at present known, the fauna of the middle beds of the Boone comprises 45 species or varieties. It is essentially a fauna of brachiopods, and among these the Spirifers are by all means the most abundant. Measured in variety the Producti are essentially their equals, but in numbers they are far inferior. *Spirifer incertiformis* and *S. floydensis* are especially abundant, and shells of *Syringothyris* and *Reticularia* are also numerous. Of the Producti, *P. burlingtonensis* is the best represented, though it is much less abundant than the Spirifers just mentioned.

In considering the relations of this fauna it must be borne in mind that the specific identifications are more or less provisional. As regards the specific identifications the disfigurement of the specimens—that is, the loss of characters which they have suffered through exfoliation or other accidents—is more likely to cause them to be identified with kindred species when they are really distinct than to cause them to appear distinct when they are really identical. Be this as it may, it is obviously impossible to discuss the relations of the fauna except upon the evidence as it now stands. With the undetermined species and with a few that appear to be new (*Chonetes miseri, C. batesvillensis, Pustula incrassata,* and *Spirifer incertiformis*) we have in such discussion no concern.

In a few points the fauna of the middle Boone shows affinities with that of the upper Boone from the same area and with that of the "Spring Creek limestone," which are closely related to one another and for present purposes may be treated as a unit. As evidence in this direction one might cite *Productella hirsutiformis, Avonia arkansana* var. *multilirata, Spirifer martiniiformis, Reticularia setigera* var. *internascens,* and some others. This evidence is weak, however, in comparison with that which is opposite in character. The greater number of species, especially the more abundant and more characteristic species of either fauna are conspicuously absent from the other. To pass over the *Producti, Spirifer floydensis, S. incertiformis, Syringothyris subcuspidatus,* and *Pseudosyrinx gigas* are found in the fauna of the middle Boone but not in that of the upper Boone and "Spring Creek limestone," whereas *Spirifer arkansana* and a great rhynchonelloid development (*Camarotoechia, Leiorhynchus,* and *Moorefieldella*) are found in the faunas of the upper Boone and "Spring Creek limestone" but not in that of the middle Boone. These comparisons might be pursued much further, but they would lead to the same conclusion that the middle fauna, though allied to the upper ones in a few articles, is overwhelmingly different.

To reach any substantial conclusion as to the precise relations of this fauna to the typical Mississippian faunas of Iowa and Missouri is at present out of the question. Its relations seem to lie distinctly with the lower Mississippian faunas rather than with the middle

Mississippian, and little, if at all, with the upper Mississippian. The relative abundance of *Platyceras* types, unless it is interpreted in terms of environment rather than of time, is suggestive of the Burlington fauna. *Productus burlingtonensis* to some extent confirms the evidence of the Platycerata, though similar Producti occur in higher and in lower faunas. *Rhipidomella jerseyensis* and *Hustedia circularis* might be regarded as still further confirmation, for they occur in the Fern Glen and Chouteau faunas, which appear to be closely allied to the lower Burlington fauna. *Pustula gradata*, if it is the same as *P. alternata*, and also *Brachythyris suborbicularis* span Burlington and Keokuk time and might be cited for either geologic epoch.

As suggesting Keokuk rather than Burlington time, we have *Cladochonus beecheri*, *Productus magnus*, *P. crawfordsvillensis*, *P. mesialis*, *Spirifer floydensis*, *Pseudosyrinx gigas*, and *Syringothyris subcuspidatus*, a somewhat more weighty assemblage. Obviously, however, this is far from being a characteristic Burlington fauna or a characteristic Keokuk fauna. The flashes of resemblance are neither very numerous nor very illuminating.

As might be expected, the fauna that we have here shows greater affinity with the typical Boone fauna than with the typical faunas of the Mississippian, which are more remote, but its Boone affinities are surprisingly tenuous in view of its geographic proximity. A discussion of this relation is embarrassed by the fact that the Boone faunas as compared with those of the typical Mississippian are but little known. I have myself, it is true, devoted considerable study to them, but the study has been unequal—much to certain groups, to others little. In a general way the species found in the Boone are the same as those of the typical Mississippian rocks, but they are somewhat differently assembled and comprise as well some types that are absent or have not yet been found in the typical Mississippian. The typical Boone, aside from the St. Joe limestone member, which has a fauna of its own, contains at least two distinguishable faunas—an upper one supposed to be of Warsaw age and a lower one, which seems to represent the Burlington and Keokuk faunas undifferentiated. I do not wish to convey the impression that a more intimate knowledge of these faunas will not afford means for dividing them more finely, but those two divisions are the most obvious ones.

Neither of the two faunal facies found in the typical Boone is represented with full integrity by the fauna of the middle Boone near Batesville. The later one is, indeed, somewhat pointedly suggested by such forms as *Productus magnus*, *Rhynchopora palmeri*, and *Spirifer washingtonensis* var. *incomptus*, even though the identification with those species is not final. Nevertheless, most of the significant members of that fauna are lacking in this one—for instance, *Spirifer lateralis*, *S. washingtonensis*, and many other species, including some that are undescribed. On the whole this fauna from Batesville contains more species that are close to or actually identical with species of the Burlington and Keokuk part of the Boone than species that are similarly related to species of the Warsaw part, and the general aspect of the fauna seems to be older than Warsaw, in spite of the few forms that suggest that epoch. A more specific treatment of this phase of the subject must be deferred until my detailed study of the Boone faunas is brought to completion. The only safe statement at present seems to be that this fauna from Batesville does not faithfully represent any of the faunas known from the the typical Boone but appears to be more solidly related to the earlier faunas, which are of Burlington and Keokuk age, although possessing a few features that suggest the later epoch.

If one were to forget for the moment the paleontologic evidence and were to consider that of lithology, geography, stratigraphic succession, and such tracing as has been done, he would probably conclude that the Boone of the Batesville region was the same as the Boone farther west—for instance, the same as the Boone in its typical outcrop in Boone County, though somewhat altered in its extension to the east. He might even be inclined to believe that the middle part of the Batesville Boone, which furnished the present fauna and which to me seemed a distinguishable part of the formation, was the St. Joe member. This hypothesis the character of the fauna collected by Mr. Miser seems to put beyond the pale of serious consideration. On the other hand, the alternative extreme, that these beds represent the whole of the Boone, seems also improbable, though by no means to be dismissed without consideration. For example, the pronounced change in the faunas that appears to have occurred between middle and upper Boone time in the Batesville region might be cited in favor of this interpretation, which, if adopted, would make much of the Batesville Boone post-Boone in age. Furthermore, if, as is now believed, the upper part of the typical Boone is of Warsaw age, the upper part of the Batesville Boone would needs be post-Warsaw—possibly Spergen, possibly St. Louis in age. That the upper Boone fauna of the Batesville region is neither a Spergen nor a St. Louis fauna is beside the mark, for it almost necessarily has to correspond with some one of the typical Mississippian faunas, and it is equally unlike any of them.

If what seems to be the more conservative hypothesis were adopted, the middle part of the Boone in the Batesville region would correspond to the Burlington and Keokuk part of the typical Boone, and

the upper part of the Boone near Batesville to the Warsaw part of the typical Boone. Where in the largely unexplored Boone section near Batesville the boundary between Keokuk and Warsaw occurs can not now be designated. Possibly there is no good stratigraphic boundary; possibly even no good paleontologic boundary, for although the faunas at present known are wide apart in facies, they are also rather wide apart in their occurrence within the formation.

It will be seen that of the three hypotheses which presented themselves in the forepart of this discussion, the one which at the end of it seems the most probable is that the Boone of the Batesville region is an eastward extension of the typical Boone, somewhat transformed in its lithologic and still more in its faunal characters, the upper fauna becoming more completely transformed than the middle fauna but both having undergone vital changes. Although this hypothesis is adopted, it is adopted provisionally and without wholly dismissing the alternative one that the upper part of the Boone in the Batesville region is younger than the upper beds of the typical Boone.

As connected with the adoption of a hypothesis involving pronounced changes in the lithologic character of the Boone and even more pronounced changes in its fauna, we may scan the character of our early Mississippian sediments in a very broad way. Our Burlington and Keokuk rocks appear to be part of a limestone lens of almost continental proportions. It can hardly be doubted that the Madison limestone and its correlates come within the same general period of time, and it seems probable that these western limestones were originally, even if they are not now, continuous with those so well known in the Mississippi Valley. All the direct evidence on this head is, one might say, buried beneath the deposits of the Great Plains region. These Mississippian rocks have, we know, been removed in places during Carboniferous time. To what extent they are now continuous under cover and to what extent they were originally continuous, though in part removed by erosion, is, for the reason given, largely speculative. My own belief is that the Burlington and Keokuk rocks formed one lobe of a widespread limestone lens, chiefly developed in western seas. To the south and east, on the other hand, this limestone lens surely gave way to clastic deposits, for one can scarcely doubt that the "Knobstone group" of Indiana and Kentucky, the Waverly group of Ohio, the Marshall formation and Coldwater shale of Michigan, and in part the "Siliceous group" of Tennessee were in a broad way contemporaneous. Although these formations, which comprise sands, both fine and coarse, and shales of various colors including black, with but small proportions of intermingled calcareous matter, are so strikingly different from the Burlington and Keokuk in lithologic character, they differ even more strikingly in their faunal content. If these faunal and lithologic transitions took place, it seems likely from all the evidence that the sediments and faunas of the Batesville region now known as Boone were in the transition zone where the calcareous lens was merging with its clastic equivalent.

The discussion must turn next to a fauna recently described [5] that came from some limestones supposed to represent an attenuated extension of the Boone in an opposite direction—that to the southwest, this to the east. The region in which these limestones occur—San Saba County, Tex.—is remote from Batesville, and the two faunas are widely unlike. This was to be expected not only from geographic considerations but because the fauna from Texas is peculiar in consisting of diminutive types, as well as in other ways. Nevertheless, if both represent the Boone, they may be essentially contemporaneous and their differences may answer to differences in environment. The fauna from Texas, however, has a facies that impresses one as primitive, so that if the rocks containing it represent some particular part of the Boone, instead of being the thin end of a Boone wedge, they would apparently represent the lower part. On the other hand, the fauna from Arkansas, if the rocks near Batesville represent the modified Boone, belongs by stratigraphic position in the middle part.

It seems desirable before concluding this discussion to bring together and set down the facts regarding the other Mississippian faunas of the Batesville region that are related to the one here described, even though the same ground has already been traversed in other reports. Those reports covered collections made at Marshall as well as at Batesville, and although they offer ready means for separating the two faunas, I shall repeat the record for this region alone, with an eye to discussing the classification of the Batesville section. The following list, which is taken from Bulletin 595, shows the species that have been identified in the upper part of the Boone near Batesville. In the list of species from the middle Boone (see p. 75) I have marked with an asterisk those that occur in the upper Boone; so in the list of species from the upper Boone I am marking those that occur in the fauna of the Moorefield shale.

[5] Girty, G. H., Mississippian formations of San Saba County, Tex.: U. S. Geol. Survey Prof. Paper 146, pp. 25 et seq., 1926.

Species from the upper part of the Boone chert near Batesville, Ark.

[Based on lots 387, 387a, 388, 389, 390, 1237B, 1248W. For description of these localities see pages 96–97, and for further details see United States Geological Survey Bulletin 595, 1915]

*Triplophyllum sp. a.
Triplophyllum? sp.
*Batostomella sp.
Stenopora sp.
Rhombopora? sp.
*Lingula albapinensis.
*Orbiculoidea newberryi var. moorefieldana.
Derbya? sp.
*Productella hirsutiformis.
*Productella hirsutiformis var. batesvillensis?
*Productus coloradoensis?
*Productus ovatus.
Productus sp. a.
Productus sp. b.
*Rhipidomella arkansana.
*Leiorhynchus carboniferum.
*Leiorhynchus carboniferum var. polypleurum?
*Camarotoechia purduei var. agrestis?
*Moorefieldella eurekensis.
*Spirifer martiniiformis.
*Spirifer arkansanus.
*Reticularia setigera var. internascens.
*Martinia? pilosa.
Conocardium meekanum var. magnum.
Conocardium sp. a.
Conocardium sp. b.
*Parallelodon multiliratum.
*Bembexia nodimarginata.
Bembexia sp.
Pleurotomaria aff. P. carbonaria.
Pleurotomaria sp.
Euomphalus planidorsatus.
Sphaerodoma? sp.
*Primitia moorefieldana?
Bairdia aff. B. cestriensis.

At this point I find it necessary to digress and for the sake of clarity to repeat what has already been set down in another place. When the Moorefield shale was described it was made to contain at its base beds which had previously been named "Spring Creek limestone," consisting of about 18 feet of earthy black limestone and dark or black shale more or less mixed with sand. In fact, the "Spring Creek limestone" furnished most of the fossils that were later described as constituting the fauna of the Moorefield shale. Though in color similar to the black Moorefield shale above it, the "Spring Creek limestone" is different in its rock materials, and though in both features, perhaps, conspicuously different from the typical Boone, it is not so very different from the modified Boone of the Batesville region. Furthermore, as already described, when the fauna of the upper Boone came to be known, it proved to be essentially identical with that of the "Spring Creek limestone," while the residual Moorefield fauna, deprived of its "Spring Creek limestone" species, was conspicuously different from both. The following list shows the species identified in the "Spring Creek limestone" near Batesville; the only ones found in the overlying shaly beds at the same locality are marked by an asterisk.

Fauna of the "Spring Creek limestone" of the Batesville region, Arkansas

[Based on lots 1248A, 1248R, 1248T, 1248V, 1248Y, 1248Z, 2048, 2049, 2049a, 2049b, 2049c, 2049d, 2049f, and 2053. For a description of these localities see pages 96–97, and for further details see United States Geological Survey Bulletin 439, 1911]

Triplophyllum sp.
Enchostoma bicarinatum.
Batostomella dubia.
Batostomella parvula.
Stenopora sp.
Fenestella aff. F. rudis?
Fenestella aff. F. multispinosa?
Lingula batesvillae.
Lingula albapinensis.
Orbiculoidea newberryi var. moorefieldana.
Orbiculoidea newberryi var. marshallensis?
Orbiculoidea newberryi var. ovata.
Orbiculoidea newberryi var. caneyana.
Chonetes sp.
Productella hirsutiformis.
Productella hirsutiformis var. batesvillensis.
Productus coloradoensis?
Productus ovatus.
Avonia arkansana var. multilirata.
Pustula biseriata.
Pustula subsulcata.
Pustula subsulcata var janus.
Pustula moorefieldana.
Pustula moorefieldana var. pusilla.
Rhipidomella arkansana.
*Leiorhynchus carboniferum.
Leiorhynchus carboniferum var. polypleurum.
Camarotoechia purduei.
Camarotoechia purduei var. agrestis.
Moorefieldella eurekensis.
Moorefieldella eurekensis var. subcuboides.
Girtyella brevilobata.
Girtyella turgida var. elongata.
Spirifer arkansanus.
Spirifer moorefieldanus.
Spirifer increbescens.
Reticularia setigera var. internascens.
Spirifer martiniiformis.
Martinia? pilosa.
Ambocoelia laevicula?
Spiriferina subelliptica var. fayettevillensis.
Composita subquadrata var. lateralis.
Composita madisonensis var. pusilla.
Composita humilis.
Eumetria verneuiliana.
Solenomya? sp.
Sphenotus? meslerianus?
Sphenotus? sp.
Solenopsis nitida?
Edmondia crassa.
Edmondia crassa var. suborbiculata.
Nucula rectangula.
Leda vaseyana (fide McChesney).
Leda nasuta.
Parallelodon multiliratum.
Cypricardinia moorefieldana.
Schizodus batesvillensis.
*Deltopecten batesvillensis.
Deltopecten? sp.

