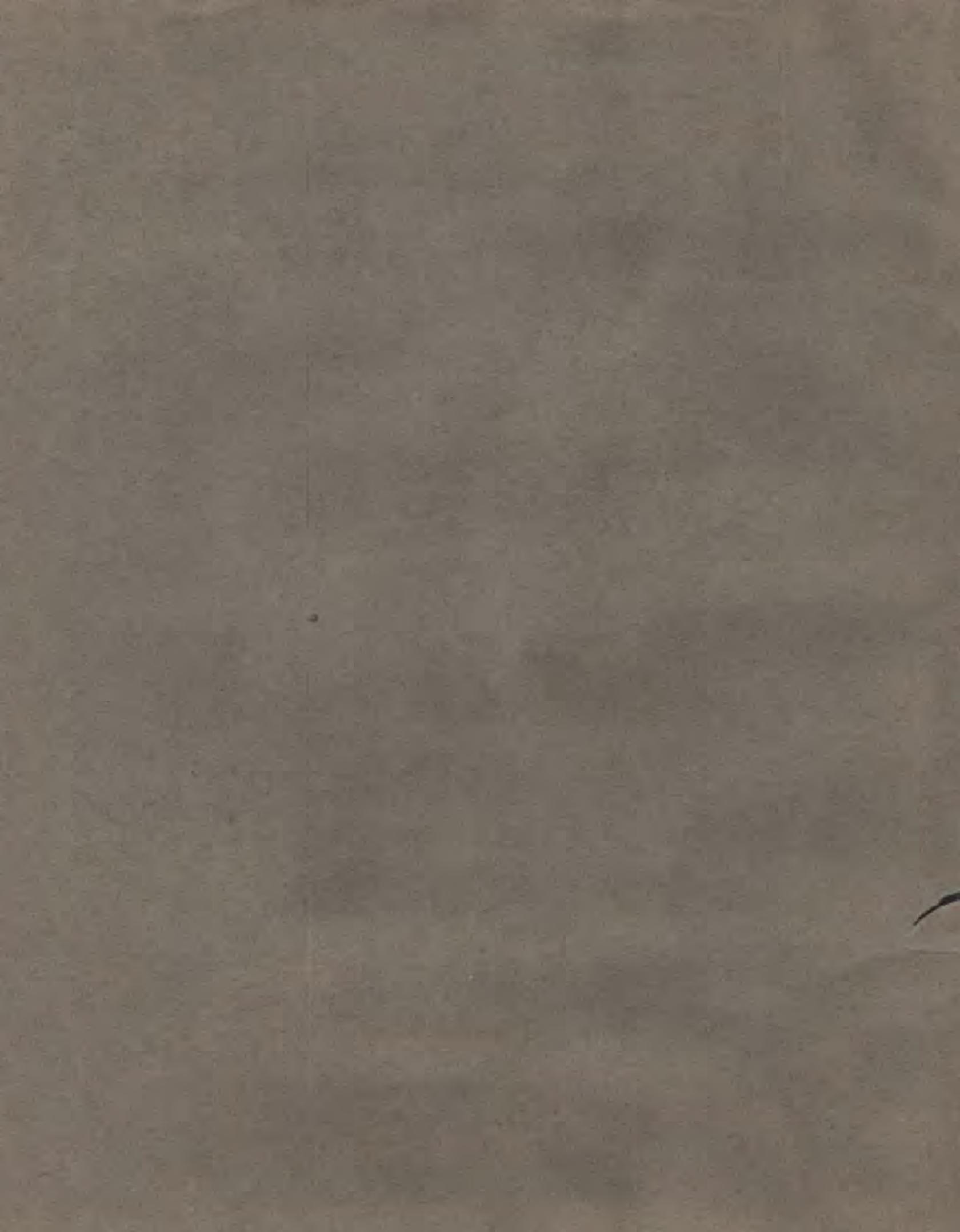


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**STRATIGRAPHY AND FAUNA
OF THE LOUISIANA LIMESTONE
OF MISSOURI**

GEOLOGICAL SURVEY PROFESSIONAL PAPER 203



UNITED STATES DEPARTMENT OF THE INTERIOR

Harold L. Ickes, Secretary

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Professional Paper 203

STRATIGRAPHY AND FAUNA
OF THE LOUISIANA LIMESTONE
OF MISSOURI

BY

JAMES STEELE WILLIAMS

Prepared in cooperation with the
MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES



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STRATIGRAPHY AND FAUNA OF THE LOUISIANA LIMESTONE OF MISSOURI

By JAMES STEELE WILLIAMS

ABSTRACT

The Louisiana limestone (the Lithographic limestone of early Missouri reports) is one of the oldest Carboniferous formations in the upper Mississippi River Valley. Although now generally thought to be of Carboniferous age, it was for some years thought to be of Devonian age, and at the present time some investigators consider it more likely to be Devonian than Carboniferous.

The Louisiana limestone occurs at the surface only in north-eastern Missouri and in the central part of western Illinois. Subsurface data show that it does not extend underground far beyond the area in which it crops out. Throughout most of its extent, it is underlain conformably by the Saverton shale, here considered also of Carboniferous age, but at some places in Illinois it rests on Devonian rocks. It is overlain at most localities in Missouri by the Hannibal shale, but in some places in Illinois it is overlain unconformably by the Glen Park formation. There are thus unconformities both above and below it.

The formation is typically composed of dense to "lithographic," blue to gray limestone beds ranging from 2 to 18 inches in thickness and separated by 1/2-inch to 2-inch brown dolomitic clay partings. It includes, however, a few inches of yellow-brown limy mudstone or soft clayey and dolomitic limestone below the hard limestone beds. In places, the upper part of the formation is very dolomitic. Stratigraphic sections give the thickness and lithologic composition of the formation at various places; and thin sections and chemical analyses show the mineral and chemical compositions of selected specimens.

Although the fine texture and composition of the Louisiana limestone suggest its adaptability for use as lithographic stone and although some of it was satisfactorily used for lithographic stone about 1880, it is not quarried at present, mainly because of the difficulty in obtaining sufficiently large blocks and because the use of stone in lithography has greatly decreased. The Louisiana limestone is suitable for many types of highway construction, and, locally, for limited use in the manufacture of portland cement. It has been used as a source of lime for mortar and for soil sweetening. It is a source of building stone for certain types of rough masonry and concrete mass work. It is not used extensively for any of these purposes because other limestones occurring in the same general area are more uniformly suitable and can be obtained at less cost. Considerable quantities of Louisiana limestone, however, are used as riprap and rubble along the Mississippi River.

The fauna of the Louisiana limestone has a wide biologic range, nearly all the invertebrate classes commonly occurring in Carboniferous rocks being represented in it. Some classes, especially the brachiopods, include a wide variety of species. Interesting features of the fauna are the large number of small individuals, both dwarfs and normally small species; the presence of color patterns on a trilobite and possibly on two brachiopods; and the presence of many forms whose biologic positions and relationships are very little known.

Fossils of nearly all classes are more abundant in the yellow-brown mudstone and in the clay partings than in most limestone

beds. They are very rare in the dolomite beds. There seems little indication of pronounced ecological preferences between the classes or genera in the relations of their occurrence to different types of sediments, except that the pelecypods and the *Conularias* seem to have lived best under ecological conditions represented in part by a muddy substratum. Several species of pelecypods and of *Conularia* are restricted to the yellow-brown limy mudstone.

The age assignment and correlations of the Louisiana limestone here adopted or proposed are based largely on its invertebrate fauna, but stratigraphic relationships and other data are also considered. The assignment of the Louisiana to the Carboniferous period rather than to the Devonian period is thought to be amply justified by the existing invertebrate evidence, but the difficulties involved in definitely assigning it to either period are recognized and discussed. Correlation of the Louisiana with other formations of Kinderhook (lower Mississippian) age in Missouri, with formations at the type Kinderhook section at Kinderhook, Ill., and with beds exposed in the classic Kinderhook exposures at and near Burlington, Iowa, are discussed in the text. The occurrences of Louisiana species in Carboniferous formations in other States and in Europe are mentioned and their possible significance considered. The Louisiana limestone is probably the equivalent of part of the lower Avonian of Great Britain, part of the Tournaisian (lower Dinantian) of western continental Europe, part of the Lower Carboniferous of the U. S. S. R., and of other beds generally correlated with them.

The fauna of the Louisiana limestone did not originate from Upper Devonian faunas in Missouri but migrated from an eastern area. Possible courses of the migration as well as possible locations of land areas and areas of marine deposition are illustrated by six sketches (pl. 5) based on structural, faunal, ecologic, stratigraphic, and lithologic data as now known and currently interpreted.

The dense "lithographic" texture and the thinness of most of the limestone beds of the Louisiana, their alternation with thinner beds or "partings" of yellow-brown calcareous and dolomitic clay, the relatively large number of small fossils, and the greater abundance of fossils in the clay partings, suggest that the Louisiana limestone was deposited in an unusual environment. The writer concludes that the Louisiana limestone may have originated in an intermittently enclosed or partly enclosed basin in warm, shallow, little agitated waters; that the deposition of the dense limestone beds was rather rapid; that environmental factors frequently and regularly changed to halt the deposition of dense limestones and to initiate the deposition of dolomite or dolomitic clay which now forms the partings; that the waters were frequently more concentrated than normal sea water; and that the high concentration limited the size to which many species could grow.

Eighty species of invertebrate fossils are described in the systematic part of the report and all but two are illustrated. The species are described under the following classes and genera:

Spongiae, *Leptodiscus*; Anthozoa, *Neozaphrentis*, *Plumalina*, *Microrcyathus*, *Conopoterium*; Chaetopoda, *Conularia*, *Spirorbis*, *Cornulites*; Blastoidea, *Mesoblastus*?; Crinoidea, *Platycrinus*, *Allagecrinus*, *Poteriocrinus*; Brachiopoda, *Lingula*, *Orbiculoidea*, *Crania*, *Rhipidomella*, *Schuchertella*, *Chonetes*, *Productella*, *Strophalosia*, *Leptalosia*, *Camarophoria*, *Allorhynchus*, *Camarotoechia*, *Paraphorhynchus*, *Rhynchopora*?, *Delthyris*, *Acanthospirina*, *Spirifer*, *Syringothyris*, *Ambocoelia*, *Cyrtina*, *Nucleospira*, *Athyris*, *Camarophorella*, *Selenella*; Pelecypoda, *Grammysia*, *Nucula*, *Palaeoneilo*, "Leda", *Parallelodon*, *Aviculopecten*; Amphineura, *Gryphochiton*?; Gastropoda, *Bellerophon*?, *Bembexia*, *Pleurotomaria*?, *Murchisonia*?, *Loxonema*, *Platyceras*; Cephalopoda, "Orihoceras", *Aganides*, *Protocanites*, *Prolecanites*?; Trilobita, *Proctides*?, *Brachymetopus*, *Proetus*.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

The Louisiana limestone is exposed at the surface only in northeastern Missouri and western Illinois and has been definitely identified in wells only in these two States. It is referred by most geologists to a position near the base of the Kinderhook group, and it is thus one of the oldest of the Mississippian formations of the type Mississippian region. Its fauna, which extends into shales immediately below it, was for 6 years after its discovery generally thought to be Devonian, though in recent years nearly all paleontologists have considered it Mississippian.

The Louisiana limestone has been recognized as a unit for many years, and certain well-known outcrops have been visited by many geologists. The stratigraphy of the formation has not, however, been studied previously in any detail throughout its extent,¹ and except for a report on the fossils from one county in Missouri, the fauna has not been treated as a whole. The present study is an attempt to give a more complete account than has hitherto been available of the stratigraphy and fauna of the formation; to examine briefly its composition and economic possibilities; to determine its relations to other formations of the same approximate age; and to fit it into its logical place in the geological history of the region in which it occurs.

The field work on which this report is based was begun under the auspices of the Missouri Bureau of Geology and Mines² in the summer of 1922. Most of the field season of 1922, the entire field season of 1923, and part of the field season of 1924 were devoted to field studies of the Louisiana limestone. Many outcrops of the formation in Missouri have been visited one or more times since 1924. Three trips of 2 or 3 days each were made into Illinois. The Louisiana limestone was not mapped in detail, but every known outcrop in Missouri was examined, and fossils were collected there from nearly all fossiliferous localities

¹ Since the greater part of the present report was written, R. C. Moore has published an excellent summary of the existing knowledge of the stratigraphy of the lower Mississippian formations in Missouri. Although said by its author to be "essentially reconnaissance in nature," this summary gives many interesting details of the stratigraphy. Its extensive scope, however, prevents detailed treatment of any one formation, and it makes no attempt to describe the faunas.

² Name changed in 1932 to Missouri Geological Survey and Water Resources.

and horizons. The stratigraphic part of the report was completed in 1924, and the descriptions of fossils were essentially completed 3 years later. Many of the fossil descriptions and the chapters on correlation and paleogeography were revised in 1933. A few changes were made in the manuscript in 1937, but no attempt was made to bring all phases of the report up to that date.

ACKNOWLEDGMENTS

The writer has not hesitated to discuss problems raised during this investigation with any interested geologist or paleontologist. As publication of these results has been so long delayed, he has had the opportunity to talk to many investigators and is consequently under obligation to many of them. Obviously it would be impossible to mention all by name. Therefore, the writer wants to take this opportunity to thank all these geologists collectively for their opinions and suggestions, even though some of the suggestions were not followed in this report. The investigators include former colleagues and former students at the University of Missouri, members of the Missouri Bureau of Geology and Mines, fellow members of the United States Geological Survey, and friends in the United States National Museum and in various universities. Several of them are given personal credit in pertinent sections of the report. The writer is especially grateful to H. A. Buehler, Director of the Missouri Bureau of Geology and Mines, for financial help during the investigation and for permission to publish these results elsewhere when it appeared his funds would not be sufficient to publish them, and to the late R. R. Rowley for the loan of many specimens from his very complete collection and for help in finding good exposures and in collecting. Among those not mentioned elsewhere, special thanks are also due Carl O. Dunbar, G. M. Ehlers, Courtney Werner, and the late A. W. Slocum for the loan of type specimens from collections in their charge; W. W. Rubey and the late W. A. Tarr for suggestions at various times regarding structural features and petrologic terminology; W. P. Woodring for criticizing parts of the report; H. S. McQueen for supplying subsurface data; Frederick D. Krueger and Carl and Edwin Branson for assisting the writer in the field; Edwin Kirk, G. A. Cooper, the late A. F. Foerste, M. G. Mehl, A. K. Miller, and Raymond Peck for suggestions regarding species and genera which they had studied or were then studying. Special thanks are due E. B. Branson and the late G. H. Girty. The investigation was suggested by Dr. Branson and, in its original form, approved by him as a thesis for the Ph. D. degree at the University of Missouri. Dr. Girty read and criticized in detail the descriptive paleontology in the report and also gave valued suggestions from time to time. The entire report has been read by J. B. Reeside, Jr., and parts of it have been read by other colleagues of the United States Geological Survey.

Most of the photographs were made by the University of Missouri Photographic Service and retouched by Miss Coral Fleenor. Photographs of thin sections of the Louisiana limestone were made by M. I. Goldman and the writer. W. G. Schlecht aided in many phases of the office work.

PREVIOUS WORK

The Louisiana limestone was first mentioned in geological literature by Swallow,³ who described a "pure, fine, compact, even-textured siliceous limestone," which he called the †Lithographic limestone⁴ "from its evident adaptation to lithographic purposes." He placed it at the base of the so-called Chemung group (Devonian) in Missouri and identified it "at numerous localities from Marion, along the eastern border of the belt occupied by the upper members of this system, to Green county." In his reports on Marion and Cooper Counties,⁵ published in the same volume, Swallow gave localities in those counties at which he had found exposures. Meek⁶ followed Swallow in placing the †Lithographic limestone in Swallow's Chemung group and reported it from Moniteau County.

In 1861, Meek and Worthen⁷ proposed the name Kinderhook "for the beds between the Black slate and the Burlington limestone," which included the formations in Swallow's Chemung group of Missouri. This name was proposed because there was "a general dissimilarity in specific characters" among the fossils from the Chemung of New York and the Kinderhook of the West, which indicated that the Kinderhook group should be classed as Carboniferous. The name Kinderhook came from the town of Kinderhook, Pike County, Ill., near which the rocks of this group are well exposed.

In his report on the Geology of Wright County, published in 1873, Shumard⁸ placed the so-called Chemung group, consisting of the †Vermicular sandstone and shales and the †Lithographic limestone, in the Carboniferous system.

Broadhead,⁹ in his report on the general geology of Missouri, published in 1874, proposed that "those beds called Chemung in 1855 by Swallow and also by James Hall in his Iowa Report, since called the Kinderhook group by Worthen in his Illinois report and also by White in his Iowa report" be called the Chouteau group,

as the group is much thicker and better exposed in Missouri and as the Chouteau limestone is the chief formation in the group. The †Lithographic limestone was the basal member of Broadhead's Chouteau group, and he reported it from Pike, Ralls, St. Clair, Cedar, and Green Counties. He noticed, however, well-marked lithological differences between the †Lithographic limestone of southeastern Missouri and the †Lithographic limestone of northeastern Missouri.¹⁰

In 1892, Keyes¹¹ suggested that Swallow's †Lithographic limestone be called the Louisiana limestone, as the formation was "exposed best perhaps at Louisiana, in Pike County, Missouri" and as its lithographic texture did "not extend throughout its entire range."

The first doubt that the so-called Louisiana limestone in southwestern Missouri was not equivalent to the Louisiana formation in northeastern Missouri was expressed in 1894, when Winslow¹² quoted R. R. Rowley as saying of the so-called Louisiana limestone of southwestern Missouri that "it is undoubtedly a member of the Kinderhook or Chouteau stage and as it underlies the vermicular shale, the inference is that this lower limestone is the Lithographic (Louisiana): but the fossils here bear a stronger resemblance to the forms of Chouteau limestone which belongs above the vermicular."

In his report on the Paleontology of Missouri, also published in 1894, Keyes¹³ mentioned a difference in the lithology of the Louisiana limestone of northeastern Missouri and the so-called Louisiana limestone of southwestern Missouri and remarked that the stratigraphic relations of the Louisiana limestone "are for the most part uncertain." In 1898, Shepard¹⁴ still called a limestone at the base of the Kinderhook group in southwestern Missouri the Louisiana limestone, but in 1900, Keyes¹⁵ stated that the so-called Louisiana limestone of southwestern Missouri was "not thought to be the same" as the Louisiana limestone of northeastern Missouri.

In 1901, Weller,¹⁶ from a study of the faunas of the Kinderhook group in southwestern Missouri, concluded that the so-called Louisiana limestone of southwestern Missouri could not be correlated with the Louisiana limestone in northeastern Missouri and that each represented an accumulation in a relatively restricted area.

In 1908, R. R. Rowley¹⁷ described the Louisiana limestone of Pike County and described and figured its

³ Swallow, G. C., The First and Second Annual Reports of the Geological Survey of Missouri, pp. 105-106, 1855.

⁴ A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U. S. Geological Survey.

⁵ Swallow, G. C., Scientific geology of Marion County: Idem, p. 177, Cooper County: Idem, p. 196.

⁶ Meek, F. B., Report on Moniteau County: Idem, pt. 2, p. 103.

⁷ Meek, F. B., and Worthen, A. H., Note to the paper of Meek and Worthen on the age of the Goniatite limestone: Am. Jour. Sci., 2d ser., vol. 32, p. 288, 1861.

⁸ Shumard, B. F., Geology of Wright County: Report of the Geological Survey of the State of Missouri, 1855-1871, pp. 205-212, 1873.

⁹ Broadhead, G. C., Report of the Geological Survey of the State of Missouri, including field work of 1873 and 1874, p. 26, 1874.

¹⁰ Broadhead, G. C., Cedar County: Idem, p. 66, 1874.

¹¹ Keyes, C. R., The principal Mississippian section: Geol. Soc. America Bull. vol. 3, p. 289, 1892.

¹² Winslow, Arthur, Lead and zinc deposits: Missouri Geol. Survey, vol. 7, p. 394, 1894.

¹³ Keyes, C. R., Paleontology of Missouri, pt. 1: Missouri Geol. Survey, vol. 4, pt. 1, pp. 51-52, 1894.

¹⁴ Shepard, E. M., A report on Greene County: Missouri Geol. Survey, vol. 12, p. 49, 1898.

¹⁵ Keyes, C. R., Kinderhook stratigraphy: Jour. Geology, vol. 8, p. 318, 1900.

¹⁶ Weller, Stuart, Correlation of the Kinderhook formations of southwestern Missouri: Jour. Geology, vol. 9, No. 2, p. 147, 1901.

¹⁷ Rowley, R. R., The geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, 1908.

fauna. His is the most complete paper on the formation, but it does not take into account the exposures elsewhere in Missouri. Weller,¹⁸ in 1914, figured and described the then known brachiopods of the formation. In a paper on the Chouteau limestone, published in 1916, Keyes¹⁹ stated that the Louisiana limestone was beneath the Chouteau limestone in central Missouri, but Branson²⁰ has collected typical Chouteau fossils from these beds. In 1918, Branson²¹ gave a short description of the formation and also limited its outcrops to Pike, Marion, and Ralls Counties in northeastern Missouri, which are the only counties in Missouri in which the writer has found it. Since the field work for this report was finished, the Louisiana has been incidentally described in a report by Krey²² on the structural geology of an area along the Mississippi River north of St. Louis, and it has been described and its known faunas listed in a report by Moore²³ which has as its main object the regional correlation of the lower Mississippian formations of Missouri.

STRATIGRAPHY

GEOLOGIC POSITION OF THE LOUISIANA LIMESTONE

The Mississippian rocks of Missouri are commonly divided into four groups—the Kinderhook at the base, the Osage, the Meramec, and the Chester. The Louisiana limestone is here included in the Kinderhook group. It occurs only in northeastern Missouri and western Illinois. Its position with regard to other formations in the Kinderhook group in northeastern Missouri and to other Mississippian formations is shown below in tabulated form. The generalized composite columnar section (fig. 7) shows its relations to overlying and underlying formations.

Mississippian formations of northeastern Missouri

Chester group (if present, in small areas only).

Meramec group:

- Ste. Genevieve limestone.
- St. Louis limestone.
- Spergen limestone.
- Warsaw shale.

Osage group:

- Keokuk limestone.
- Burlington limestone.

Kinderhook group (as exposed in northeastern Missouri):

- Chouteau limestone.
- Hannibal shale.
- Louisiana limestone.
- Saverton shale.

Mississippian or Upper Devonian:

- Grassy Creek shale.

Other formations of the Kinderhook group than those listed above occur in central, southeastern, and southwestern Missouri, and the relations between these formations and the Louisiana limestone are discussed in more detail on pages 43-46.

RELATION TO UNDERLYING ROCKS

The Louisiana limestone is underlain throughout its extent in Missouri by mudstones, shales, and sandstones here referred to the Saverton shale. In Illinois it is said to rest on shales designated by various geologists as Saverton, Grassy Creek, and Sweetland Creek, and Krey²⁴ reports that it rests directly on Devonian rocks near Hardin.

At most places in Missouri the Saverton is a blue mudstone whose average thickness is about 2 feet, but in some places it is a blue shale, and at two localities in southeastern Pike County thin beds of sandstone are tentatively referred to it. The mudstones now placed in the Saverton were included in the Grassy Creek shale, as originally defined by Keyes, and several investigators²⁵ still include them in it, refusing to recognize the Saverton as a distinct formation. The writer, himself, has doubted the advisability of giving it formational rank, largely because the type locality affords no satisfactory contact between it and the Grassy Creek shale as restricted by Keyes and because it is not evident just what beds Keyes meant to include in his Saverton. He suggests in his original description that the Saverton shale "probably attains a maximum thickness of at least 75 feet" and others have said that it was about 70 feet thick at the type locality. Only 36 feet of mudstones and shales occur beneath the Louisiana and above the Silurian in the good exposures about 1 mile south of the type locality. Although it is not clear how many feet of the mudstones and shales Keyes included in the Saverton at the type locality, there is no doubt as to which beds he intended to include in it at Louisiana, Mo. The mudstones of the Saverton here, as indeed in most places in Missouri, can be sharply distinguished by their lithology from the black beds of the Grassy Creek (restricted). They contain also a fauna that is quite distinct from that of the black beds. It appears to the writer that for the reasons cited the Saverton

²⁴ Krey, Frank, *op. cit.*, p. 34, 1924.

²⁵ Three papers that have recently appeared, here listed, propose to use the name Grassy Creek in three different ways. Branson, E. B. and Mehl, M. G., *Conodonts from the Grassy Creek shale of Missouri: Missouri Univ. Studies*, vol. 8, No. 3, pp. 171-184, 1933; Greger, D. K., *Inarticulate brachiopods from the Grassy Creek shale of Pike County, Missouri: Am. Midland Naturalist*, p. 110, 1935; Weller, J. M., "Grassy Creek" shale: *Illinois State Acad. Sci. Trans.*, vol. 28, No. 2, pp. 191-192, 1935. Branson and Mehl would designate as Grassy Creek all the shales included in this paper in the Saverton and Grassy Creek formations. Greger would restrict Grassy Creek to Ordovician shales. Weller would drop the name Grassy Creek and refer both shales to the Saverton. The writer believes that the shales should be differentiated because in most places they are distinct lithologically and faunally and may not belong to the same period. Despite the fact that most of the shale exposed at the place taken by many to be the type locality of the Grassy Creek is probably Ordovician, general usage has for some years been to designate the black shales of Mississippian or Upper Devonian age as Grassy Creek, and as Keyes' designation of a type locality is uncertain and mentions two places, it seems in order for someone to designate a type locality that will conform to generally accepted usage.

¹⁸ Weller, Stuart, *The Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon.* 1, 1914.

¹⁹ Keyes, C. R., *Terranal affinities of the original Chouteau limestone: Iowa Acad. Sci. Proc.*, vol. 23, pp. 113-118, 1916.

²⁰ Branson, E. B., *A geologic section from 40 miles west of St. Louis County to Jackson County, Missouri: Am. Jour. Sci.*, 4th ser., vol. 49, 1920.

²¹ Branson, E. B., *Geology of Missouri: Univ. of Missouri Bull.*, vol. 19, No. 15, p. 65, 1918.

²² Krey, Frank, *Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Missouri Bur. Geology and Mines*, 2d ser., vol. 18, 86 pp., 18 pls., 1924.

²³ Moore, R. C., *Early Mississippian formations in Missouri: Idem*, 2d ser., vol. 21, 283 pp., 13 pls., 2 figs., 1928.

should probably be distinguished from the Grassy Creek.

The lower contact of the Louisiana formation is here drawn at the base of a 1- to 2-inch bed of yellow-brown calcareous magnesian mudstone or very argillaceous limestone that at the type locality occurs below the alternating series of dense blue limestones and thin dolomitic clay partings that comprise the main part of the Louisiana limestone. This thin bed has been included in the Louisiana limestone by many investigators but has recently been included in the underlying Saverton mudstone and shale sequence by others. Chemical analyses of a specimen from this bed (see p. 27) show that it is very calcareous and should perhaps be classed as a very argillaceous soft limestone or as a marl, if that term is used in a broad sense. These analyses show also that it contains magnesium. Examination of its powder shows crystals of dolomite. It contains essentially the same fauna as the beds above, and its yellow-brown color is similar to that of the dolomitic clay partings between the limestone beds above. It does, however, grade into the underlying mudstone in some places. To the writer it appears to be the initial deposit of a series of yellow-brown calcareous and dolomitic clay and mudstone partings alternating with dense blue limestone beds, and because of this and its faunal and lithologic resemblance to the partings above, it is here included in the Louisiana limestone.

The gradational nature of the lower contact of the Louisiana as thus defined is shown by the occurrence of many Louisiana species in the Saverton mudstones and by the merging of the yellow-brown calcareous and argillaceous bed into these mudstones. There appears to have been no break in deposition between the Saverton and Louisiana in Missouri. The unconformity in Illinois where the Louisiana rests on the Devonian is probably an overlap.

The paleontologic relations between the different parts of the Louisiana and the underlying Saverton are shown in the tables on pages 32-33. The nature of the Saverton at various localities is shown in the local sections, pages 16-25.

RELATION TO OVERLYING ROCKS

Wherever observed in Missouri the Louisiana is overlain by beds either definitely or tentatively referred to the Hannibal shale. In Illinois it is overlain by beds that have rather recently been included in the Glen Park formation. At most localities in the eastern part of its area of outcrop in Missouri the blue and green shales of the Hannibal rest on the uppermost beds of the Louisiana.

At most localities in western Pike, Ralls, and Marion Counties, however, the Louisiana is directly overlain by very thin "wavy" beds of dolomite and sandy argillaceous limestone, which lie below the green and blue-black shales of the Hannibal. They are here included

in the Hannibal because they overlie unconformably typical Louisiana limestone in southwestern Marion County (see section at locality 552, p. 24). These "wavy" beds are unfossiliferous in Marion County and contain no distinctive fossils at sparsely fossiliferous localities in northwestern Ralls and central Pike Counties. In Ralls County (see section at locality 526, p. 22), they include at least one bed of oolite and some thicker beds of dolomite, and in Marion County some white and brown dolomites and beds of limestone that has a mottled appearance. These thin "wavy" beds are quite different in appearance from the dolomites in the top of the Louisiana at Hannibal and other places in the northern part of the area of outcrop of the Louisiana. They resemble more closely beds in Illinois that were formerly included in the Hannibal but are now referred to the Glen Park. Diagnostic Glen Park fossils have not, however, been found in them.