Allerisma walkeri var. abbreviatum.
Bembexia nodimarginata.
Bucanopsis cancellata?
Bellerophon sp.
*Strophostylus aff. S. carleyanus.
Orthoceras aff. S. crebriliratum.
Bactrites? smithianus?
*Goniatites choctawensis?
Griffithides sp.
Paraparchites nicklesi.
Primitia moorefieldana.
Bairdia attenuata.

To round out the subject as I would wish, it has seemed desirable to add a list of the Moorefield fauna proper, that obtained from the formation exclusive of the "Spring Creek limestone." This list is given below. The facts as here set forth suggest a regrouping of the Mississippian rocks near Batesville, such that the "Spring Creek limestone" shall be considered part of the Boone instead of part of the Moorefield. This thesis has, however, another aspect. The paleontology of these rocks in the region of Moorefield, east of Batesville, is very inadequately known, but there is reason to believe that they will afford much that is new. It is from there, in fact, that most of the fauna which I am about to list was obtained, especially the goniatites, which form its most distinctive element. The "Spring Creek limestone" has not been definitely recognized in the section at Moorefield, but some beds that on lithologic, stratigraphic, and paleontologic grounds I thought to represent that horizon were so closely associated with some goniatite-bearing ledges that it seemed almost out of reason to refer them to separate formations. The Moorefield shale, in this its typical region, contains more beds of limestone and affords a better prospect of obtaining fossils than the exposures near Batesville, which in fact I found exceptionally poor in both respects. The "Spring Creek limestone" and the overlying beds of the Moorefield shale, then, may prove to be more completely merged lithologically and especially paleontologically at Moorefield than they were found to be at Batesville.

Fauna of the Moorefield shale exclusive of the "Spring Creek limestone" as known from Batesville and Moorefield, Ark.

[Based on collections from stations 2051, 2051b, 2051c, 1245A, 1245B, and 1248x. From United States Geological Survey Bulletin 595, page 14. The localities mentioned are described on pages 96-97 of the present report]

Orbiculoidea newberryi var. caneyana.
Leiorhynchus 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.
Girtyoceras meslerianum.

The absence of synonymic lists from the description of species next following will probably be noted. Such lists form an important, one might almost say an essential, part of formal works in the field of descriptive paleontology. Material like this, however, which comes from but two localities and is but indifferently preserved, is unsuited to formal treatment, and to combine long lists of citations with sketchy descriptions might be thought inappropriate if not pretentious. In fact, this account of the middle Boone fauna at Batesville may be regarded as an annotated faunal list on a somewhat extensive scale. It seemed adequate, therefore, to cite only a few works such as would properly present one side of a picture of which the descriptions and figures presented the other.

Another item, essential in many reports but here not specifically given, is that of horizon and locality. The reasons for this omission are the same as for the foregoing. Only two collections are involved, both from beds at the same horizon and at localities not far apart. The localities are described on pages 73–74 and 96–97, and the species which each of them yielded are shown inthe table on page 75.

DESCRIPTION OF SPECIES

Cladochonus beecheri (Grabau)

1899. *Monilopora beecheri* Grabau, Boston Soc. Nat. Hist. Proc., vol. 28, No. 16, p. 411, pl. 1, figs. 2, 3, pl. 2, figs 1–5. Keokuk group: Crawfordsville, Ind.

This species seems to be fairly common, though only seven specimens are in the collection, and those are ill preserved. They consist mostly of single corallites, are mostly internal molds, and are mostly imperfect at one end or at both. They are chiefly distinguished by their large size, some being as much as 8 millimeters in diameter, which would probably mean 10 millimeters if the epitheca were still present. As to length, not even a reasonable estimate can be made, because the corallites, now imperfect, did not taper to a point but were truncated at the proximal end. The longest fragment measures 13 millimeters, and I can not doubt that a length of 15 millimeters was attained or exceeded by many. The corallum apparently branched freely, for several of the corallites have two lateral scars where they were connected with others.

In its large size this form suggests *C. beecheri*, and, indeed, it suggests no other American species.

Cladochonus aff. C. longi (Rowley)

1901. *Auloporà longi* Rowley, Am. Geologist, vol. 27, p. 352, pl. 28, fig. 57. Upper and lower parts of Burlington limestone: Louisiana, Mo.

This is a much more delicate type than the foregoing, distinguished not only by its small size but by the long, slender stem or stolonal part of the epitheca. The general appearance suggests *C. longi*, and the proportions are not far different. The species is poorly represented.

Cyathaxonia? n. sp.

This unusual coral is represented by a few fragmentary specimens. Only a partial description can be given, and even in that some points are open to verification or correction. The shape appears to have been subcylindrical or very gradually tapering, and the size (for the genus to which it is provisionally assigned) very large. The diameter is at least 13 millimeters. The structure consists of three rather distinct zones, an axial zone occupied by the columella, a peripheral zone or epitheca, and an intermediate zone traversed by the septa.

The columella is very massive. In transverse section it is surrounded by a few concentric lamellae, and longitudinal sections also show a few plates running up and down the sides but at the same time cemented to one another and to the columella.

The septa occur in pairs and possibly should be classed as primary and secondary. Such they may be, but they do not everywhere conspicuously alternate in size, and the effect of pairing is produced by their union, two at a time, at their inner ends. The thick plates thus produced then continue inward and are amalgamated with the columella. Each of the septa is made up of two plates, and they become thicker peripherally until their sides are in contact, thus forming a solid and very thick epitheca. I am unable to give the precise number of septa, but there are probably at least 60 (apparently from 60 to 70). The interseptal loculi are not very long radially and are narrower than the septa. They are apparently unoccupied, tabulae or dissepiments being absent.

In some respects this coral has the characters of *Cyathaxonia*, yet in others it is more or less anomalous. As compared with other Mississippian Cyathaxonias, this species is exceptionally large. The way the septa unite in pairs before their inner ends consolidate with the columella is also unusual, as well as the structure of the columella of concentric plates, in the outer parts at least. The columella is far less complex than in the characteristic types of *Lonsdaleia*, and that genus is quite out of the question on other grounds. The coral is somewhat more closely related to *Lithostrotion*, but it lacks the outer vesicular zone of that genus, which is, in fact, almost as little to be considered as *Lonsdaleia*. The species is doubtfully a *Cyathaxonia*, but if not of that genus, it appears, so far as the facts are now known, to represent an undescribed one.

Triplophyllum? sp.

This type is represented by a single rather small specimen which appears to be constructed more after the plan of *Triplophyllum* than after that of *Cyathaxonia?* sp., with which it is associated. Besides its small size it is characterized by its very rapid, very irregular expansion. Approximately it has a length of 25 millimeters and a diameter, where it is widest, of about the same.

Rhombopora? sp.

This species is represented by a single small fragmentary specimen, of which it did not seem advisable to make thin sections. The following notes were accordingly made under unfavorable conditions, and some of them may need correction.

The branches are about 3 millimeters in diameter and have a strongly and abruptly thickened mature zone comprising about half the radius on each side. The surface is divided into rather regular hexagons by low, relatively broad ridges. The hexagonal areas are, of course, depressed, but the aperture in the center, which is rather small and circular, is surrounded by a raised peristome. Apparently the zooecial tubes are without diaphragms. The tops of the ridges appear to be granular, but no well-defined acanthopores have been observed.

The generic position of this striking form remains in doubt so long as some of the structural characters are in doubt. The very sharply defined mature zone, the evenly thickened walls, the open zooecial tubes, without diaphragms, and the vestibulate configuration of the hexagonal areas defined by the walls are all suggestive of *Rhombopora*. The peculiar and striking appearance of the outer surface, due to the regular hexagonal areas with their small apertures and elevated peristomes, reminds one of the genus *Stenopora* when specimens are broken just so as to show the centrally perforated diaphragms. In this bryozoan, however, all the cells have this appearance simultaneously instead of sporadically, and the suggested relationship to *Stenopora* is also contradicted by the fact that diaphragms are apparently nowhere present.

Cystodictya pustulosa Ulrich?

1890. *Cystodictya pustulosa* Ulrich, Illinois Geol. Survey, vol. 8, p. 495, pl. 76, figs. 2, 2a. Keokuk group: Kings Mountain tunnel, Ky.; Keokuk, Iowa; Warsaw and Nauvoo, Ill.

To this species are referred several small fragments, chiefly interesting because of the rarity of Bryozoa of any sort at these localities. The zooecia open from distinct prominences or low pustules, but at the same time the pustules occur in longitudinal rows and are

connected by obscure ridges. This is also true of typical *C. pustulosa*.

Rhipidomella aff. R. jerseyensis Weller

1914. *Rhipidomella jerseyensis* Weller, Illinois Geol. Survey Mon. 1, p. 157, pl. 20, figs. 36–43. Fern Glen formation: Elsah, Ill.; Kimmswick, Mo.

The single small pedicle valve included here is associated with *Schizophoria compacta* and may be a misleading specimen of that species, but it apparently belongs to the related genus *Rhipidomella* and has the general appearance of *R. jerseyensis*. Its characters are too imperfectly known for a trustworthy identification.

Schizophoria compacta Girty, n. sp., MS.

This species is represented by three brachial valves and one pedicle valve from station 3203 and by a mere fragment from station 3204. The shape is subcircular, somewhat wider than long; the length of the largest specimen is about 23 millimeters. The brachial valve is rather strongly gibbous but develops a narrow and obscure sinus. The pedicle valve is shallow, deepest in the posterior part; toward the front it also is apparently depressed into a faint sinus. The beak is moderately incurved.

The surface is marked by fine radial lirae, some of which are more prominent than others. At least on the exfoliated surface (such being the condition of all my specimens) some of the lirae are defined by much deeper striae than others. They may thus be actually rather depressed than prominent, but they are rendered in this way especially conspicuous.

This form much resembles a manuscript species found in the Boone limestone and is probably identical with it. The critical characters necessary to a good identification are, however, not well shown, and it may prove more nearly related to such species as *S. chouteauensis* and *S. sedaliensis*.

Orthotetes? sp.

Strophomenoid shells are rare in the Boone fauna near Batesville, and the scanty material does not permit a decision as between the two probable genera *Orthotetes* and *Schuchertella*. Such importance as the material possesses is negative and is derived from the fact that the species is not large and not abundant, so far as the evidence can be trusted.

Chonetes miseri Girty, n. sp.

Plate 9, Figures 1–3

Shell small, subquadrate or deeply semicircular, very long for its width. The dimensions of the typical specimen are, width 8 millimeters, length 6 millimeters. The cardinal line slightly exceeds the width in front, the outlines contracting gradually forward and being broadly rounded about the anterior margin.

The convexity of the pedicle valve is high and symmetrical, the most prominent point being about midway, in a side view, with diminished curvature toward the posterior and the anterior margins. Corresponding to this the posterior part of the valve has a conspicuously flattened appearance and the umbonal parts are depressed. A sinus is not developed.

The brachial valve is not known.

The surface is marked by rather fine faint radial lirae crossed by rather strong coarse crenulations, which are most conspicuous upon the crests of the lirae.

C. miseri is in a measure intermediate between *C. logani* and *C. planumbonus*, approximating the one in sculpture, the other in configuration. The surface markings are comparable to those of *C. logani* except that they are appreciably finer and a little fainter. In shape the shell is relatively narrower and less extended at the hinge line. It is somewhat more convex and differs greatly in the flattened posterior region, which in *C. logani* is arched with a prominent umbo.

On the other hand, *C. miseri* resembles *C. planumbonus* in the flattened posterior region and obscure umbo but differs in the greater convexity, in the smaller size, and in the less transverse shape. The sculpture, though similar, shows decided differences. It is finer and far more regular. In *C. planumbonus* the concentric markings are the dominant superficial features, the lirae being so faint as to be sometimes scarcely appreciable. Often they can be recognized only as radial rows of scalelike crenulations. The crenulations may be connected laterally to form lamellose concentric lines which are sharp and sometimes have a wavy irregular course. Nothing comparable to this has been observed in the present form, which is regular in its sculpture and has the radial lirae quite as distinct as the concentric crenulations. On other specimens than the typical one, however, the crenulations make continuous lamellose lines that are close and regular in their distribution, like delicate fluted frills. Much, however, depends upon the light in which the specimens are viewed. If they are held at one angle the concentric lines are conspicuous, or even the only ones visible; if they are held at another the radial lirae come into prominence. Similar considerations must be taken into account in connection with exfoliation, which I suspect sometimes affects the relative strength of these markings. The specimens of *C. planumbonus* which I have used for comparison, though numerous, may be weathered or exfoliated to such an extent that their sculpture has been appreciably modified.

Chonetes miseri Girty, var.

This specimen, the only one of its kind, is a pedicle valve having a peculiar shape and possibly a peculiar sculpture. The posterior region is flattened, as in the typical specimen, but over the anterior half the curvature is subangular from side to side with some-

what obliquely flattened slopes. This tends to give the outline more of a triangular shape.

The shell is in large part exfoliated, but where the sculpture is shown (approximately) it consists of strong lamellose concentric lines with very faint or obsolete radial lirae. This occurs far around at one side, however, where the radial lirae are regularly weak and the concentric markings, if not exceptionally strong, at least exceptionally conspicuous in consequence.

Except for the flattened umbo the configuration of this shell recalls *C. geniculatus*, but obviously the sculpture is entirely different. The sculpture is more like that of *C. planumbonus*, but the resemblance is probably exaggerated by the part of the shell where the surface markings are shown and by the exfoliation which they have suffered. The specimen may be only an abnormal form of *C. miseri*, but it is too abnormal to be passed over without special mention.

Chonetes aff. C. shumardianus DeKoninck

1847. *Chonetes shumardiana* De Koninck, Monographie des genres *Productus* et *Chonetes*, p. 192, pl. 20, figs. 1a–d. Carboniferous: Knobs of Jefferson County, Ky.

1914. *Chonetes shumardanus* De Koninck. Weller, Illinois Geol. Survey Mon. 1, p. 89, pl. 8, figs. 1–7. New Providence shale: Kentucky.

The form identified as above is of moderate size, some specimens probably measuring as much as 20 millimeters in width, of quadrate shape, distinctly wider than long, and of rather high convexity. The pedicle valve bears a faint sinus, and the brachial valve doubtless a corresponding fold. The pedicle valve is rather strongly convex. Of the brachial valve only one fragmentary specimen has been examined, and it is but gently arched.

The most characteristic feature of this form is its fine sharp liration. The shell is thick, and most of the specimens are deeply exfoliated. One of them retains part of the surface intact, and there the lirae are fine, sharp, and rigid; five to seven of them occur in a space of 1 millimeter, and they are crossed by fine, sharp crenulations.

This form approaches *C. shumardianus* very closely but shows, or appears to show, a few minor differences. None of the specimens from Batesville is as large as many of those from Kentucky, and their convexity is perhaps a little higher. Weller describes the median sinus in *C. shumardianus* as being entirely obsolete. This appears to be only true in part, as some of my specimens from Kentucky have an appreciable sinus, though others appear to be regularly arched. It is the larger specimens, generally, that have a sinus. The Kentucky specimens occur in shale and have been more or less flattened, a process which would tend to lower the convexity and obliterate the sinus. To some extent the not very material differences between them and the Batesville specimens can be accounted for in this way.

This form might be identified with *C. illinoisensis* almost as well as with *C. shumardianus*. The scale of liration can be matched almost equally well in both. The convexity is stronger than it is in *C. illinoisensis*, but on the other hand that species, like this one, has a median sinus. Weller, it is true, says that the lirae in *C. illinoisensis* are not crenulated; nevertheless, many of my specimens from Burlington and points adjacent clearly show the presence of fine crenulations, and I suspect that Weller's specimens, like some of mine, had lost this feature, which, I believe, is characteristic not only of *C. illinoisensis* but of a large group of *Chonetes* to which *C. illinoisensis* belongs.

Chonetes batesvillensis Girty, n. sp.

Plate 9, Figures 4–6

Shell rather small, none of the specimens observed being wider than 15 millimeters. Shape semicircular or subquadrate. Cardinal angles quadrate or slightly acute. Hinge line equaling the width in front.

Pedicle valve rather convex; beak and region adjacent, more or less depressed. The type specimen bears toward the front a faint mesial depression, but other pedicle valves are regularly rounded.

The only brachial valve seen is nearly flat.

The surface is marked by moderately coarse, sharply defined radial lirae, of which three or four occur in 1 millimeter. The lirae are crossed concentrically by fine, sharp elevated lines that generally are conspicuous only upon their crests but locally are continued across the interspaces. The lirae are all but interrupted at intervals by the development of large "spines," of which only the openings now remain. The sculpture has a certain irregular appearance, due to a slightly unequal development of the lirae and their partial interruption by the "spines" as well as to the locally stronger and more continuous development of the concentric lines.

In the general character of its sculpture this form is intermediate between *C. illinoisenis* and *C. ornatus*, having much coarser lirae than the one and much finer lirae than the other. The specimens of *C. illinoisensis* studied by Weller evidently did not show that the lirae were crenulated, but specimens in my collection have this character quite distinct. Consequently in this feature also the present form is intermediate. I might refer it to *C. burlingtonensis* provisionally (not having specimens by me for comparison) but for Weller's description of the concentric lines, "which are more strongly developed across the intercostal furrows than upon the costae themselves and are often or nearly quite obsolete." This is far from true of the form from Batesville. The concentric lines are always present and always a conspicuous feature. They commonly appear as crenula-

tions, and only here and there (where the lirae are locally weak) are they noticeably continuous. The large "spines," their tendency to interrupt the lirae, and the generally somewhat irregular character of the sculpture would also seem to distinguish this form from *C. burlingtonensis* and indeed from most of the species of *Chonetes* occurring in the typical Mississippian section. To some extent such characters may be made appreciable by the accidents of preservation or partly obscured in the same way, so that the value of this difference can not at this time be accurately estimated.

Productella hirsutiformis (Walcott)?

Plate 9, Figure 10

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

1909. *Productella hirsutiformis* (Walcott). 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* (Walcott). Girty, U. S. Geol. Survey Bull. 439, p. 50, pl. 3, figs. 1–4. Moorefield shale: Batesville and Moorefield, Ark.

To this species is referred a single specimen, a pedicle valve which is about 30 millimeters in length and about 50 millimeters in width. The convexity is very low and on the whole very regular. The shell is deeply exfoliated, but nowhere affords any evidence of having had radial costae. It is true that over a small area irregular, interrupted radial markings can be seen, but at that point the specimen is more deeply exfoliated than anywhere else—essentially an internal mold, in fact—and these markings are to be regarded as belonging to the inner surface. Extremely faint concentric undulations are about the only other markings visible. The evidence is fairly conclusive that the shell bore small scattered spines, but it is not conclusive as to their number and arrangement. Clearly, however, a row of spines protruded from it close to the hinge line, so close and so regularly arranged as to suggest the genus *Chonetes*, though of course an assignment to that genus can not be considered.

The characters noted above seem to ally this form with *Productella hirsutiformis* and *P. patula*, but no trustworthy identification can be made with such evidence as is available.

Productus magnus Meek and Worthen

Plate 9, Figures 11, 12

1861. *Productus magnus* Meek and Worthen, Acad. Nat. Sci. Philadelphia Proc., p. 142. Keokuk limestone: Monroe County, Ill.; Ste. Genevieve County, Mo.

1914. *Productus magnus* Meek and Worthen. Weller, Illinois Geol. Survey Mon. 1, p. 147, pl. 15, figs. 1–8. Upper part of Keokuk limestone: Monroe County, Ill.; St. Louis County, Mo.

This species is represented only by brachial valves, and a satisfactory identification is not possible without the pedicle valve. Nevertheless, the resemblance between the brachial valve of the Boone form and that of *P. magnus* is striking.

The specimens are preserved as external molds and show a large shell distinctly wider at the hinge than at any point in front and having slight sinuses in the outline just below the auricles. The largest specimens have a width at the hinge of 65 or 70 millimeters; the length of such specimens is about 45 millimeters. The visceral disk is large and in a general way flat or slightly convex (the mold is here being described), and the trail is rather narrow and somewhat abruptly and strongly deflected. Pieces of the shell show that a deposit was laid down around the upper part of the trail, thinning downward so that the inner surface of the valve was much more abruptly and strongly deflected than the outer surface.

The surface markings are not clearly shown. Radial costae are present, but they are rather fine and rather weak. Concentric wrinkles are also to be seen, chiefly toward the cardinal angles and on the trail (where, however, the markings are more like fascicles of growth lines), but these also are rather feeble, rather fine, and it would appear rather irregularly distributed. No evidence of spines has been observed.

The shells here considered differ a good deal in size, and if size is an index the larger ones belong to *P. magnus* rather than to *P. crawfordsvillensis*, two species which are related to each other and are not readily distinguishable if represented only by brachial valves. Some of the smaller shells, on the other hand, may belong to *P. crawfordsvillensis*—one especially which is about 50 millimeters in width and 40 millimeters in length. Apparently, however, the brachial valve of *P. crawfordsvillensis* has a much longer trail than that of *P. magnus*, and if so, this small shell is in better agreement with *P. magnus*.

Productus crawfordsvillensis Weller?

Plate 9, Figures 13, 14

1914. *Productus crawfordsvillensis* Weller, Illinois Geol. Survey Mon. 1, p. 116, pl. 12, figs. 4–7. Beds of Keokuk age: Crawfordsville, Ind.

This identification rests almost wholly upon a brachial valve preserved as an external mold, but it is also used for two pedicle valves and several other brachial valves of inferior character. These pedicle valves are so poor that although no satisfactory identification of *P. crawfordsvillensis* is possible without a knowledge of the pedicle valve, they have been disregarded as evidence. The brachial valve which thus has mainly determined the identification is transversely subquadrate in outline, slightly extended at the ears and slightly emarginate below them. The visceral disk is very large and the trail short. These two parts make with one another an angle that is slightly obtuse, joining in a strong curve without any distinct

boundary. The visceral disk is almost flat or in the mold gently convex, divided in the anterior part by a faint median sinus. The width at the hinge is 45 millimeters; the length 35 millimeters.

The surface is marked by radial costae that are sharply defined upon the trail and upon part of the visceral disk but are fainter as they approach the beak. They are rather fine, about six in 5 millimeters. The visceral disk is crossed by concentric wrinkles, which are rather fine, irregular, and mostly rather weak. Fine, sharp, regular incremental lines are also shown, especially upon the trail. If this valve bore spines, the evidence for them has been obscured.

The general character of this brachial valve recalls especially *P. magnus* and *P. crawfordsvillensis*. *P. magnus*, determined like this species upon the brachial valve, has been identified in the other collection, and a marked similarity between the two brachial valves is at once seen. This one, however, is much smaller, and the outline is more quadrate, with subparallel sides. It differs still more conspicuously in the radial costae, which are much more sharply developed. In the presentation of *P. crawfordsvillensis* and *P. magnus* offered us by Weller, this specimen is in most respects nearer *P. crawfordsvillensis*. The brachial valve of *P. crawfordsvillensis*, however, has a rather uncommonly long trail, a fact that is brought out more clearly in Weller's description than in his figures, and in this respect the two valves differ rather strongly. Furthermore, the identification here adopted lacks the evidence, confirmatory or otherwise, of the pedicle valve with its more or less characteristic curvature and profuse development of spines upon the prolonged trail.

To other described species this form seems less comparable than to these two, unless it were entered with the catholic *Productus semireticulatus*. There is, however, an undescribed species, *P. crassilabrum* of my manuscript, to which it may belong. I refer to the form which in the Moorefield fauna of Arkansas I identified as *Productus semireticulatus* var. *coloradoensis* and which from the same horizon, but from northeastern Oklahoma, Snider cited as *P. coloradoensis*. Brachial valves of that species resemble this brachial valve very closely. Many have the trail somewhat more prolonged, and some have a stronger development of the concentric wrinkles, but these differences are not constant. In *P. crawfordsvillensis* the spines on the trail of the pedicle valve should be indicated by dimples upon the trail of the brachial valve. In *P. crassilabrum* the trail of the pedicle valve is not so prolonged, and it is not furnished with numerous spines. Consequently the present form, from our incomplete data, seems really in better accord with *P. crassilabrum* than with *P. crawfordsvillensis*.

Productus mesialis Hall?

Plate 9, Figures 15–19

1858. *Productus mesialis* Hall, Iowa Geol. Survey Rept., vol. 1, pt. 2, p. 636, pl. 19, figs. 2a–c. Keokuk limestone: Nauvoo, Ill.

1914. *Productus mesialis* Hall. Weller, Illinois Geol. Survey Mon. 1, p. 112, pl. 10, figs. 7–13; pl. 83, figs. 14–17. Keokuk limestone: Pierce City, Mo.; Nauvoo, Ill.

The specimens referred here seem to be possessed of essentially the same characters, but their preservation is such that these characters have been to some extent obscured and to some extent perhaps transformed. The form thus presented may be described as a small or medium-sized member of the *semireticulatus* group, distinguished in the way of configuration by having the pedicle valve more or less flattened over the visceral disk and strongly deflected about its margin. This character, though shared by all the specimens, may have been exaggerated or even entirely produced by compression. It is conspicuous in the specimen which chiefly suggested the identification adopted and which on that account might be mistaken for a brachial valve. This specimen is about 45 millimeters in width and 30 millimeters in length, measured from the beak to the anterior margin. It is marked by rather fine costae, which are rather feebly expressed and tend to become even feebler on the anterior slope. The visceral disk is crossed by fine, rather regular and strong concentric corrugations. The trail, which is shorter than the visceral disk, bears a few very large spines, each of which covers several of the costae and gives rise to low plications that extend forward to the margin. To what extent spines were developed on the visceral disk is uncertain, as the shell is exfoliated there. The other pedicle valves agree with this one so far as their characters are preserved, the chief difference being that some are more closely striated.

The brachial valve from the same locality that shows corresponding characters is somewhat smaller than the pedicle valve described, about 33 millimeters in width and 27 millimeters in length. The visceral disk is nearly flat, and the marginal parts are so strongly curved that the short trail forms with it an angle distinctly acute. The radial costae are of about the same character as those of the pedicle valve, but they are more sharply defined. The costae are crossed by concentric wrinkles, which are moderately fine, strong, and regular. This valve developed at least a few spines of its own, but it affords no evidence in the way of nodes as to how the pedicle valve may have been equipped.

These shells resemble *P. mesialis* in their size, in their somewhat geniculate pedicle valve, and in the large spines that developed from it. On the other hand, it is not certain how far the geniculate shape

may have been accidental or due to compression. The spines, though large, are far less numerous, and the mesial sinus, though distinct enough, is much less pronounced than those of *P. mesialis*. This form appears from the evidence to be more nearly related to that species than to any other, but the affirmative evidence is not wholly to be trusted, and the negative evidence, if constantly maintained, discredits the identification. At all events the material is not sufficiently good to form the basis for a new species even if a new species were clearly indicated.

Productus burlingtonensis Hall

Plate 9, Figures 20–24

1858. *Productus flemingi* var. *burlingtonensis* Hall, Iowa Geol. Survey Rept., vol. 1, pt. 2, p. 598, pl. 12, figs. 3a–g. Burlington limestone: Burlington, Iowa; Quincy, Ill.

1914. *Productus burlingtonensis* Hall. Weller, Illinois Geol. Survey Mon. 1, p. 104, pl. 9, figs. 1–10. Burlington limestone: Burlington, Iowa; Springfield, Mo.; Quincy, Ill.

The shells referred here belong to the *semireticulatus* group and have little to distinguish them, save that they are of medium size, highly arched, and rather finely striated. The most perfect pedicle valve has a width at the hinge of nearly 40 millimeters and a length of 35 millimeters from the umbonal prominence to the front margin. Some specimens are slightly larger, others smaller. The shell is strongly arched, with the anterior slope considerably produced so that the umbonal parts project far beyond the hinge line and have a squarish shape. Transversely the vault is flattened across the top and indented into a narrow, inconspicuous sinus. The sides descend steeply but near the hinge suffer an abrupt outward deflection so as to form rather small oblique arched auricles.

The surface is marked with fine, even, radial costae and over the visceral disk by rather fine, rather strong, and rather regular concentric wrinkles. Small but numerous spines once projected from the surface, as is now indicated by obscure nodes, which are visible chiefly on the anterior half of the shell.

The best brachial valve observed has characters corresponding to the pedicle valve just described. It is gently concave over the visceral disk and strongly though not abruptly curved about its margin to form a trail that is nearly straight radially and distinctly shorter than the disk itself. Low radial undulations cross the visceral disk. Three of these are elevated, one forming the mesial fold, the others situated one on each side a little below the hinge line. It is not certain that the brachial valve bore spines, but the spines of the pedicle valve are reflected upon it in the shape of rounded depressions—low nodes on the specimen itself, which is an external mold.

Though somewhat larger than the generality of shells found at Burlington, these specimens agree with *P. burlingtonensis* very closely. In fact, I am unable to name any characters of importance in which they show material difference. On the other hand, it is not clear to what extent they differ from those here identified as *P. mesialis?*, and the line between the two groups is more or less arbitrary, though this fact may signify not so much that the two forms can not be distinguished as that the doubtful specimens no longer show the distinctive characters. It seems more probable that some of the specimens placed with *P. mesialis?* may really belong here than that any of the specimens referred here really belong under *P. mesialis?*. Between characteristic representatives of the two forms which I have sought to discriminate, marked differences appear. One difference is that of configuration, the prolonged anterior slope and the gibbous umbonal region of the present form contrasting strongly with the flattened umbonal region and the irregular curvature of the other species. The other species also has a few large spines; this a larger number of much smaller ones.