At all localities in Illinois visited by the writer the Louisiana limestone is overlain by dolomites, sandy shales, calcareous sandstones, and oolites referred to the Glen Park. The Louisiana has, however, been reported to be directly beneath the Hannibal shale in some places in Illinois, and a section taken in the southern portion of Hamburg, Ill. (see p. 25), shows that the Glen Park is there unconformable on the Louisiana. At this locality the upper beds of the Louisiana have been eroded to an irregular surface containing channels and depressions ranging from a few inches deep and a few inches wide to as much as 24 inches deep and 20 to 30 inches wide at the top. These channels and other cracks in the Louisiana have been filled with soft shaly sandstone and thin dolomitic limestones of the Glen Park. In one part of the exposure pebbles and blocks of Louisiana limestone occur in a matrix of thin shaly sandstones. The relations at this locality are shown in figure 1. The pres-

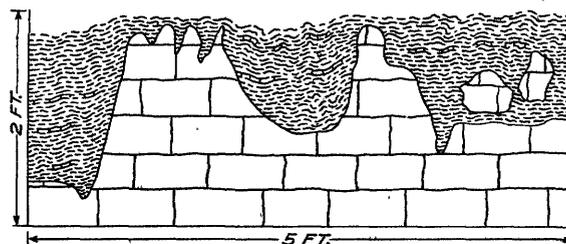


FIGURE 1.—Sketch showing relations between the Louisiana limestone and overlying Glen Park formation at Hamburg, Ill.

ence of an unconformity in Illinois at the top of the Louisiana is further shown by Krey's²⁶ report of a conglomerate of cemented pebbles of Louisiana limestone in the basal part of the Hannibal shale near Rockport, Ill.

The unconformity is not so impressive in Missouri and has been identified at only a few exposures, probably in the main because the actual contact at most

²⁶ Krey, Frank, *op. cit.*, p. 36.

localities is visible only for short distances, if it can be seen at all; in part because the erosion depressions are shallow, suggesting only a short period of erosion; and in part because it has not been possible to establish thin zones in the basal part of the Hannibal or in the upper part of the Louisiana by which a weak unconformity might be detected. The occurrence of beds of dolomite and limestone in the basal part of the Hannibal in western Ralls and Marion Counties suggests, however, that the unconformity may represent a longer erosional interval than other relations have indicated.

The existence of an unconformity in Missouri is, however, well shown in the east face of Lovers Leap at Hannibal, Mo. (see section at locality 635, p. 23). There a bed of dolomite about 22 inches thick is the uppermost bed in the Louisiana. It is underlain by 8 or 10 feet of brown and white lenslike beds of dolomite and dolomitic limestone. At several places along the cliffs at the base of Lovers Leap, erosion has cut channels through the massive layer and into the thinner dolomites. These channels are filled with green and brown shales of the Hannibal. Some of the larger channels are as much as 5 feet deep and 8 or 10 feet across at the top. The diagrammatic drawing, figure 2, and the photograph, plate 2, *B*, show the unconformity between these two formations at Lovers Leap.

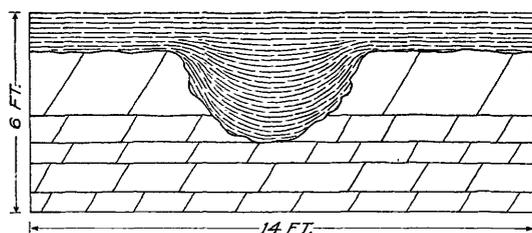


FIGURE 2.—Sketch showing relations between the dolomitic beds in the upper part of the Louisiana limestone and the overlying Hannibal shale along the east face of Lovers Leap, at Hannibal, Mo.

The unconformable relations between the Louisiana and the Hannibal are also suggested by the filling of cracks in the Louisiana limestone with Hannibal shale at locality 599, at the mouth of Buffalo Creek, 1 mile South of Louisiana, Mo.

The unconformity between the Louisiana and the thin "wavy" dolomitic and limestone beds tentatively referred to the Hannibal was observed at only one place. This was at locality 552, in southwestern Marion County (see p. 24). At this locality thin "wavy" beds of dolomite and sandy argillaceous limestone overlie an irregular surface of dense to fine-grained limestone. Irregular "hills" of Louisiana limestone as much as 8 or 10 inches high and 12 to 14 inches long are covered by thin beds of dolomite, which appear to have been deposited to conform to the irregular surface. The basal beds of the overlying "wavy" limestones and dolomites are continuous from lower areas on one side of the "hills," over the "hills," and on to the lower areas beyond. In other parts of the

exposure, the irregular surface is overlain by beds of dolomite that appear horizontal. The relations between the Louisiana and the overlying beds at two places in this outcrop are shown by the diagrammatic drawings (figs. 3, 4). The writer has unsuccessfully

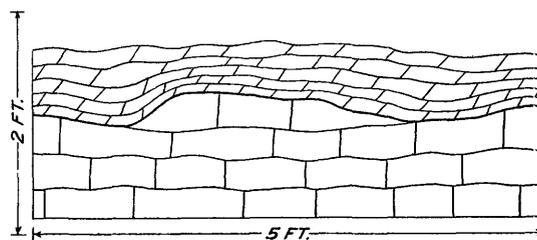


FIGURE 3.—Sketch showing relations between the Louisiana limestone and overlying dolomitic limestone beds tentatively referred to the Hannibal shale, locality 552, Marion County, Mo.

sought to explain these relations by unusual forms of bedding or by secondary dolomitization, and has reluctantly concluded that they represent an unconformity.

Although only the Hannibal and Glen Park directly overlie the Louisiana, other younger formations occur above it in the measured sections. These formations range from slightly younger than the Hannibal shale to as young as the St. Louis limestone. The youngest ones occur only in sections extending a considerable distance above the Louisiana. For most of them, only enough descriptive details are given to show their general character and to allow them to be differentiated. The formations are designated by names thought to represent the most recent usage, but the writer does not accept responsibility for their validity. Some of

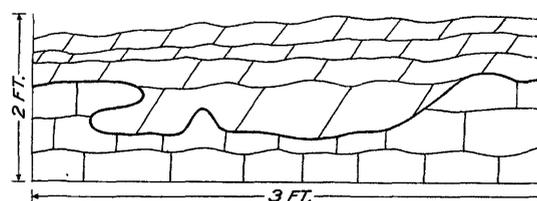


FIGURE 4.—Another sketch from locality 552 showing relations between same beds as shown in figure 3.

these younger formations could not be differentiated at every outcrop. Especially is this true of two of the units, the Sedalia limestone and the Glen Park formation (as used in Illinois). The first has been established and the second recognized in nearby areas since the greater part of the field work was done. This accounts for the designation of certain beds by combined names, such as "Chouteau and Sedalia undifferentiated."

EXTENT AND THICKNESS

The Louisiana limestone is exposed at the surface in Missouri only in Pike, Marion, and Ralls Counties. The generalized areal distribution is given on figure 5. Because of the small scale of the map and the narrowness of the outcrop belt, the width of the Louisiana is exaggerated in most places, and variations in its thick-

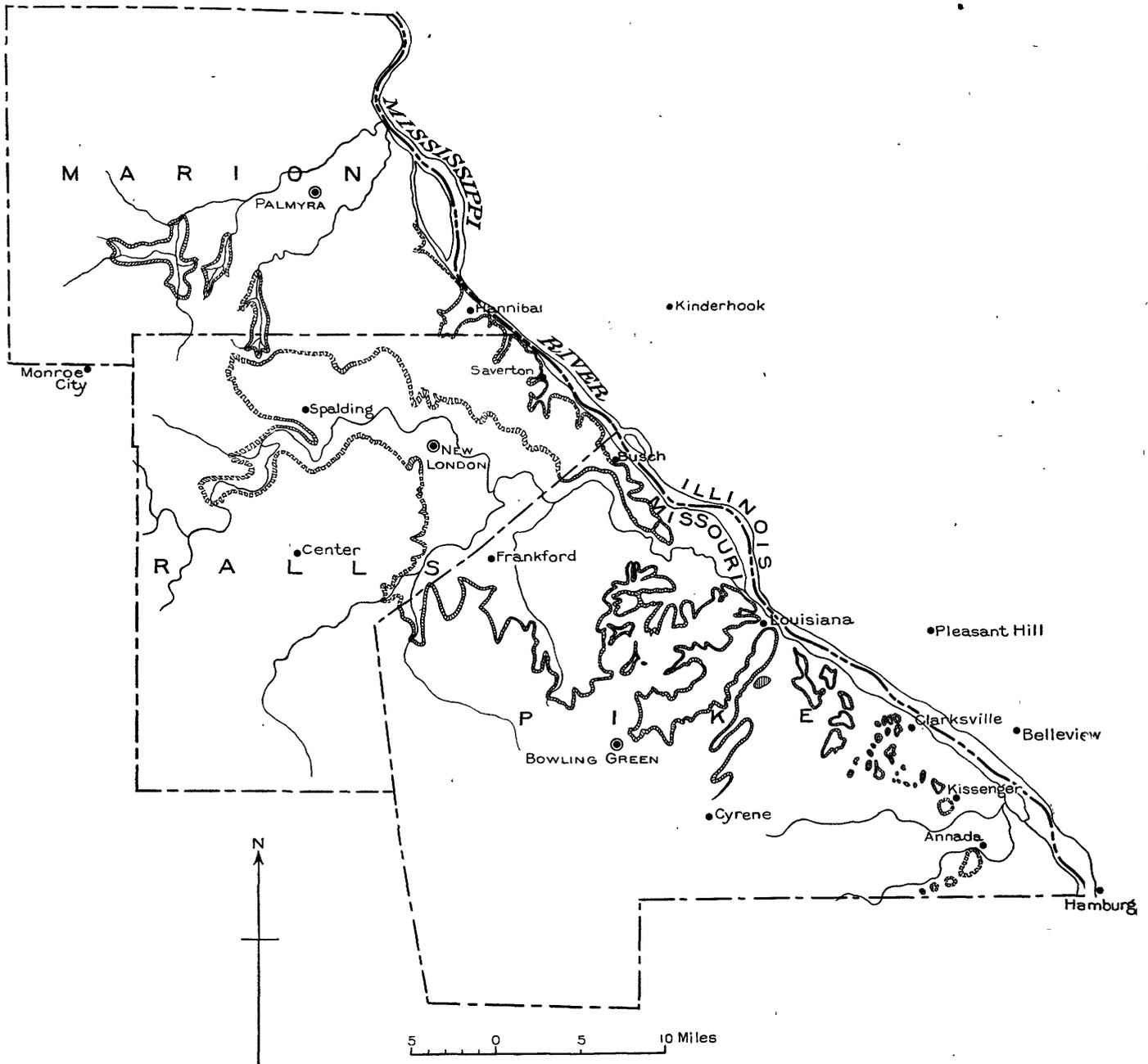


FIGURE 5.—Index map showing areal distribution of the Louisiana limestone at the surface in Missouri. Base from Krey, 1924. The more generalized parts of the outcrop belt are shown by broken lines.

ness cannot be shown. Data for the distribution in Pike County are largely from the geologic map of the county by R. R. Rowley and from field work by the writer. Data for Marion and Ralls Counties are from various sources, including field work by the writer.

In Illinois the surface exposures of the Louisiana limestone are limited to Calhoun, southern Pike, and western Jersey Counties. Its extent under the surface beyond its area of outcrop is not certainly known. Well logs are the only source of information about it, and they are too few and too unreliable for precise results. Their unreliability is in large part due to the occurrence in many logs of two or more shales—the Maquoketa, Hannibal Saverton, or Grassy Creek—in contact, and to the occurrence of dolomites in three distinct stratigraphic units—the Louisiana, the Hannibal, and the Glen Parl. Well logs, as interpreted, and surface outcrops of sections in which it does not occur show that the Louisiana does not extend south of the latitude of southern Calhoun County in Illinois, and of southern Pike County in Missouri. Its westernmost extent is east of an imaginary line extending from central southern Pike County, Mo., northwest through western Ralls and eastern Monroe and Shelby Counties into central Knox County. Its northernmost occurrence is 10 or 15 miles south of the northern boundary of Missouri. Its eastern limit roughly parallels the Mississippi River but the northern part of this limit is nearer the river than the southern part. In no place is it more than 25 miles east of the Mississippi.

The greatest exposed thickness of the Louisiana limestone is in the Mississippi River bluffs near Saverton, Ralls County, in the northeastern part of its area of outcrop (see local section at locality 786). Here a thickness of 54 feet, with the lower contact not exposed, occurs below the Hannibal shale. The Louisiana is shown by outcrops to thin to the west, south, and east from this locality, and because well data show that it also pinches out to the north, it has been aptly described as an elongate lenticular mass. The thinning is not at equal rates in all directions, however, and well data indicate that it is interrupted by an area of increasing thickness to the north. The Louisiana thins very rapidly to the east and northeast of the locality of greatest thickness. To the west, northwest, and southwest it thins less rapidly and to the southeast it thins rather slowly until its thickness has decreased to about 5 feet, and then, Rubey²⁷ reports, it very gradually and very uniformly thins and pinches out, but in doing so maintains a gradually declining thickness of not over 5 feet for about 8 miles. The shape of the Louisiana limestone body is shown on the isopach map, figure 6.

Sources of information used in addition to investigations by the writer in the preparation of the isopach map are as follows:

²⁷ Rubey, W. W., personal communication, 1932.

Exposed sections

- Branson, E. B., The Devonian of Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 17, 1922.
- Krey, Frank, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Missouri Bur. Geology and Mines, 2d ser., vol. 18, 1924.
- Laudon, L. R., The stratigraphy of the Kinderhook series of Iowa: Iowa Geol. Survey, vol. 35, 1929.
- Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, 1928.
- Rowley, R. R., The geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, 1908.
- Swallow, G. C., Geology of Marion County: Missouri Geol. Survey, First and Second Ann. Repts., pp. 171–185, 1955.
- Weller, Stuart, Notes on the geology of southern Calhoun County: Illinois Geol. Survey Bull. 4, pp. 219–233, 1907.
- and St. Clair, Stuart, Geology of Ste. Genevieve County, Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 22, 1928.

Well logs

- Bell, A. H., The Dupo oil field: Illinois Geol. Survey Press Bull. ser., No. 17, 1929.
- The Darmstadt anticline and related structures: Illinois Geol. Survey Press Bull. ser., No. 18, 1929.
- Structure and oil possibilities of the Warsaw area, Hancock County, Illinois: Illinois Geol. Survey Press Bull. ser., No. 24, 1932.
- and Workman, L. R., The Media anticline, Henderson County, Illinois: Illinois Geol. Survey Press Bull. ser., No. 13, 1928.
- Collingwood, D. M., Oil and gas possibilities of parts of Jersey, Greene, and Madison Counties, Illinois: Illinois Geol. Survey Rept. Investigations No. 30, 1933.
- Currier, L. W., Geology of northeastern Adams County: Illinois Geol. Survey Bull. 43, pp. 305–323, 1923.
- Hinds, Henry, U. S. Geol. Survey Geol. Atlas, Colchester-Macomb folio (No. 208), 1919.
- Krey, Frank, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Missouri Bur. Geology and Mines, 2d ser., vol. 18, 1924.
- Lee, Wallace, U. S. Geol. Survey Geol. Atlas, Gillespie-Mount Olive folio (No. 220), 1926.
- McQueen, H. S., personal communications, 1933.
- Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, 1928.
- Mylius, L. A., A restudy of the Staunton gas pool: Illinois Geol. Survey, Extract from Bull. 44, 1919.
- Oil possibilities of the Posten School structure, Monroe County, Illinois: Illinois Geol. Survey Press Bull., 1921.
- Nebel, M. L., Brown County: Illinois Geol. Survey Bull. 40, pp. 21–50, 1919.
- Savage, T. E., and Nebel, M. L., Geology and mineral resources of the La Harpe and Good Hope quadrangles: Illinois Geol. Survey Bull. 43, pp. 9–94, 1923.
- Shaw, E. W., U. S. Geol. Survey Geol. Atlas, New Athens-Okawville folio (No. 213), 1921.
- U. S. Geol. Survey Geol. Atlas, Carlyle-Centrella folio No. 216), 1923.
- Wilson, M. E., The occurrence of oil and gas in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 16, 1922.
- Workman, L. E., The geological columnar section at Monmouth, Illinois, as revealed by the new deep wells: Illinois Acad. Sci. Trans., vol. 19, pp. 300–306, 1926.

The gradual southward and southeastward thinning is shown by measured sections at the following places. At Buffalo Hill, near Louisiana. (local section 599),

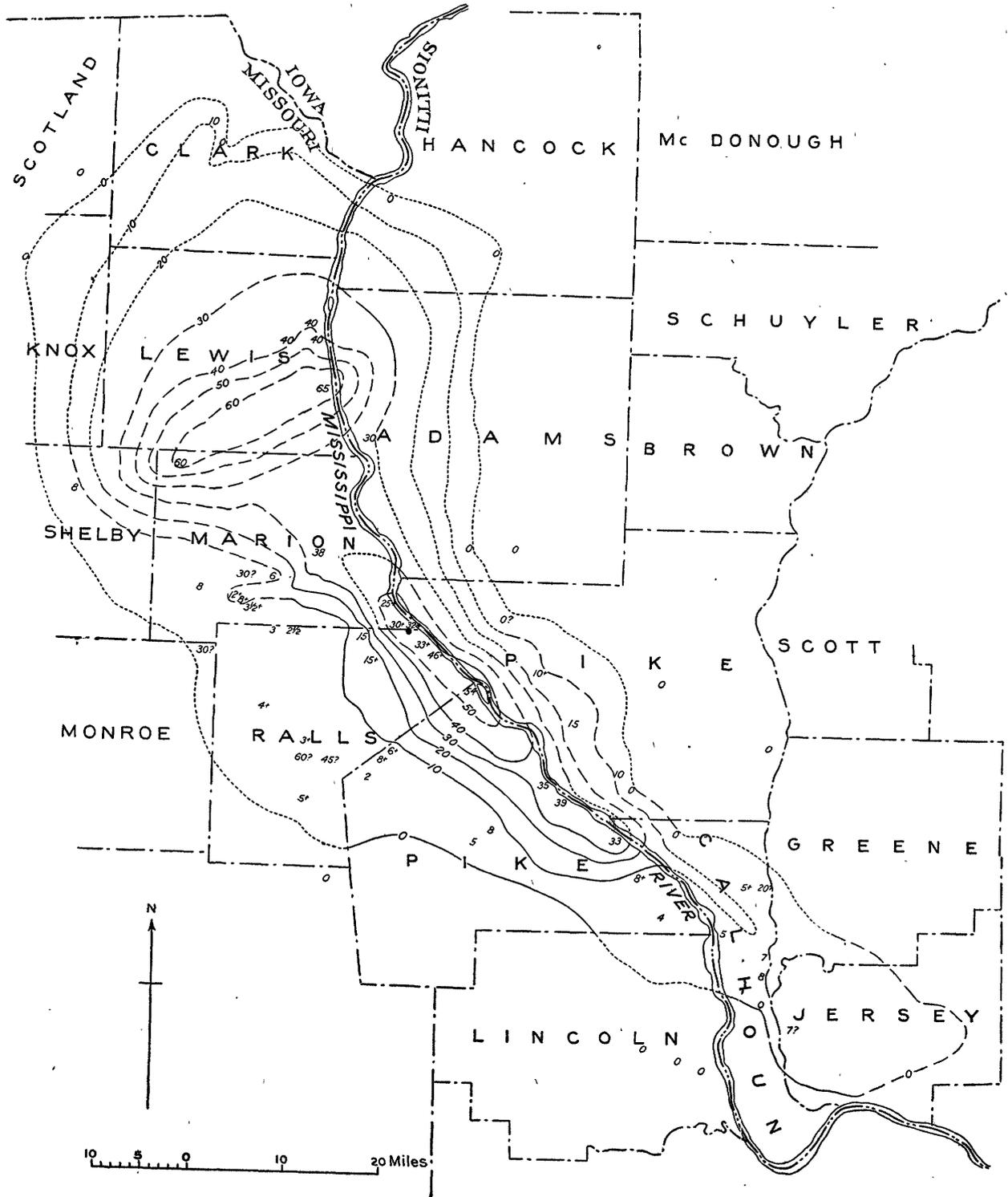


FIGURE 6.—Isopach map showing thickness, in feet, and shape of the Louisiana limestone body. Interpretation is based on outcrop and well data (see p. 8). Solid isopach lines indicate fairly reliable data; dashed lines, less reliable data; dotted lines, very little data. Miscellaneous measurements of thickness are also plotted; some of these are based on well data that conflict with outcrop data or are for other reasons thought to be unreliable. These are disregarded in the writer's interpretation, though plotted for the readers' information.

about 1½ miles south of the thickest section, a complete vertical section of 39 feet was measured. Farther south, at Clarksville (local section 618), the formation is only 13 feet thick. Near Kissenger, about 5 miles south of Clarksville (local section 623), a complete section is not exposed, but it does not appear to be more than 8 or 10 feet thick. At Annada, near the southern boundary of Pike County (local section 625), only about 3½ feet of the formation is exposed, although it may be thicker. No Louisiana limestone is exposed in Lincoln County, and at Winfield the Hannibal rests directly on Devonian rocks (see local section 502). At Hamburg, Ill., east across the Mississippi River and a few miles south of Annada, Mo. (local section, p. 25), the Louisiana is 5 feet thick. About 3½ miles south of Hardin, Ill., which is about 7 miles southeast of Hamburg, the Louisiana is said to be absent and Hannibal shale rests directly on Devonian limestones.²⁸ Several feet of Louisiana limestone are said by Krey²⁹ to occur at Nutwood, a few miles southeast of this locality, but he reports that it is absent at Grafton, about 11 miles southeast of Nutwood.

It has not been certainly identified in any well log south or southeast of Grafton, and in most of the wells the Hannibal rests either on pre-Mississippian formations or on beds referred with more or less certainty to one of the shale formations that commonly underlies the Louisiana.

The rapid eastward and northeastward thinning is suggested by reports of the absence of the Louisiana at Kinderhook, Ill., about 8 miles northeast of its thickest measured section; at Pleasant Hill, Ill., 20 miles southeast of the thickest section, and about 8 miles east of Louisiana, Mo.; near and north of Bellevue, about 6 miles east of Clarksville, Mo.; and at other places in Pike and Adams counties, Ill. Its absence from Kinderhook and Pleasant Hill, Ill., is reported by Moore,³⁰ who states that it has either pinched out or is buried at Kinderhook, and that it is not present at Pleasant Hill, where the Hannibal rests directly on the Saverton shale, which commonly underlies the Louisiana. Moore is also the authority for the statement that the Louisiana pinches out north of Bellevue. Krey³¹ says that the Louisiana is absent where its horizon is exposed near Bedford, Ill., and that no good exposures have been observed in Illinois farther north than the southern limit of Pike County. No Louisiana has been identified in well logs from Pittsfield, Ill.,³² from near West Point,³³ Ill., or from any locality east or northeast of these places. It does,

however, occur almost throughout the northern four-fifths of Calhoun County, but it is very thin wherever exposed.

The thinning to the southwest and west is shown by both measured sections and well logs. The Louisiana is not over 5 feet thick near Bowling Green, which is about 15 miles south and slightly west of the section of greatest thickness and about 12 miles west of the type locality. Rowley reports³⁴ "less than eight feet" 2 miles northeast of Bowling Green. No Louisiana occurs in sections near Edgewood, a few miles southeast of Bowling Green, and McQueen³⁵ reports that it does not occur in well logs at Vandalia, where the Hannibal rests on sandstones tentatively referred to the Sylamore; at Mexico; or at Centralia. Sections by Branson³⁶ show that it does not occur 3 miles north of Williamsburg, where Pennsylvanian shales rest on Devonian limestones, or in central Montgomery County, where Chouteau limestone rests directly on Devonian limestones.

The Louisiana is not over 5 feet thick in outcrops examined near the northwestern corner of Pike County, about 15 or 20 miles southwest of the thickest section. Rowley³⁷ reports that it is hardly 2 feet thick near Elk Lick post office (sec. 13, T. 54 N., R. 5 W.). The writer measured 5 feet of Louisiana between the Hannibal and Saverton shales along Spencer Creek about 5 miles north of Elk Lick, and it is at least 8 feet thick about 3 miles east of Elk Lick (see local section 799). McQueen³⁸ reports a thickness of 15 feet of Louisiana limestone from a well about 7 miles east of Perry, Ralls County, and 8 miles southwest of Elk Lick (O. E. Smith well, sec. 35, T. 54 N., R. 6 W.). He refers about 5 feet of limestone observed at depths of between 157 and 160 feet in the well of the Center Oil & Gas Co., at Center, Ralls County, to the Louisiana, but it may be thicker there. The formation may also be represented in 45 feet of limestone at its approximate horizon in the well of the Texas Empire Pipe Line Co., (NE¼NE¼ sec. 5, T. 54 N., R. 5 W.), near Center, but other formations also are probably represented in this thickness.

Near New London, about 10 miles directly west of the thickest exposed section, the Louisiana is at least 18 feet thick (NE¼SE¼ sec. 2, T. 55 N., R. 5 W.). Four miles north of New London (NW¼ sec. 24, T. 56 N., R. 5 W., see local section 648) it is more than 15 feet thick. About 8 miles west of New London and 18 miles west of the thickest exposed section (SE¼SW¼ sec. 28, T. 56 N., R. 6 W.), along a tributary to Salt River about 1½ miles west of Spalding, it is about 4 feet thick. Its exposed thickness along Salt River, 3

²⁸ Weller, Stuart, Geology of southern Calhoun County: Illinois State Geol. Survey Bull. 4, p. 228, 1907.

²⁹ Krey, Frank, op. cit., p. 35.

³⁰ Moore, I. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 55, 1928.

³¹ Krey, Frank, op. cit., p. 35.

³² Krey, Frank, op. cit., p. 78.

³³ Krey, Frank, op. cit., p. 76.

³⁴ Rowley, R. R., Geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 30, 1908.

³⁵ McQueen, H. S., personal communication, 1933.

³⁶ Branson, E. B., The Devonian of Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 17, pp. 23-29, 1922.

³⁷ Rowley, R. R., op. cit., p. 30.

³⁸ McQueen, H. S., personal communication, 1933.

miles farther west and 5 miles south (see local section 545) is also about 4 feet.

The northwestward thinning, and the thinning, thickening, and thinning northward from the thickest exposed section are also shown by outcrops and well logs. Near Hydesburg, about 12 miles northwest of the thickest exposed section (see local section 772), the Louisiana is at least 15 feet thick. In its northwesternmost exposures between Warren, in southwestern Marion County, and Rensselaer, in northwestern Ralls County (see local sections 526, 552, 592, 728, 733), it varies in thickness, but the writer has not seen it over 12 feet thick. In average sections it ranges from 2 feet 6 inches to 8 feet. McQueen³⁹ states that it is 8 feet thick in the J. H. Moore well (sec. 10, T. 59 N., R. 10 W.) near Bethel, Shelby County, and Krey⁴⁰ refers 60 feet of limestone in the log of the Mohr well, near Nelsonville, northwestern Marion County, to it. No undisputed Louisiana limestone has been definitely recognized in wells farther northwest, although its horizon has been penetrated in wells at Baring, northern Knox County; Gorin, southeastern Scotland County; and at other places. It probably does not extend that far northwest.

In an incomplete section near Saverton, about 6 miles north of the 54-foot section (see local section 641), 46 feet of Louisiana limestone is exposed. The topography indicates that this exposure represents very nearly the full thickness of the Louisiana limestone at this locality. Near Hannibal, still farther north (see local section 635), the greatest thickness measured was 37 feet, but the bottom is not exposed. Data on thicknesses beyond a point 2 miles north of Hannibal are available only in well logs. At Palmyra, about 6 miles north and 7 miles west of Hannibal, 25 feet of Louisiana limestone has been reported from wells by Krey.⁴¹ Krey also reports a thickness of 30 feet from a well near Quincy. McQueen⁴² notes the occurrence of 65 feet of "soft rock" in the W. H. Thomas well at La Grange, Mo., which may be the Louisiana or may include it. Still farther north, at Canton, the Louisiana is 50 feet thick according to Moore.⁴³ Moore also reports that it is 62 feet thick at Warsaw, Ill., but Bell⁴⁴ refers these beds to the Hannibal and reports the Louisiana absent there. It has not been definitely identified in a well that crosses its horizon at Kahoka, Mo., about 18 miles northwest of Warsaw. McQueen⁴⁵ states that a thick section in the log of the well of the Missouri Condensed Milk Co. at Kahoka probably represents the time of deposition of formations from the

Maquoketa shale to the Hannibal shale. About 10 feet of limestone observed by McQueen in cuttings from the Harkness well, a few miles northwest of Kahoka, may represent the Louisiana. The Louisiana is said by Moore⁴⁶ to be absent at Fort Madison, Iowa, and it has not been recognized in well logs or outcrops at Burlington, Iowa, or at any other localities north of Kahoka.

The extent of the Louisiana and its approximate thickness at various places in its area of outcrop and in areas where well logs showing it are available is shown on the isopach map, figure 6. Detailed sections, showing the thickness at various places in the area of outcrop are given on pages 13-25.

LITHOLOGIC FEATURES

The Louisiana limestone is typically composed of dense blue to gray limestone beds separated by brown dolomitic clay partings, but it includes a few beds of yellow-brown calcareous mudstone or soft argillaceous limestone below the hard limestone beds. The typical composition and stratigraphic relations are shown in figure 7, in which the Louisiana lies directly below the Hannibal shale and directly above the Saverton shale. Though not shown on figure 7, it is at some places overlain by the Glen Park formation and at a few places directly underlain by Devonian limestones. In figure 7 it appears as if the lowest beds of the Louisiana are of the same age everywhere, though it is not very likely that they are exactly contemporaneous throughout the area of outcrop. This construction, therefore, probably overemphasizes the unconformity at the top of the Louisiana. A characteristic exposure at the type locality is shown on plate 1, *A*. The lower part of the formation is shown on plate 1, *B*, *C*, and the upper part on plate 2.

The limestone beds of the Louisiana range from 2 to 18 inches in thickness, but have an average thickness of about 6 inches; and the clay partings in most places range from ½ inch to 2 inches in thickness. At some places, the Louisiana includes very argillaceous yellow-brown dense limestone beds, and elsewhere beds of dolomite are numerous in its upper part. The dense, blue limestone, which is typical and widespread, weathers to a dove to white color, and breaks with conchoidal fracture. Owing to its dense texture, it has been used as a lithographic stone. The lowest limestone bed is commonly about 15 inches thick and dense, but in some areas in western Marion County, it is thin and crystalline. The formation is generally dolomitic near the upper contact, especially in exposures north of the type locality.

In Marion County and in the northern part of Ralls County, the upper part of the formation is composed of beds of brown argillaceous dolomite separated by

³⁹ McQueen, H. S., personal communication, 1933.

⁴⁰ Krey, Frank, op. cit., p. 69.

⁴¹ Krey, Frank, op. cit., p. 68.

⁴² McQueen, H. S., personal communication, 1933.

⁴³ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, vol. 21, 2d ser., p. 45, 1928.

⁴⁴ Bell, A. H., Structure and oil possibilities of the Warsaw area, Hancock County, Illinois: Illinois Geol. Survey, Press Bulletin ser., No. 24, p. 2, 1932.

⁴⁵ McQueen, H. S., personal communication, 1933.

⁴⁶ Moore, R. C., *idem*, p. 45.

thin beds and lenses of limestone. This dolomitic phase is probably the result of thickening of the dolomitic clay partings at the expense of the limestone beds. Locally in Ralls and Marion Counties thin dolomitic limestone beds occur only at 2- to 3-foot intervals in the upper part of the formation, and they are separated

The dolomitic clay partings range from ½-inch to 2 inches in thickness in Pike County, but they are much thicker in the upper part of the formation in Ralls and Marion Counties. In the lower part of the formation the partings have about the same thickness in Ralls and Marion Counties as in Pike County. Where weathered the partings are of soft clay, but where unweathered they are of hard yellow-brown argillaceous dolomite, which is commonly speckled with small particles of limonite. At some places hard dolomitic partings grade laterally into soft clay partings, the partings thicken and thin in short distances. They are continuous in most places, but at some exposures they are merely lenses of clay. Masses of crystalline calcite occur at some places between the limestone beds, and where these occur the clay partings are absent or inconspicuous.

Geodes and masses of crystalline calcite are common in the dolomitic facies of the Louisiana in Ralls and Marion Counties and occur in the partings or in the limestone beds at most localities. Some of the geodes have diameters of more than 1 foot, but most of them are about 2 or 3 inches in diameter. Stylolites are rare, but specimens containing stylolites were collected along Grassy Creek in Pike County.

A yellow-brown sandy calcareous mudstone or soft clayey limestone bearing the same fauna as the limestone beds can commonly be recognized at the base of the Louisiana and above the blue mudstones of the Saverton, though at some places it cannot be recognized or is covered. At Buffalo Creek and elsewhere near Louisiana it is 4 inches thick. Near Clarksville, this yellow-brown mudstone is much thinner and appears to grade laterally into lenses of blue mudstone, but many such apparent transitions are merely wash from the thinner yellow-brown beds above. The blue mudstones of the Saverton commonly weather yellow-brown, but the weathered blue mudstone can generally be distinguished from the originally brown mudstone. The yellow-brown mudstone is at least 9 inches thick at some of the exposures along the Mississippi River in Ralls County. Reasons for including this mudstone in the Louisiana formation are given on page 5.

TOPOGRAPHIC EXPRESSION

Where a considerable thickness of the typical lithology of the formation is exposed, the limestone beds of the Louisiana form rather high vertical cliffs. Vertical joints crossing an alternation of clay partings ranging from ½ inch to 2 inches in thickness with limestone beds having an average thickness of about 6 inches give these cliffs the appearance of walls of masonry. The vertical joints, which are common at nearly every exposure at intervals approximating the thickness of the limestone beds, break the formation into crudely rectangular blocks. These blocks are easily dislodged by the action of frost, the wind, and other agents of

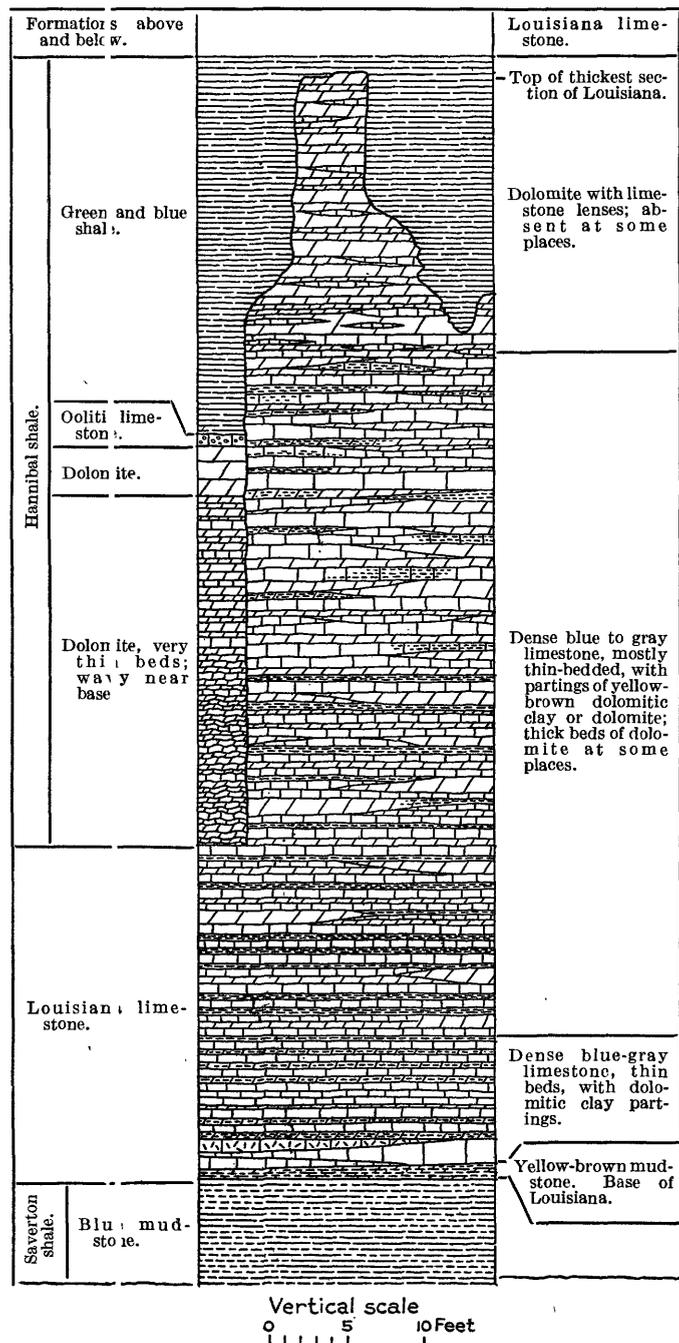


FIGURE 7.- Generalized composite columnar section of the Louisiana limestone.

by beds of brown dolomite. These dolomitic beds are massive at some places and slabby at others, and at some places slabby beds grade laterally into massive beds of argillaceous dolomite and the dolomitic limestone partings are absent. The slabby phase of the formation is probably the result of weathering.



A. LOUISIANA LIMESTONE AT LOUISIANA, MO.

Exposure along Town Branch in northwestern part of city of Louisiana. Locality 593. Shows nearly complete thickness. Black line near base of exposure indicates contact with underlying mudstone (Saverton).



B. LOWER CONTACT OF LOUISIANA LIMESTONE AT CLARKSVILLE, MO.

Locality 618. 1, Louisiana limestone; 2, light-blue mudstones of the Saverton, about 30 inches thick; 3, black shales of Grassy Creek; 4, Edgewood limestone.



C. LOWER CONTACT OF LOUISIANA LIMESTONE AT LOUISIANA, MO.

Locality 593. 1, Basal limestone bed of the Louisiana, about 12 inches thick; 2, yellow-brown calcareous mudstone; 3, blue mudstones of the Saverton.



A. IRREGULAR CONTACT BETWEEN LOUISIANA LIMESTONE AND OVERLYING HANNIBAL SHALE, ABOUT 1 MILE NORTH OF HANNIBAL, MO.

Locality 635.



B. CONTACT BETWEEN SAME FORMATIONS AT LOVERS LEAP, HANNIBAL, MO.

Locality 930.



C. DOLOMITIC BEDS IN THE UPPER PART OF LOUISIANA LIMESTONE AT LOVERS LEAP.

Locality 930.

erosion and fall into accumulations of talus below the outcrops. Where the formation is not so thick the Louisiana forms low terraces. Where it is thin and not so closely jointed, the separate limestone beds form 4- to 6-inch steps, or the formation may be completely concealed by overwash from the Hannibal shales.

In the northern part of the area of outcrop where massive dolomite makes up a greater part of the formation, the cliffs are not so high, the beds are more massive, and the exposures do not have the same resemblance to walls of masonry as they do near the type locality.

LOCATION OF REPRESENTATIVE OUTCROPS

The Louisiana limestone is best exposed along the bluffs of the Mississippi River in Pike, Ralls, and Marion Counties, but other streams in these three counties afford good exposures. Complete vertical sections are few, for the lower part is usually covered by talus.

PIKE COUNTY

A complete vertical section of the Louisiana is exposed at the mouth of Buffalo Creek, about 1½ miles south of the town of Louisiana, Mo., along the Chicago, Burlington & Quincy Railroad. This section is described in detail on page 17. The formation is also well exposed in the bluffs and stream valleys in and near the town of Louisiana. Among the better of these exposures are the following: At the base of Allen's Hill, along Town Branch in the northern part of the town of Louisiana; at the foot of Jackson Street, along Town Branch; at the Eighth Street Quarry, along Town Branch; along the Mississippi River front near the pump house of the Louisiana Milling Co.; and at the Chicago & Alton Railroad bridge in the southern part of Louisiana.

Complete vertical sections are exposed in the bluffs of the Mississippi River just north of the town of Clarksville, Mo. The outcrop farthest south along the line of bluffs of the Mississippi River is at Salt Peter Bluff near Annada, about 2 miles north of the southern boundary of Pike County.

The thickest section measured by the writer is along the Mississippi bluffs near the boundary between Pike and Ralls Counties. Other good outcrops are along Grassy Creek, northwest of Louisiana; along South Spencer Creek, and at other places in the northwestern and northern parts of Pike County.

RALLS COUNTY

The best outcrops in Ralls County are south and west of Saverton and along the bluffs of the Mississippi River. Detailed sections were made along Lick Creek, about 2¼ miles southwest of Saverton, and along the Mississippi bluffs near the boundary between Pike and Ralls Counties. Exposures are also found along Salt River and along the valleys tributary to South River, north of the town of Rensselaer.

MARION COUNTY

In Marion County, the best outcrops also occur along the bluffs of the Mississippi River. Good, but not complete sections were measured in the bluffs along the Chicago, Burlington & Quincy Railroad, south of Hannibal; along the St. Louis & Hannibal Railway, west of Hannibal; and about 1 mile north of Hannibal, along the public road that parallels the Mississippi River. The formation is exposed near the base of nearly all the hills in and around Hannibal. Other outcrops in Marion County occur along South Fork of North River and the valleys tributary to it, about 8 miles north of Monroe City, and about 4 miles west of Woodland. The Louisiana is not exposed in northern Marion County, as it is covered by younger Mississippian formations.

LOCAL SECTIONS

The 26 local sections given in the following pages were selected from more than 70 made in the progress of the field work. They show the variations in lithology, thickness, and faunules of the Louisiana limestone in the counties in which it outcrops in Missouri. Their locations are shown in figure 8. Fossil collections and specimens for chemical analyses were obtained from many of the localities. One section from Lincoln County, where the Louisiana probably does not occur, is also given to show the relations between Kinderhook formations in one county adjacent to those having Louisiana outcrops. No sections are given from Audrain, Monroe, Shelby, and Lewis Counties, which are the other adjacent counties in Missouri, because all the exposed rocks in these counties are younger than the Louisiana limestone. In most of them the Burlington is the oldest Mississippian formation exposed, but Chouteau limestone crops out in some counties. One section described from beds in Illinois is also given. This section shows the relations of the Louisiana to some of the formations in the extreme southeastern part of its area of outcrop.

LINCOLN COUNTY

The Louisiana limestone is not exposed in Lincoln County. Ordovician rocks underlie the greater part of northeastern Lincoln County, but Mississippian rocks outcrop on many high hills. The writer was unable to secure a good section which showed the stratigraphic relations of the Mississippian formations in that part of the County. Isolated outcrops indicate, however, that the Louisiana is absent or very thin there, for at two localities the Chouteau limestone is separated from underlying limestones referred to the Mineola (Devonian) limestone of E. B. Branson by unexposed intervals of only a few feet. If the strata are not faulted at these localities (and there is no physical evidence of a fault visible), the Hannibal is also very thin or absent. These localities are: (1) On the side of a hill along the public road about 3½ miles northwest of Elsberry

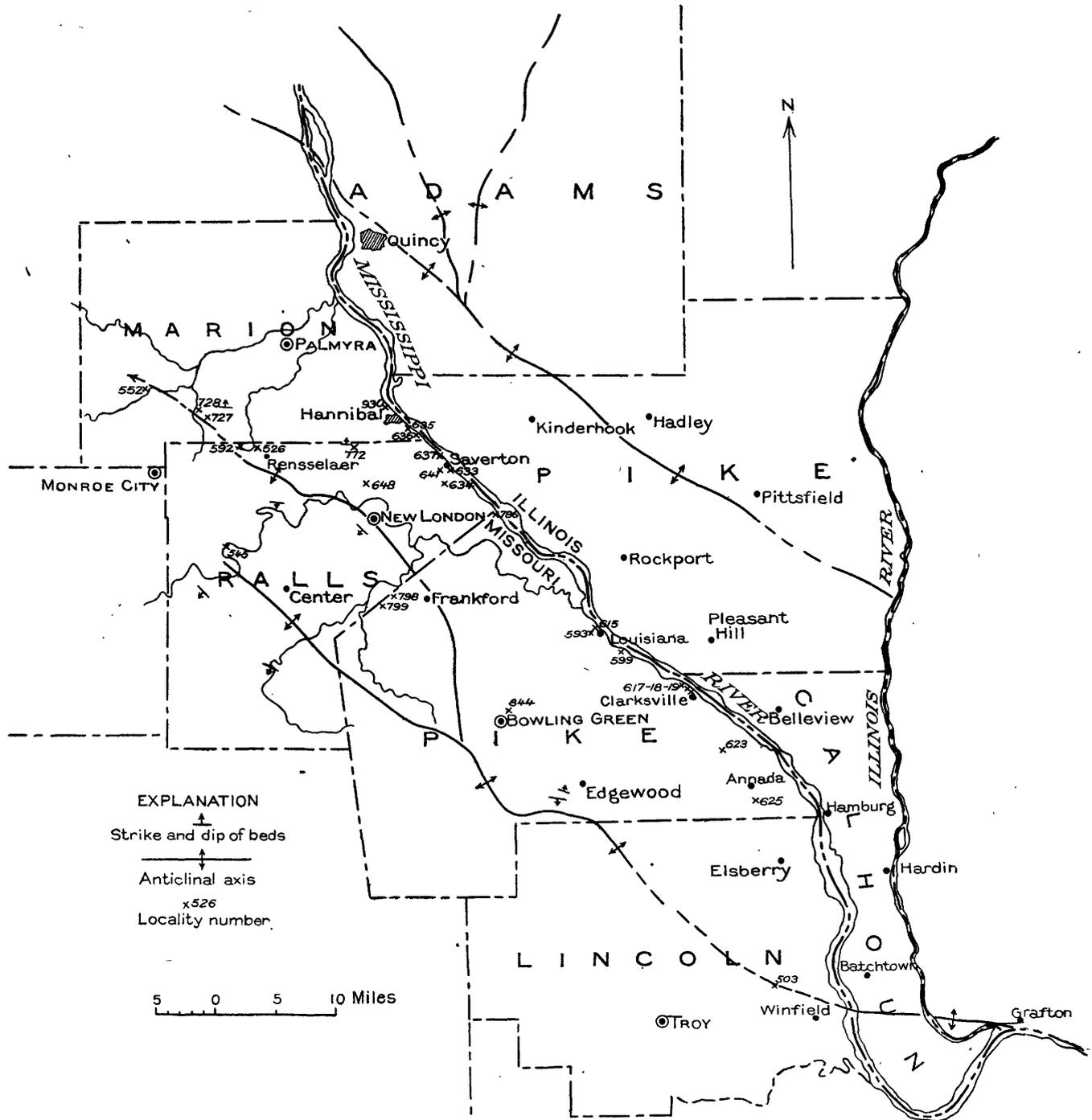


FIGURE 8.—Index map of Marion, Ralls, Pike, and Lincoln Counties, Mo., and of Adams, Pike, and Calhoun Counties, Ill., showing location of stratigraphic sections and of main structural features described in this report. The northeasternmost anticline shown is the Pittsfield-Hadley anticline; the southwesternmost one is the Cap au Gres faulted flexure.

(SE¼ sec. 18, T. 51 N., R. 2 E.) and (2) about 1 mile southwest of New Hope, along the public road, near the Hickory Ridge School (sec. 3, T. 50 N., R. 1 E.).

The Louisiana is surely absent in central Lincoln County, along the Cap au Gres faulted flexure, as none is present where its horizon is exposed in sections measured 1 mile north of Winfield and along McLean Creek, half a mile east of Argenville. In these sections the Hannibal is directly on the Mineola (Devonian) limestone. The section along McLean Creek is given below.

The following section was measured by E. B. Branson and the writer along McLean Creek, about half a mile east of Argenville and about 4 miles northwest of Winfield. The strata are tilted by the Cap au Gres faulted flexure in such a way that formations ranging from the St. Peter (Ordovician) sandstone to the St. Louis (upper Mississippian) have been exposed along the creek, and the succession can be seen by walking along the stream bed. The formations dip to the southeast at angles varying from 2° to 80°. The outcrops of formations above the Chouteau limestone are so scattered along the stream that complete description and accurate measurement were impossible, but the entire thickness of the Chouteau and formations below it is exposed, and the measurements of these formations are fairly accurate. The writer is alone responsible for the formation names used.

Section along McLean Creek, ½ mile east of Argenville

[Locality 503, SE¼ sec. 9, T. 49 N., R. 2 E.]

Carboniferous (Mississippian):	Feet
Burlington limestone: Coarsely crystalline, highly crinoidal limestone, many geodes of quartz near base of formation.....	95
Sedalia (?) and Chouteau limestones (undifferentiated): Dark bluish-gray to brown compact argillaceous limestone.....	56
Hannibal shale: ⁴⁷ Black to bluish-green thin-bedded shale.....	46
Disconformity, indicated by absence of intervening formations.	
Devonian:	
Mineola limestone of Branson: Dark bluish-gray, coarsely crystalline limestone, weathers brown. Crowded with horn corals. <i>Atrypa reticularis</i> (Linnaeus) and <i>Stropheodonta demissa</i> (Conrad) are also common.....	9
Disconformity, indicated by absence of intervening formations.	
Ordovician:	
Maquoketa shale: Greenish-gray sandy shale, with 3-foot bed of sandstone at top.....	45
Unexposed interval.....	59
St. Peter? sandstone: Coarse friable brown sandstone, massive.	

⁴⁷ Branson and Mehl (Missouri Univ. Studies, Vol. 8, No. 4, p. 268, 1933) have referred shales at this stratigraphic position in nearby localities to the Bushberg sandstone member of the Sulphur Springs formation, and it is probable that they would refer this to the Bushberg rather than the Hannibal. The writer believes it probable that other beds referred questionably in this report to the Hannibal may belong to the Sulphur Springs formation, but in the absence of more definite proof it is considered best to refer them to the Hannibal (?). Branson and Mehl also place in the Bushberg sandstone the beds in central Missouri included by most authors in the Sylamore sandstone.

PIKE COUNTY

About 25 sections of the Louisiana limestone were measured in Pike County but only 9 are given here. These 9 sections show a decrease in thickness of the formation from the northern boundary of the county to the southern boundary and from the bluffs of the Mississippi River to the western part of the county. They also show most of the variations in lithological character within the county and at different horizons in the formation. The lists of fossils collected at various localities and horizons indicate the changes in the nature of the fauna.

The thickest section of Louisiana limestone measured by the writer is along the Mississippi River bluffs about 1½ miles north of Busch, near the boundary between Ralls and Pike Counties. The exposure is on the side of a hill along the Chicago, Burlington & Quincy Railroad. The lower part of the Louisiana limestone is not exposed, and its contact with the overlying Hannibal shale cannot be precisely located. A thickness of 54 feet of Louisiana limestone was measured by hand level. The formation is covered in places by dense growths of underbrush, but the exposure was sufficient to show that its thickness is at least 54 feet. Pieces of Louisiana limestone are present in the talus accumulations at the bases of the bluffs in many places between this locality and Ashburn, and outcrops in which a few feet of Louisiana limestone are exposed are numerous.

Section of Mississippian formations, 1½ miles north of Busch

[Locality 786, NE¼ sec. 35, T. 56 N., R. 3 W.]

Burlington limestone:	Feet
Coarsely crystalline, crinoidal limestone containing much chert as thin beds and lenses; to top of hill.....	15-20
White, coarsely crystalline limestone, massive; apparently free from chert.....	5
Gray to white, coarsely crystalline limestone containing nodules and lenses of chert.....	6
Gray to cream, coarsely crystalline, highly crinoidal limestone, small amount of chert; thickness estimated.....	15
Brown sandy limestone, contains many crinoid stems (may be Sedalia limestone of Moore).....	10-12
Partial thickness of Burlington limestone.....	
<hr style="border-top: 3px double #000;"/>	
Disconformity, indicated by absence of intervening formations.	
Hannibal shale: Represented mostly by a vegetation-covered slope. At the contact with the Burlington above, occurs about 2 feet of greenish-blue shale; poorly exposed beds of soft, green sandstone lie about 10 feet below upper contact of formation. These sandstone beds range from green to gray, in some places they show the characteristic worm borings, and elsewhere they appear to be replaced by sandy shale. The lower contact is covered. Thickness measured by hand level, about.....	70
Louisiana limestone: Dense blue compact limestone in beds 6-12 inches thick, separated by thin clay partings. Grades into brown to gray, hard dolomite in upper 20 feet.....	54
Unexposed, covered by vegetation to base of cliff, about.....	50-60

Chemical analyses of samples from this locality are given on page 26.

Several sections of Louisiana limestone were measured near the town of Louisiana, but only a few of them are given. The formation outcrops in all the bluffs and along all the streams near Louisiana, and fossils were collected from nearly every outcrop, but complete sections could not be secured at every collecting locality. About 35 feet is exposed along Town Creek in the northwestern part of Louisiana, west of the residence of B. A. Pappenfort. It is exposed along the side of a hill, immediately above the creek. The upper contact was not exposed in the vertical section along the creek, but the writer was able to study it in the small valleys tributary to the valley of Town Branch. Burlington limestone is exposed in an old quarry at the top of the hill, but the thickness of the Hannibal shale could not be satisfactorily measured. No Chouteau limestone was exposed.

Section of Mississippian formations along Town Branch, Louisiana, Mo.

[Locality 593, SW¼ sec. 18, T. 54 N., R. 1 W.]

	Ft.	in.
Burlington limestone: Coarsely crystalline gray to cream-colored limestone, highly crinoidal; contains beds and lenses of chert; exposed on top of hill; no detailed description attempted; exposed.....	80-90	
Disconformity, indicated by absence of intervening formations.		
Hannibal shale: Gray to brownish-green sandy shale, very poorly exposed; no sandstone in place or as float; thickness estimated.....	70-80	
Louisiana limestone:		
Dense bluish-gray limestone broken into small rectangular blocks by jointing; beds are about 3 inches thick near the top and average 6 to 7 inches in the lower part; soft brown shale partings separate the limestone beds; partings average about 1½ inches in thickness; where unweathered the partings are of hard brown argillaceous dolomite; limestone beds are drab to white where weathered. At base of exposure there is a 12-inch bed of limestone. Fossils are abundant in the clay partings well up in the formation, and <i>Spirifer marionensis</i> Shumard, <i>Productella pyxidata</i> Hall, <i>Syringothyris hannibalensis</i> (Swallow), and other fossils were collected from the limestone beds. Thickness measured, upper contact not exposed.....	35	
Brownish-green calcareous mudstone or argillaceous shale, literally crowded with fossils. <i>Spirifer marionensis</i> Shumard and <i>Productella pyxidata</i> Hall are the most abundant forms....	4	
Saverton shale: A few feet of blue to black mudstone exposed along creek downstream from above locality. Not measured.		

Fossils are abundant in the calcareous mudstone below the lowest limestone bed and have been collected from the limestone beds at practically all horizons exposed at this locality. Fossils are more abundant in the sandy clay partings than in the limestone beds. *Neozaphrentis? acuta* (White & Whitfield), *Or-*

biculoidea limata Rowley, *Crania (Lissocrania) dodgei* Rowley, *Spirifer marionensis* Shumard, *Strophalosia beecheri* Rowley, *Productella pyxidata* Hall, *Chonetes ornatus* Shumard, *Rhipidomella missouriensis* (Swallow), *Cyrtina acutirostris* Shumard, *Syringothyris hannibalensis* (Swallow), *Athyris hannibalensis* (Swallow), *Camarophorella buckleyi* (Rowley), *Selenella pediculus* (Rowley), "*Leda*" *spatulata* Herrick, and *Parallelodon sulcatus* (Weller) were collected by the writer from the brown mudstone beneath the limestone beds at this locality. The following fossils in the writer's collection came from the limestone beds or the clay partings that separate them: *Chonetes geniculatus* White, *Chonetes ornatus* Shumard, *Productella pyxidata* Hall, *Rhipidomella missouriensis* (Swallow), *Selenella pediculus* (Rowley), *Spirifer marionensis* Shumard, *Cyrtina acutirostris* Shumard, *Syringothyris newarkensis* Weller, *Syringothyris hannibalensis* (Swallow), *Athyris hannibalensis* (Swallow), *Athyris lamellosa* (L'Éveillé), *Aviculopecten marbuti* (Rowley), *Pleurotomaria? sp.*, *Ptyctodus calceolus* Newberry and Worthen, and *Dinichthys sp.*

The following section was measured on the side of a bluff along the Chicago, Burlington & Quincy Railroad, about 250 feet north of the Louisiana Milling Co. A complete section of the Louisiana limestone is not exposed here. Its greatest exposed thickness is estimated at 35 feet. This section is given chiefly to show the lithology of the lower part of the formation.

Section along Chicago, Burlington & Quincy Railroad, northern part of Louisiana

[Locality 615, NE¼ sec. 18, T. 54 N., R. 1 W.]

Carboniferous (Mississippian):		
Louisiana limestone:		
Typical dense blue "lithographic" limestone, separated by thin clay partings; beds 6-8 inches thick; exposed to top of cliff, estimated.....	35	
Yellow-brown, calcareous mudstone or argillaceous limestone.....		4
Partial thickness of Louisiana limestone.....	35	4
Saverton shale: Blue mudstone, yielding <i>Spirifer marionensis</i> Shumard and other fossils.....		1
Carboniferous or Devonian:		
Grassy Creek shale:		
Black thin-bedded fissile shale.....	3	6
Bluish-gray to green shale.....		6
Total thickness of Grassy Creek shale.....		4
Disconformity, shown by irregular surface of Edgewood limestone.		
Silurian:		
Edgewood limestone:		
Bowling Green limestone member: Brown sandy dolomite.....		4
Noix oolite member: Composed of two beds of oolite separated by a very thin bed of limestone literally crowded with horn corals: upper bed 18 inches thick, lower bed about 6 feet thick.....		7

A good specimen of *Parallelodon sulcatus* (Weller) as well as *Spirifer marionensis* Shumard, *Orbiculoidea elongata* Williams, n. sp., *Chonetes ornatus* Shumard, *Productella pyxidata* Hall, *Palaeoneilo ignota* Herrick, "*Leda*" *diversoides* (Weller), "*Leda*" *spatulata* Herrick, *Parallelodon louisianensis* Williams, and *Platyceras pulcherrimum* Rowley were collected from the calcareous mudstone below the limestone beds. Several specimens of *Chonetes geniculatus* White were procured by washing clay taken from the clay partings just above the lowest limestone beds, and *Rhipidomella missouriensis* (Swallow), *Productella pyxidata* Hall, *Syringothyris hannibalensis* (Swallow), and *Platyceras pulcherrimum* Rowley were collected from the limestone beds and the clay partings.