Productus aff. P. gallatinensis Girty

1899. *Productus gallatinensis* Girty, U. S. Geol. Survey Mon. 32, pt. 2, p. 533, pl. 68, figs. 11*a*–11*d*, 7*a*–7*c*. Madison limestone: Yellowstone National Park.

This form is represented by a single pedicle valve, some of whose characters are not well shown. It resembles several of the small semireticulate Producti, notably *P. gallatinensis* and *P. parvus*. *P. parvus* generally forms a broad shell which is divided by a more or less distinct sinus. This specimen is more elongate and slender, and it lacks a sinus. *P. parvus* is rather copiously supplied with spines. The facts with regard to this specimen are not clear, but apparently the spines were much less numerous. The most conspicuous difference is found in the transverse wrinkles, which in this shell are uncommonly large and strong for its size, much more so than on any of my specimens of *P. parvus* from Pella, Iowa, which have been used for comparison. The same difference, though it is less pronounced, distinguishes this specimen from the type specimen of *P. gallatinensis*, with which, however, it appears to agree closely in other respects. Both specimens are exfoliated and are possibly misleading in the matter of spinose equipment. They may have had many more spines than are indicated in their present condition.

Productus ovatus var. minor Snider

1915. *Productus ovatus* var. *minor* Snider, Oklahoma Geol. Survey Bull. 24, p. 79, pl. 3, figs. 19–21. Fayetteville shale: Northeastern Oklahoma.

This name, as used here, covers several specimens of the *ovatus* group distinguished by their small size and fine striation. The specimens, which are probably mature, measure only about 13 millimeters in width,

though but few of them can be measured accurately. In such characters as are shown they agree very closely with *P. ovatus* var. *minor*, but they may be only a dwarfed variety of *P. ovatus*, which is possibly all that the typical variety *minor* is also.

Avonia arkansana var. multilirata Girty?

Plate 9, Figure 25

1910. *Productus arkansanus* var. *multiliratus* Girty, New York Acad. Sci. Annals, vol. 20, No. 3, pt. 2, p. 217. Basal part of Fayetteville shale: Fayetteville quadrangle, Ark.

1911. *Productus arkansanus* var. *multiliratus* Girty, U. S. Geol. Survey Bull. 439, p. 43, pl. 2, figs. 10, 11. Moorefield shale: Batesville quadrangle, Ark.

Under this title is included a single pedicle valve which appears to be in a half-grown stage. The outline is more or less quadrate, though the sides conspicuously converge forward. The cardinal angles are rounded, probably through breakage. The convexity is low and rather regular. The beak is small and projects but little beyond the hinge line. The vault is flattened across the top and depressed into a rather weak and narrow sinus; it descends very gradually to the ill-defined auricles.

The surface markings comprise radial costae, concentric wrinkles, and spines. The costæ are fine and sharp, but somewhat irregular and intermittent. The concentric wrinkles, which are weak and irregular across the vault, become stronger as they approach the sides and considerably disturb the radial costae, which consequently take on more or less the character of elongated, disconnected spine bases. The spines are apparently small and numerous. Their development renders the costae somewhat nodose and discontinuous.

This specimen in many respects closely resembles *A. arkansana* var. *multilirata*. That variety is, of course, much more elongated and convex, but it shows little disparity in a proportional part of the posterior end. The lirae on the Boone specimen also appear to be less continuous, more distinctly interrupted or at least semidiscontinuous. Another species which deserves consideration in this connection is *Productus setiger*, but if the Boone specimen is mature, obvious differences in shape aside from differences in sculpture would show that it can not be classed with that species. If, on the other hand, it is not mature, it would, when fully grown—if one may predict its characters—have been rather large for *P. setiger*, just as it now has radial lirae that are too irregular and concentric wrinkles that are too weak and inconspicuous in the auricular region. It seems to have less in common with *P. setiger* than with *A. arkansana* var. *multilirata*, and, all things considered, it is less likely to belong to the latter than to some species at present undescribed.

Pustula aff. P. gradata Swallow

1863. *Productus gradatus* Swallow, St. Louis Acad. Sci. Trans., vol. 2, p. 93. Keokuk limestone: Keokuk, Iowa; Lewis and St. Louis Counties, Mo.

The single specimen referred here is an imperfect brachial valve which shows the inner surface but is more or less deeply exfoliated in places. The characters shown are therefore in large part not the real surface characters, which must be inferred. Unquestionably the outer surface was crossed by strong concentric corrugations, which were more or less imbricated. The bands that were defined in this way differ greatly in width, though most of them are rather narrow. The surface was also clearly beset with numerous small spines, which appear to have arranged themselves in several rows on each band, to have been oblique, and to have been attached to elongated bases.

These characters indicate rather clearly that this shell is a member of the *punctata* group of *Pustula* of which *P. alternata*, *P. genevievensis*, and *P. biseriata* are representative Mississippian species. The size of this specimen, which must be nearly 40 millimeters in length, indicates a relationship with the larger species rather than with *P. biseriata*. As between *P. alternata* and *P. genevievensis*, the characters actually observed offer no grounds for choice, but the probabilities undoubtedly favor *P. alternata*. Now under *P. alternata* Weller places as synonyms *P. vittata* Hall and *P. gradata* Swallow, and perhaps he is right in doing so. Shells of this group, however, do vary a great deal in their surface markings, and typical *P. alternata* can readily be distinguished among them. The same is probably true, though not equally, of *P. vittata* and *P. gradata*. All three names I believe stand for real differences in the shells themselves, the chief question being to what extent the three types are merged into one by intergradation. At present I am inclined to believe that careful discrimination will lead to the recognition of all three species, and the evidence—very unsubstantial, it is true—suggests *P. gradata* as the better identification for the Boone specimen. Even with ample allowances for differences between the markings of the pedicle and brachial valves of such shells, it scarcely seems possible that this specimen can be the brachial valve and the associated specimen identified as *A. arkansana* var. *multilirata?* the pedicle valve of the same species.

Pustula incrassata Girty, n. sp.

Plate 9, Figures 7–9

Although this species is represented in the collection by seven specimens, they are all apparently pedicle valves, and one of them is so much more perfect than the rest that the following description is for the most part drawn from it alone.

Shell small; outline subcircular, widest at the hinge, strongly rounded across the front, the sides becoming nearly straight above and diverging posteriorly. Convexity moderate; curvature rather regular, though longitudinally it is a little stronger in the posterior part and transversely a little stronger in the median part. Umbo rather depressed, spreading at a wide angle. Ears small, ill defined. The surface lacks both concentric wrinkles and radial costae. Spines are fairly numerous but small, and they project from inconspicuous roundish bases. The shell is very thick and lamellose, and the surface of the type specimen is marked by sharply defined imbricating layers, an appearance which is probably due in part to exfoliation. Other specimens suggest that the original markings consisted of fine irregular striae of growth, some of which here and there were distinctly stronger than the rest.

The other specimens are more deeply exfoliated than the typical one, in places reduced to the condition of internal molds. They show that upon the inside, there was a solid elevation or platform which extended from a point near the beak distinctly less than half the length of the shell. It rises rather sharply at the sides but declines gradually at the front and perhaps at the back as well. In shape it is distinctly elongated, widening somewhat toward the anterior end. The shell seems to be excavated somewhat on each side of the platform about midway, so that internal molds show a rather broad, deep channel down the middle of the umbonal region, with a distinct moundlike elevation on each side. Many Producti show the same feature, all perhaps in some measure, and in certain ones it is developed to an astonishing degree.

In some respects this species recalls *Pustula moorefieldana* var. *pusilla*, but comparisons between them are somewhat hampered by the fact that the typical specimens of that form are brachial valves and of this pedicle valves. The brachial valves of *P. moorefieldana* var. *pusilla* all show a few angular ridges which divide the surface into concentric bands. Some corresponding feature would be expected on the pedicle valve also, but nothing of the sort is shown by the pedicle valves of *P. incrassata*. The pedicle valve of *P. moorefieldana* var. *pusilla* is, in fact, imperfectly known. The best specimen available for comparison is more inflated than *P. incrassata;* its spines produce distinct elongated bases, and it has, moreover, an uncommonly thin instead of an uncommonly thick shell. *P. incrassata* might perhaps be regarded as a dwarfed form of *Productella hirsutiformis* var. *batesvillensis*, so reduced in size that it was only 9 millimeters wide instead of 30 millimeters. So to interpret the relationship would be at present a mere assumption, with some evidence unfavorable to it. Another related species is one described in manuscript as *Productella planiconvexa*. Pedicle valves of that species are relatively much broader. They are less convex, and they show certain superficial differences, for the spines are apparently larger and less numerous, and the surface is crossed by concentric corrugations, which though not strong are distinct, regular, and fine.

Rhynchopora palmeri Girty, n. sp., MS.?

Rhynchopora palmeri is a manuscript name proposed for a series of specimens in my collection which appear to belong to a species that was identified and figured by Weller in his invaluable monograph as *R. beecheri*, but that is probably not true *R. beecheri*, especially if that species be restricted to the more common of the varied forms covered by the original description. The present collection contains but two specimens, both very fragmentary, which resemble *R. palmeri* so far as their characters are shown.

Rhynchopora sp.

This species is almost certainly different from that referred to *R. palmeri*, though both are represented by mere fragments. It has more slender and more numerous plications, of which five occur in the sinus, so that six must occur on the fold. The number of lateral plications can not be given.

Spirifer floydensis Weller?

Plate 10, Figures 1–5

1914. *Spirifer floydensis* Weller, Illinois Geol. Survey Mon. 1, p. 351, pl. 49, figs. 15–19. "Knobstone" group: Floyd County, Ind.

This species is extremely abundant, but the specimens examined are crushed, broken or exfoliated, so that in spite of their number the characters that belong to them, especially the more minute characters, are not well shown.

In a general way, this form markedly resembles *S. arkansanus* (of which I was at first inclined to regard it as a variety) and *S. floydensis*. It is on the average distinctly smaller than *S. arkansanus*, no specimens of this form being as large as the typical specimens of that. The plications are generally stronger; few specimens, if any, have the broad, flat costae that are rather characteristic of *S. arkansanus*. The plications bifurcate more rarely, and so far as observed they never have the appearance, so common in *S. arkansanus*, of being double or in pairs. However, the plications of both the fold and the sinus increase by the subdivision of others, and furthermore the first plication on each side of the fold of the brachial valve is as a rule bifurcated. Presumably a corresponding condition exists on the pedicle valve, but it is less conspicuous. The plications of the sinus are sometimes noticeably finer than those of the lateral areas, and, in addition, they are sometimes noticeably fainter. As to the size of the plications, a coarsely ribbed and a finely ribbed

variety can be distinguished, but the extremes are not far apart, and most of the intermediate stages can be found.

Of the fine surface markings nothing definite can be said. Most of the specimens show no sculpture whatever. A very few have what appear to be traces of fine radial striae. These specimens are exfoliated, and to this fact they probably owe the appearance mentioned, for some of the specimens referred to *S. martiniiformis*, which should be entirely smooth if correctly identified, show, in places, fine striae comparable to these. Two or three specimens that seem to retain the outer layers of the shell more intact than the rest, on the other hand, present to view only obscure growth lines without trace or with only the faintest trace of radial markings. Fine, regular radial lirae are a well-recognized and presumably constant character of *S. arkansanus*, and thus, again, another difference is suggested.

Although one might wish to identify this species with *S. arkansanus*, which occurs at essentially the same locality but at a higher horizon, it manifests a closer agreement, so far as one may judge at this time, with *S. floydensis*. Many specimens agree closely with Weller's description and figures; others have a somewhat deeper and more angular sinus in the pedicle valve. In neither species are the fine details of sculpture at present definitely known.

Some of these shells might be mistaken for a large variety of *S. keokuk*. In that species the median rib in the sinus of the pedicle valve is commonly larger than the other ribs of the sinus; in this, the median rib tends to be small rather than large, and in consequence the sinus in such specimens has a somewhat deep, angular shape, while that of *S. keokuk* is shallow and rounded. The plications of *S. keokuk* are as a rule more elevated, but in this character and in the shape of the sinus the two species overlap to some extent.

Weller compares *S. floydensis* with *S. keokuk*, and in a general way it appears to bear the same relation to *S. keokuk* that this species does. On the other hand, the median sinus in some of these specimens is deeper and more angular than in the figured specimens of *S. floydensis*, and the plications seem more generally to be simple. Some specimens from Indiana which I have tentatively identified as *S. floydensis* (they have rather strongly rounded plications) show fine radial lirae crossed by rather stronger growth lines. Something of the sort is suggested by these specimens, but the facts are so uncertain that they may show difference instead of agreement.

The present species differs rather conspicuously from the associated one cited as *S. incertiformis* in its coarser costae and more gibbous and prominent umbo. The finely ribbed variety of this species, above referred to, differs only in the configuration of the umbo, and many specimens (owing probably to their numerous imperfections) occupy a doubtful place.

Spirifer incertiformis Girty, n. sp.

Plate 10, Figures 6–17

This form occurs with the one cited as *S. floydensis?* and in nearly equal abundance. From that species it is distinguished by its finer costae and by its wider umbonal angle, the umbonal region appearing somewhat flattened and the beak incurved and not very conspicuous. The sinus of the pedicle valve is broad toward the front, more or less angular, and rather deep. It is not, however, well defined but joins the lateral areas in a regular curve without any definite boundary. The fold of the brachial valve has corresponding characters, but it is more sharply bounded. In a number of specimens the costae on the lateral areas are arranged in groups of two or three, and this arrangement may have been rather general, for doubtless exfoliation has tended to obscure it. It is not conspicuous, but it can be clearly seen if looked for, especially over the posterior half of the shell. The costae are grouped by their spacing, not by their prominence, without the least suggestion of the bundling or fasciculation that is so conspicuous a feature of *Spirifer triplicatus*.

The cardinal area of the pedicle valve is moderately high, about 6 or 7 millimeters in most specimens, and somewhat variable in direction. It may be almost erect—that is, almost complanate with the shell margins—but is commonly much less inclined backward from the hinge. It is curved in the upper part, rather strongly in some specimens, but almost flat below. The delthyrium is wider than it is high, measuring 10 or 11 millimeters at the hinge line.

All the specimens collected are more or less exfoliated and are almost smooth, for the most part without a trace of such fine surface markings as may have been originally present. This fact would indicate that the markings were rather fine, and from the evidence available, including some external molds, they almost certainly consisted of fine radial lirae, cancellated by fine lamellose concentric lines.

In most of the characters observed this species appears to agree closely with *S. incertus* as described and figured by Weller, and the relation between them hangs more upon possible differences in sculpture than upon observed differences in configuration. *S. incertus* is marked by fine regular concentric lamellae or imbrications, and it is doubtful whether the present form has anything at all comparable. Imbrications as strong as those of *S. incertus* would leave traces, one would expect, even on the exfoliated surface, but the exfoliated specimens from Batesville are essentially smooth. Indeed, from the best evidence available I am fairly satisfied that this species is marked by fine radial striae, which *S. incertus* lacks, and that it

lacks coarse imbrications, which *S. incertus* possesses. If this difference exists, the present species can not be *S. incertus*. It is in fact, more nearly related to *S. subequalis*, which has a similar configuration, especially in the flattened, spreading shape of the umbo of the pedicle valve, and also similar finely cancellated surface markings. *S. subequalis* is, however, much more coarsely costate, besides differing in other ways—it is more extended transversely, its brachial valve is more gibbous, and it shows other differences.