The best section near Louisiana is at Buffalo Hill, at the mouth of Buffalo Creek, where the formation is exposed high above the river and talus accumulations do not cover its base. A complete vertical section of the Louisiana, Saverton and Grassy Creek was measured with a tape. The contact with the Hannibal shale above was visible, but much of this formation is covered with vegetation. Its thickness was measured with a hand-level. The Hannibal-Burlington contact was well exposed and was carefully studied, and the writer did not recognize any Chouteau limestone in the section. The brown sandy crinoidal bed about 3 feet thick in this and other sections around Louisiana has been called Chouteau, but the writer has seen nothing to convince him that it is not Burlington. It is not very fossiliferous, but all fossils collected are known from the Burlington.

Section at mouth of Buffalo Creek

[Locality 599, NW ¼ sec. 28, T. 54 W., R. 1 W.]

Carboniferous (Mississippian):

	Ft.	in.
Burlington limestone:		
Thin beds of chert alternating with 2-foot beds of coarsely crystalline crinoidal limestone	15	
Light-gray, coarsely crystalline, highly crinoidal limestone; very little chert	20	
Typical coarsely crystalline, highly crinoidal limestone containing lenses of chert	77	
Brown sandy limestone, crinoidal (so-called Chouteau limestone)	3	
Partial thickness of Burlington limestone	115	

Disconformity (?) shown by absence of intervening formations.

Hannibal shale:

Greenish-yellow shaly sandstone in 18-inch beds, vermicular	12
Greenish-blue to brown shale, poorly exposed	12
Interval, unexposed	65
Very sandy greenish-brown shale	3
Total thickness of Hannibal shale	92

Disconformity?, suggested by fillings of Hannibal shale in cracks in Louisiana limestone; contact observable for only a short distance.

Carboniferous (Mississippian)—Continued.

Louisiana limestone: Ft. in.

Six to eight-inch beds of dense blue "lithographic" limestone, separated by thin clay partings; brownish-yellow argillaceous dolomitic limestone near top. The lowest limestone bed is about 12 inches thick. Crystalline masses of calcite are common. At some parts of the exposure calcite masses replace the clay partings and at other places they are in the limestone beds. Thickness measured by tape	39
Brownish-red calcareous mudstone or argillaceous limestone, containing much limonite	4

Total thickness of Louisiana limestone 39 4

Saverton shale: Blue to black mudstone 2

Carboniferous or Devonian:

Grassy Creek shale:

Black very thin-bedded, fissile shale, unfossiliferous	4
Yellow sandy shale	1

Total thickness of Grassy Creek shale 5

Disconformity, indicated by absence of intervening formations.

Silurian:

Edgewood limestone:

Bowling Green limestone member: Yellow-brown dolomite, exposed	2-6
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This outcrop has probably yielded more good fossils than any other outcrop of the Louisiana limestone. They are listed in the table on page 32. Most of the good specimens have come from the clay partings, but fossils were collected from the limestone beds also and many came from the shale beneath the limestone beds. Many small specimens were secured by washing the clay obtained from the clay partings. The material from the partings above the two lower limestone beds yielded the most specimens.

Chemical analyses of samples from this locality are given on page 27.

The Louisiana limestone is well exposed along the bluffs of the Mississippi River at Clarksville. The section given below was measured back of the houses on the west side of the pike across from the toll house in the northern part of Clarksville. For several years the Louisiana limestone was quarried here and used for riprap along the Mississippi River. The formation is so broken that pieces are often blown off the sides of the cliffs by the wind and are easily loosened by changes in temperature.

The measurement was made by tape at one point along the bluffs and by hand-level at another point with essentially the same result. The writer worked along the strike of the formations where it was possible to secure better exposures, and the section given below is composite. The brown mudstone below the lowest limestone bed is in no place over 3 inches thick and probably averages less than 1 inch. The blue mudstone

averages about 30 inches in thickness. Quarries have been worked for years in the Burlington limestone which caps the hills around Clarksville.

Section at Clarksville

[Localities 617-619, sec. 9, T. 53 N., R. 1 E.]

	Ft.	in.
Carboniferous (Mississippian):		
Hannibal shale: Greenish-brown shales, poorly exposed.....	1	
Contact observed for only a short distance; seemingly conformable.		
Louisiana limestone:		
Light-brown dolomitic limestone beds about 1 foot thick; grades into dolomite near top..	4	
Dense blue to white limestone beds separated by clay partings; partings are of hard dolomitic limestone where not weathered; limestone beds more argillaceous near top; lowest limestone bed is about 12 inches thick.....	29	
Yellow-brown calcareous mudstone or argillaceous limestone.....	4	
Total thickness of Louisiana limestone..	33	4
Saverton shale: Blue sandy mudstone yielding many Louisiana species.....	2	6
Carboniferous or Devonian:		
Grassy Creek shale:		
Black to purple fissile shale literally filled with black nodules, which are probably coprolites.....	3	2
Bluish-gray sandy clay.....	6	
Total thickness of Grassy Creek shale...	3	8
Disconformity shown by uneven contact.		
Silurian:		
Edgewood limestone:		
Bowling Green limestone member: Brown sandy dolomite, exposed.....	15	

Many good fossils were collected along the bluffs at Clarksville. A number of specimens were secured by washing the clay collected from the clay partings in the lower part of the formation. Among these were the following: *Neozaphrentis parasitica* (Worthen), *Conopterium effusum* Winchell, *Chonetes geniculatus* White, *Chonetes ornatus* Shumard, *Productella pyridata* Hall, *Ambocoelia minuta* White. Other fossils collected here are given in the table on page 32.

Chemical analyses of samples collected near Clarksville are given on page 26.

The following section is exposed along a small creek near Kissenger, in the southeastern part of Pike County. This locality is about one-eighth of a mile northwest of Salem Church. The Devonian beds are exposed in the stream bed where the stream crosses the road, and the younger formations occur a short distance upstream. The exact thickness of the interval between the top of the exposed Saverton (?) shale and the lowest exposed Louisiana limestone could not be measured, as the exposures are separated by at least 100 yards along the

stream, a vertical interval of probably 6 feet. The Louisiana limestone is not over 14 feet thick at the most.

Section 1½ miles west of Kissenger

[Locality 623, sec. 3, T. 52 N., R. 1 E.]

	Ft.	in.
Carboniferous (Mississippian):		
Hannibal shale: Greenish-blue shale, exposed.....	2	
Louisiana limestone: Dense blue to drab, much jointed limestone beds averaging about 4 inches in thickness, separated by thin clay partings; at top of formation a 1-foot bed of dense limestone is overlain by a 1-foot bed of hard brown dolomite; measured by hand-level upstream.....	8	
Interval, unexposed along stream; hand-level measurement.....	6	
Saverton (?) shale: Friable brownish-yellow to reddish-brown coarse-grained sandstone; similar thin sandstone beds occur at several places in the Saverton shale in Pike County; no fossils obtained, hence age is unknown.....	6	6
Disconformity, indicated by absence of intervening formations.		
Devonian:		
Callaway limestone: Blue to drab argillaceous fossiliferous limestone, thin-bedded, containing <i>Atrypa reticularis</i> (Linnaeus) in abundance....	7	
Disconformity.		
Silurian:		
Edgewood limestone:		
Bowling Green limestone member: Brown sandy limestone or dolomite, beds about 2 feet thick; exposed.....	4	

Many good fossils were collected from a zone about 4 feet below the top of the Louisiana limestone. They include *Neozaphrentis parasitica* Worthen, *Rhipidomella missouriensis* (Swallow), *Productella pyridata* Hall, *Spirifer marionensis* Shumard, *Syringothyris hannibalensis* (Swallow), *Loxonema missouriensis* Williams, n. sp., *Parallelodon sulcatus* (Weller), and *Parallelodon louisianensis* Williams. *Spirifer marionensis* and *Productella pyridata* were also collected from the dolomite beds just below the contact with the Hannibal shales.

The outcrop of Louisiana limestone farthest south along the bluffs of the Mississippi River is on Salt Peter Bluff, less than a mile south of the town of Annada. The hill is covered with brush and timber, and good exposures occur only in a few places on its sides. Burlington limestone caps the hill, and the Louisiana limestone is poorly exposed and was seen on only the south-eastern side of the hill. The writer's attention was attracted by loose pieces of Louisiana limestone, and after considerable searching, the beds described below were found in place in two or three small areas.

Section 1 mile south of Annada

[Locality 625, NE¼ sec. 30, T. 52 N., R. 2 E.]

	Ft.	in.
Carboniferous (Mississippian):		
Burlington limestone: Coarsely crystalline, highly crinoidal, gray to cream limestone, containing chert as lenses and lenticular beds; caps top of hill. Thickness not measured.		

Carboniferous (Mississippian)—Continued.	
Sedalia and Chouteau limestones (undifferentiated): Dense to finely crystalline, white to brown argillaceous limestone; apparently grades into Burlington limestone above. Thickness exposed estimated at.....	30
Unexposed interval, roughly estimated at.....	80-100
Louisiana limestone: Only three beds with a total thickness of 18 inches were found in place, but float indicates that at least 4 feet of limestone is present. It is dense blue to drab and is broken by jointing.....	4
Saverton (?) shale: Hard brown quartzitic sandstone in two beds; sandstone such as this occurs in both the Saverton and the Grassy Creek at several places in Pike County; fossils were not found, and age is uncertain.....	7
Disconformity (?), suggested by the absence of intervening formation.....	
Devonian:	
Callaway (?) limestone: Dark blue to gray, dense to finely crystalline limestone; contains <i>Atrypa reticularis</i> (Linnaeus).....	12
Disconformity.	
Silurian:	
Edgewood limestone:	
Bowling Green limestone member: Brown sandy dolomite; thickness estimated.....	20
Noix oolite member. Not measured.	
Ordovician:	
Maquoketa shale: At base of hill.	

Fossils collected from the Louisiana are *Productella pyxidata* Hall, *Chonetes ornatus* Shumard, *Chonetes ornatus* var. *glensparkensis* Weller, and *Syringothyris hannibalensis* (Swallow). All of the above were from the limestone beds. The formation was deeply weathered, and most of the shale partings had been removed by erosion.

Chemical analyses of the Louisiana limestone from this locality are given on page 26.

The presence of Louisiana limestone at locality 844, 1¼ miles northeast of Bowling Green, Mo., is indicated by pieces of typical dense blue lithographic limestone in loose material from excavations and by its having been recognized in the carefully recorded log of the city well at Bowling Green. The exposed beds at the place where the section was made are all younger than the Louisiana. Older beds occur farther down on the hillsides and in nearby valleys. Pieces of float of typical Louisiana limestone were found on several nearby hillsides but no exposed beds in place could be found. These pieces of float seem adequate evidence to prove that the Louisiana extends westward from areas where it is exposed into this region.

The following section of Mississippian rocks is exposed in a cut along the Chicago & Alton R. R. about 1¼ miles northeast of Bowling Green and about one-fourth mile west of the Chicago & Alton bridge over the Bowling Green-Louisiana public road. The ex-

posure is not an exceptionally good one, as the side of the cut is covered in many places by surface wash and by vegetation.

Section 1¼ miles northeast of Bowling Green

[Locality 844, NE¼ sec. 24, T. 53 N., R. 3 W.]

	ft.	in.
Hannibal shale: Greenish-blue shale, poorly exposed...	6-8	
Hannibal (?) shale: Blue-gray to brown sandy and dolomitic limestone, in wavy beds 1-3 inches thick: specks of limonite show plainly on fresh surfaces....	4	
Interval, unexposed to railroad track, covered by vegetation and talus, estimated thickness.....	2	
Louisiana limestone: Not exposed but presence indicated by float from excavations and by nearby well logs.		

The log of the city well at Bowling Green was furnished the writer by H. S. McQueen, Assistant State Geologist of Missouri. It shows that a dense limestone occurs a few feet above the Bowling Green (Silurian) limestone member and below a finely crystalline limestone. The writer believes that the finely crystalline limestone is the brown sandy and dolomitic limestone exposed at the base of the section given above, and that the dense limestone below it is probably the Louisiana. The maximum thickness of Louisiana is not over 5 feet. Rowley⁴⁸ reports a thickness of less than 8 feet of Louisiana limestone 2 miles northeast of Bowling Green, and about half a mile from this locality.

A few small individuals that are probably species of *Camarotoechia* were collected from the Hannibal (?) here.

The Louisiana limestone is probably not over 10 feet thick in the northwestern part of Pike County. The section given below contains only 6 feet of Louisiana limestone but the top of the formation is eroded. A section measured about 1 mile farther west (locality 799, NE¼ sec. 6, T. 54 N., R. 4 W.) has 6 feet of Louisiana limestone, but there is an unexposed interval of 6 to 8 feet between the lowest Louisiana limestone exposed and the highest Saverton shale exposed. The thickness of Saverton shale at locality 799 is 5½ feet. The section at locality 798 was described from outcrops along a small branch on the farm of Charles Williams north of the road, 2½ miles west of Frankford. The exposure is on the side of a cliff overhanging a small branch. This cliff is not over 11 feet high, and the section is exposed from the stream bed to a height of about 8 feet above the stream. No outcrops occur above the Louisiana limestone, but the slope above it resembles a slope formed on shale, and no Louisiana limestone was found in the float on this slope. The lower beds of the formation are exposed about 50 feet north of the road, but the section described was measured about 200 feet farther north.

⁴⁸ Rowley, R. R., *Geology of Pike County: Missouri Bur. Geology and Mines*, 2d ser., vol. 8, p. 30, 1908.

Section of Mississippian rocks 2½ miles west of Frankford

[Locality 798, SW¼ sec. 32, T. 55 N., R. 4 W.]

	Ft.	in.
Louisiana limestone: Dense compact blue to drab limestone in beds 3-6 inches thick, separated by yellow sandy clay partings, which are hard where not weathered. Measured by tape.....	6	
Saverton shale: A few beds poorly exposed along stream bed, black to dark-blue shale.....	1	6

The lower beds of the Louisiana are very fossiliferous at this locality. A *Camarotoechia* closely related to or conspecific with *C. tuta* Miller is very abundant. *Lingula fleenori* Williams, *Chonetes ornatus* Shumard, *Chonetes ornatus* var. *glenparkensis* Weller, *Chonetes geniculatus* White, *Productella pyxidata* Hall, *Rhipiodomella missouriensis* (Swallow), *Spirifer marionensis* Shumard, "*Orthoceras*" n. sp. A, and *Proetus missouriensis* Shumard, were collected from the lower part of the exposure.

Chemical analyses of samples of limestone and of clay partings collected at this locality are given on pages 26, 27.

RALLS COUNTY

The shale below the lowest limestone member of the Louisiana is much thicker in Ralls County than in Pike County. Sections in this county show a decrease in thickness toward the north, along the Mississippi bluffs, and westward, away from the Mississippi River.

A section with beds ranging from the Maquoketa shale to the Louisiana is exposed on a high bluff of a tributary to Lick Creek. From a point about one-half mile west of its mouth, this creek flows parallel to the public road leading to Saverton for about three-eighths of a mile, and the section was obtained by working upstream from the mouth of one of the tributaries entering that part of Lick Creek parallel to the Saverton road.

This place is near the type locality for the Saverton shale. As noted elsewhere, the name Saverton was proposed for a blue shale that occurs between the black Grassy Creek shale and the Louisiana limestone. Several authors state that it is about 70 feet thick at the type locality. The writer found no well-exposed section at the station in Saverton, but the Saverton and other formations are poorly exposed on the hillsides near it. The following sections from the vicinity of Saverton suggest that not only the Grassy Creek shale but also some of the Maquoketa shale were included in previous estimates.

Section about 1 mile south of Saverton

[Locality 633, NE¼ sec. 19, T. 56 N., R. 3 W.]

	Ft.	in.
Carboniferous (Mississippian):		
Louisiana limestone: Dense blue to buff limestone 4- to 6-inch beds separated by very thin clay partings. In some places where partings are lenticular the limestone beds join.....	10	
Unexposed interval (includes Saverton shale).....	12	6
Carboniferous or Devonian:		
Grassy Creek shale: Black fissile shale.....	24	
Disconformity, shown by absence of intervening formations.		

Silurian: Ft. in.

Edgewood limestone:

Bowling Green limestone member: Hard blue fine grained dolomite which weathers yellow-brown; in one bed.....	8
Noix oolite member: Gray oolite, in two beds; thickness estimated.....	5-6

Disconformity (?).

Ordovician:

Maquoketa shale: Blue shale; exposed in stream bed.....	6
---	---

The lower part of the Louisiana is well exposed along the valley of a small stream which flows through the barnyard south of the house of S. E. Lowe. The sides of the valley are not very steep, and only a few feet of limestone is exposed, but the shale immediately below the limestone beds of the formation is in a vertical section and was measured by tape.

Section of Mississippian rocks 2 miles southwest of Saverton

[Locality 634, NE¼ sec. 30, T. 56 N., R. 3 W.]

	Ft.	in.
Louisiana limestone:		
Dense blue limestone in beds 4 to 8 inches thick, separated by thin clay partings; partings average one-eighth of an inch in thickness; in some places masses of crystalline calcite occupy the space between limestone beds; exposed.....	4	
Brown sandy calcareous mudstone.....	4	
Saverton shale:		
Very sandy blue to gray mudstone.....	3	
Thin-bedded blue shale; thickness to water-level in stream.....	1	6

Pelecypods are more abundant at this locality than at any other visited. All of the pelecypods collected here, except *Grammysia hannibalensis* (Shumard), came from the lower part of the 4-inch brown sandy mudstone. Most of the specimens are molds of interiors and were obtained by splitting the mudstone along bedding planes. The species of pelecypods collected were: *Grammysia hannibalensis*, "*Leda*" *diversoides* (Weller), *Nucula* (*Palaeonucula*) *krugeri* Williams, *Palaeoneilo ignota* Herrick, "*Leda*" *rowleyi* Williams, and "*Leda*" *spatulata* Herrick. *Cyrtina acutirostris* Shumard and *Syringothyris hannibalensis* (Swallow) were also collected from the shale beds.

The thickest section of Louisiana limestone measured in Ralls County is about 1½ miles southwest of Saverton. At this locality a bluff extends for more than a mile along the south side of Lick Creek, and the Grassy Creek shale and Louisiana limestone are exposed at many places along the bluff. The following section was measured by hand level and tape at an old quarry about half a mile west of the junction of Malaruni Creek and Lick Creek. According to farmers living in this neighborhood, the Louisiana limestone was quarried here about 1880 and shipped to eastern cities for use as a lithographic stone. The difficulty of securing large blocks of limestone made it unprofitable, and the quarry was worked for that purpose for only about a year. The limestone here and at nearly every other locality visited is broken by jointing and weather-

ing into rectangular blocks, which average about 8 by 6 by 6 inches.

The dolomitic facies of the limestone in the upper part of the sections in Marion County is conspicuous at this locality and grades into typical dense blue limestone below. The shales in the lower part are also well exposed, and complete vertical sections of them were obtained. A small spring flows from below the lowest limestone bed.

Section along Lick Creek, 1½ miles southwest of Saverton

[Locality 641, SW¼ sec. 19, T. 56 N., R. 3 W.]

Carboniferous (Mississippian):

	Ft.	in.
Louisiana limestone:		
Light gray and cream-colored to white limestone and dolomite, beds 8 to 12 inches thick. Limestone is very rare in upper beds of this part of formation; beds near top average only about 3 inches in thickness. Thickness by tape to top of hill.....	24	6
Dense blue limestone beds 8 to 10 inches thick separated by soft clay partings one-fourth inch to 1 inch in thickness. Limestone beds are thinner near top, averaging only about 4 inches thick, and partings are thicker and composed of brown argillaceous dolomite. Measured by hand level.....	21	
Yellow-brown calcareous mudstone grading into blue mudstone below.....	2-5	
Partial thickness of Louisiana limestone..	45	11
Saverton shale:		
Sandy blue mudstone.....	3	9
Blue to brown sandy shale, grades into massive blue mudstone above and into black fissile shale below.....	12	
Total thickness of Saverton shale.....	15	9

Carboniferous or Devonian:

Grassy Creek shale: Very thin bedded fissile shale, black to dark blue where unweathered, brown where weathered, exposed above creek, about... 20

On the north side of a cliff facing a small stream tributary to the Mississippi River the section of Louisiana limestone given below is exposed along the Hannibal-Saverton public road west of the home of J. M. Steel. Neither the top nor the bottom contact is visible, but the section shows the differences in lithology between the top and bottom of the formation so well that it is inserted here. The lower part is exposed along the Mississippi River bluffs in only a few other sections north of this locality.

Section of Louisiana limestone 2 miles north of Saverton

[Locality 637, NE¼ sec. 12, T. 56 N., R. 4 W.]

	Ft.	in.
Alternating beds of blue dolomitic limestone and cream-colored to yellow and brown argillaceous dolomite of about the same thickness.....	10	
Light-brown to cream-colored argillaceous dolomite beds 8 to 18 inches thick, separated by 2- to 3-inch beds of thin dolomitic limestone, which grade later-ly into argillaceous dolomite.....	15	

Interval, unexposed, approximately.....	10	
Dense blue to buff limestone, beds 6 to 8 inches thick, separated by yellow sandy clay partings, which average less than an inch in thickness.....	2	6
	37	6

Fossils were sought in the dolomitic phase at the top of the formation, but none were found.

About 15 feet of Louisiana limestone is described in the following section at an old quarry west of the New London-Hannibal road about 4 miles north of New London. Neither top nor bottom of the formation is exposed. The lower part of the exposure is typical of the Louisiana limestone in Pike County, and the upper part resembles the dolomitic phase, which outcrops mainly in Marion County. Fragments of shale thrown out by workers on the road indicate that the Saverton shale occurs a short distance below the base of the exposure of Louisiana, but no shale was found in place.

Section of Louisiana limestone 4 miles north of New London

[Locality 648, NW¼ sec. 24, T. 56 N., R. 5 W.]

	Feet
Brown to cream-colored argillaceous dolomite beds 6 to 8 inches thick, with some thin beds of brown to buff limestone.....	7
Dense blue to buff limestone; beds 6 to 8 inches thick separated by yellow-brown clay partings, which average about 1½ inches in thickness near the bottom of section, but toward the top they are over twice as thick; where not weathered the partings are of hard argillaceous dolomite; limestone beds not so thick near top.....	8
	15

Syringothyris hannibalensis (Swallow) was collected from a bed about 2½ feet above the base of the exposure.

Chemical analyses of samples from this locality are given on page 26.

A section in which the Louisiana limestone, Saverton and Grassy Creek shales and Callaway limestone are exposed occurs along a small creek in a pasture on the Cable farm about one-fourth mile south of the Hydesburg-Oakwood road, 1½ miles southeast of Hydesburg. The formations dip northwest, exposing the beds in such a way that the section given below could be measured with a tape.

Section 1½ miles southeast of Hydesburg

[Locality 772, SW¼ sec. 3, T. 56 N., R. 5 W.]

Carboniferous (Mississippian):

	Ft.	in.
Louisiana limestone:		
Brown to blue dolomitic limestone and dolomite; beds average about 3 inches in thickness.....	7	
Dense blue limestone, beds ranging from 8 to 11 inches in thickness, separated by lenticular brown dolomitic partings, which thicken and thin in short distances. Many masses of crystalline calcite both in partings and in the limestone beds; a 15-inch bed of limestone at base.....	8	
Brown sandy mudstone.....	9	
Partial thickness of Louisiana limestone..	15	9

Carboniferous and Devonian(?):		Ft.	in.
Saverton and Grassy Creek shales (undifferentiated):			
Blue sandy mudstone, grading into brown mudstone above.....	1	6	
Blue to purple fissile shale, grading into blue sandy mudstone above, poorly exposed....	12-15		
Green shale.....	1	6	
<hr/>			
Total thickness of Saverton and Grassy Creek shales.....	18		

Devonian:

Callaway limestone: Dense to finely crystalline blue limestone containing many corals; exposed to stream bed, approximately..... 2

About 12 feet of Louisiana limestone is exposed above water-level on the banks of Salt River near the ford in SE¼ sec. 13, T. 55 N., R. 7 W. The section here described is one-fourth mile upstream from the ford, and the rocks are exposed on the south side of Salt River. Only about 3 feet of the blue-green shale of the Hannibal is continuously exposed, but on the cliff above, which is covered with vegetation, green and brown shale outcrops at intervals for probably 20 feet. These outcrops indicate that the Hannibal shale has a thickness of at least 25 feet. On top of the bluff a few feet of Burlington limestone is exposed. The 8 feet of dolomite is here referred to the Hannibal (?) rather than to the Louisiana because of its lithologic similarity to beds that unconformably overlie the Louisiana at locality 552. No fossils were found in it.

Section of Mississippian rocks along Salt River, 8 miles northwest of Center

[Locality 545, SE¼ sec. 13, T. 55 N., R. 7 W.]

	Ft.
Hannibal shale: Blue-green shale, poorly exposed.....	15-20
Hannibal (?) shale: Hackly thin-bedded yellow-brown sandy dolomite, beds 1 to 3 inches thick, containing geodes and masses of crystalline calcite.....	8
Contact appears conformable.	
Louisiana limestone: Compact gray to buff limestone, beds 3 inches to 1 foot in thickness, measured to water-level.....	4

Fossils collected from the limestone beds were *Rhipidomella missouriensis* (Swallow), *Spirifer marionensis* Shumard, and *Syringothyris hannibalensis* (Swallow).

About three feet of Louisiana limestone is exposed in a section measured in a valley tributary to South River. The best exposure is about one-fourth mile south of the road in a wooded pasture, but the dolomitic and shaly beds of the Hannibal are also exposed along the road. Nothing appears directly below the Louisiana limestone, but Saverton shale occurs in the stream bed farther down stream.

Section of Mississippian rocks about 1½ miles west of Rensselaer

[Locality 526, SW¼ sec. 4, T. 56 N., R. 6 W.]

	Ft.	in.
Hannibal shale: Greenish-gray shale, a few feet exposed near top of hill.....	3	

Hannibal (?) shale:		Ft.	in.
Gray oolitic limestone, fossiliferous.....		4-6	
Massive yellow-brown sandy dolomite; yields many fossils.....		2	
Thin-bedded yellow-brown sandy dolomite.....		14	
<hr/>			
Thickness of Hannibal (?) shale.....		16	4-6

Louisiana limestone: Dense blue "lithographic" limestone separated by thin clay partings; exposed to stream bed..... 2 6

Interval, not measured.

Saverton shale: Sandy blue mudstone (exposed downstream). Contact with Louisiana not visible.

No fossils were collected from the Louisiana at this locality. Fossils from the dolomite beds referred to the Hannibal (?) are: *Rhipidomella missouriensis* (Swallow), *Chonetes geniculatus* White, *Camarotoechia* cf. *C. tuta* (Miller), and *Syringothyris newarkensis* Weller. All of these fossils are known elsewhere from the Hannibal, but they also occur elsewhere in the Louisiana. In addition a few unidentifiable fragments probably belonging to other species were collected.

A section is exposed along a small ravine in a field south of the Monroe City-Hannibal road, which follows along the Marion-Ralls county boundary at this locality. The dolomite beds of the Hannibal outcrop beneath a bridge over a small stream which crosses the road, and the Louisiana limestone and Saverton shale occur in several places farther down the stream valley and along tributary gullies.

Section of Mississippian rocks 2 miles northwest of Rensselaer

[Locality 592, NE¼ sec. 5, T. 56 N., R. 6 W.]

Hannibal (?) shale:		Feet
Very thin beds of brown sandy dolomite.....		2
Brown sandy dolomite in beds 2 to 4 inches thick.....		4
Interval, estimated.....		2
Louisiana limestone: Dense blue-gray limestone, beds 3 to 6 inches thick, broken by jointing into rectangular blocks, many geodes and crystalline masses of calcite; poorly exposed.....		3
Saverton shale: Sandy blue to purple mudstone, exposed.....		3

MARION COUNTY

Outcrops of Louisiana limestone in Marion County occur near Hannibal, south of West Ely, and along the tributaries of North River, west of Woodland. The upper part of the formation is much more dolomitic in this county than in Pike and Ralls Counties. The thickness decreases in sections west of the Mississippi River, and the formation is covered by younger rocks toward the western limits of Marion County. The following 6 of the 22 sections of the Louisiana limestone measured in Marion County were selected to show the regional variations.

The Hannibal-Saverton road follows along the Mississippi River bluffs in the southeastern part of Marion County. The Louisiana limestone is well exposed at several places along this road, and some of these sec-

tions have been described among the sections from Ralls County. The section given below was measured by tape from outcrops on the side of a cliff along the west side of the road, about 2½ miles southeast of Hannibal. It shows the differences in lithology between the upper and lower parts of the formation. Nothing is exposed below the limestone.

Section of Louisiana limestone 2½ miles southeast of Hannibal

[Locality 636, SW ¼ sec. 35, T. 57 N., R. 4 W.]

	Feet
Brown argillaceous dolomite and slightly dolomitic limestone, resembling the unweathered dolomitic clay partings in sections from Pike County; beds 18 to 24 inches thick	7
Alternating 2-inch beds of blue to buff slightly dolomitic limestone with 4- to 6-inch beds of hard brown dolomite. Limestone beds weather to brown	5
Dense blue limestone beds 6 to 8 inches thick near bottom of exposure alternating with lenticular beds of yellow-brown clay, whose thickness averages about 1 inch	6

No fossils were secured at this locality.

Chemical analyses of specimens from the locality are given on p. 27.

The upper part of the Louisiana limestone is well exposed in the bluffs on the east side of Lovers' Leap in the southern part of Hannibal. Formations ranging from the Burlington limestone to the Louisiana limestone appear in a section which was measured by tape and hand-level. About 30 feet of dolomite in the Louisiana limestone is exposed at the base of the section and forms a cliff above the Hannibal-Saverton road. The Hannibal shale is exposed on a steep slope above the Louisiana limestone, and the Burlington limestone, which overlies the Hannibal shale, forms sheer cliffs, which extend to the top of the bluff. No Chouteau was recognized in the section.

The disconformity between the Hannibal and Louisiana formations is shown at several places in the cliffs above the road, where the upper massive dolomite of the Louisiana has been eroded to an uneven surface before the deposition of the shales of the Hannibal. None of the erosion channels noticed are very deep, and most of them do not penetrate the full thickness of this bed. Some few channels that penetrated as far as 5 feet into the Louisiana were noted, however. The channels are filled with Hannibal shale. Most of them have a thin layer of brown shale next to the dolomite. The brown shale grades up into blue shale. A drawing of one of these channels is shown in figure 2.

Section of Mississippian rocks at Lovers' Leap, Hannibal

[Locality 635, SE ¼ sec. 28, T. 57 N., R. 4 W.]

	Feet	in.
Burlington limestone:		
Gray to cream-colored coarsely crystalline limestone, beds 3 to 4 feet thick, containing beds and concretions of chert, some beds of brown sandy limestone, one 18-inch bed of brown sandstone near the top. Exposed as vertical cliffs and not accessible for detailed description. Thickness estimated	80-90	

Burlington limestone—Continued.

	Feet	in.
Highly crinoidal, coarsely crystalline, brown limestone; typical brown Burlington limestone	10-12	
Brown sandstone in one bed	1	
Finely crystalline, highly crinoidal brown limestone	6-8	
Partial thickness of Burlington limestone	<u>111</u>	
Hannibal shale: Greenish-brown to greenish-gray sandy shale, with beds of very argillaceous greenish-brown sandstone. One of these sandstone beds is about 5 feet above the base of the formation. Measured roughly by hand-level	70	
Disconformity, shown by uneven contact.		
Louisiana limestone:		
Brown argillaceous dolomite	1	8-12
Thin lenslike beds of brown dolomite and drab dolomitic limestone; dolomitic beds predominating and more continuous	8-10	
Brown dolomite in thick beds, with some few thin beds	15	
Alternating beds of dense gray to drab dolomitic limestone and brown argillaceous dolomite; beds 4 to 8 inches thick. Measured to road	5	
Partial thickness of Louisiana limestone	<u>30-32</u>	

The writer attempted several times to obtain fossils from the Louisiana at this locality, but was unsuccessful. No fossils have been listed from the Louisiana from this locality, although it has been visited by many collectors.

Chemical analyses of samples from this locality are given on page 26.

The outcrops of Louisiana limestone farthest north occur in the river bluffs and along small ravines about 1½ miles north of Hannibal. The section given below was measured along the bluff near the Wabash Railway bridge, 1 mile north of Hannibal. Burlington limestone caps the bluffs, but it was not exposed in the section given below.

Section of Mississippian rocks 1 mile north of Hannibal

[Locality 930, SW ¼ NE ¼ sec. 20, T. 57 N., R. 4 W.]

	Feet
Hannibal shale: Greenish-gray sandy shale, with a few beds of very argillaceous green sandstone; thickness exposed	50-60
Louisiana limestone: Brown dolomite in beds 6 to 10 inches thick, with 3-foot bed at top; exposed above road, about	25

The Louisiana dips northward, and only a few feet of the formation is exposed above the river level about a mile northwest of this locality.

The section given below was reached by walking up the tributaries of Sees Creek, which flows north on the east side of the Union Valley church, in sec. 22, T. 57 N., R. 7 W. This stream is a tributary to North River, which it joins about 4 miles farther north. Devonian limestone is exposed in the stream bed near the church, and the following poorly exposed section was measured above the Devonian along the north bank of a small tributary that flows northwestward across section 23.

Section 2 miles northwest of Ely

[Locality 727, SW¼ sec. 23, T. 57 N., R. 7 W.]

	Ft.	in.
Carboniferous (Mississippian):		
Louisiana limestone: Dense brown to drab limestone, beds 4 to 6 inches thick, separated by thin clay partings; poorly exposed; float indicates a greater thickness.....	3	6
Carboniferous and Devonian (?):		
Saverton and Grassy Creek shales (undifferentiated): Greenish-blue to brown shale, very poorly exposed, character indicated by soil; thickness estimated.....	25-30	
Disconformity, indicated by absence of intervening formations.		
Devonian:		
Callaway limestone: Dense to finely crystalline blue limestone; exposed to bed of stream.....	3	

Chemical analyses of samples of Louisiana limestone from this locality are given on page 26.

The section given below was measured in the bluffs on the south bank of Sees Creek along a north-south road near the center of section 22. The Saverton shale is poorly exposed along the creek a few feet west of the road. A few beds of Louisiana limestone occur above the Saverton shale. About one-eighth of a mile upstream, some 8 feet of Louisiana limestone is exposed in a section, the lower limit of which is determined by the bed of a small stream. The upper contact of the formation is not exposed. About one-half mile north of the 8-foot section of Louisiana limestone, about 40 feet of Hannibal shale outcrops above the stream bed. Chouteau limestone occurs near the top of the bluff at this point. The following is a composite section taken from the three exposures mentioned above.

Section of Mississippian rocks 3 miles northwest of Ely

[Locality 728, SW¼ sec. 22, T. 57 N., R. 7 W.]

	Feet
Chouteau limestone: Finely crystalline gray sandy limestone, in 1 bed.....	4
Unexposed interval, measured by hand level.....	20-25
Hannibal shale: Bluish-green to brown sandy shale, with prominent ledges of brown sandstone about 12 feet below top. Bluish-green shale occurs just below upper contact of formation; thickness measured by hand level.....	35-40
Hannibal (?) shale: Brown thin-bedded dolomitic limestone and dolomite with 1-foot beds of blue to brown dolomite at top.....	12
Louisiana limestone: Dense blue to drab limestone, beds 3 to 6 inches thick near bottom, separated by brown dolomitic partings, which average 2 to 4 inches in thickness; toward top dolomitic beds are thicker and more persistent. Masses of crystalline calcite are common in limestone beds. Dolomites in upper part of formation are very fossiliferous.....	8
Saverton shale: Green to light-gray shale or mudstone, poorly exposed; thickness estimated roughly.....	10-20

Many fossils were collected at this locality. Several small specimens came from the dolomitic clay partings that had been broken into slabs by weathering and lay about over the Saverton shale. They include *Chonetes ornatus* Shumard, *Selenella pediculus* (Rowley), *Spirifer*

marionensis Shumard, and *Ambocoelia minuta* White. A bed of limestone that crops out near the river bed about one-eighth mile upstream from the road is very fossiliferous. *Rhipidomella missouriensis* (Swallow) is most abundant at this horizon, but *Chonetes ornatus* Shumard, *Spirorbis kinderhookensis* Gurley, *Syringothyris hannibalensis* (Swallow), *Selenella pediculus* (Rowley), *Spirifer marionensis* Shumard, *Bemboxia minima* (Rowley), *Proetus tenuituberculus* Williams, and *Proetus missouriensis* Shumard were also collected from it. Fossils are also numerous in place in the dolomitic clay partings in the lower 8 feet of the section, and *Syringothyris hannibalensis* was collected from the limestone beds above the basal bed in the lower 8 feet. Most of the fossils secured from the clay partings were small specimens, but larger specimens are also common. Some fossils, which probably came from the Hannibal shale, were collected from the slope under which this formation is exposed.

The following section was measured at the westernmost exposure of the Louisiana limestone. It was compiled from discontinuous exposures along a small stream known locally as Burche's Branch, which is tributary to South Fork of North River. The locality is about one-half mile south of the village of Newmarket, Marion County, and 2 miles south of Warren.

The exposures are on both sides of the place where the Newmarket road crosses Burche's Branch. About one-half mile upstream from this place the Hannibal shales form a cliff about 50 feet high along the side of the stream. Dolomitic beds here referred tentatively to the Hannibal crop out on either side of the road. These same beds also occur downstream about one-eighth mile. The outcrops of Louisiana limestone begin here and extend on downstream for a short distance. A few inches of shales of the Saverton(?) formation is exposed below the Louisiana. Because the outcrops are discontinuous and in places poorly exposed, the thicknesses and description of the beds above the Louisiana are incomplete and lack precision.

Section of Mississippian rocks 8 miles north of Monroe City

[Locality 552, NE¼NE¼ sec. 12, T. 57 N., R. 8 W.]

	Ft.	in.
Hannibal shale:		
Brown and green shales, estimated thickness.....	20-30	
Brown and yellow-brown sandstone, contains worm borings; forms a resistant ledge, about....	3	
Shale, soft, gritty, blue to green.....	10-15	
Sandy shale, blue where fresh, weathers brown, has plant markings including form known as <i>Spirophyton</i> ; forms a resistant ledge.....	6-8	
Shale, bluish-green to black, slightly sandy.....	15-20	
Interval, along stream, possibly.....	5	
Hannibal (?) shale:		
Dolomite, sandy, brown beds 4-8 inches or more thick, estimated thickness.....	7	
Thin discontinuous beds of brown dolomite with irregular lenslike beds of white limestone of dolomite; has mottled appearance; beds 1 to 3 inches thick.....	6	

	Ft.	in.
Hannibal (?) shale—Continued.		
Very thin beds of dolomite and sandy, argillaceous limestone, average thickness less than 1 inch; beds uneven, and "wavy"-----	4	
Partial thickness of Hannibal and Hannibal(?) formations-----	60-90	
<hr/>		
Disconformity, shown by uneven erosion surface of Louisiana limestone.		
Louisiana limestone:		
Dense to fine-grained limestone in beds 4 to 8 inches thick separated by dolomitic partings that average less than 1 inch in thickness; but some partings are 3 inches thick-----	7	
Medium-crystalline gray limestone-----	6	
Greenish-brown mudstone-----	6	
Total thickness of Louisiana limestone-----	8	
<hr/>		
Saverton(?) shale: A few inches of blue shale exposed downstream.		

Fossils are common in the limestone beds of the Louisiana at this locality, and specimens were collected from both the sandy clay partings and the limestone beds. Gastropods are common near the top of the formation but are poorly preserved. Most of the gastropod specimens collected could not be definitely identified but have been referred to *Bellerophon*(?) sp. Other fossils collected here are: *Plumalina gracilis* (Shumard), *Mesoblastus*(?) sp., *Rhipidomella missouriensis* (Swallow), *Chonetes ornatus* Shumard, *Camarotoechia* cf. *C. tuta* (Miller), *Selenella pediculus* (Rowley), *Aviculopecten marbuti* (Rowley), and *Proetus missouriensis* Shumard. A 6-inch bed of crystalline limestone at the base of the formation is very fossiliferous.

ILLINOIS

Detailed sections were made at only two or three localities in Illinois, but outcrops were examined and the relations of the Louisiana to overlying and underlying formations studied at several places. The writer has not, however, made any attempt to see every Louisiana outcrop in Illinois. Nearly all of the outcrops visited were at localities to which the writer had been directed by W. W. Rubey. Only one section is given here, and it is inserted mainly to show the relations between the Louisiana limestone and the overlying strata.

This section was made from outcrops exposed along Hamburg Creek, in the southern part of Hamburg. Most of the beds described were measured in a vertical section back of the Methodist Church on High Street, but the younger beds crop out upstream from this locality and older ones are exposed downstream to a point beyond the place where the Bluff Road crosses Hamburg Creek.

	Ft.	in.
<i>Section at Hamburg, Illinois</i>		
Carboniferous (Mississippian):		
Glen Park formation:		
Oolitic limestone, very fossiliferous, exposed-----		10-11
Limestone, hard, sandy, argillaceous; a few beds exposed in stream bed; thickness estimated-----	1	6
Interval, unexposed, about-----		6-8
Limestone, sandy, argillaceous, blue to brown, dolomitic, and sandstones, shaly. Some beds hard, others soft; beds 1 inch or less in thickness and uneven, "wavy"-----		10±
Partial thickness of Glen Park formation-----	12-13	
<hr/>		
Disconformity, shown by erosion surface of Louisiana limestone and filled cracks in limestone.		
Louisiana limestone: Dense, "lithographic" limestone, beds 4 to 6 inches in thickness, separated by very thin clay partings scarcely thicker than bedding planes-----		5
Saverton (?) shale: Shale, light greenish-gray fresh; darker greenish-gray where weathered-----		10
Devonian:		
Cedar Valley limestone: Very fossiliferous, brown, argillaceous limestone; many corals, brachiopods, and other fossils, exposed--	4-5	
Older formations: Exposed downstream-----		

This section is interesting mainly because of the distinctly unconformable relations of the Louisiana and the Glen Park formation and because of the resemblance of the beds here included in the Glen Park to the beds included in the Hannibal? in western Pike and Marion Counties. The unconformity is clearly shown by the uneven surface developed by the erosion of the upper part of the Louisiana limestone. Channels as deep as 2 feet have been formed in the Louisiana and are filled with material like that in the overlying beds. The unconformity is also shown by filled cracks in the Louisiana and by pieces of Louisiana limestone in a matrix of the overlying sandy beds. These relations are shown diagrammatically in figure 1. The Glen Park appears to grade upward into beds of the Hannibal formation.

COMPOSITION OF THE LIMESTONE

MINERAL COMPOSITION

The texture of the typical limestone beds of the Louisiana is so dense that it is rarely possible to identify the component minerals. Thin sections of the "lithographic" beds were made from specimens collected near the base of the formation at Buffalo Hill near Louisiana (see local section 599) and near Saverton (collecting locality 639). Mr. Carle Dane examined these thin sections in 1924 and reported that the groundmass in each

section is composed of a very finely granular aggregate of crystals, which so far as can be determined are mainly rhombohedral. Most of those that could be identified are of calcite. Quartz is sparingly represented. Very small amounts of limonite occur in patches, and clay is rarely seen in the sections.

A thin section of a dolomitic parting from Hannibal, Mo. (local section 643), was also examined by Mr. Dane. This section is composed mainly of fine grains of dolomite but it also contains a considerable number of larger, recrystallized rhombohedrons and some brown iron-stained clay in the interstices.

In 1933 Mr. C. S. Ross examined thin sections made from two specimens, one a dense limestone about 2 feet above the base of the Louisiana at an exposure on Buffalo Creek, about 1 mile south of Louisiana, Mo. (see local section 599); the other a hard dolomitic parting about 3 feet above the base at the same place.

The dense limestone is composed of grains and granular aggregates of a very fine-grained carbonate averaging 0.001 to 0.003 millimeter in diameter. The thin section contains very little interstitial material—an indication that the specimen is very pure. A photograph of the specimen from which these thin sections were made is given on plate 3, *A*, and photomicrographs of the thin sections are shown on plate 4, *A*, *B*. Chemical analyses of specimens from this same horizon and locality are given below.

The examination of a thin section and powder from the hard dolomitic parting showed that it is composed mainly of dolomite rhombs, which have an average diameter of slightly less than 0.04 millimeter. Interstitial material, estimated roughly by Mr. Ross to compose about one-fourth of the specimen, consists of a mixture of fine-grained carbonate and ferruginous clayey material. A chemical analysis of material from this specimen is given on page 27. A photomicrograph of a thin section of it is shown on plate 4, *C*, and a photograph of a specimen is shown on plate 3, *B*.

A small piece of weathered clay parting from Buffalo

Hill was powdered and examined by Mr. Ross. This parting had the appearance of a yellow-brown shaly or clayey mass. The grains in it were not very cohesive. The groundmass was composed of fine grains and granular aggregates. The grains were finer than those of the hard dolomitic parting and apparently consist mainly of calcite with an occasional rhomb of dolomite. The proportion of materials that might be designated as impurities was much greater than in the hard dolomitic parting. Chemical analyses of this weathered parting are given on page 27. It is shown in the photograph of a hand specimen on plate 3, *A*.

Mr. Ross also examined a specimen of the yellow-brown calcareous mudstone from near Louisiana (local section 615). As the grains were very fine and indistinct, a preliminary examination without a thin section did not reveal definitely what they were. Quartz appeared to make up about 25 percent of the rock, and crystals of calcite and dolomite were recognizable. Chemical analyses of this sample are given on page 27. A specimen is shown on plate 3, *C*.

The texture of the "lithographic" beds of the Louisiana is about the same as that of the lithographic beds of the Solenhofen of Bavaria. The photomicrographs on plate 4 show the relative textures of a sample from near the base of the Louisiana at Buffalo Hill (local section 599) and of a sample from Bavaria.

CHEMICAL COMPOSITION

Samples of the lower limestone beds of the Louisiana contain 85 to 96 percent of calcium carbonate and have only small amounts of magnesium carbonate. Samples from the top of the formation in Pike County and the upper part in Ralls and Marion Counties have as much as 40 percent of magnesium carbonate. The chemical composition of the lower part of the formation is fairly uniform throughout the area of outcrop, as shown by the tables of analyses of samples from widely separated exposures, but the dolomitic facies at the top is much thicker toward the northern limit of the outcrops, and the

Analyses of samples from the Louisiana limestone

Lower part

Locality No.	Approximate location	CaCO ₃ ¹	MgCO ₃ ¹	R ₂ O ₃	Insolubles ²	Total
625	Southeastern Pike County.....	90.65	1.95	1.30	6.80	100.70
619	Near Clarksville.....	89.80	1.75	.55	8.60	100.70
599	Near Louisiana.....	95.70	2.00	.45	2.20	100.35
798	Northwestern Pike County.....	94.50	2.05	1.00	2.20	99.75
786	Northeastern Pike County.....	95.60	2.65	.30	1.30	99.85
641	Eastern Ralls County.....	96.55	3.20	.25	.90	100.90
648	Northeastern Ralls County.....	94.90	2.35	.40	2.35	100.00
727	Western Marion County.....	94.40	1.95	.55	2.90	99.80

Upper part

619	Near Clarksville.....	50.80	26.60	3.65	18.35	99.40
599	Near Louisiana.....	59.10	30.90	1.95	6.40	98.35
641	Eastern Ralls County.....	75.35	18.35	2.05	4.15	100.10
648	Northeastern Ralls County.....	76.20	20.45	1.15	2.35	100.15
635	Hannibal.....	75.55	20.70	1.30	2.80	100.35

¹ CaCO₃ and MgCO₃ calculated from CaO and MgO, respectively.

² Insoluble in hydrochloric acid of specific gravity 1.16.

samples from this region in the main contain greater relative amounts of carbonate of magnesium.

The preceding calculated analyses, which were prepared by chemists for the Missouri Bureau of Geology and Mines, show the differences in chemical composition between the upper and lower parts of the formation. They also give the regional variations in the chemical composition. More detailed analyses were not made because the writer felt that the benefit to be derived from them in a report of this kind would not justify the additional expense. All the samples analyzed came from stratigraphic sections shown on the map, page 14. Descriptions of these sections are given on pages 15-25.

The gradation from the lower "lithographic" limestone facies of the formation into the dolomitic facies in the upper part, which is common at places near the northern margin of the Louisiana limestone, is shown by the analyses from locality 636, southeastern part of Marion County. The section here consists of dense blue limestone beds separated by clay partings in the lower part of the exposure, grading up through about 5 feet of alternating beds of blue dolomitic limestone and hard brown dolomitic partings into 7 feet of brown dolomite at the top. Samples of the hard beds were taken at intervals of about 2 feet and lettered from the bottom up. A more complete description of this exposure, which is considered typical of the formation in Marion County, is given on page 23.

Analyses of samples from locality 636, southeastern part of Marion County

Sample No.	CaCO ₃ ¹	MgCO ₃ ¹	R ₂ O ₃	Insoluble ²	Total
636-H-----	59.00	36.70	0.95	3.40	100.05
636-G-----	86.80	11.20	.45	1.70	100.15
636-F-----	94.30	4.20	.50	1.25	100.25
636-E-----	93.60	5.55	.45	1.05	100.65
636-D-----	89.30	9.15	.45	1.50	100.40
636-C-----	92.40	6.50	.40	1.15	100.45
636-B-----	95.40	3.75	.35	1.05	100.55
636-A-----	96.50	2.05	.20	2.10	100.85

¹ CaCO₃ and MgCO₃ calculated from CaO and MgO, respectively.

² Insoluble in hydrochloric acid of specific gravity 1.16.

The following analysis was made from a sample collected at locality 798, northwestern part of Pike County. It is considered typical of the unweathered partings between the limestone beds throughout the area.

Analysis of parting at locality 798, in northwestern Pike County

Calcium carbonate (calculated from CaO) ..	62.50
Magnesium carbonate (calculated from MgO)	14.60
Sesquioxides (R ₂ O ₃)	5.85
Insoluble in hydrochloric acid of specific gravity 1.16	15.15
Total	98.10

Two analyses made in 1933 by J. G. Fairchild of the United States Geological Survey permit comparison of

one of the hard dolomitic partings of the Louisiana limestone with material from a soft weathered parting. Both of the samples were collected between dense limestone beds at locality 599, Buffalo Hill, south of Louisiana, Mo. The analyses, as calculated, are as follows:

Analyses of partings at locality 599, Buffalo Hill

	Insoluble ¹	Fe ₂ O ₃ and Al ₂ O ₃	CaCO ₃ ²	MgCO ₃ ²	Total
Hard dolomitic parting ..	6.82	1.86	56.06	35.57	100.31
Soft clay parting	14.30	3.68	71.21	9.08	98.27

¹ Insoluble in 1-5 hydrochloric acid.

² CaCO₃ and MgCO₃ calculated from CaO and MgO, respectively.

The greater relative abundance of calcium carbonate in the soft clay parting suggests that the differences between the partings are not due wholly to weathering, but that probably the partings themselves differ somewhat at different horizons and at different localities.

The following partial analysis of a specimen of the yellow-brown mudstone at the base of the Louisiana was made in 1933 by E. T. Erickson of the United States Geological Survey. The specimen was collected from an exposure in the northern part of Louisiana, Mo. (See local section 615.) Remarks on its mineralogical composition are given on page 26.

Analysis of a mudstone at Louisiana, Mo.

Insoluble in 1-5 hydrochloric acid, (including SiO ₂ from R ₂ O ₃ =0.40)	48.75
R ₂ O ₃ (minus SiO ₂ 0.40)	2.86
CaCO ₃ (calculated from 22.87 CaO)	40.33
MgCO ₃ (calculated from 2.59 MgO)	5.42
CO ₂ present.	

Organic matter indicated by qualitative tests to be small in amount.

ECONOMIC USES AND POSSIBILITIES

The Louisiana limestone has not been utilized commercially to any great extent, except for local riprap, because the Burlington limestone, which is purer and superior to the Louisiana for most uses, is easily available in Pike, Marion, Ralls, and other counties in northeastern Missouri. However, the adaptability of the Louisiana limestone for different uses is reviewed below, and available test data are presented.

Lithographic stone.—The Louisiana was named the Lithographic limestone by Swallow⁴⁹ on account of "its evident adaptation to Lithographic purposes." Some of the plates in Swallow's report⁵⁰ were printed from lithographs made on this stone. S. E. Lowe, who lives about 2½ miles southwest of Saverton, informed the writer that the Louisiana was quarried along Lick Creek near his home (locality 641) about 60 years ago and shipped to eastern markets for lithographic use.

⁴⁹ Swallow, G. C., The First and Second Annual Reports of the Geol. Survey of Missouri, pp. 105-106, 1855.

⁵⁰ Idem, p. 63.

According to Mr. Lowe, the stone was polished and wrapped in straw at the quarry, and most of it was then hauled in wagons to Saverton for shipment by railroad to Chicago or New York. Mr. Lowe stated that he had seen pieces of lithographic stone as large as a dining-table top. He was unable to give the year in which the quarry was operated but believed it to be about 1882. It was his impression that despite the installation of expensive quarrying machinery, the quarry was operated only about 9 months, having been forced to close because of the difficulty in securing large blocks of the limestone at a reasonable cost. The writer has been unable to find any production data on this quarry or to find published information concerning the time of its operation. An examination of the outcrop quickly shows that difficulty would be experienced in obtaining large unbroken blocks of the limestone. This difficulty would no doubt be found at every outcrop of the Louisiana limestone. A comparison of thin sections of typical Louisiana limestone and the famous lithographic stone of Bavaria (Pl. 4, B, D,) shows that the texture of the two are very similar. As regards texture, therefore, the Louisiana appears to be well suited to lithographic use. Its successful use for lithographs suggests that most of the other qualities necessary are satisfactory. It is not however quarried for this purpose because it is at most places broken into small blocks and also because the use of stone in lithography has decreased.

Highway material.—A sample of the Louisiana was accepted by the Missouri Highway Commission in 1924 for all types of highway construction in which they were engaged except for water-bound macadam, which requires a rock with a high cementing value. F. V. Reagel, State testing engineer, supplied the writer with the following report on a sample of Louisiana collected from the Cable farm, locality 772, southeast of Hydesburg.

Tests for quality

Percent of wear.....	4.8
French coefficient of wear.....	8.3
Hardness.....	17.0
Toughness.....	11.8
Weight per cubic foot.....	164.37
Specific gravity.....	2.63
Absorption, pounds per cubic foot.....	.986
Absorption, percent.....	.6
Cementing value.....	15.4

Mr. Reagel has also made the following comments on the sample tested:

The hardness of 17 is above the average and indicates that the stone will withstand abrasion. Our requirement of hardness is 12. The toughness of 12 is exceptionally high for limestone and indicates ability to withstand impact. Our requirement for toughness is 2.

The French coefficient test is a test designed to show the effect of a combination of abrasion impacts. The result of 8.3, while not exceptionally high, is entirely satisfactory for stone for all

purposes. The cementation test of 15 indicates a stone of low cementing value and, therefore, not to be recommended for water-bound macadam, although the other characteristics are entirely satisfactory. The water-bound type of pavement, however, is fast becoming obsolete because it is not economical for modern traffic.

The stone shows the required physical properties as shown by the French coefficient, hardness, and toughness tests to be entirely satisfactory for bituminous type pavement, both penetration and mixed type. It shows ability to withstand the use of a heavy roller without excess crumbling, which ability is necessary for the penetration type of bituminous pavement. The low absorption and absence of cleavage planes indicate that the stone would probably not be seriously injured by freezing after being placed in construction work.

Portland cement.—The increasing number of uses made of Portland cement has developed a demand for pure limestone for its manufacture. The lower part of the Louisiana in some regions could be used for Portland cement, but the upper part of the formation contains too much magnesia for this use at all localities from which samples have been analyzed. Three to four percent of magnesium carbonate renders a limestone undesirable for this purpose.⁵¹

Lime for mortar.—Lime has been burned from this formation near Louisiana at different times, and many of the older houses in Louisiana have been plastered with lime from it. The lower beds are said to have furnished quick-slacking, rapid-setting, white to gray lime, but the limes from the dolomitic beds were slow-setting and would not carry as much sand as the pure lime. Because pieces of dolomitic limestone from the dolomitic beds were very frequently mixed by quarrymen and lime manufacturers with pieces of the high-calcium limestone, lime from the Louisiana was not considered as good for plaster as lime from the Burlington limestone.

Fertilizer.—Lime and limestone are widely used as sweeteners for acid soils, and they effect beneficial changes in both the chemical and physical properties of the soils. The Louisiana could, with profit, probably be more widely utilized as a source of agricultural lime than it now is. The high content of magnesia, it has been shown,⁵² makes it more effective in neutralizing soil acidity and more durable than high-calcium limestones such as the Burlington, but the greater difficulty in crushing is unfavorable, and the superiority of dolomitic limestones over high-calcium limestones is not well known in the region in which the Louisiana crops out.

Building stone.—The Louisiana is broken by jointing into such small pieces that it cannot be utilized as a building stone except for very rough masonry and for concrete mass work. It has been used to a very limited extent in both types of construction. Because it is naturally broken and can therefore be handled easily and at low cost, it would seem to have considerable

⁵¹ Eckel, E. C., Portland cement materials and industry in the United States: U. S. Geol. Survey Bull. 522, p. 45, 4913.

⁵² Stewart, Robert, and Wyatt, F. A., The comparative value of various forms of limestone: Soil Science, vol. 7, p. 277, 1919.



4. HAND SPECIMEN OF LOUISIANA LIMESTONE FROM THE LOWER 5 FEET OF THE LOUISIANA IN THE SECTION EXPOSED AT BUFFALO HILL, 1 MILE SOUTH OF LOUISIANA, MO.

Locality 599. Shows the dense texture and characteristic fracture of the limestone beds and the appearance of one of the dolomitic clay partings, which is clinging to the lower surface of the limestone.