Though similar in a general way, characteristic specimens of this species are readily distinguished from characteristic specimens of the associated form identified as *S. floydensis?* Without taking into account possible differences in sculpture, *S. floydensis?* is more coarsely costate and has a more prominent and jutting umbo. Specimens occur, however, that seem to be intermediate, having finer costae than *S. floydensis?* and a more prominent beak than *S. incertiformis*. I have regarded such specimens as constituting a mutation of *S. floydensis?*, and they can be recognized by the configuration of the umbo, if that is adequately shown. Were many characters of these specimens not in doubt, however, such questions probably would not arise.

A few specimens included under this caption, one especially, shows a peculiar phase that possibly should be given recognition as a distinct variety. This specimen is a pedicle valve, and the costae in the sinus, instead of becoming numerous by subdivision, increase gradually in size so that toward the front they are conspicuously larger than the plications on the lateral areas.

Spirifer washingtonensis var. incomptus Girty, n. var., MS.

Plate 10, Figures 18–21

This identification rests primarily upon a large but imperfect pedicle valve, on which the following descriptive sketch is based, and secondarily upon two small and probably immature pedicle valves that apparently belong to the same species.

The cardinal angles appear to have been a little extended and acute, thus constituting the greatest width, which was about 37 millimeters; the length was 22 millimeters. The convexity is rather high, and the median sinus broad, deep, and fairly well defined. The plications are rather large and strong. Three occur in the sinus, the median one the largest, and ten on each of the lateral slopes. The sculpture, observed close to the cardinal line, consists of fine radial lirae crossed by fine lamellose concentric lirae.

The two smaller specimens show characters similar to those of the large one, with such modifications as might be expected in young shells of the same species. It is a noteworthy fact, as bearing upon the original sculpture of the specimens identified as *S. floydensis*, few of which show any surface markings at all, that all three of the present specimens are clearly marked by fine superficial radiating lirae.

This form is distinguished from the associated Spirifers especially by its coarse and strongly expressed costae. The costae are finer than those of the specimens referred to *Brachythyris suborbicularis*, and they are also stronger; the specimens so referred are further distinguished by their shape and their lack of fine sculptural markings. This species is of the general character of *S. keokuk*, but it is larger and especially has much coarser plications. It is, in fact, rather more like *S. increbescens*. In its general shape it differs conspicuously from typical *S. washingtonensis*, being more compact and less alate. In the Joplin district, however, a short-hinged variety of *S. washingtonensis* is associated with the typical form, and this the Batesville shell greatly resembles. In fact, it would at present be difficult to name any important difference between them. Nevertheless, comparisons have been possible only between pedicle valves, and between these only in certain characters, so that although negative evidence is wanting (apart from that of geologic age and faunal association) the affirmative evidence for the identification is inconclusive.

Spirifer martiniiformis Girty

Plate 12, Figures 18–20

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

1915. *Spirifer martiniiformis* Girty, U. S. Geol. Survey Bull. 595, p. 30, pl. 1, figs. 2–4. Boone chert: Batesville, Ark.

Of more than a score of specimens referred to *S. martiniiformis* in lot 3204, all, with possibly one exception, are pedicle valves. They show a rather large species (though a length of 35 millimeters is the maximum observed) having the general appearance of *Martinia* and *Reticularia*. The width is greater than the length, the convexity high, the beak prominent and incurved, and the cardinal angles strongly rounded. The cardinal area is high, rather well arched in the upper part, defined by pronounced angles, and divided by a rather narrow delthyrium. The pedicle valve is depressed along the median line into a conspicuous sinus, which is broad and subangular toward the front but in the umbonal region is only a narrow, shallow though distinct groove.

The shell in these specimens is exfoliated and presents a smooth, shining, finely fibrous appearance, and such external molds as could be found show it to be practically devoid of surface markings. On the inside the valve possesses dental plates of considerable height and length, placed rather close together and diverging but slightly toward the front.

If only its external characters were considered, this form would be referred to *Martinia*, but the presence of strongly developed dental plates makes such a

reference impossible. Though having the configuration of *Reticularia* and like it possessing dental plates, the complete absence of a median septum would remove that genus also from consideration, even aside from the fact, which is well assured, that the surface lacks the concentric bands and rows of spines so characteristic of *Reticularia*. From *R. setigera* var. *internascens*, with which they are associated, these shells are readily distinguished by a number of characters, several of which are useful even in the imperfect condition in which all these specimens are found. Besides marked differences of structure, this form has a conspicuous median sinus, and it has a perfectly smooth surface, whereas the *Reticularia* shows the characteristic concentric banding, even if exfoliated, and also either indications of the rows of spines or, if the exfoliation goes deeper, the intricate network of fine lines. That these shells belong to the same species as those obtained somewhat higher in the formation and described as *Spirifer martiniiformis*, I can not doubt, for an essential agreement was found in every character shown.

Spirifer sp.

This specimen, which is a pedicle valve, does not perhaps deserve individual notice except for its appearance of combining the external expression of *Brachythyris* with the internal characters of *Spirifer*. It has at first sight a broadly ovate shape with a short hinge line and a surface marked by large depressed radial plications. The sinus is well developed though ill defined, and it tends to be somewhat angular or sharply rounded. The beak is prominent and suberect.

The general aspect, therefore, is highly suggestive of shells of the *Brachythyris* group, and the specimen might pass without challenge if identified as *B. suborbicularis*, were it not so broken as to show the presence of two powerful dental lamellae. The specimen is obviously imperfect and probably owes its shortness of hinge to that fact. Certainly the cardinal extremities are broken, but the portions also missing around the rest of the margin may be sufficient to compensate for this loss and still make the shell a short-hinged species. The best interpretation, however, seems to be that this is an aberrant specimen of the form referred to *S. floydensis*, distinguished especially by unusually large depressed costae.

Syringothyris subcuspidata (Hall)

Plate 11, Figures 4–9

1858. *Spirifer subcuspidatus* Hall, Iowa Geol. Survey, vol. 1, pt. 2, p. 646, pl. 20, figs. 61*a*, *b*. Keokuk limestone: Keokuk, Iowa; Nauvoo and Warsaw, Ill.

1914. *Syringothyris subcuspidatus* (Hall). Weller, Illinois Geol. Survey Mon. 1, p. 401, pl. 71, figs. 3–7. Keokuk limestone: Warsaw, Ill.

Though this form is in a general way similar to *Pseudosyrinx gigas* and occurs in the same fauna, the two species are readily distinguished unless the specimens have lost many of their original characters. In those shells the cardinal area is so much better developed than the opposite side that the area slopes forward from the hinge line, making an acute angle with the plane of the valve. In these, the relations are just the reverse; the cardinal area is not so long as the opposite side, the area slopes backward instead of forward, and the angle is obtuse instead of acute. Furthermore, those shells are highly punctate, while these are apparently impunctate; and lastly those are without the inner tube or syrinx which these possess. This last character, though fundamentally the most significant, is under the existing conditions the least available for discriminating the two forms because it is in so few specimens shown definitely or even at all. The presence of a syrinx is, of course, most readily determined if the fossils are preserved as internal molds; those from the Boone, however, are preserved in a limestone matrix without enough differentiation in color to render the facts at all clear. A syrinx has been identified in at least some of the specimens referred to *S. subcuspidata*, whereas it has not been identified in any of those referred to *P. gigas*. In view of the poor preservation of even the best of these specimens my observations do not prove the absence of this structure.

The punctate character of the shell in *P. gigas* is in most specimens very conspicuous, but in some it is not so readily ascertained. Nearly all the species of *Syringothyris* are described by Weller as having a punctate shell, but in my experience the punctate structure can rarely be seen, and still more rarely is it developed in a degree comparable with that of *P. gigas*. The shells under consideration seem to be without punctae, though this may mean only that they are finely punctate. At all events they offer a marked contrast to those cited under *P. gigas* and at the same time demonstrate a point in common with *S. subcuspidata*, the punctate structure of which Weller was unable to observe, though he did not doubt that it was originally present.

The cardinal area is essentially flat in some specimens but gently concave in others. Its direction can be determined definitely only in specimens that are perfect about the margin, and those are few. It sometimes appears to make more of a right angle with the plane of the valve than an obtuse angle, though this can not be stated positively and is stated at all only to suggest that a certain variation does occur, but in any event a marked contrast is shown in this regard with *P. gigas*.

Of the numerous species of *Syringothyris* recognized by Weller in the Mississippian faunas of the Mississippi Valley, none has so many characters in common with the present form as *S. subcuspidata*. In fact, at this time I am unable to name any differences of

importance. Though probably not to be classed as important, one difference may exist in the plications of the pedicle valve, which, in my shell, are very subdued, much less distinct than they are represented in Weller's figures.

Pseudosyrinx gigas Weller

Plate 11, Figures 10–15

1914. *Pseudosyrinx gigas* Weller, Illinois Geol. Survey Mon. 1, p. 410, pl. 66, figs. 1–5. Keokuk (?): Kentucky. Keokuk limestone: Warsaw, Ill. Beds of Keokuk age: Crawfordsville, Ind.

This species is abundant at both stations, but the largest and best specimens were obtained at station 3203. Some of these shells are of large size, one measuring no less than 65 millimeters at the hinge line. The width, however, is conditioned by the angle included between the sides of the cardinal area, together with the height of the area. The height naturally varies with age, but the angle made by the sides, though constant for each specimen, varies from one specimen to another. In the large specimen just mentioned, which is uncommonly broad, this angle is about 105°, while in a narrow specimen it is only 80°. The height of the area in the narrow specimen is about 40 millimeters and in the broad one about 55 millimeters. Few of my specimens have the area as high as 40 millimeters, however.

Besides their size, one of the noteworthy features of these shells is the height of the cardinal area, which in comparison with the length of the side opposite to it is very great. The greater height of the area causes it to have a strong forward inclination from the cardinal line. In most specimens the area is nearly flat, but it may be appreciably curved, especially in the upper part, and the growth of the valve as a whole may be somewhat twisted.

A third conspicuous feature of these shells is their highly punctate structure, which is especially conspicuous in the specimens from station 3204 but is readily seen in all of them.

Several other features possibly deserve mention. The sinus of the pedicle valve widens rapidly and may be very broad at the anterior margin. It is ill-defined, but the fold corresponding to it in the brachial valve has very definite boundaries. The lateral plications of the pedicle valve are commonly depressed and, though, distinctly defined, far from conspicuous. They are as a rule distinctly stronger than the lateral plications of the brachial valve.

In none of the specimens observed has a syrinx been discovered, and in one specimen which was ground down across the apex the structure was apparently absent. If the syrinx was undeveloped, as it appears to be, this form belongs under *Pseudosyrinx* instead of *Syringothyris*, and it appears to agree very closely with *P. gigas*.

Brachythyris suborbicularis (Hall)

Plate 11, Figures 1–3

1858. *Spirifer suborbicularis* Hall, Iowa Geol. Survey Rept., vol. 1, pt. 2, p. 644. Keokuk limestone: Keokuk, Iowa; Warsaw, Ill.

1914. *Brachythyris suborbicularis* (Hall). Weller, Illinois Geol. Survey Mon. 1, p. 374, pl. 61, figs. 1–8, pl. 62, figs. 1–2. Burlington limestone: Springfield, Mo.; Sulphur Springs, Mo. Keokuk limestone: Keokuk, Iowa; Springfield, Mo. Beds of Keokuk age: Crawfordsville, Ind.

Some of the forms assumed by *Spirifer floydensis?* simulate species of the *Brachythyris* group very closely, so that one is sometimes in doubt where certain specimens belong, though only, of course, if they are in an imperfect condition. A few specimens in my collections, however, can safely be referred to *Brachythyris* because of their configuration, of their lack of superficial sculpture, and, where the facts have been determined, of their lack of internal structures in the pedicle valve.

The most characteristic of the specimens here referred have a rather elongate shape and contract above to a somewhat short hinge line. The surface is covered by rather large, weak plications, which are distributed somewhat in the following manner: The sinus begins as a narrow, deep groove inclosed between two bounding costae. Shortly the groove becomes shallow or flat and defined by incised lines which form the inner outlines of two costae, one on each side, given off by the bounding costae of the sinus. Thus in the anterior part the sinus is ill-defined, though its boundaries can be determined by tracing forward the plications that bound it in the umbonal region. It has one plication on each side and a flat, narrow bottom defined by grooves, like a sort of depressed plication, which traces back into the simple sulcus or sinus of the umbonal region. The lateral plications number eight or more, the exact number being difficult to determine because they grow finer and fainter toward the sides and gradually lose definition entirely. The surface is apparently quite without fine superficial markings except those of the nature of growth lines.

Besides specimens having the characters just recited, I am including in this species others whose shape is broader and still others whose plications are almost obsolete.

Although comparison can not be made in every detail, this form agrees very closely with *B. suborbicularis*, so that with the facts at hand it can not be distinguished specifically.

Reticularia setigera var. internascens Girty, n. var., MS.

Plate 12, Figures 1–12

In ordinary states of preservation shells of this type retain few characters that are useful for the differentiation and identification of species. The range of varia-

tion in shape is slight, and the very nature of the sculpture renders exfoliation inevitable if specimens are obtained in the usual way by being broken from hard rock. When the details of the sculpture are, though somewhat rarely, ascertained, they can generally not be ascertained in enough specimens to give much assurance as to the range of variation. Possibly on this account Weller was led to supplement such characters as are customarily used by the striated markings of the inside of the shell and the amount of surface covered by them.

The present form, which is represented by numerous though ill-preserved specimens, is of fairly large size, a width of 30 millimeters, however, being very rarely exceeded. The brachial valve is much wider than long and has a rather regular transversely elliptical shape. The pedicle valve, because of the projection of the umbonal parts, has the two dimensions more nearly equal, though here also the width is almost invariably greater. The proportions, however, vary.

The pedicle valve is highly convex. The beak tapers rapidly to a point and is not strongly incurved. The cardinal area is rather high and slopes backward but slightly from the cardinal line, but the curvature, chiefly localized in the upper part, brings the point of the beak to an angle of about 45° from the perpendicular. Many pedicle valves lack an appreciable sinus, but others show a faint depression down the median line, which becomes distinct only as it approaches the anterior border.

The brachial valve is less convex than the pedicle valve but is a little inflated in the umbonal region.

The surface markings are of the usual type, but they appear rather widely different in different specimens, largely, I believe, as a result of varying preservation. As a rule the surface is crossed by rather conspicuous, fine, regular corrugations, which gradually increase in size toward the front. It is also more or less covered by fine inosculating lines that have a generally radial direction. They form a sort of irregular network of crêpelike wrinkles, and the finely roughened surface which they produce is distinctly different from that made by the straight, continuous radial lines on the interior of *R. pseudolineata*, such as are shown by some of Weller's figures and by some of my specimens from the Keokuk limestone at Keokuk. I am not quite satisfied, however, that this character is uniformly present in *R. pseudolineata*, as I have specimens presumably of that species from the chert beds of the Joplin region that have a hachured surface much like that which I have just attempted to describe, only coarser. In apparent association with such specimens others having rectilinear markings also occur. Have we two distinct or one variable species?

Returning to the specimens from Batesville, the surface where it is not so deeply exfoliated sometimes shows small elongated excavations or nicks (really the loci of spines) which are very regularly arranged and, though they are not connected, produce an appearance as of slender, widely spaced radiating grooves. One may suspect that both sorts of markings had their origin in the spinose character of the outer surface, or rather that all three are an expression of changes in the mantle by which the entire shelly structure was created. Presumably as deposits were laid more and more thickly over the older parts of the shell, the individual scars made by the spines became transformed into the fine reticulation above described. The details of the transformation are, however, hard to understand, for the reticulation is far too fine to correspond directly to the relatively large and widely spaced spines.

On the inside the pedicle valve possesses a median septum and dental plates. The septum is rather low and thick and is confined to about one-third of the shell in the posterior part. Incredible as it may seem, the dental plates are fairly strong in some specimens and quite undeveloped in others. Where present they are somewhat less than half as long as the septum; they are situated rather close to it and are distinctly but not strongly divergent.

In the brachial valve a median septum may fairly be described as absent, though internal molds show an incised line which represents a linear elevation of inconsiderable height. Much more obvious are two rather narrow, elongated muscle scars, somewhat enlarged in the lower part and rounded at the end, that are situated not far apart close to the median line. These appear as excavations on the shell itself, where they are separated by a narrow ridge down the center and are bounded on the outer side by a rather thick elevated margin. In some aspects of preservation these three ridges might be misinterpreted as a median septum and, possibly, two socket plates.

Although no structure that could appropriately be called a septum has been observed in any brachial valve, a septum may sporadically be developed, for in *R. pseudolineata* also it is not invariably present. Weller, indeed, describes it as a character of that species, but his figure of a specimen from Callaway County, Mo. (fig. 11), fails to show a septum, and the only brachial valve in my collection from the same locality also fails to show one. Of other chert specimens (and no type of preservation would more faithfully disclose the facts than internal molds in chert) some have a well-developed septum, but others have not. This statement should be qualified to some extent, inasmuch as most of them have at least a faint groove along the median line, somewhat more pronounced than the other radial grooves that cover the inner surface. This groove could hardly be identified as the impression of a septum, however; but if the structure here is a septum, it is not hard to find speci-

mens which though they must be referred to *Spirifer*, have a much better septum in the pedicle valve, for on internal molds the mound of matrix that filled the space between the dental plates bears not uncommonly a distinct groove. One other concession must also be made. The faint groove on the brachial valve of the specimens under discussion might be all that remained of an appreciable septum nearly buried in a secondary deposit, or callus. As against this we should bear in mind that the specimens still showing the impression of a high or at least a distinct septum were presumably thickened in a corresponding manner.

This species is clearly not *R. pseudolineata*. It resembles that species in the almost complete obsolescence of fold and sinus but differs in almost every other important character. It agrees rather better with *R. cooperensis*, though it is hard to compare the two on equal terms. The very different faunal association and geologic age in which the present form occurs establishes a strong presumption against its belonging to the species named. It is a larger shell, and besides this and one or two minor differences, the dental plates of the pedicle valve are relatively shorter, more nearly parallel, and placed more closely to the median septum. *R. setigera* must also be dismissed after a brief consideration. Like the other, it occurs with a markedly different fauna. It is commonly flexed into a much more pronounced fold and sinus, and the concentric rows of spines are generally much farther apart, though enough variation is shown in this regard to lay the statement open to exception. Possibly too, the absence of a median septum in the brachial valve of the present species and the presence of the two elongated muscle scars may be reckoned a distinguishing character not only from *R. setigera* but from other species. A much closer agreement is found with a form which occurs at the same general locality but at a somewhat higher horizon, which I propose to call *R. setigera* var. *internascens*. I can not yet say that the two forms agree in every essential point, though they agree in many, but at least I am unable to mention any essential point in which they differ.

Spiriferina subelliptica var. fayettevillensis Girty

1910. *Spiriferina subelliptica* var. *fayettevillensis* Girty, New York Acad. Sci. Annals, vol. 20, No. 3, pt. 2, p. 221. Basal part of Fayetteville shale: Fayetteville, Ark.

1911. *Spiriferina subelliptica* var. *fayettevillensis* Girty, U. S. Geol. Survey Bull. 439, p. 74, pl. 8, fig. 5. Moorefield shale: Batesville, Ark.

This species is inadequately represented by specimens which are both few in number and imperfect in preservation. The width of the larger specimens must have been as much as 20 millimeters. The fold and sinus are simple and are similar to the lateral plications except that they are conspicuously larger and stronger. Each of the lateral slopes bears six or possibly seven simple costae. The surface is marked by regular concentric lamellae, which are rather closely arranged. The shell substance is strongly and coarsely punctate.

So far as the characters are shown this form is in complete agreement with the one from the "Spring Creek limestone" identified as *S. subelliptica* var. *fayettevillensis*, and with one, much better represented, from the "Mayes formation" of Oklahoma, which apparently belongs to the same species. The general probabilities also favor this identification and add materially to the not wholly conclusive evidence of the specimens themselves.

Spiriferina sp.

Plate 12, Figures 13–17

The shells included here differ from one another sufficiently to suggest that they might be referred to different species if their characters were adequately known. Probably, therefore, it will be better to describe in a few words two or three specimens individually rather than to embrace all in a general description.

One pedicle valve from station 3203 is of uncommon size—at least 40 millimeters in width—very transverse, and with acute cardinal angles. Each of the lateral areas bears seven or eight costae separated by subangular furrows. The sinus, which is simple, is relatively large and shallow. The surface is crossed by rather coarse, regular concentric lamellae, and the shell is traversed by a few small tubules. A median septum is apparently present.

Another pedicle valve (from station 3204) is still larger, possibly 50 millimeters in width, and apparently not so transverse. The plications are larger and weaker, the median sinus being especially broad. The shell appears to be feebly punctate, and a median septum appears to be present.

The other specimens are mostly smaller and presumably younger, but they have essentially the same characters, especially the punctate structure and the lamellose surface.

The two most diagnostic characters ascribed to these shells, the median septum and the punctate structure, are more or less dubious. They are, in fact, so obscure that I at first referred these fossils to *Spirifer moorefieldanus*. More careful study directed to these critical characters led me to believe that a median septum was present in the pedicle valve. Consequently I was inclined to refer the species under the genus *Delthyris*. The shell substance appears fibrous and impunctate even to a careful inspection, and it was almost by accident that I discovered that one of the smaller specimens when wet showed punctae. This led me to reexamine the larger specimens, and these also proved to be punctate, but the punctae are so few and so irregular, in so far as one can see, that

they might almost be due to some boring organism. The larger specimens share with the small ones the character of lamellose surface markings and probably of a median septum, for it is the larger ones that show these best. It would seem unwise, therefore, when they have such significant characters in common, to attempt to distinguish between the small specimens and the large ones that are so feebly and so erratically punctate. I have considered whether this form might not be the same as, or a variant of, the one identified as *Spiriferina subelliptica* var. *fayettevillensis*. They do not, to be sure, differ greatly in configuration, though they do in size, the larger specimens in this group being very much larger than any known specimens of the other. The shell structure in the specimens referred to *S. subelliptica* var. *fayettevillensis* is conspicuously punctate, so that that feature was recognized from the first. The punctae are finer as well as more obvious, and the concentric lamellae are finer and more closely arranged. There would thus appear to be two distinct species, but the distribution between them of the specimens contained in the collection is not free from doubt.

Hustedia circularis (Miller)

1892. *Retzia circularis* Miller, Indiana Geol. Survey Eighteenth Ann. Rept., adv. sheets, p. 72, pl. 9, figs. 32–34. Chouteau limestone: Sedalia, Mo.

1914. *Hustedia circularis* (Miller). Weller, Illinois Geol. Survey Mon. 1, p. 451, pl. 76, figs. 47–52. Chouteau limestone: Sedalia, Mo.; Pettis County, Mo.

The only specimen referred here is probably a pedicle valve. It is a small oval shell about 6.5 millimeters long and 5.5 millimeters broad, rather strongly arched, and marked by slender but well-defined rounded costae to the number of 16 or 18. The surface near the anterior margin appears to be slightly depressed across the middle, and the median stria is apparently a little deeper than the other striae that separate the costae. There are eight or possibly nine costae on each side of the median stria. The shell substance is distinctly punctate.

This specimen seems to agree perfectly with *H. circularis* in all its ascertained characters, but this agreement is not enough, in the group of shells to which it belongs, to establish its identification. The generic position of neither *H. circularis* nor the present form is certainly known, nor can it be determined from the exterior alone.

Bembexia magna Girty, n. sp., MS.?

This is a fine large species, but it is represented by a specimen so fragmentary that its characters can be given only in part. The final volution may have been as much as 35 millimeters in diameter. The whorls were probably well rounded, so that the suture was deeply depressed, and the spire was probably moderately high. The slit band is a conspicuous feature and was probably situated on the periphery or a little above. It is a shallow groove, about 2 millimeters wide, guarded by sharp ridges and crossed by fairly regular, closely arranged lamellose lines. The character of the surface above the slit band is not well shown, but it clearly was marked by rather strong, regular transverse lirae, coarser and more widely spaced than those on the band. The lower surface also is marked only by strong, regular transverse lirae, flattened or broadly rounded on top and rising abruptly from somewhat wider interspaces.

The simple character of this species, its regularly rounded volutions, marked only by transverse lirae which are interrupted by a broad, prominent slit band, make this a striking form and one easily to be recognized if it had been already described from our Mississippian faunas. Nothing like it, however, appears in the literature, except possibly two large forms named by Worthen but too imperfectly known for recognition. I have, however, a species described in manuscript as *Bembexia magna*, whose characters are almost exactly like those of the present specimen, though the two forms are of a markedly different geologic age and are associated with markedly different faunas. In the characters shown, the only differences noted are that the present form may be a little more strongly and coarsely striated on the surface below the slit band and a little less sharply striated on the surface above it.

Orthonychia ungula Weller

Plate 12, Figures 21, 22

1906. *Orthonychia ungula* Weller, St. Louis Acad. Sci. Trans., vol. 16, p. 461, pl. 7 figs. 36–37. Glen Park limestone: Glen Park, Mo.

Three specimens are included here, none of which is in exact agreement with the species cited. One from station 3203 closely resembles Weller's figure of *O. jeffersonensis*, but the figure represents a perfect shell, while my specimen is broken at the apex in such a manner as to indicate that that part was originally slightly hook-shaped. Of the two specimens figured by Weller to represent *O. ungula*, my specimen is less curved than one and less slender than the other. A second specimen from station 3203 and another much like it from station 3204 are even more imperfect, but their present appearance is suggestive of the smaller and more curved specimen of *O. ungula*.

Orthonychia undata (Winchell)

Plate 12, Figures 23, 24

1865. *Metoptoma undata* Winchell, Acad. Nat. Sci. Philadelphia Proc., p. 31. [Kinderhook group], bed No. 5: Burlington, Iowa.

1901. *Igoceras undata* (Winchell). Weller, St. Louis Acad. Sci. Trans., vol. 11, No. 9, p. 202, pl. 20, fig. 16. Kinderhook group, bed No. 7: Burlington, Iowa.

This identification is primarily concerned with a single specimen from station 3203 which has a rather

rapidly expanding shape and is erect, straight, and almost symmetrical, although it is slightly compressed so that one axis is a little longer than the other in transverse section. The rate of expansion and other characters are very suggestive of *O. undata* as figured by Weller, but the size is less than half that of the typical specimen. The straight axis and absence of longitudinal folds distinguish this form from *Capulus fissurella* and similar species, while the more rapid expansion and the absence of folds distinguish it from the broad variety of "*Platyceras infundibulum*" figured by Meek and Worthen. A very similar though even smaller and less perfect specimen was collected at station 3204.

Orthonychia sp.

The single specimen included here resembles the one from the same locality referred to *O. undata*, but it is decidedly more slender. It resembles the form or forms described by Meek and Worthen under the name of *Platyceras infundibulum*, but has only half the height of any of those specimens and lacks the plications of some of them. Its rate of expansion is intermediate between the slender specimen for which the provisional name *extinctor* was suggested and the more spreading one shown by Meek and Worthen's Figures 3b and 3c.[6]

Platyceras oxynotum Girty, n. sp.

Plate 12, Figures 28, 29

Shells of the *Platyceras* type are rather abundant in the middle Boone fauna near Batesville, but almost all the specimens collected are fragmentary—a fact which renders a satisfactory identification, in a genus where even good specimens are identified with difficulty, almost impossible. The typical specimen cited under this title is a large and nearly complete shell having the shape of a rapidly expanded cone which is bent into a hook at the apex but is more gently curved toward the aperture. Even the apex does not form a closed coil, and the whole shell makes only about one complete volution. The expansion is rapid, but only in the anterior-posterior dimension; the transverse expansion is much more gradual, with the result that the shell has a strongly compressed appearance, and the anterior side is even somewhat angulate or keeled, consequently also the aperture is much longer than it is wide, measuring about 28 by about 21 millimeters. The entire shell has a maximum length of about 48 millimeters. It is only slightly unsymmetrical with reference to a plane passing through the long axis of the aperture but displays a backward inclination so that in side view the apex projects very appreciably beyond the posterior outline of the parts below. A few large obscure folds are introduced toward the aperture, which is sinuous in two directions—that is, the sides of the shell are plicated, and its margin is scalloped.

In side view this specimen much resembles Keyes's figure of *P. latum*, although it is even more loosely coiled, and the apex rises higher above the plane of the aperture. The outline of the aperture, however, is here laterally compressed, much longer than wide, while there it is rounded and wider than long. The same may be said of *P. capax*, which is little more than a small form of *P. latum*.

Platyceras latum Keyes

Plate 12, Figures 25–27

1888. *Platyceras latum* Keyes, Am. Philos. Soc. Proc., vol. 25, p. 242, pl., figs. 10, 11. Burlington limestone: Burlington, Iowa.

1894. *Capulus latus* Keyes, Missouri Geol. Survey, vol. 5, p. 176, pl. 53, figs. 13*a*, *b*. Burlington limestone: Burlington, Iowa, Hannibal, Mo.

I am covering under this title a number of specimens, mostly somewhat fragmentary, that vary considerably among themselves. In general they have a conical shape, gently arched so as to make a more or less complete turn, rather less than more, and inclined so that the apex considerably overhangs the posterior end of the aperture. The aperture itself is rounded, about as wide as it is long, and somewhat campanulate, the shell tending to flare appreciably in the lower part. Seemingly the inclination is mainly backward, little if at all to one side, and the growth is fairly symmetrical with reference to a plane passing through the anterior-posterior axis.

One noteworthy deviation from this generally symmetrical shape is shown by several specimens and consists in a strong expansion toward the left posterior segment with a straightening of the outline so that the aperture to that extent is somewhat triangular instead of circular, and the greater development of the shell is on the left-hand side. Seemingly also some specimens have a stronger backward inclination than others, but unless specimens are rather perfect about the aperture, which few of mine are, this may be more of an appearance than a reality.