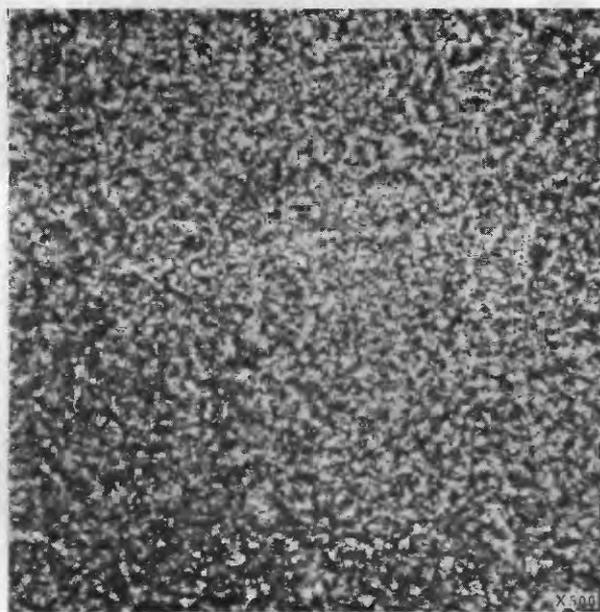
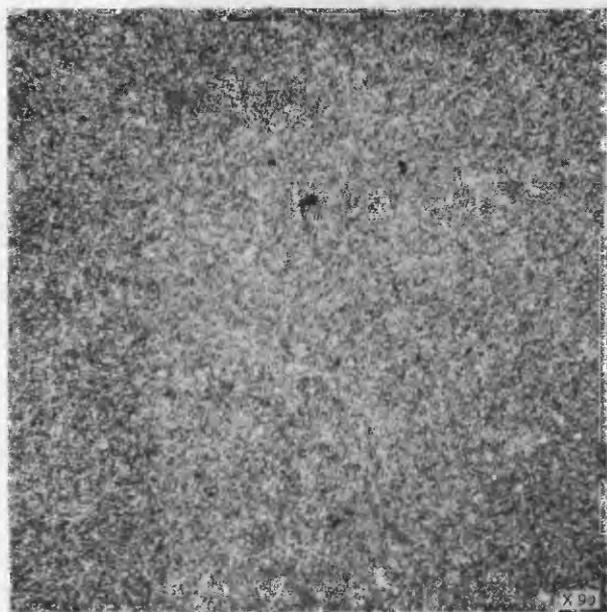
B. HAND SPECIMEN OF RELATIVELY HARD DOLOMITIC PARTING BETWEEN LIMESTONE BEDS OF THE LOUISIANA LIMESTONE FROM THE LOWER 5 FEET OF THE LOUISIANA IN THE SECTION EXPOSED AT BUFFALO HILL.

Locality 599.

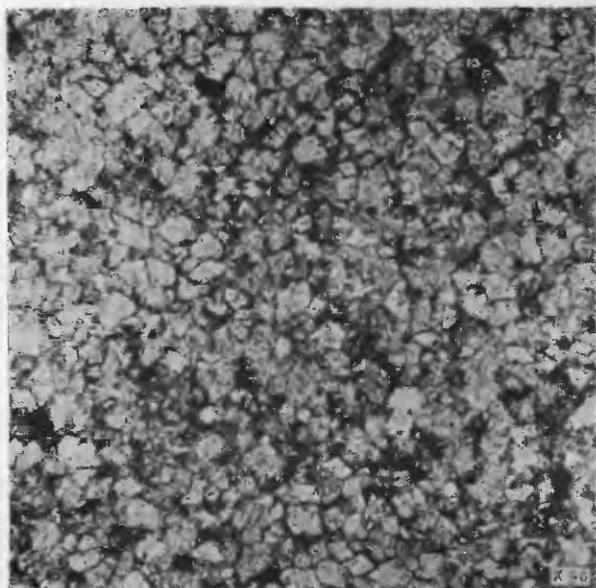


C. HAND SPECIMEN OF YELLOW-BROWN CALCAREOUS MUDSTONE AT BASE OF LOUISIANA LIMESTONE AT LOUISIANA, MO.

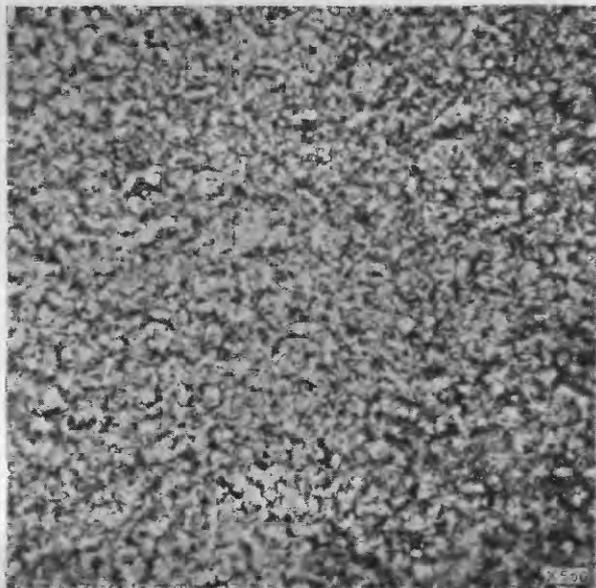
Locality 615.



A, B. PHOTOMICROGRAPHS (DIFFERENT MAGNIFICATIONS) OF THIN SECTIONS OF THE TYPICAL FINE-GRAINED LOUISIANA LIMESTONE SHOWN IN PLATE 3, A.



C. PHOTOMICROGRAPH OF THIN SECTION OF DOLOMITIC PARTING SHOWN IN PLATE 3, B.



D. PHOTOMICROGRAPH OF THIN SECTION OF LITHOGRAPHIC LIMESTONE FROM SOLENHOFEN, BAVARIA.

possibilities for more extensive local use for concrete mass work.

Riprap and rubble.—Considerable quantities of Louisiana limestone are used annually as riprap and rubble along the Mississippi River. Its occurrence in cliffs along and not far above the river level and its weathering into blocks which accumulate in talus piles facilitates its use for this purpose. Exposures near Clarksville have furnished much material for use as riprap. A few blocks of Louisiana limestone have been used for railroad ballast and to retard erosion in gullies near the Mississippi River.

Minor uses of limestone.—Limestone is used in a great many different industries, but the main uses to which it is put in northeastern Missouri have been discussed above. Lime from the Louisiana limestone could probably be used for many of the manifold uses to which lime is put in industry, but the small number of industries requiring considerable amounts of lime and the presence of the more easily usable Burlington limestone in the region have prevented any commercial demand for the Louisiana for such uses.

STRUCTURE

The most conspicuous structural feature of the region in which the Louisiana crops out is the Cap au Gres faulted flexure.⁵³ The Pittsfield-Hadley anticline, which also occurs in this region, is a much smaller anticline and lies a considerable distance northeast of the Louisiana outcrops. It therefore exerts little influence on the attitude of the Louisiana limestone. Both the structures named are described in the discussion of the paleogeography, pages 49–52. Their trends are shown on figure 8.

Neither of the two anticlines is marked by steep dips, except in very local areas, and the Louisiana limestone throughout most of its area of outcrop appears to be, and for all essential purposes is, horizontal. The average dip is to the northeast and probably does not exceed 25 feet to the mile.

More pronounced dips were, however, noted at some localities. Most of them were directly related to the main crest of the Cap au Gres flexure and are either the result of the location of the dipping beds on the flanks of the flexure or represent small flexures associated with it. Dips ranging from 5° to about 15° to the north and northeast were observed on the north flank at localities 1022 and 1023, near the plunging end of the flexure, in southwestern Marion County; and at locality 772, near Hydesburg, in northern Ralls County. Perceptible southwest dips occur on the south flank of the Cap au Gres flexure at locality 996 near Shiel, northwestern Ralls County, and at locality 988, southwest of New London, central Ralls County. A fault

or a sharp fold is suggested by steeply dipping beds along Sulphur Creek, about 1½ miles south of Cyrene, Pike County. At one place along the creek, the Maquoketa shale dips northwest at a high angle, whereas less than a half mile farther south the beds dip southwest.

Dips probably associated with the smaller anticline that branches off the Cap au Gres flexure west of Bowling Green occur in southwestern Ralls County. These dips were noted in the Chouteau along Salt River in NW¼ sec. 22, T. 55 N., R. 7 W., and along Spencer Creek NE¼ sec. 34, T. 54 N., R. 6 W. At this latter locality the beds dip about 10° southwest. A dip of 7° S. 70° W. observed at a locality about 1 mile south of Saverton, Ralls County, is not closely related to either the Cap au Gres flexure or Pittsfield-Hadley anticline and may represent a local structure that has not been heretofore noticed.

All the dips mentioned here are plotted approximately on figure 8.

STRATIGRAPHIC PALEONTOLOGY

COMPOSITION OF THE FAUNA

The Louisiana fauna is distinctly a brachiopod fauna, brachiopods being represented by more species and many more individuals than any other class. Gastropods and pelecypods are represented by more species than any other classes excepting brachiopods. The pelecypod element in the fauna is a relatively new one and is important for use in correlation. Cephalopods and corals are represented by several species but comparatively few individuals; and crinoids, bryozoans, and annelids by a considerable number of individuals but by few species. Foraminifera, sponges, blastoids, and fish teeth are rare. Plants are represented by broken stems. Ostracodes are common among the small fossils, and conodonts, though not common, have been found.

The fauna is remarkable because of the large number of species that occur in no other formation, because of its unusual variety and biologic range, and because of the number of forms whose systematic positions are so doubtful that they might well be considered problematical. Other unusual features are the relatively large number of small individuals and the presence of a trilobite with a color pattern and a brachiopod with markings that may also represent a color pattern.

Many of the small individuals are undoubtedly immature, as larger forms of the same species are associated with them. Others must be considered adult forms of small species, because there is a maximum size above which no individuals are known. Brachiopods are most abundant among the small forms, among the more common being *Schuchertella louisianensis* Williams, *Chonetes geniculatus* White, *Chonetes ornatus* Shumard, *Ambocoelia minuta* White, *Selenella pediculus* (Rowley), and *Cyrtina acutirostris* (Shumard).

⁵³ The relationship of this feature to the Mississippi River anticline of Howell is not definitely known. See Howell, J. V., Tectonic map of central United States; Kansas Geol. Soc. Guidebook, Fifth Ann. Field Conference, 1931.

Crinoid stem fragments are common in the small fauna, as are the calyces of the small crinoid *Allagecrinus americanus* Rowley. Branching bryozoans, worms, and ostracodes are also common, and conodonts and larger fish teeth have been collected. Several of the species are represented by individuals that may be arranged to show growth stages. Such stages have been worked out for *Cyrtina acutirostris* and for two species of *Ambocoelia*, and papers describing them are in preparation.

VERTICAL AND FACIES DISTRIBUTION OF THE FOSSILS

The limestone beds of the Louisiana were formerly thought to be unfossiliferous. Keyes,⁵⁴ in 1894, said that "the Lithographic or Louisiana limestone has been found to be devoid of organic remains except an occasional form in the thin shaly partings above the bottom-most layer." At that time most of the fossils listed from the formation had been collected from a "thin seam of buff, sandy shale, seldom over 3 or 4 inches in thickness at the very base of the limestone." Keyes,⁵⁵ however, stated in 1897 that the fossils were not confined to the shale or the shaly partings. It is not widely known, even at this date, that practically all species collected from the basal mudstones and dolomitic shaly partings in the lower part of the Louisiana also occur in the limestone beds. Good specimens are harder to obtain from the limestone beds than from the mudstones and clay partings, but in the northeastern part of Pike County and in Western Marion County the lower limestone beds are abundantly fossiliferous, and the writer has collected some fossils from the upper limestone beds near Louisiana and Clarksville, and at other places. Nearly all species that are abundant in the lower limestone beds have also been collected from the upper beds. In fact, all the common species have been collected at practically all horizons in the formation except at localities where the upper part is composed wholly of dolomite. The rare species have come from various horizons and, because they are rare, have little stratigraphic significance. It is true, however, that fossils are in general less common as one goes higher and higher above the base of the Louisiana. Fossils appear to be especially abundant, if not most abundant, in the parting above the lowest limestone bed.

Many of the Louisiana limestone species occur also in the blue mudstone of the Saverton below the yellow-brown mudstone, and for this reason the lower limit of the formation is not a distinct paleontological line. As previously stated, the writer believes that the lower boundary of the Louisiana should be drawn below the yellow-brown mudstone because of its lithologic similarity to the dolomitic clay-partings in the formation and

because of the great number of Louisiana species that are found in it. Some or all of the blue mudstone should also be included in the formation if the lower boundary is selected on a paleontological basis rather than on a lithological basis, but it seems best to rely upon lithology and place the lower limit of the formation above the blue mudstones.

The similarity between the fossils of the blue mudstones of the Saverton and the yellow-brown calcareous mudstones and limestone beds of the Louisiana is shown in the distribution table on pages 32-33. The writer has not separated the limestone beds of the Louisiana into faunal zones as there appear to him to be no definite zones within the limestone unit, but fossils collected from the yellow-brown calcareous mudstone, the limestone beds, and the dolomitic beds, where the upper part of the formation is composed almost entirely of dolomite, have been listed separately because of possible stratigraphic significance. For most of one field season records were kept of the horizons from which each collection from the limestone beds came, but after the conclusion was reached that there was no zonal distribution of common forms, such records were no longer kept.

The vertical and facies distributions of the Louisiana species are shown on the distribution table.

Good specimens were hard to obtain from the limestone beds as the fossils preserved in the dense limestones break easily or peel off, leaving nothing but internal molds or molds with small pieces of shelly material clinging to them. A thin bed of crystalline limestone near the base of the formation in western Marion County is very fossiliferous, but the fossils do not break out of it easily and are best studied while partly embedded in the limestone and partly exposed on its surface or in natural sections. The dolomitic beds are practically unfossiliferous.

Specimens from the basal mudstone and the dolomitic clay partings are commonly well preserved, especially the small forms. Where the partings are weathered or where the mudstone is soft and damp, the larger forms are apt to break easily when handled, but the small forms are not affected. The small forms are collected mainly by washing the weathered clay or mudstone and separating the residue by methods common to microscopic paleontology.

Aside from the greater abundance of nearly all classes of fossils in the mudstone and the dolomitic clay partings, there seems to be little evidence of the preference of certain classes for certain lithologic facies. The pelecypods are, however, an exception. Except for a very few species, they are confined to the yellow-brown mudstone, in which they are preserved mostly as internal molds. Some other classes in the fauna are more or less restricted to one variety of rock, but this restriction is thought to be more accidental than significant because these classes are represented by few individuals.

⁵⁴ Keyes, C. R., Paleontology of Missouri: Missouri Geol. Survey, vol. 4, pt. 1, p. 54, 1894.

⁵⁵ Keyes, C. R., Relations of the Devonian and Carboniferous in the Upper Mississippi Valley: St. Louis Acad. Sci. Trans., vol. 7, p. 364, 1897.

In this group are the trilobites, which are known only from the limestone beds; the cephalopods, which are much more abundant in the limestone beds; and the annelids, which, largely because of the restriction of *Conularia* to it, are more abundant in the yellow-brown mudstone.

The greater abundance of fossils in the clay partings may be in part only apparent, though one would expect to see sections or other indications of fossils on polished surfaces of the dense limestones if fossils were very abundant in them. Most of the fossils are calcareous and hence cannot be recovered from the limestone by dissolving the matrix in acid, but some are preserved partly as iron oxide and can be recovered. Insoluble residues of the limestone beds show very few fossils.

GEOGRAPHIC DISTRIBUTION OF FOSSILS

The region around the town of Louisiana, Mo., has furnished most of the fossils that have been described from the formation; and it is the best-known collecting locality, as the abundance of outcrops in the bluffs along the Mississippi River there early attracted paleontologists. The outcrop at the mouth of Buffalo Creek is perhaps the best collecting locality near the town of Louisiana, for the total thickness of the formation is exposed and is all readily accessible. Collections can also be obtained from the shales below. The bluff at the base of Allen's hill, on Town Branch, is the best collecting ground within the city limits of Louisiana, but good fossils were obtained at an outcrop at the Eighth Street quarry, also on Town Branch, and from an exposure north of the pump house of the Louisiana Milling Co., along the Mississippi River. However, all of the outcrops in the town of Louisiana have yielded some fossils.

The outcrops along the Mississippi bluffs north of the town of Clarksville are highly fossiliferous and yielded many of the species that were described in the older reports by Winchell, Hall, White, and others. A complete section of the Louisiana limestone and the shales beneath is exposed there in old quarries.

Good collections were also made 2½ miles west of Frankford, in the western part of Pike County, and about 2½ miles southwest of Saverton. Pelecypods are the most conspicuous element in the collections from the last-named locality.

The following list shows the localities cited by number in the text and distribution table.

REGISTER OF COLLECTING LOCALITIES

Marion County:

552. NE¼ sec. 12, T. 57 N., R. 8 W., about 8 miles north of Monroe City.
 728. SW¼ sec. 22, T. 57 N., R. 7 W., 3 miles northwest of Ely.
 1009. NW¼ sec. 24, T. 57 N., R. 7 W., about 2½ miles north of Ely.
 1010. SE¼ sec. 14, T. 57 N., R. 7 W.

1022. SE¼ sec. 29, T. 57 N., R. 6 W., about 6 miles west of Withers Mills.
 1122. Along North River, exact locality unknown.
 1123. Hannibal, Mo., exact locality unknown.
 1126. Marion County, locality unknown.

Pike County:

593. SW¼ sec. 18, T. 54 N., R. 1 W., Town Branch, Louisiana, Mo.
 593a. Louisiana, Mo., exact locality unknown or uncertain.
 597. SW¼ sec. 18, T. 54 N., R. 1 W., end of Jackson Street, Louisiana.
 599. NW¼ sec. 28, T. 54 N., R. 1 W., mouth of Buffalo Creek, 1 mile south of Louisiana, Mo.
 600. SW¼ sec. 18, T. 54 N., R. 1 W., Eighth Street quarry, Louisiana.
 607. SW¼ sec. 11, T. 53 N., R. 1 W., 2½ miles east of Stark.
 614. SW¼ sec. 17, T. 54 N., R. 2 W., about 7 miles west of Louisiana.
 615. NE¼ sec. 18, T. 54 N., R. 1 W., north of Louisiana Milling Co., Louisiana, Mo.
 617. SW¼ sec. 9, T. 53 N., R. 1 E., Clarksville.
 618. SW¼ sec. 9, T. 53 N., R. 1 E., Clarksville.
 623. Sec. 3, T. 52 N., R. 1 E., near Salem Church, 1½ miles west of Kissenger.
 625. NE¼ sec. 30, T. 52 N., R. 2 E., about 1 mile south of Annada.
 798. SW¼ sec. 32, T. 55 N., R. 4 W., 2½ miles west of Frankford.
 800. NW¼ sec. 12, T. 54 N., R. 5 W., 5½ miles northwest of Spencersburg.
 1121. Near Elk Springs, sec. 13, T. 54 N., R. 5 W., northwest part of Pike County.
 1124. Pike County, locality unknown.

Ralls County:

545. SE¼ sec. 13, T. 55 N., R. 7 W., about 9 miles northwest of Center.
 634. NE¼ sec. 30, T. 56 N., R. 3 W., 2½ miles southwest of Saverton.
 639. NW¼ sec. 7, T. 56 N., R. 3 W., 1½ miles north of Saverton.
 648. NW¼ sec. 24, T. 56 N., R. 5 W., about 4 miles north of New London.
 772. SW¼ sec. 3, T. 56 N., R. 6 W., 2 miles southeast of Rensselaer.
 967. About in NW¼SE¼ sec. 36, T. 55 N., R. 5 W., about 7 miles east of Center.
 988. NE¼SE¼ sec. 2, T. 55 N., R. 5 W., about 2 miles southwest of New London.
 996. SE¼SW¼ sec. 28, T. 56 N., R. 6 W., about 4½ miles south of Rensselaer.
 1125. Ralls County, locality unknown.

DISTRIBUTION TABLE

The localities at which the various species from the Louisiana have been collected are given by counties in the distribution table, pages 32-33, which has been prepared from information secured by the writer in his collecting, from an examination of all available published descriptions, and from information supplied by other collectors. The relative abundance of the species at the different localities as indicated is based on the writer's experience and is approximate only. The exact localities from which many of the species described by early paleontologists came were not given in the original or in subsequent descriptions, and this deficiency accounts for some of the omissions in the table.

AGE AND CORRELATION

GENERAL DISCUSSION

The exact position of the Devonian-Carboniferous boundary at many places is in dispute. The reasons for this lack of agreement are various. Among them may be cited the lack of adequate marine fossils in significant beds near the boundary in the type regions and the consequent difficulty of correlating beds elsewhere with them; differences in the position generally assigned the boundary in different countries; different relative weights given to stratigraphic and faunal evidence by different investigators; conflicting evidence from different classes of fossils; a lack (in some countries) of recent work on faunas of important beds; the probability of continuous sedimentation in certain areas from late Devonian into early Carboniferous time; and facies differences. Nearly all of these causes of dispute contribute to the difficulty of determining a generally satisfactory location for the Devonian-Carboniferous boundary in the United States; and, as the Louisiana limestone lies so near the boundary most commonly used here, they also contribute to the uncertainty regarding its age.

Conferences of investigators interested in Carboniferous problems have been held from time to time in Europe to consider disagreements about the positions of the boundaries and about other questions concerning the Carboniferous period. At these conferences, agreements by which many European paleontologists have abided have been reached. The most authoritative recent conference was the Congress on Carboniferous Stratigraphy held in Heerlen in June 1927.⁵⁶ At this conference, it was agreed by a vote, to use cephalopod zones as a more or less arbitrary basis for designating the position of the Devonian-Carboniferous boundary, which was tentatively placed at the top of the zone of *Gonioclymenia*. As the Congress was composed mainly of stratigraphers and paleontologists familiar with the typical regions of both systems, the stratigraphic position adopted for the boundary is probably the one in general use in these regions. Papers published since the Congress show that this boundary is now widely used in Europe, despite the objections expressed by several prominent geologists.

Adoption in the United States of the boundary agreed upon for western Europe would provide a more uniform dividing line than would any other available method. The effective use of this principle demands the rather definite correlation of thin units near the boundary. Unfortunately, data available for such

⁵⁶ See Congrès pour l'avancement des études de stratigraphie carbonifère, Compte rendu, Liège, 1928.

A more recent congress of Carboniferous stratigraphers and paleontologists was held in Heerlen in 1935. A brief report of this Congress was published in Glückauf, Jahrg. 71, Nr. 52, pp. 1266-1277, 1935. This report shows that the Devonian-Carboniferous line was at this second Congress raised from the base to the top of the Assise d'Étroeuungt. This is said to make the base of the Carboniferous correspond with the first appearance of the cephalopod genera *Gattendorfia*, *Protocanites*, *Pseudarietites* and *Paralyticeras*. The genus *Protocanites* occurs in the Louisiana limestone,

correlations appear insufficient. The first appearance of the significant cephalopod genus *Protocanites* in the Louisiana limestone in this country and in rocks of Carboniferous age in western Europe suggests that the dividing line in the United States should be below the Louisiana limestone. Correlations based on the first appearance of any genus are not ordinarily reliable, but in this instance other paleontologic data support the suggested assignment of the Louisiana to the Carboniferous, and relatively few data oppose it.

Correlation with other areas in the United States does not aid much in choosing between a Carboniferous or a Devonian age assignment for the Louisiana limestone, because the Devonian-Carboniferous boundary in nearly all regions where Late Devonian and Early Carboniferous beds are in contact is in dispute and there seems very little reason for choosing one boundary in preference to another. Few attempts have as yet been made to determine the Carboniferous-Devonian boundary in the United States by correlations with European beds about which agreements have been reached. Instead, local data have been used. Slight differences in the relative weight assigned to the various items of faunal and stratigraphic evidence have been sufficient to cause the individual investigator to assign thin formations near the boundary to the one system or the other, according to his personal emphasis. In the absence of data for satisfactory correlation with typical areas, faunal relationships to beds whose ages are generally agreed upon seems to offer the best method for age determination.

REASONS FOR THE ASSIGNMENT TO THE CARBONIFEROUS

Despite the contradictory implications of some features of the fauna, the writer believes that the Louisiana limestone is more logically placed in the Carboniferous than in the Devonian and that it is a part of the Kinderhook group of the Mississippian series. It was included in the Carboniferous by Winchell,⁵⁷ who first used Mississippian as a "geographical designation for the Carboniferous limestones of the United States" and by Williams,⁵⁸ who defined the Mississippian series as "that series of rocks, prevailingy calcareous, which occupies the interval between the Devonian system and the Coal Measures, and is typically developed in the States forming the upper part of the valley of the Mississippi River, viz., Missouri, Illinois, and Iowa." Winchell's definition of the Mississippian is brief and in general terms, and it is not evident just what he intended to include in it. However, it is clear that he considered the Louisiana along with other formations that are now generally referred to the Mississippian to be of Carboniferous rather than of Devonian age. He also thought that it was probable that the "blue shales"

⁵⁷ Winchell, A., Am. Philos. Soc. Proc., vol. 11, p. 79, 1869.

⁵⁸ Williams, H. S., Correlation papers: Devonian and Carboniferous: U. S. Geol. Survey Bull. 80, p. 135, 1891.

beneath the Louisiana were younger than the black shales which he thought to be of Devonian (Genesee) age.

Credit for the establishment of the Mississippian in its present use is generally given to H. S. Williams. Although the Louisiana was not specifically mentioned in his definition, it is clear that he intended to include it in the Mississippian, because he did specify that the Chouteau group of Broadhead is Mississippian, and the Louisiana limestone was included under the name Lithographic limestone in Broadhead's Chouteau group. The Louisiana had previously been placed in the Carboniferous by Winchell, Meek, Worthen, and others, but James Hall, Swallow, White, and others had thought it Devonian.

STRATIGRAPHIC EVIDENCE FOR EARLY CARBONIFEROUS AGE

The position of the Louisiana limestone beneath the Burlington limestone and beneath pre-Osage formations fixes it as of pre-Osage age. Its position above the Grassy Creek and Saverton shales has for the last 20 or 25 years been considered by many geologists sufficient to justify its reference to the Carboniferous (Mississippian) rather than to the Devonian. As other paleontologists, however, consider the Grassy Creek and Saverton shales Devonian, the age of those formations cannot be considered as definitely agreed upon.

For many years the shales below the horizon of the base of the Louisiana limestone and above Devonian and Silurian limestones in northeastern Missouri were generally considered Devonian. In his original description of the Grassy Creek shale, Keyes⁵⁸ referred these shales to the Devonian. He appears to have meant to include in the Grassy Creek all the shales in Pike County now referred to the Saverton and Grassy Creek formations. Rowley,⁶⁰ in 1908, assigned the predominantly black shales here called Grassy Creek⁶¹ to the Devonian but included the overlying blue shales here called Saverton in the Louisiana limestone because of their faunal similarity to the Louisiana. Rowley's assignment of the black shales to the Devonian was made mainly on the evidence of a single valve of a brachiopod identified as a *Stropheodonta* and on the *Lingulas*, but he appears not to have considered the evidence very strong, because on a later page he said "it is more than probable that the black shale should be ranged along with the blue as a part of the Louisiana formation."⁶² As most geologists had done for many years, he included the Louisiana in the Mississippian.

In 1911 Ulrich⁶³ placed the shales below the Louisiana

limestone in his Waverlian system, which he considered along with his Tennessean system as equivalent to the "old Mississippian system." In 1912 Keyes,⁶⁴ like Rowley, considered the blue shales immediately under the Louisiana limestone to be distinct from the black shales that underlie them. Instead of including them in the Louisiana limestone, he proposed that they be called the Saverton shales. He considered both the blue (Saverton) and black (Grassy Creek) shales to be Mississippian. Branson⁶⁵ considered both shales as one Devonian formation in 1914, when he published a paper on the Devonian fishes of Missouri; but in 1922⁶⁶ he weighed the evidence for and against their Devonian age and decided that both shales (which he continued to regard as in reality only one formation, the Grassy Creek) are of Mississippian rather than of Devonian age. This conclusion was based mainly on stratigraphic relations. In support of this conclusion Branson cited the fact that the Grassy Creek shale, as he interpreted the formation, overlaps formations ranging in age from Middle Ordovician to Middle Devonian and concluded that "the unconformity below the shales is profound." He believed that the shales graded upward "into the Louisiana limestone of the Mississippian without any indication of unconformity." The paleontological evidence, especially that of the fishes, Branson thought suggested a Devonian age, but he did not consider it strong. His opinion of the correlative value of the fishes in these beds coincided with that expressed by Ulrich⁶⁷ in 1915, that the Upper Devonian fishes apparently extend upward into the Mississippian.

Krey,⁶⁸ like Branson, also considered the Grassy Creek and Saverton shales as one formation, to which he applied the name Sweetland Creek shales. He also considered these shales to be of Mississippian age.

Moore,⁶⁹ in 1928, considered the shales below the Louisiana as two formations, the Saverton and Grassy Creek shales. This interpretation is followed in this report. Moore, like Branson and Krey, placed the Grassy Creek shale in the Mississippian mainly on stratigraphic evidence but intimated that confirmatory but not positive evidence was given by the classification as Mississippian of some of the formations correlated with the Grassy Creek. In addition, he gave reasons aside from the stratigraphic evidence which suggested to him that the Saverton shale also was Mississippian. After a rather extensive discussion, in which he cited Mississippian affinities of a number of species of fishes

⁵⁸ Keyes, C. R., Nether delimitation of our carbonic rocks: Iowa Acad. Sci. Proc., vol. 19, pp. 153-155, 1912.

⁵⁹ Branson, E. B., The Devonian fishes of Missouri: Univ. Missouri Bull., vol. 15, No. 13, Sci. ser., vol. 2, No. 4, pp. 59-60, 1914.

⁶⁰ Branson, E. B., The Devonian of Missouri: Missouri Bur. Geology and Mines, vol. 17, 2d ser., pp. 5-6, 1922.

⁶¹ Ulrich, E. O., Kinderhookian age of the Chattanooga series: Geol. Soc. America Bull., vol. 26, p. 98, 1915.

⁶² Krey, Frank, Structural reconnaissance of the Mississippi Valley area etc.: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 33, 1924.

⁶³ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, vol. 21, 2d ser., pp. 32-42, 1923.

⁵⁸ Keyes, C. R., Some geological formations of the Cap-au-Gres uplift: Iowa Acad. Sci. Proc. vol. 5, p. 63, 1898.

⁶⁰ Rowley, R. R., The geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, pp. 24-25, 1908.

⁶¹ Since this report was submitted for publication a paper discussing the Grassy Creek shale on Grassy Creek has been published. See Greger, D. K., Am. Midland Naturalist, vol. 16, pp. 110-113.

⁶² Rowley, R. R., op. cit., p. 26.

⁶³ Ulrich, E. O., Revision of the Palaeozoic systems: Geol. Soc. America Bull., vol. 22, p. 608, 1911.

in the Saverton, he concluded that the fish fauna considered by Branson to suggest a Devonian age is "intermediate in character between the recognized upper Devonian faunas and those of known Kinderhook age."⁷⁰ If either or both of the shales below the Louisiana limestone are, as Branson,⁷¹ Krey, Moore, and others believe, of Mississippian age, then it follows that the Louisiana limestone, because of its position above these shales and below beds of Osage age is also of Mississippian age.

The Mississippian age of the formations immediately underlying the Louisiana limestone, and hence of the Louisiana itself, is further suggested in some recent papers by the assignment to the Mississippian of nearby formations correlated with these formations. This suggestion, however, depends upon the validity of the correlations and of the Mississippian age of the nearby formations. These formations include the Sweetland Creek shale of Iowa and Illinois, the Chattanooga shale and equivalent formations of Kentucky, Virginia, and Tennessee, and other formations in these and nearby areas.⁷²

FAUNAL EVIDENCE FOR CARBONIFEROUS AGE

The stratigraphic evidence for the Mississippian age of the Louisiana limestone is fully confirmed by the much closer relationship of its fauna to Mississippian faunas than to Devonian faunas. Fifty-eight genera of invertebrates and two genera of fishes are represented in the species here described from this formation. These totals do not include any Foramenifera, ostracodes, or conodonts, which are here mentioned but have not been studied by the writer. Of the 58 invertebrate genera, 15 are not known from zones below the Mississippian and only one is elsewhere restricted to the Devonian.

⁷⁰ Moore, R. C., *idem*, p. 42.

⁷¹ Since this paper was submitted, two articles that place the shales here designated as the Grassy Creek and Saverton shales in the Devonian have been received by the writer. These papers are: Branson, E. B., and Mehl, M. G., Conodonts of the Grassy Creek shale of Missouri: Missouri Univ. Studies, vol. 8, No. 3, 1933; and Romer, A. S., and Grove, B. H., Environment of the early vertebrates: Am. Midland Naturalist, vol. 16, No. 6, pp. 805-856, 1935. Branson and Mehl would place the Mississippian-Devonian boundary at the top of the Louisiana limestone. They base this conclusion mainly on the conodonts but partly also on the fishes. Romer and Grove appear to rely entirely on the fishes for their age assignment. Partly because the conodont evidence does not seem very strong and is impaired by the relatively few described conodont faunas of definite Mississippian age, partly because other investigators of conodont faunas place the Mississippian-Devonian boundary below formations correlated with the Louisiana limestone, partly because the evidence from the fishes is interpreted differently by different paleontologists, and partly because the age of these shales is so dependent on the age of disputed beds placed in or correlated with the Chattanooga shale, the writer prefers to follow the evidence of the larger invertebrate fossils and place at least the upper one of these shales (the Saverton) in the Mississippian.

⁷² For some recent papers dealing with these formations, see the following references and papers cited therein: Wanless, H. R., Geology and mineral resources of the Alexis quadrangle: Illinois Geol. Survey Bull. 57, p. 42, 1929. Ulrich, E. O., The Chattanooga series with special reference to the Ohio shale problem: Am. Jour. Sci. 4th ser., vol. 34, pp. 157-183, 1912. Bassler, R. S., The stratigraphy of the central basin of Tennessee: Tennessee Division of Geology, Bull. 38, pp. 136-146, 1932. Swartz, J. H., Age and stratigraphy of the Chattanooga shale: Am. Jour. Sci., 5th ser., vol. 17, pp. 431-448, 1929. Cooper, C. L., Conodonts from the Arkansas novaculite, Woodford formation, Ohio shale, and Sunbury shale: Jour. Paleontology, vol. 5, No. 2, pp. 143-151, 1931. Laudon, L. R., Stratigraphy of the Kinderhook series of Iowa: Iowa Geol. Survey, vol. 35, pp. 352-355, 1931. Pohl, E. R., The black shale series of central Tennessee: Am. Jour. Sci., 5th ser., vol. 20, pp. 151-152, 1930. Savage, T. E., and Sutton, A. H., Age of the black shale in south-central Kentucky: Am. Jour. Sci., 5th ser., vol. 22, pp. 441-448, 1931.

The other 42 genera have ranges that include both the Devonian and the Mississippian. The one supposedly Devonian genus is *Productella*, a genus which, like other genera and so-called genera of productoid and productelloid shells, is often identified in or rejected from faunas with considerable doubt. If, as has been suggested, some of those Mississippian species of other regions that very closely resemble species of *Productella* but have recently been changed to other genera are found actually to belong in *Productella*, not a single genus elsewhere restricted to the Devonian will occur in the Louisiana. *Productella* is listed from the Berea (†Corry) sandstone of Pennsylvania, a formation that is undoubtedly of Carboniferous age. The weight of the evidence of the 15 Mississippian genera is somewhat lessened because three of them are confined to the Louisiana limestone and one of them, *Conopoterium*, is so closely related to Devonian genera that its validity is in doubt. When fully considered, however, the evidence of the genera, in spite of these limitations, is overwhelmingly in favor of a Mississippian assignment.

Genera in the Louisiana that indicate post-Devonian age are widely distributed among the invertebrate classes, but none of them are pelecypods or gastropods. They are: sponges, *Leptodiscus*; corals, *Microcyathus* and *Conopoterium*; blastoids, *Mesoblastus*; crinoids, *Albagecrinus*; bryozoans, *Tabalipora*; brachiopods, *Allo-rhynchus*, *Paraphorhynchus*, *Rhynchopora*, *Acanthospirina*, *Camarophorella*; amphineuran, *Gryphochiton*; cephalopods, *Protocanites*, *Prolecanites*; trilobites, *Proetides*. The genus *Protocanites* is considered adequate to prove Carboniferous age by most workers on formations exposed in western Europe.

Additional evidence for Mississippian age is given by a number of genera that are more suggestive of the Mississippian, although they occur in both Devonian and Mississippian rocks. This evidence, however, is partly offset by a number of other genera that are more suggestive of the Devonian than of the Mississippian.

Genera more suggestive of the Mississippian are: *Poteriocrinus*, which is said by some to occur in typical form only in post-Devonian rocks, *Platycrinus*, *Syringothyris*, and possibly, *Brachymetopus*. Genera most strongly suggestive of the Devonian are *Delthyris*, *Cyrtina*, *Selenella*, *Cornulites*, *Loxonema*, and three or four genera of pelecypods. Species of *Delthyris* and *Cyrtina* other than those here described have, however, been recognized in other Mississippian rocks by Stuart Weller and others, and *Cyrtina* or a closely allied genus has been reported from much younger rocks; a species of *Selenella* has been tentatively identified by Girty from a limestone of Boone age in Texas; and species of the other genera, other than Louisiana species, are also known from undoubted Mississippian rocks. The brachiopod genera, *Centronella* and *Trigeria*, have formerly been included in faunal lists from the Louisiana lime-

stone and, figuring prominently in faunal summaries, have cast doubt on its Mississippian age. No claim has been made by any paleontologist who has described species of these genera from the Louisiana that they have been positively identified. The uncertainty is largely because the internal characters had not been heretofore determined. The writer believes that these species are more properly placed in *Allorhynchus*, a Mississippian genus. The only two genera of fishes here identified are perhaps also more suggestive of the Devonian than of the Mississippian, but they have both been reported from other formations thought by many to be of Mississippian age. These genera are *Ptyctodus* and *Divichthys*.

The absence of some common Mississippian genera from the Louisiana is conspicuous, but not as significant or as striking as the absence of common Devonian genera. Especially conspicuous is the absence of Carboniferous productoid genera and so-called genera, such as *Avonia*, *Pustula*, *Linoproductus*, and *Productus*, and of *Brachythyris* and *Spiriferina*. That the absence of some of the productoid forms is probably due to little understood environmental conditions is indicated by the presence of *Linoproductus* in bed 1 of Weller at Burlington, Iowa, which probably is older than the Louisiana. Living conditions particularly unfavorable for the other genera mentioned may also explain their absence from the Louisiana, or it may be explained by the very early Mississippian age generally assigned the Louisiana.

The absence of most of the genera that in New York and the eastern United States are dominant in the Devonian, is more impressive than the absence of some common Mississippian genera. Some of these genera are: *Aulopora*, *Favosites*, *Heliophyllum*, *Tropidoleptus*, *Dalmanella*, *Atrypa*, *Stropheodonta*, *Leptostrophia*, *Hypothyridina*, *Styliolina*, *Pterinea*, and *Phacops*. Further evidence for the Mississippian age of the Louisiana fauna is given by the abrupt faunal change from the Upper Devonian of nearby regions. This change is well shown by a comparison of the genera. Branson⁷³ lists 41 genera from the Snyder Creek shale, youngest Upper Devonian formation in Missouri. Of these 16 are common to the Snyder Creek and the Louisiana, but most of the common genera are long-ranging and have no stratigraphic significance. Prominent genera in the Snyder Creek that are absent from the Louisiana are: *Aulopora*, *Ceratopora*, *Chonophyllum*, *Stromatopora*, *Atrypa*, *Pentamerella*, *Stropheodonta*, *Goniophora*, *Modiomorpha*, *Paracyclas*, and *Diaphorotoma*. Faunal differences almost as striking are shown by comparison of the genera in Upper Devonian formations of Illinois and Iowa with the Louisiana genera. An exception to this statement may be found in the Sheffield formation of Laudon in Iowa, but the specific

differences between that fauna and the Louisiana fauna strongly suggest age differences between them.

Comparisons of species, like comparisons of genera, are very favorable to a Mississippian age assignment for the Louisiana. No species in the Louisiana except *Ptyctodus calceolus* Newberry and Worthen, is known to occur in Devonian rocks. Furthermore, some of the genera common to the Mississippian and Devonian have species in the Devonian that are very different from the Mississippian species. This is especially true of the Spirifers, no species at all resembling the common Devonian species *S. euryteines* Owen and *S. disjunctus* Sowerby occurring in the Louisiana. Quite marked differences also exist between the more common Devonian species of *Athyris*, *Schuchertella*, *Chonetes*, *Camarotoechia*, and the Louisiana representatives of these genera. Several Louisiana species of pelecypods and gastropods do, however, resemble Hamilton species. Their resemblance has been explained by Weller by the hypothesis that they originated from a Hamilton fauna.

The lower, as against upper, Mississippian age of the Louisiana is fully established by its stratigraphic position below the Burlington limestone. Even if it were not so established, it would be strongly indicated by the presence together in the fauna of the following genera: *Plumalina*, *Schuchertella*, *Productella*, *Paraphorhynchus*, *Nucleospira*, *Protocanites*, *Brachymetopus*, and *Ptyctodus*.

REASONS FOR ASSIGNMENT TO KINDERHOOK GROUP

By definition, Meek and Worthen⁷⁴ included in the Kinderhook group "the beds lying between the Black slate and the Burlington limestone, which have heretofore been considered the equivalents of the Chemung group of New York." These formations, they said in a later paper,⁷⁵ constitute "the lowest division of the sub-Carboniferous or Mountain limestone series" and "the group includes the Choteau limestone, the Lithographic limestone, and the Vermicular sandstone and shales of the Missouri Report, the so-called Chemung rocks of the Iowa Report, that part of the Waverly sandstone of Ohio which overlies the Black slate of that region, and the Goniatite limestone of Rockford, Indiana."⁷⁶ The so-called black slate of Meek and Worthen's description is now considered by most paleontologists to belong to the Kinderhook. The reasons for its Mississippian age assignment have been stated in previous paragraphs.

Following Meek and Worthen's designation of it as Kinderhook and because of its Mississippian age and stratigraphic position below the Burlington limestone,

⁷⁴ Meek, F. B., and Worthen, A. H. Note to paper On the Age of the Goniatite limestone: Am. Jour. Sci., 2d. ser., vol. 32, p. 288, 1861.

⁷⁵ Meek, F. B. and Worthen, A. H., The sub-Carboniferous limestone series (of Illinois): Illinois Geol. Survey, vol. 1, p. 109, 1866.

⁷⁶ Idem, p. 109.

⁷³ Branson, E. B., The Devonian of Missouri: Missouri Bur. Geology and Mines, vol. 17, 2d ser., p. 41, 1922.

the Louisiana is placed now and has long been by nearly all geologists in the Kinderhook group. Its relations to the beds exposed near Kinderhook, Ill., in the region of the type locality of the Kinderhook group, are not, however, as yet satisfactorily determined.

CORRELATION WITH OTHER LOWER MISSISSIPPIAN FORMATIONS

Many circumstances make the close correlation of the Louisiana limestone with other lower Mississippian formations at present very difficult. Kinderhook sections in nearby regions are quite different from those that contain the Louisiana, and formations exposed in one outcrop area can be recognized by lithology alone in few, if any, other areas. The Louisiana cannot be traced laterally at the surface into any other formation, as can facies of some formations that have been given local names in Missouri. It cannot be shown by subsurface data to be continuous with any other Kinderhook formation, because in areas where the horizon is not exposed well logs are too few or have not been adequately prepared or studied. Satisfactory correlations cannot be made by matching unconformities, because more unconformities are known in some sections than in others, and it is impossible to determine by any means except by faunal correlations which unconformities are equivalent. In the present state of knowledge close faunal correlations are, as the writer will try to show, only suggestive and not in any sense conclusive. In time more detailed correlations can no doubt be reliably made, but there will always be a limit beyond which faunal correlations are not reliable under conditions similar to those existing here. Where, as here obtains, fairly thin beds in one section cannot be recognized by lithologic character in a section of approximately the same age nearby, at least two explanations immediately come to mind. One is that the horizon of a given bed in one section is represented in the other by an unconformity. The other is that rocks of different lithologic characters were deposited at the same time in the two areas. This last explanation undoubtedly is the better for differences between some of the Kinderhook sections. If it is correct, conspicuous differences between faunas within the Kinderhook may be more correctly ascribed to facies and environmental differences than to time differences; and correlations based solely on numerical superiority of common species or genera of fossils will not be reliable. The difficulty of making close faunal correlation of the Louisiana with other Kinderhook formations is in part also caused by the lack of published recent work on the descriptive paleontology and the zonal distribution of the fossils of these other formations. The deficiency of recent published work of this type for the Hannibal and Chouteau formations in Missouri and the formations exposed at Kinderhook, Ill., and at Burlington, Iowa, especially hinders the correlation of the Louisi-

ana. E. B. Branson and his associates have completed such studies for the first two formations, but they are as yet unpublished.^{76a} G. H. Girty and the writer have in progress reports of this type on the formations exposed at Kinderhook and at Burlington, and considerable changes from published lists have already been noted in the stratigraphic distribution of some species and genera. When these reports are published and the species compared with those at other localities, more definite faunal correlation of the Louisiana will probably be possible. Another factor that, however, hinders the faunal correlation is the restriction of many species and some genera of the Louisiana fauna to the Louisiana limestone. Yet, in spite of the many difficulties to be met and the many uncertainties that remain to be disposed of before conclusive interpretations can be made, certain correlations are suggested by the facts now available.

Because of the cited difficulties in correlation by tracing and matching lithologic units, the fauna of the Louisiana, in spite of its disadvantages, offers about the only basis for correlation with nearby formations. In fact, faunal evidence is at present the most reliable of the various methods of correlation between most of the Kinderhook formations in the Mississippi Valley.

CORRELATION WITH BEDS AT KINDERHOOK AND BURLINGTON

There are two well-known Kinderhook sections near the area in which the Louisiana crops out. One of these is at Kinderhook, Ill., the type locality for the Kinderhook group. It lies east of the northernmost outcrops of the Louisiana limestone in Missouri, and is separated from the nearest of them by the Mississippi River and about 10 miles of valley fill. The outcrop of Louisiana limestone in Illinois nearest to Kinderhook is about 15 miles away. The other famous section is at Burlington, Iowa, about 75 miles north of the most northerly exposure of Louisiana limestone and separated from it by an area underlain by younger rocks. The relative locations of these sections and of some other areas of Kinderhook rocks to the Louisiana outcrops are shown on figure 8. It is impossible to trace the rocks of any one of these sections into those of any other.

Both the Burlington and Kinderhook sections have been studied many times and by many geologists. Their lithologic features are not unlike, and although they cannot be correlated by tracing, it does seem possible to recognize, by lithologic resemblance, beds that occur in both sections. In so doing, it is necessary, however, always to bear in mind that like beds may represent only like conditions of sedimentation and may not be contemporaneous. Fossils are more abundant and the section is more complete at Burlington. Consequently, more study has been given the section there

^{76a} These studies have since been published in Univ. Missouri Studies, vol. 13, 1938.

than at Kinderhook. It would not be profitable here to review the work of all who have contributed to the knowledge of these sections and their faunas. Concerning the faunas it is necessary to state, however, that no descriptive work treating them as faunas has been published for over 30 years, a fact that hinders their correlation with other nearby faunas. A significant and very helpful discussion of the brachiopods was published by Weller in 1914, but no descriptive work on the other classes has been published recently and no further descriptive work on the brachiopods has appeared since 1914.

The stratigraphy of the section at Burlington has within recent years been carefully studied by Van Tuyl, Moore, Laudon, and the writer, and is well known. The section at Kinderhook has also been visited by many investigators and a description of it has also recently been published in Moore's comprehensive treatment of the lower Mississippian formations of Missouri. Both of these sections were studied many times by Stuart Weller, and others have also contributed much to the knowledge of them. The sections given by Weller⁷⁷ and by Worthen,⁷⁸ in which the beds were numbered are better known than more recent sections in which they were named. Weller's and Worthen's sections are as follows:

Weller's section at Burlington, Iowa

	Feet
7. Soft, buff, gritty limestone.....	3-5
6. White oolitic limestone.....	2-4
5. Fine-grained yellow sandstone.....	6-7
4. Fine-grained, compact, fragmental, gray limestone....	12-18
3. Thin band of hard, impure limestone, filled with <i>Chonetes</i> ; sometimes associated with a thin oolite band.....	½-¾
2. Soft, friable, argillaceous sandstone, sometimes harder and bluish in color, filled with fossils in the upper portion, the most abundant of which is <i>Chonopectus fischeri</i>	25
1. Soft blue argillaceous shale (exposed).....	60

Worthen's section at Kinderhook, Ill.

	Feet
5. Loess capping the bluff.....	20
4. Burlington limestone.....	15
3. Thin-bedded, fine-grained limestone.....	6
2. Thin-bedded sandstone and sandy shales.....	36
1. Argillaceous and sandy shales, partly hidden.....	40

Subsurface data show an unbroken sequence of about 300 feet of shale below the exposed part of bed 1 at Burlington. No logs of wells at Kinderhook, were available, but wells near there and farther north and east show that the Kinderhook consists of about 235 feet of shales and sandstones. No limestone resembling the Louisiana to any extent has been recognized in them.

Weller⁷⁹ has correlated the Louisiana with beds

⁷⁷ Weller, Stuart, The succession of fossil faunas in the Kinderhook beds at Burlington, Iowa: Iowa Geol. Survey, vol. 10, p. 65, 1900.

⁷⁸ Worthen, A. H., Geology of Pike County: Illinois Geol. Survey, vol. 4, p. 27, 1877.

⁷⁹ Weller, Stuart, The northern and southern Kinderhook faunas: Jour. Geology, vol. 13, p. 625, 1905.

2-4 in the section at Burlington and with beds 2 and 3 in Worthen's section at Kinderhook. In both of these sections there are fine-grained limestones (bed 4 at Burlington and bed 3 at Kinderhook) that somewhat resemble the Louisiana limestone. These limestones are but sparingly fossiliferous. Largely because of lithologic resemblance, but also because of the occurrence of *Paraphorhynchus striatocostatum* (Meek and Worthen) in both, Weller has considered these limestones the same and has correlated them with at least part of the Louisiana. Their correlation with the Louisiana was in most part based on the presence of *Productella pyridata* Hall and *Paraphorhynchus striatocostatum* in the limestone at Kinderhook, and also on the occurrence at Burlington, where bed 4 is said to contain a modified *Chonopectus* fauna, of *P. striatocostatum* and *Syringothyris halli* Winchell, which is related to *S. hannibalensis* (Swallow) of the Louisiana fauna. Weller's correlation of bed 2, the *Chonopectus*-bearing sandstone, at Kinderhook with the Louisiana seems to have been based on the provisional identification of *Spirifer marionensis* Shumard and the reported presence of *Chonetes ornatus* Shumard, and of *C. geniculatus* White, in bed 2, and on several common genera. His correlation of bed 2 at Burlington with the Louisiana was based mainly on the identification of bed 2 at Burlington with bed 2 at Kinderhook but was also supported in a measure by 10 or 12 common genera and by the reported occurrence of *P. striatocostatum* and of forms identified as *Chonetes geniculatus* and *Chonetes* cf. *C. ornatus* in bed 2 at Burlington.

Moore's⁸⁰ correlations between these three sections differ considerably from Weller's. He rejects Weller's correlation of part of the Louisiana with the fine-grained limestones in the Kinderhook and Burlington sections and cites in support of his position the presence of five or six species in the limestone at Burlington that do not occur in the Louisiana limestone. He believes that the failure of the Louisiana limestone and Kinderhook and Burlington sections to match, especially in the relations of the various lithologic units to the Burlington limestone, also confirms his hypothesis. He rejects the correlation of part of the Louisiana with bed 2 at Kinderhook and with bed 2 at Burlington, and instead correlates these beds with the Hannibal shale of the Missouri sections. Moore justifies his correlation by maintaining that it is possible to trace the Hannibal of Missouri into the section at Kinderhook. He believes this to be possible in spite of the fact that the Hannibal sections in this part of Missouri are separated from the Kinderhook section by an interval of at least 10 miles, an interval that includes the Mississippi River Valley and areas of younger rock, and in spite of the fact that the lithologic character of the two sections is quite different. The tracing, he says, is possible because

⁸⁰ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 50, 1928.

beds near Pleasant Hill, Ill., which is south of Kinderhook, can be identified by lithologic character, "vermicular" markings, stratigraphic position, and thickness with the Hannibal shale across the Mississippi River in Missouri. These beds, although changing in lithologic features, can be traced northward into bed 2 at Kinderhook. The exposures, one would judge from Moore's statements and from other reports, are not, however, continuous. Moore accepts the correlations made by most writers of bed 2 at Burlington with bed 2 at Kinderhook. This correlation was based on lithologic features, stratigraphic position, and to a degree on fossils. If it is correct, and if bed 2 at Kinderhook is equivalent to the Hannibal, then it follows that bed 2 at Burlington is also at least in part equivalent to the Hannibal. Moore presents confirmatory faunal evidence for the correlation of bed 2 at Burlington with the Hannibal shale. This evidence consists of a comparison of the fauna of bed 2 at Burlington with a composite fauna assigned to the Hannibal shale but collected from four localities, only one of which is in Missouri. These localities are at Louisiana, Mo., Pleasant Hill, Ill., Rockport, Ill., and Kinderhook, Ill. Considerable differences are evident between these four faunal lists. A comparison of the fauna of the Hannibal shale from Louisiana with bed 2 at Burlington, made from Moore's lists, shows a few more species in common between these two formations than between the Louisiana limestone and bed 2. There are, however, as many genera common to the Louisiana and bed 2 as to the Hannibal at Louisiana and bed 2. As most of the species common to the Hannibal and bed 2 are pelecypods, their common occurrence may, as Weller has suggested, be largely due to similarity of facies. The correlation of bed 2 at Burlington with the Hannibal does, however, receive some support from the occurrence of certain genera in bed 2 that do not occur below the Hannibal in northeastern Missouri. Most of the "new" genera do, however, occur in other parts of Missouri in formations thought to be as old as the Louisiana and may themselves be influenced by facies. Most of Moore's faunal evidence for the correlation of bed 2 at Burlington with the Hannibal is taken from that part of the composite Hannibal list that is derived from bed 2 at Kinderhook. As the correlation of bed 2 at Kinderhook with the typical Hannibal rests, as before stated, in the main on tracing, its value and that of the consequent correlation of bed 2 at Burlington with the Hannibal is dependent on the degree of continuity of outcrops and on the persistence of distinct lithologic features of the beds referred to the Hannibal. The faunal evidence cited, if taken alone, more strongly supports Moore's correlation of beds 2 at Kinderhook and Burlington with part of the Hannibal than it does Weller's correlation of these beds with part of the Louisiana, but, as the writer has tried to show, the evidence taken from Moore's lists is not in any sense

conclusive. If beds 2 at Burlington and Kinderhook are equivalent to the Hannibal, then beds above them will be as young as or younger than the Hannibal and consequently younger than the Louisiana. Moore also has correlated beds 3, 4, and 5 at Burlington and bed 3 at Kinderhook with the Hannibal and beds above them with younger formations. This interpretation, if it is assumed that the Hannibal is approximately the same age throughout its area of outcrop, makes the Louisiana the time equivalent of a part of beds 1 at Burlington and Kinderhook, or of beds not represented or exposed in these two areas.

Laudon,⁸¹ like Moore, correlates bed 2 at Burlington with the Hannibal shale rather than with part of the Louisiana. He cites in support of his correlation that "of the 28 species of brachiopods found in the Hannibal of Missouri 12 are found in the English River (bed 2). Of the 15 species of pelecypods found in the Hannibal, 9 are found in the English River. The gastropod element in the Hannibal is very small, with only four representatives, and of these only one is found in the English River. Two cephalopods are found in the Hannibal, and one of these occurs in the English River. The English River fauna contains 48 percent of the Hannibal species." Laudon does not state what the common species are, where in Missouri they occur, or whether they were identified by himself or by others. If, as one would imply from his statements, the species cited were collected from unquestioned Hannibal shale in Missouri, his evidence is the strongest yet presented for correlating the Hannibal with bed 2 at Burlington. Unlike Moore, Laudon correlates all beds of Kinderhook age above bed 2 at Burlington with the upper part of the Chouteau limestone of Missouri. These beds include bed 3, "the fine-grained limestone," correlated by Weller with part of the Louisiana and by Moore with part of the Hannibal.

The writer's study of the Louisiana fauna influences him to agree with Moore and Laudon that the Louisiana is older than bed 2 at Burlington. This relation, according to the belief of most paleontologists, would also suggest that it was older than bed 2 at Kinderhook. The writer's study has convinced him, however, that these correlations are based on incomplete evidence, some of which when fully considered is conflicting. It seems evident that new facts will have to be discovered before it is possible, if it ever is to be possible, to correlate beds in these three areas with any degree of assurance. Some of these facts may be supplied by fuller collections. Others appear likely to come from descriptive studies now being made. Still others will come no doubt from a better understanding of the relations of faunas to facies.

The influence of facies on Kinderhook faunas is shown strikingly by Moore's lists of fossils from the beds at

⁸¹ Laudon, R., The stratigraphy of the Kinderhook series of Iowa: Iowa Geol. Survey, vol. 35, p. 365, 1931.

Kinderhook and at Burlington. The strong pelecypod element in all the sandstones is all but missing in the limestones. In addition, the gastropods also are relatively much more numerous in the sandstones. The brachiopods have not been so much influenced by facies as the pelecypods and gastropods. Of 27 genera of pelecypods contained in Moore's lists from Kinderhook and Burlington, 21 occur only in the sandstones. Of 18 genera of gastropods, 8 or 10 occur only in sandy beds. The facies influence is perhaps not actually as strong as the above figures would indicate, because some few of the genera occur in only one formation and also because the sandstones are more fossiliferous than the limestones, but it is undoubtedly an important factor that must be taken into consideration in any correlations made.

Interesting facts bearing on the faunal correlation of the Louisiana with beds in the sections at Kinderhook and at Burlington are shown in the following tables. The data for the occurrence of species and genera in those two sections are taken from the lists published by Moore.⁸² Some additions and corrections to these lists can perhaps be made, but they are the most complete and most recent published lists available. One table shows the distribution in the lower five beds of the section at Burlington of species and genera from the Louisiana (except those genera that also occur in the Hannibal) and of species and genera from the Hannibal (except those genera that also occur in the Louisiana). The other shows the distribution of such species and

⁸² Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, pp. 25-31, 1928.