My specimens are mostly or wholly exfoliated, so that their surface characters can no longer be seen. One which is crushed and fragmentary and therefore especially uncertain as to its relations shows very fine longitudinal costae of several sizes. These are superficial, and consequently the othes specimens may originally have been ornamented in like manner. If so, they can scarcely be cited as *P. latum*, and of course this particular specimen is, for the same reason, more than under suspicion.

The characters just enumerated bring these shells into close relationship with *P. latum*, at least in point of configuration. Those with the unsymmetrical aperture of course are in that respect not like *P. latum*, although they seem to be a mere modification of those

[6] Meek, F. B., and Worthen, A. H., Illinois Geol. Survey, vol. 5, pl. 17, 1873.

that are. None of my specimens is as large as the one originally figured, and the smaller ones are more like *P. capax*, which seems little more than a small variety of *P. latum*, distinguished in addition, by its possibly less oblique shape.

Proetus sp. aff. P. roundyi var. alternatus Girty

1926. *Proetus roundyi* var. *alternatus* Girty, U. S. Geol. Survey Prof. Paper 146, p. 40, pl. 6, figs. 13a–15b. Limestone of Boone age: San Saba County, Tex.

Of this form the collection contains only a single specimen, a small pygidium of semicircular outline about 6 millimeters wide and 4 millimeters long. It is rather strongly arched from side to side, the axial lobes rising considerably from the pleural lobes. The pleural lobes are not strongly arched themselves but descend with considerably obliquity. The axial lobe is broad at the anterior end, though not so broad as the pleural lobes. The segmentation is fairly sharp over the anterior half of the pygidium but obscure or incomplete over the posterior half, so that the number of segments can not be counted with any certainty. Besides this the axial lobe is largely exfoliated. Nevertheless, it has four distinguishable segments toward the anterior end, with space for three or possibly four indistinct ones posterior to them. The segments of the pleural lobes seem to correspond exactly with those of the axial lobe, so that there are four distinct pleural segments in the anterior part with several others suggested or incompletely defined in the posterior part. The pleural segments thus appear as an outward prolongation of the axial segments; the pleural segments, however, are subdivided, with the anterior semisegment of each pair narrower than the other and slightly depressed below it. In the general obsolescence of the segmentation posteriorly the subdivision of the segments is first obscured and then the definition of the segments themselves. The marginal parts of the pygidium are unsegmented, forming a distinct but undefined border. The surface throughout appears to be uniformly and finely granulose.

I have been unable to locate this pygidium under any of our Mississippian species of *Proetus*. It appears to belong to an undescribed species or else, as its small size suggests, to be a young specimen of some known form. Of the described species some have more numerous segments; some that have about the same number of lateral segments have more numerous axial segments. Even in this specimen the correspondence between the segments of the axial and pleural lobes may not be as complete as I suppose, though discordance must be limited to the posterior half. *Proetus swallowi* has a like number of segments on the pleural lobes (seven), but it has eleven on the axial lobe, and it is also much larger. *Proetus tennesseensis* comes nearest perhaps to the Boone form. It is described as having eight or nine segments on both the axial and pleural lobes, but nothing is said about the pleural segments being subdivided. Winchell remarks that the length of the pygidium is nearly twice the breadth, proportions very different from those of my specimen, but Winchell evidently meant to say just the opposite, as he gives measurements "length 3/8 inch and breadth 5/8 inch." In some respects this pygidium much resembles that of *P. roundyi*, especially the variety *alternatus*. That species, however, has 11 axial segments; this apparently only 7 or 8.

Cytherella sp.

This, the only ostracode in the collection, consists of a single valve which is poorly preserved but which clearly belongs to the genus *Cytherella*. It occurs on a chip of rather siliceous limestone, and the character of the inner or contact margin can not be determined. The outline is a little more strongly curved along the dorsal than along the ventral side and more strongly curved at the anterior than at the posterior end. A faint indentation occurs near the middle of the valve—probably the external expression of a muscle scar. The specimen, which is probably a left valve, does not closely resemble any described species. The measurements are, length 0.96 millimeter, height 0.60 millimeter.

REGISTER OF LOCALITIES CITED

387. Batesville quadrangle, Ark. Loose pieces of chert in the bed of Spring Creek, a mile or two above Ruddell's mill. Upper chert member of the Boone.

387*a*. Same as 387. Another loose piece found near by. Upper chert member of the Boone.

388. Batesville quadrangle, Ark. Spring Creek, 1 mile above the trestle near Ruddell's mill. Loose pieces of chert from the top of the hill, probably about in place. Upper chert member of the Boone.

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

390. Batesville quadrangle, Ark. Hillside along Spring Creek, half a mile north of Ruddell's mill, near Batesville, Ark. Lower part of black calcareous shale near the middle of the upper chert member of the Boone.

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

1245A. Batesville quadrangle, Ark., Howards Wells, in SE. ¼ sec. 28, T. 14 N., R. 5 W. Moorefield shale.

1245B. Batesville quadrangle, Howards Wells, Ark. Specimen thrown out in digging well. Given by the proprietor, Mr. Howard. Moorefield shale.

1284A. Batesville quadrangle, Spring Creek, Ark. In railroad cut east of trestle over wagon road. Moorefield shale ("Spring Creek limestone").

1248R. Batesville quadrangle, Spring Creek, Ark. Moorefield shale ("Spring Creek limestone").

1284T. Batesville quadrangle, Spring Creek, Ark. Loose material on railroad embankment. Moorefield shale ("Spring Creek limestone").

1248V. Batesville quadrangle, Spring Creek, Ark. Loose material on railroad embankment. Moorefield shale ("Spring Creek limestone").

1248W. Batesville quadrangle, Ark. Found loose on the railroad embankment along Spring Creek near Batesville. Upper chert member of the Boone.

1248X. Batesville quadrangle, Ark. NE. ¼ SW. ¼ sec. 34, T. 14 N., R. 5 W. Moorefield shale ("Spring Creek limestone").

1248Y. Batesville quadrangle, Spring Creek, Ark. Railroad embankment. Moorefield shale ("Spring Creek limestone").

1248Z. Batesville quadrangle, Spring Creek, Ark. Débris along railroad bank. Moorefield shale.

2048. Batesville quadrangle, Ruddell's mill on Spring Creek, 2½ miles west of Batesville, Ark. Moorefield shale ("Spring Creek limestone").

2049. Batesville quadrangle, 2½ miles west of Batesville, Ark., cut on railroad above Ruddell's mill; about same as 2048. Moorefield shale ("Spring Creek limestone").

2049a. Batesville quadrangle, Ruddell's mill, 2½ miles west of Batesville, Ark. A single loose block of "Spring Creek limestone."

2049b. Same as 2049a. Another loose block. Moorefield shale ("Spring Creek limestone").

2049c. Same as 2049a. Another loose block. Moorefield shale ("Spring Creek limestone").

2049d. Batesville quadrangle, Ark. Railroad ballast adjacent to cut at Ruddell's mill. Evidently from the "Spring Creek limestone."

2049f. Batesville quadrangle, Ark. Loose material from Moorefield shale ("Spring Creek limestone"); Spring Creek, Ark., same locality as 2049a.

2051. Batesville quadrangle, Moorefield, Ark.; hill opposite Godfrey's house. Moorefield shale.

2051b. Batesville quadrangle, Moorefield, Ark.; hill near Godfrey's house. Moorefield shale.

2051c. Batesville quadrangle, Moorefield, Ark. Moorefield shale.

2053. Batesville quadrangle, cut on railroad about half a mile west of White River Junction, Ark. Moorefield shale ("Spring Creek limestone").

3203. Batesville quadrangle, 1 mile southeast of James, Ark. Limestone in Boone chert, 150–160 feet above base of Boone.

3204. Batesville quadrangle, limestone quarry at Denieville, Ark. Limestone in Boone chert, about same horizon as 3203.

PLATES 9–12

PLATE 9

Chonetes miseri Girty, n. sp. (p. 81).

Figures 1–3. A pedicle valve seen from above, ×4 and natural size; side view in outline.
Boone chert, James, Ark. (station 3203).

Chonetes batesvillensis Girty, n. sp. (p. 82).

Figures 4, 5. A pedicle valve taken as the type. Seen from above, ×2 and natural size.
Boone chert, Denieville, Ark. (station 3204).

Figure 6. Another pedicle valve, seen from above, ×2.
Boone chert, James, Ark. (station 3203).

Pustula incrassata Girty, n. sp. (p. 86).

Figures 7–9. A pedicle valve seen from above, ×3 and natural size; side view in outline.
Boone chert, Denieville, Ark. (station 3204).

Productella hirsutiformis (Walcott)? (p. 83).

Figure 10. A fragment of a pedicle valve, deeply exfoliated. Its general relations appear to be with *P. hirsutiformis* as identified in the Moorefield shale.
Boone chert, Denieville, Ark. (station 3204).

Productus magnus Meek and Worthen (p. 83).

Figures 11, 12. A brachial valve preserved as an external mold with fragments of shell adhering to it. Seen from above and side view in outline.
Boone chert, James, Ark. (station 3203).

Productus crawfordsvillensis Weller ? (p. 83).

Figures 13, 14. A brachial valve preserved as an external mold. Seen from above and side view in outline.
Boone chert, Denieville, Ark. (station 3204).

Productus mesialis Hall? (p. 84).

Figures 15, 16. External mold of a brachial valve that has been somewhat deformed by pressure. Seen from above and side view in outline.

Figures 17–19. A pedicle valve that has been somewhat deformed by pressure and has lost some of its surface characters through exfoliation. Anterior view, posterior view, and side view in outline. The brachial valve shown by Figures 15 and 16 may belong with the species identified with *Productus burlingtonensis;* this is hardly true of the pedicle valve, by reason of its large spines.
Boone chert, Denieville, Ark. (station 3204).

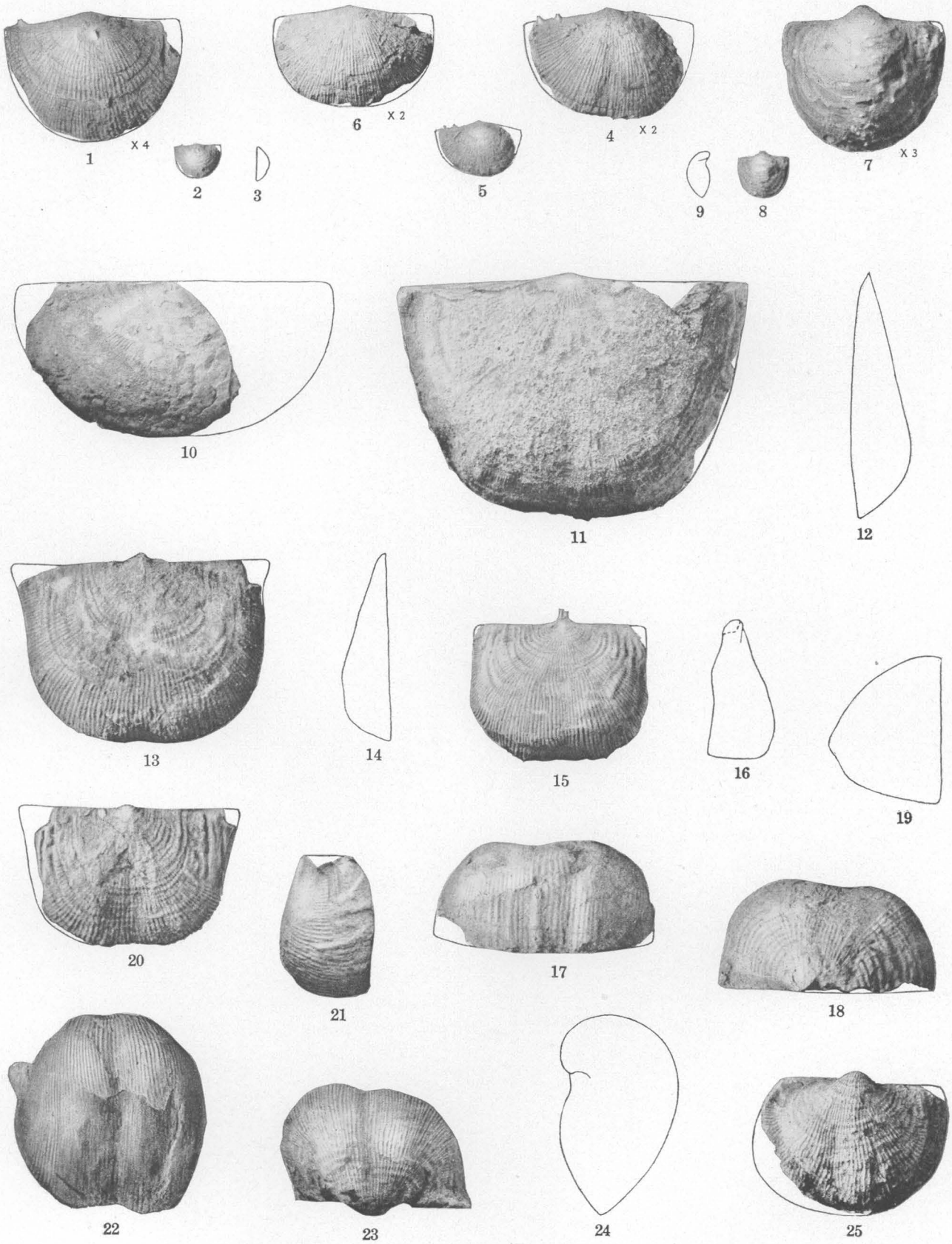
Productus burlingtonensis Hall (p. 85).

Figures 20, 21. External mold of a brachial valve. Visceral disk and side view.

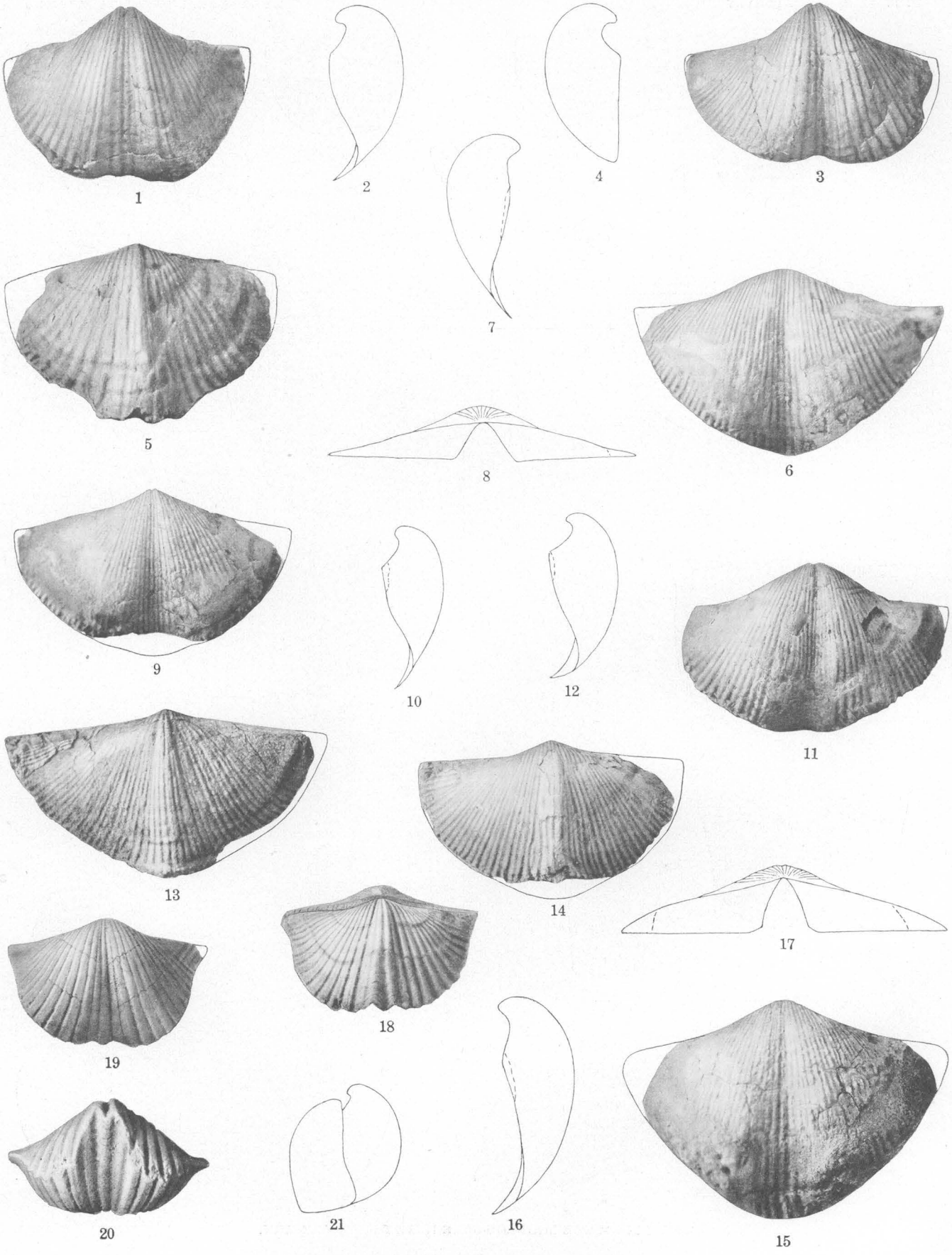
Figures 22–24. Three views of a pedicle valve that has been obliquely compressed
Boone chert, James, Ark. (station 3203).

Avonia arkansana var. *multilirata* Girty? (p. 86).

Figure 25. An imperfect pedicle valve of doubtful affinities.
Boone chert, James, Ark. (station 3203).



FOSSILS FROM THE MIDDLE BOONE NEAR BATESVILLE, ARK.



FOSSILS FROM THE MIDDLE BOONE NEAR BATESVILLE, ARK.

PLATE 10

Spirifer floydensis Weller? (p. 87).

Figures 1, 2. A pedicle valve, seen from above and side view in outline.

Figures 3, 4. Similar views of another pedicle valve.

Figure 5. An exfoliated brachial valve.

Boone chert, James, Ark. (station 3203).

Spirifer incertiformis Girty, n. sp. (p. 88).

Figures 6–8. Three views of a pedicle valve of more than average length.

Figures 9, 10. A small transverse pedicle valve.

Figures 11, 12. Two views of a strongly arched specimen which probably owes this peculiarity to compression.

Figure 13. A brachial valve which is scarcely more than an internal mold.

Figure 14. A brachial valve, similarly preserved, of somewhat different type.

Boone chert, James, Ark. (station 3203).

Spirifer incertiformis Girty var. (p. 89).

Figures 15–17. Three views of a pedicle valve distinguished by large costae in the sinus.

Boone chert, James, Ark. (station 3203).

Spirifer washingtonensis Weller var. *incomptus* Girty, n. var. (p. 89).

Figures 18–21. Four views of a characteristic specimen. The same species apparently occurs in the fauna under consideration, but the specimens are too poor for illustration.

Boone chert, mine dump, Prosperity, Mo.

PLATE 11

Brachythyris suborbicularis (Hall) (p. 91).

Figure 1. A large fragmentary pedicle valve.
Boone chert, Denieville, Ark. (station 3204)

Figures 2, 3. Two views of a small pedicle valve.
Boone chert, James, Ark. (station 3203).

Syringothyris subcuspidata (Hall) (p. 90).

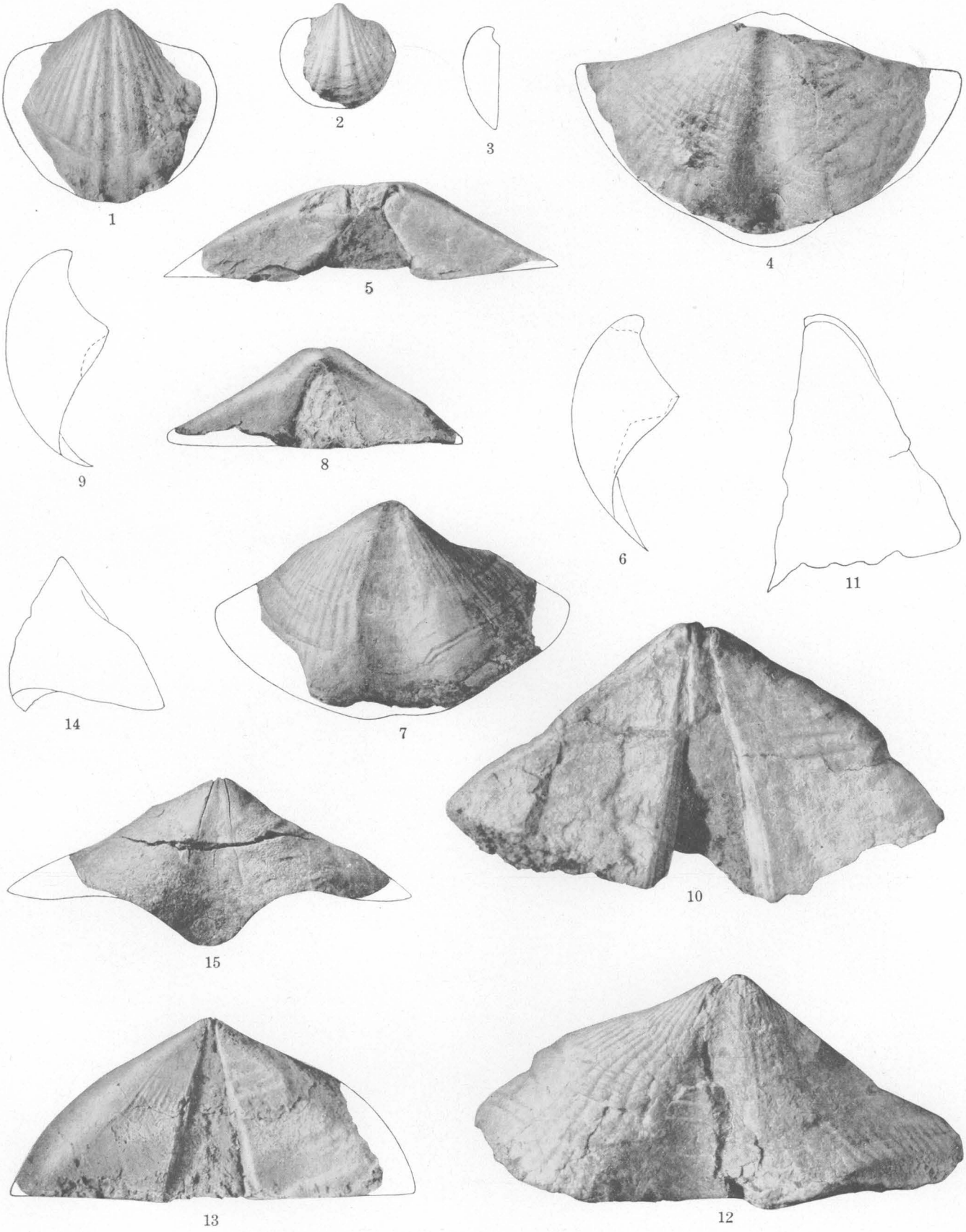
Figures 4–6. A rather broad pedicle valve, seen from above, side view in outline, and view of the cardinal area.

Figures 7–9. Three similar views of a narrower and somewhat twisted pedicle valve.
Boone chert, Denieville, Ark. (station 3204).

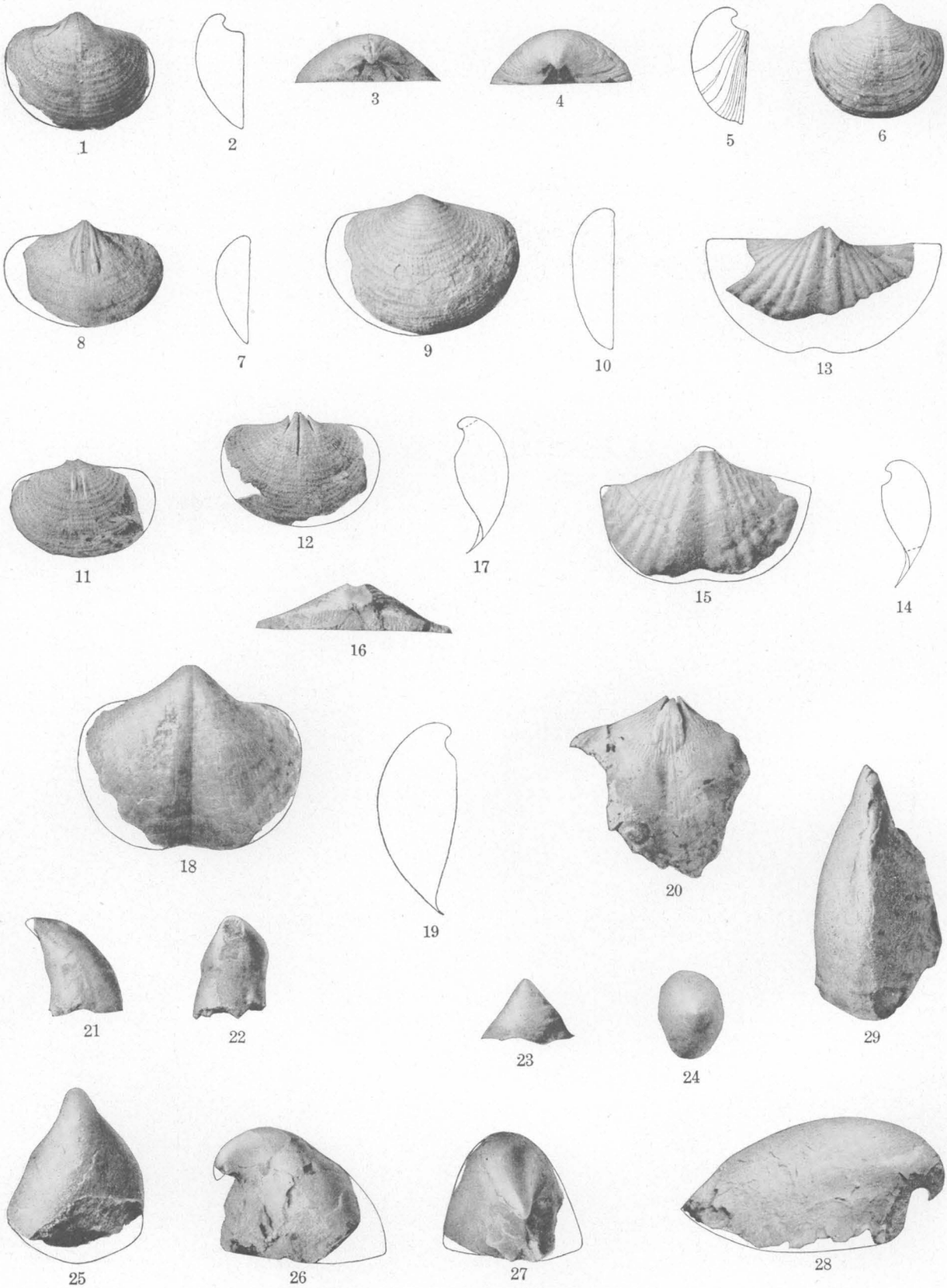
Pseudosyrinx gigas Weller. (p. 91).

Figures 10–12. Cardinal area, anterior surface, and side view of a twisted pedicle valve.

Figures 13–15. Three similar views of a small pedicle valve.
Boone chert, James, Ark. (station 3203).



FOSSILS FROM THE MIDDLE BOONE NEAR BATESVILLE, ARK.



FOSSILS FROM THE MIDDLE BOONE NEAR BATESVILLE, ARK.

PLATE 12

Reticularia setigera Hall var. *internascens* Girty, n. var. (p. 91).

Figures 1–3. Three views of an exfoliated pedicle valve.

Figures 4–6. Three views of a pedicle valve that is not so deeply exfoliated.

Figures 7, 8. A brachial valve which is practically an internal mold and shows the muscular imprints.

Figures 9, 10. A brachial valve that retains most of the shell but has been somewhat flattened by pressure.

Boone chert, James, Ark. (station 3203).

Figure 11. Internal mold of a pedicle valve in chert.

Figure 12. Internal mold of a pedicle valve in chert. The specimen shows well the median septum, the dental lamellae, and the finely hachured surface.

Boone chert, Denieville, Ark. (station 3204).

Spiriferina sp. (p. 93).

Figures 13, 14. Fragment of an exfoliated pedicle valve which retains traces of coarse concentric lamellae and is pierced by rather large and very scarce punctae. Seen from above and side view in outline.

Boone chert, James, Ark. (station 3203).

Figures 15–17. An exfoliated and somewhat broken pedicle valve. The section across the beak shows the presence of a median septum. The surface retains traces of strong concentric lamellae, and scattered punctae can be seen here and there. Seen from above, side view in outline, and cardinal area.

Boone chert, Denieville, Ark. (station 3204).

Spirifer martiniiformis Girty (p. 89).

Figures 18, 19. Two views of a pedicle valve showing the *Martinia*-like shape.

Figure 20. Internal mold of a pedicle valve showing the imprints of well-developed dental plates. The differences in shape and convexity between the specimens, shown by a comparison of Figures 18 and 20, is due to the thickness of the shell which is present in the one and absent in the other.

Boone chert, Denieville, Ark. (station 3204).

Orthonychia ungula Weller (p. 94).

Figures 21, 22. Side view and posterior view of an imperfect specimen preserved as an internal mold.

Boone chert, James, Ark. (station 3203).

Orthonychia undata (Winchell) (p. 94).

Figures 23, 24. Two views of a specimen doubtfully referred to this species.

Boone chert, James, Ark. (station 3203).

Platyceras latum Keyes (p. 95).

Figures 25–27. An imperfect specimen which is an internal mold but for small pieces of shell that still adhere to it. It is represented as seen from above, from the side, and from the posterior end.

Boone chert, James, Ark. (station 3203).

Platyceras oxynotum Girty, n. sp. (p. 95).

Figures 28, 29. The typical specimen, which is in large part an internal mold. The apex is restored from a fragment of the same shell left in the matrix. The specimen is represented as seen from the side and from above.

Boone chert, James, Ark. (station 3203).