Fossils from the Louisiana limestone and Hannibal shale found in beds of Kinderhook age at Burlington, Iowa

[Genera common to the Louisiana and the Hannibal at Louisiana, Mo., are not included]

Beds of Kinderhook age at Burlington, Iowa	Louisiana limestone		Hannibal shale at Louisiana, Mo.	
	Species	Genera ¹	Species	Genera
Bed 5. Brown sandstone. 6 ft.	Chonetes ornatus var. glenparkensis Weller. Cyrtina acutirostris? (Shumard). Athyris lamellosa (L'Éveillé). Grammysia hannibalensis (Shumard). Proetus missouriensis Shumard?	Delthyris. Ambocoelia. Cyrtina. Athyris. Nucula. Palaeoneilo. "Leda." Aviculopecten. Platyceras.	Rhipidomella thiemei (White). Productus arcuatus Hall. Pustula concentrica (Hall). Spirifer osagensis Swallow? Nucleospira barrisi White. Grammysia hannibalensis (Shumard). Schizodus trigonalis Winchell. Pernopecten cooperensis Shumard. Cypricardinia sulcifera (Winchell). Bucanopsis perelegans (White & Whitfield).	Schellwienella. Productus (M). ² Pustula (M). Avonia (M). Sphenotus. Promacrus (M). Schizodus. Pernopecten (M). Lithophagus. Cypricardinia. Bucanopsis.
	7 percent. ³	39 percent.	14 percent.	39 percent.
Bed 4. Dense limestone. 10 ft.	Paraphorhynchus striatocostatum (Meek and Worthen).	Paraphorhynchus (M). Rhynchopora (M?). Allorhynchus (M?).	No common species.	Schizodus.
	13 percent.	57 percent.		29 percent.
Bed 3. Oolitic and crystalline limestone. 8 in.	Rhipidomella missouriensis (Swallow). Paraphorhynchus striatocostatum (Meek and Worthen).	Paraphorhynchus (M). Rhynchopora (M?). Allorhynchus (M?). Aviculopecten. Loxonema.	Rhipidomella missouriensis (Swallow). Rhipidomella thiemei (White). Chonetes alatus Moore.	Schellwienella. Schizodus.
	8 percent.	52 percent.	11 percent.	33 percent.
Bed 2. Massive sandstone. 22 ft.	Chonetes geniculatus White?	Paraphorhynchus (M). Allorhynchus (M?). Nucula. Aviculopecten. Loxonema. Murchisonia.	Chonetes alatus Moore. Chonetes geniculatus White? Pustula concentrica (Hall). Sphenotus iowensis (Winchell). Grammysia plena Hall. Pernopecten circularis (Shumard). Cypricardinia sulcifera (Winchell).	Schellwienella. Productus (M). Pustula (M). Sphenotus. Promacrus (M). Cardiopsis. Schizodus. Pernopecten (M). Cypricardinia. Bucanopsis.
	1 percent.	29 percent.	8 percent.	33 percent.
Bed 1. Shale. 19 ft. exposed.	No common species.	Productella. Aviculopecten. Conularia.	No common species.	Productus (M).

¹ All these genera are known elsewhere in younger rocks.

² Genera no older than Mississippian are designated by (M).

³ Percentage of the total number listed from the bed at Burlington.

Fossils from the Louisiana limestone and Hannibal shale found in beds of Kinderhook age at Kinderhook, Ill.

[Genera common to the Louisiana and the Hannibal at Louisiana, Mo., are not included]

Beds of Kinderhook age at Kinderhook, Ill.	Louisiana limestone		Hannibal shale at Louisiana, Mo.	
	Species	Genera ¹	Species	Genera
Bed 3. Dense limestone. 6 ft.	Productella pyxidata Hall. Paraphorhynchus striatocostatum (Meek and Worthen). 100 percent. ³	Productella. Paraphorhynchus (M). ² 100 percent.	No common species.	No common genera.
Bed 2. Sandstone. 42 feet.	Chonetes geniculatus White. Spirifer marionensis Shumard. 6 percent.	Crania. Paraphorhynchus (M). Aviculopecten. Pleurotomaria. Loxonema. Brachymetopus. 50 percent.	Scalarituba missouriensis Weller. Rhipidomella thiemei (White). Chonetes alatus Moore. Chonetes geniculatus White. Pustula concentrica (Hall). Grammysia plena Hall. Parallelodon blairi (Miller and Gurley). Pernopecten cooperensis (Shumard). 22 percent.	Schellwienella. Productus (M). Pustula (M). Pernopecten (M). 40 percent.
Bed 1. Shale. 43 ft. exposed.	No fossils known from this bed.			

¹ All these genera are known elsewhere in younger rocks.

² Genera no older than Mississippian are designated by (M).

³ Percentage of the total number listed from the bed at Kinderhook.

genera in the Kinderhook section at Kinderhook. Genera that occur in both the Hannibal and Louisiana are not included in the tables because they do not aid in determining whether a given bed is more closely related to one or the other of the two formations.

These tables show more plainly than could any discussion the conflicting facts of the faunal evidence for the correlation of the Louisiana limestone with the beds at Burlington and at Kinderhook. They also show clearly the need for more data before reliable faunal correlations can be made. Their evidence may possibly be minimized because of three or four valid objections. It can be said that the lists, like most fossil lists, are not complete or final; that they are possibly the result of localized collecting; that they contain relatively more complete faunas from beds in which fossils are more abundant; and what is most important, that the tables do not consider adequately evidence from species and genera that occur in one of the sections but not in the others, or evidence from closely related species, or from relative abundance of species. It may also be said that although the tables give the genera that appear for the first time in the sections, they do not show the species that occur for the first time in various beds in this region. In spite of these possible objections, the writer believes that the tables give a relatively true concept of present status of knowledge of the faunas they treat.

The tables also show plainly the seeming influence of sedimentary facies on the faunas. The limestone beds in the sections, especially those similar to the Louisiana

in composition, have faunas more like those of the Louisiana limestone than like those of the Hannibal. The sandstones, both below and above these limestones, have faunas that seem to match those of the Hannibal more closely than those of the Louisiana.

They also illustrate clearly the inadequacies of correlating some formations by the common method of determining which formations have the most species and genera in common. They indicate that, in the absence of statistics regarding the relative abundance of the different species and genera in the different beds, the only method of faunal correlation likely to yield valid results under conditions existing here is the one that emphasizes the importance of new faunal elements. The pitfalls of this method are known to most paleontologists. Conclusions from it must be drawn with care. The first report of the occurrence of a genus or a species at a supposedly lower horizon may as well mean that the genus or species originated earlier than previously known as that the beds containing it are younger than previously thought; but where several genera are found at a supposedly lower horizon, it is good presumptive evidence, in the absence of other evidence to the contrary, that the horizon is younger than supposed. As applied to the correlation of the Louisiana and Hannibal with bed 2 at Kinderhook and bed 2 at Burlington, this type of evidence is far from conclusive, as can be seen from the tables. However, it is more suggestive of a Hannibal or younger age for the specified beds than of a Louisiana or older age.

Very little faunal evidence exists for correlating the shales below bed 2 at Hannibal and below bed 2 at Kinderhook with beds in the area underlain by the Louisiana limestone. If any of the Mississippian shales exposed at Burlington or Kinderhook or reported in well logs from Burlington or near Kinderhook are even in part equivalent to the shales below the Louisiana, as stratigraphic, lithologic, and to an extent paleontologic evidence would seem to indicate, then the Louisiana limestone is the equivalent of (1) a horizon between beds 1 and 2 at Burlington and at Kinderhook that is not represented by deposits in those areas, (2) of the upper part of the shales of bed 1, or (3) of some unexposed horizon within what seems from well logs to be an uninterrupted shale sequence below the exposed part of bed 1. All three of these alternative correlations are favored by Moore's statement that the Hannibal of Missouri can be traced into bed 2 at Kinderhook. The strength of the evidence from this statement is lessened somewhat, however, by the fact that the faunas of some of the beds referred to the Hannibal in Illinois resemble Louisiana faunas as much as or more than they do Hannibal faunas.

The first two correlations could, of course, be disproved if the Louisiana were known to occur in wells at Kinderhook or nearby, but the writer knows of no wells at Kinderhook and of no nearby wells that cut recognizable Louisiana. At the present time, it seems that any one of the three correlations suggested is about as logical as either of the other two; and with the present data, any of them seems better than a correlation that would place the Louisiana equivalent to bed 2 or higher beds at Burlington or at Kinderhook. Faunal evidence does not, however, definitely preclude the latter correlation.

CORRELATION WITH OTHER FORMATIONS IN MISSOURI

Aside from the area in the northeastern part of the State in which the Louisiana crops out, there are three other Kinderhook provinces in Missouri, namely, southeastern, central, and southwestern Missouri. The Louisiana is not represented in any of them. It thins out southeastward from the type locality and disappears north of the southeastern Missouri province. It also thins southwestward, and its southwesternmost outcrops are separated from the nearest outcrops of the formations of the central Missouri province by an area of younger rocks. Well logs from this area are few and unsatisfactory, but they indicate, as far as they may be trusted, that the Louisiana pinches out a short distance southwest of its area of outcrop. It is patent that if the Louisiana cannot be traced into the central Missouri province, it cannot be traced into the southwestern Missouri province. It would seem, then, that faunal correlation is the only one likely to prove of value in determining the relation of the Louisiana limestone to the Kinderhook formations in other parts of Missouri.

This is not exactly true, however. Although it is impossible to trace in Missouri the Louisiana limestone into the formations of the southeastern Missouri province, their stratigraphic relations can be in part determined in Illinois. At Hamburg, Ill., beds correlated on faunal evidence with the Glen Park of the southeastern Missouri province overlie about 5 feet of Louisiana limestone with indisputable erosional unconformity. There is also evidence at other places in Illinois that these two limestones are unconformable. The Glen Park is at the type locality in east-central Missouri the middle member of the Sulphur Springs formation. An unnamed shale with variable thickness underlies it there. This shale is absent in many places within the province. The Glen Park is overlain by the Bushberg sandstone member, which in Ste. Genevieve County is in turn overlain by a black shale. Weller and St. Clair⁸³ in 1928 correlated the Sulphur Springs with the younger part of the Louisiana formation on faunal grounds. The writer's study of the Louisiana fauna has shown that it has four species in common with the fauna of the Glen Park member of this formation, and that five or six species in the two faunas are closely related. The common species are *Chonetes ornatus* var. *glenparkensis* Weller, "*Leda*" *diversoides* Weller, *Parallelodon sulcatus* Weller, and *Ptyctodus calceolus* Newberry and Worthen. Closely related species include species of *Platycercus*; and *Delthyris missouriensis* Weller, a Glen Park species that is closely related to *D. clarksvillensis* (Winchell) of the Louisiana; and *Nucleospira minima* Weller, closely related to *N. rowleyi* Weller. In addition, 11 of the 31 genera that occur in the typical Glen Park and 7 of the 14 genera that occur in the beds at Hamburg referred to the Glen Park also occur in the Louisiana limestone. This faunal evidence suggests that the Glen Park and Louisiana were in part contemporaneous, or that the Louisiana sea merged at some place with the Glen Park sea and enabled some of the faunal elements to migrate from one area to the other. Another, and more probable, explanation is that the faunas were derived from a common source. In all events, there is very little difference in their age.

Kinderhook formations in the central Missouri province are the Sylamore sandstone of some authors⁸⁴ at the base and the Chouteau limestone above. A study of the faunas of these formations has been made by E. B. Branson, but it is not yet published.^{84a} No adequate published data on the zonal distribution of fossils in the Chouteau is available, and zones within the formation have not been established. Published information about the fauna of the so-called Sylamore sandstone is also meager. As previously stated, the Louisiana limestone cannot be traced into this province or recognized

⁸³ Weller, Stuart, and St. Clair, Stuart, The Geology of Ste. Genevieve County, Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 22, p. 160, 1928.

⁸⁴ Branson and Mehl (Missouri Univ. Studies, vol. 8, No. 4, p. 269, 1933) correlate these sandstones with the Bushberg rather than with the Sylamore.

^{84a} This study has been published in Univ. Missouri Studies, vol. 13, 1938.

in it by lithology. The Kinderhook formations of central Missouri have not been traced into the southeastern Missouri province; at least, no published record of such tracing is available. The writer has examined sections in both provinces and certain lithologic resemblances are striking but not sufficient bases for correlation. The Chouteau limestone in the northeastern Missouri province is thought to represent only part of the Chouteau of the central Missouri province and its occurrence above the Hannibal shale, which overlies the Louisiana there, does not necessarily indicate that the whole of the Chouteau is younger than the Louisiana. In the absence of published data, correlations between the Kinderhook in central Missouri and those in northeastern Missouri must be tentative.

Five species of the Louisiana limestone have been described or reported in recent lists from the Chouteau of central Missouri—*Chonetes ornatus* var. *glenparkensis* Weller, *Camarotoechia* cf. *C. tuta* (Miller), *Syringothyris newarkensis* Weller, *Athyris lamellosa* (L'Éveillé), and *Proetus missouriensis* Shumard. Besides these species, the writer has examined specimens of the following Louisiana species from the Chouteau: *Plumalina gracilis* (Shumard), *Rhipidomella missouriensis* (Swallow), *Athyris hannibalensis* (Swallow), and "*Orthoceras*" *chemungense* Swallow. In addition, 8 or 10 Louisiana species closely resemble and probably are closely related to Chouteau species. Over half of the Louisiana genera also occur in the Chouteau. These faunal resemblances make it appear that the Louisiana is the equivalent of some part of the Chouteau. There are, however, conspicuous differences between the Louisiana and the composite Chouteau faunas. Both are brachiopod faunas, but the dominant genera of the Chouteau are lacking or represented by very few species in the Louisiana. The genus "*Productus*" is an important element in the Chouteau fauna, but it is not represented by a single species in the Louisiana. *Spirifer* is represented by a number of species in the Chouteau and by only one in the Louisiana. *Shumardella*, an abundant form in the Chouteau, is not represented in the Louisiana. The small forms of the Louisiana are not in the Chouteau. Although over two-thirds of the genera of brachiopods in the Louisiana are represented in the Chouteau, most of the species are different. None of the coral species of the Louisiana is known from the Chouteau, and the blastoid and crinoid faunas of the Chouteau do not occur in the Louisiana. The gastropod species, with the exception of a questionable *Bellerophon*, are not the same. Some of the pelecypod genera are the same, but the abundant pelecypod fauna of the Chouteau is not found in the Louisiana, and no pelecypod species is present in both formations. Because of these differences and the lack of zonation of the Chouteau, it is hardly possible to correlate the two formations directly. The Louisiana may be equivalent to part of the Chouteau of central Missouri, or it may

be older than the Chouteau. Under this latter assumption, the Louisiana faunal elements in the Chouteau would represent migrants that lived beyond Louisiana time. Their presence would then suggest that the upper part of the Louisiana is of the same age as some of the Chouteau beds in the adjacent regions, or that seas were in continuous existence in some areas from Louisiana time into Chouteau time. The occurrence of some of the common species only or more abundantly in outcrops of the Louisiana near its northwestern margin suggests that there may have been a connection between the two seas, either directly or through an intermediate sea in this part of Missouri.

The discovery by E. B. Branson⁸⁵ of several Louisiana species in his Sylamore sandstone of central Missouri suggests to the writer that this sandstone may be more nearly the equivalent of the Louisiana than is any part of the Chouteau of central Missouri. The Louisiana elements form a greater proportion of the total fauna of the so-called Sylamore in central Missouri than of the composite Chouteau fauna in central Missouri or of the Glen Park limestone member. This correlation agrees in part with the interpretation that the Louisiana species in the Chouteau are hold-overs. The common species are: *Rhipidomella missouriensis* (Swallow), *Chonetes ornatus* Shumard, *Chonetes ornatus* var. *glenparkensis* Weller, *Cyrtina acutirostris* Shumard, *Syringothyris hannibalensis* (Swallow), *Proetus missouriensis* Shumard, *Ptyctodus calceolus* Newberry and Worthen.

Little evidence is available for correlating the Louisiana with any formation in southwestern Missouri. A few Louisiana species have been reported from each of the Kinderhook formations exposed there, but more than half of them are species that also occur in the Chouteau limestone and as they form such small proportions of the total faunas, they are of little value in correlation.

Fossils are rare in that part of the so-called Sylamore sandstone which forms the basal Mississippian deposit in southwestern Missouri, but *Ptyctodus calceolus* Newberry and Worthen, which also occurs in the Louisiana, is represented by numerous individuals at some localities. Moore⁸⁶ lists *Camarotoechia tuta* (Miller) and *Platyceras paraliium* (White and Whitfield) from the Compton limestone; *Chonetes ornatus* var. *glenparkensis* Weller, *Athyris lamellosa* (L'Éveillé), and *Grammysia hannibalensis* (Shumard) from the next higher formation, the Northview; and *Chonetes glenparkensis*, *Camarotoechia tuta*, and *Athyris lamellosa* from the Chouteau of southwestern Missouri. The Kinderhook formations of Compton or younger age in southwestern Missouri have been correlated by Weller, Branson, and others with the 60 feet or so of Chouteau

⁸⁵ Branson, E. B., oral communications, 1929-30. Branson has recently referred these beds to the Bushberg sandstone.

⁸⁶ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 121, 1928.

in central Missouri, and if these correlations are correct some one or two of them may possibly be the time equivalent of the Louisiana. It seems more likely, however, that the Louisiana is in part the time equivalent of the so-called Sylamore sandstone in this area, but a definite correlation cannot now be justified.

The writer's present conception of the correlation of the Louisiana limestone with some nearby formations in Missouri is shown on the correlation table (p. 46). This table shows also the geographic and stratigraphic ranges within these formations of 22 Louisiana species, selected mainly because they occur in the other formations shown. Several rare species found only in the Louisiana and Saverton in Missouri are not included. The following is a list of the species with the numbers used to designate them on the correlation table:

1. *Plumalina gracilis* (Shumard).
2. *Rhipidomella missouriensis* (Swallow).
3. *Chonetes geniculatus* White.
4. *Chonetes ornatus* Shumard.
5. *Chonetes ornatus* var. *glenparkensis* Weller.
6. *Productella pyxidata* Hall.
7. *Camarotoechia* cf. *C. tuta* (Miller).
8. *Paraphorhynchus striatocostatum* (Meek and Worthen).
9. *Spirifer marionensis* Shumard.
10. *Syringothyris hannibalensis* (Swallow).
11. *Syringothyris newarkensis* Weller.
12. *Schuchertella lens* (White).
13. *Cyrtina acutirostris* Shumard.
14. *Athyris hannibalensis* (Swallow).
15. *Athyris lamellosa* (L'Éveillé).
16. *Grammysia hannibalensis* (Shumard).
17. "Leda" *diversoides* (Weller).
18. *Parallelodon sulcatus* (Weller).
19. *Platyceras paralium* White and Whitfield.
20. "Orthoceras" *chemungense* Swallow.
21. *Proetus missouriensis* Shumard.
22. *Ptyctodus calceolus* Newberry and Worthen.

Several Louisiana species occur in formations in Missouri, which are either late Kinderhook or early Osage in age. Most of them are, however, long-ranging species, and all are far outnumbered in the formations in which they occur by species typical of formations younger than the Louisiana. They consequently do not mean that the Louisiana should be correlated with these formations. The species are: Pierson limestone of many authors southwestern Missouri, *Chonetes ornatus* var. *glenparkensis* Weller, *Athyris lamellosa* (L'Éveillé); St. Joe limestone member of Boone limestone, northern Arkansas and beds of the same age in southwestern Missouri, *Productella pyxidata* Hall, *Ambocoelia minuta* White, *Chonetes ornatus* var. *glenparkensis*, *Athyris hannibalensis* (Swallow), *Athyris lamellosa*, and *Platyceras paralium* White and Whitfield; Sedalia limestone, central and northeastern Missouri, *Athyris lamellosa* and *Platyceras paralium*; Fern Glen limestone, southeastern Missouri, *Athyris lamellosa* and *Platyceras paralium*. Many of the same species occur also in the Burlington limestone. Data for these occurrences are taken from

lists assembled by Moore or from references given in the description of the individual species. They illustrate the errors one is likely to be led into if correlations are made on single species, especially if the stratigraphic ranges are imperfectly known.

CORRELATION WITH FORMATIONS IN OTHER STATES

Description of Louisiana species from formations in several nearby States to an extent suggests correlation of these formations with it. More Louisiana species have been described from the so-called †Waverly beds of Ohio and the Marshall sandstone of Michigan than from rocks in other States, but the occurrence of Louisiana species in certain formations in Kentucky is also significant. Less significant is their description from formations in Pennsylvania, Oklahoma, Alberta, New Mexico, and perhaps in Nevada. Species listed in the following discussions are mainly from synonymic data; the discussions do not purport to consider all species that have been listed from the various formations.

Nine Louisiana species have been described from so-called †Waverly beds or their equivalents (so-called Marshall) in various parts of Ohio. Two of the identifications were uncertain, but the others appear to have been made with confidence. The writer has not checked any of them by examining specimens. The species common to the Louisiana limestone and the Waverly beds of Ohio are *Schuchertella lens* (White)?, *Chonetes geniculatus* White?, *Paraphorhynchus striatocostatum* Meek and Worthen, *Camarophorella buckleyi* (Rowley), *Palaeoneilo ignota* Herrick, "Leda" *spatulata* Herrick, *Grammysia hannibalensis* (Shumard), *Platyceras paralium* White and Whitfield, and *Proetus missouriensis* Shumard. In addition, many species from the Louisiana limestone closely resemble species from the so-called †Waverly. The evidence of these species might seem to suggest that the Louisiana is the equivalent of the so-called †Waverly. When examined critically, however, it fails to establish such a correlation. This is largely because some of the Louisiana species have been described only from horizons near the base of the so-called †Waverly; others have been described only from horizons well above the base; and still others only from the highest beds. Only a few of the stratigraphic ranges in Ohio are well known. Most of the Louisiana species that occur in the higher beds are far outnumbered in these beds by species characteristic of younger formations. In addition, many species are probably more representative of certain facies than of definite times. These facts, instead of suggesting the correlation of the Louisiana with all of the so-called †Waverly, suggest that some of the Louisiana species have longer ranges in Ohio than in Missouri, or that some of them, as identified, are too broad. The lack of recently published descriptive work hinders the testing of this latter possibility. Although the Louisiana is manifestly not the equivalent of all of the so-called †Waverly, it does seem that it is probably

Correlation of some Mississippian formations in Missouri
 [For names of species represented by the numbers below see list on p. 45]

Central Missouri	Northeastern Missouri	Southeastern Missouri
	Burlington limestone. (5, 7, 11, 15, 19)	
Sedalia limestone. (15, 19)		Fern Glen limestone. (15, 19)
Chouteau limestone. (1, 2, 5, 7, 11, 14?, 15, 20, 21?)	Chouteau limestone. (5, 8, 11, 15, 19, 20)	Absent.
Sylamore sandstone. (2, 4, 5, 10, 13, 21, 22)	Hannibal shale. (2, 3, 6?, 7, 9?, 11, 16)	Sulphur Springs formation.
	Louisiana limestone. (All 22 species occur here)	Bushberg sandstone member. (22)
Absent.	Saverton shale. (2, 3, 4, 6, 8?, 9, 10, 12, 13, 14, 18?, 22)	Glen Park limestone member. (5, 17, 18, 22)
	Grassy Creek shale. (22)	Absent.

the equivalent of part of it. Many Louisiana genera occur in both the Bedford shale and the Berea sandstone (†Corry sandstone) in Ohio and Pennsylvania.⁸⁷ Also several species closely related to but probably not identical with Louisiana species have been listed by Girty or by others from the Bedford shale. These include: *Productella pyridata* Hall, n. var., *Delthyris* n. sp. aff. *D. missouriensis* Weller, *Athyris* aff. *A. hannibalensis* Swallow. Only two Louisiana species, *Spirifer marionensis* Shumard and *Athyris lamellos* L'Éveillé, are definitely identified by Girty from the †Corry sandstone. Despite the fewer Louisiana species in the †Corry sandstone, the writer believes that the Louisiana limestone is more nearly the time equivalent of the Berea than of the Bedford. This opinion is based largely on the evidence of the genera.

Most of the genera in Girty's lists of fossils from each of these formations are Louisiana genera. However, certain genera listed from the Bedford do not occur in the Louisiana, and at least one of these is said to be more indicative of Devonian than of Carboniferous age. This genus is the brachiopod *Pholidops*. On the other hand, at least one Louisiana genus, *Paraphorhynchus*, not listed from the Bedford but from the †Corry sandstone is more suggestive of Carboniferous time. The correlation of the Louisiana with the Berea rather than with the Bedford is further suggested by the abundance in the former of Spirifers of the *S. marionensis* type, by athyrids of the *A. lamellosa* type, which are more characteristic of Carboniferous than of Devonian age, and by the absence of any species in the Berea or Louisiana that can be confidently identified as a normal *S. disjunctus*. If the Louisiana is truly the equivalent of the Berea and hence is younger than the Bedford, it obviously belongs in the Carboniferous system, as that system is currently interpreted in this country.

A few Louisiana species occur in formations in States adjoining Ohio, but they are not sufficient as a basis for correlating the Louisiana with any of them. These species are: *Grammysia hannibalensis* (Shumard) and *Proetus missouriensis* Shumard, in the Marshall and Coldwater formations respectively in Michigan; *Microcyathus enormis* (Meek and Worthen) and *Chonetes geniculatus* White, in the Rockford limestone of Indiana; and "*Leda*" *spatulata* Herrick, in the Pocono sandstone of the Broad Top Coal Field, Pennsylvania.

Few species of the Louisiana are known south and southeast of its area of outcrop in areas outside of Missouri. *Athyris hannibalensis* (Swallow) and *Schuchertella lens* (White) have been reported from the New Providence shale of western Kentucky, and species that appear closely related to *Rhipidomella missouriensis* (Swallow) and *Strophalosia beecheri* Rowley also occur

in it. These closely related species are *R. oweni* Hall and Clarke and *S. cymbula* Hall and Clarke. Of the Louisiana species, only *Schuchertella lens* and *Strophalosia beecheri* are unknown above the Louisiana, and *S. beecheri* is a rare species and might not, therefore, be found in many collections. The New Providence has long been considered younger than the Louisiana, and the few Louisiana species in it, though interesting, are insufficient to establish it as equivalent.

The discovery of *Rhipidomella missouriensis* (Swallow) in the upper part of the black shales (Chattanooga of some authors) of southwestern Kentucky by Savage and Sutton⁸⁸ and the occurrence there of five genera that also occur in the Louisiana suggests that it is possible that the Louisiana is very nearly, if not actually, the time equivalent of this part of the so-called black shales. If this is true, the black shales in that region contain strata with ages ranging from that of the Genesee (early Upper Devonian) to that of the Louisiana, as Genesee strata have been identified there by Savage and Sutton. As they state that part of the black shale in nearby areas is still earlier (Tully), it does not seem improbable that the range of ages represented by black shale deposits in Kentucky may extend from still earlier time (Hamilton, perhaps) to late Kinderhook. Such a discovery, though not proving it, would tend to substantiate Weller's hypothesis⁸⁹ that certain Kinderhook faunas originated from a sea that persisted from Hamilton to Kinderhook time in some eastern interior region.

One or two Louisiana species have been described from each of the following formations, but their occurrence is not, of course, sufficient for correlation: Sycamore limestone of Oklahoma, Lake Valley limestone of New Mexico, and Upper Devonian or lower Mississippian formations in Colorado and Nevada and in Alberta, Canada. An ostracode, *Ctenobolbina loculata* Ulrich, said by Bassler⁹⁰ to occur in the mudstones here considered to be the lower part of the Louisiana limestone, also has been reported from the Ridgetop and upper part of the Chattanooga shales of Tennessee.

FOREIGN CORRELATION

No data sufficient for the definite correlation of the Louisiana limestone with any formation outside of North America was brought out in the investigations incidental to the preparation of this report, and no special effort has been made to establish foreign correlations or to completely survey the foreign literature. Some Louisiana species have, however, been recently described from foreign formations, and two or three Louisiana genera have restricted geologic ranges in foreign rocks. These suggest certain age relationships.

⁸⁷ Girty, G. H., Geologic age of the Bedford shale of Ohio: New York Acad. Sci. Annals. vol. 22, pp. 303, 304, 1912. For more recent fossil lists, see Caster, K. E., Stratigraphy and Paleontology of Northwestern Pennsylvania, pt. 1, Stratigraphy: Bull. Am. Paleontology, vol. 21, 1934, and references cited therein; also Cushing, H. P., Leverett, Frank, and Van Horn, F. R., Geology and mineral resources of the Cleveland district, Ohio: U. S. Geol. Survey Bull. 818, 1931.

⁸⁸ Savage, T. E., and Sutton, A. H., Age of the black shale in south-central Kentucky: Am. Jour. Sci., 5th ser., vol. 22, p. 447, 1931.

⁸⁹ Weller, Stuart, The fauna of the Glen Park limestone: St. Louis Acad. Sci. Trans., vol. 16, p. 470, 1906.

⁹⁰ Bassler, R. S., The stratigraphy of the Central Basin of Tennessee: Tennessee Geol. Survey Bull. 38, p. 146, 1932.

Two Louisiana species, *Schuchertella lens* (White) and *Syringothyris hannibalensis* (Swallow) (identified as *S. carteri* Hall), have been identified by Tolmatchoff in the Carboniferous limestone of Kousnetzko coal basin of Russia, and *Chonetes batchatica* Tolmatchoff, a species close to *Chonetes ornatus* Shumard, of the Louisiana fauna, also occurs there. This limestone is thought by Tolmatchoff to be the equivalent of the Kinderhook and Osage groups of the United States. *Schuchertella bituminosa* Lisitzin, a species closely related to *S. lens* (White) of the Louisiana, occurs in the lower Carboniferous of the Donetz Basin, also in Russia. Its horizon is said by Rotai to be upper Tournaisian. *Spirifer marionensis* Shumard, has been described by Lebedew from the Carboniferous of Siberia, but the writer regards the identification as very uncertain. The crinoid genus *Allageacrinus* is characteristic of the Avonian of Scotland and, though possibly extending higher, the cephalopod genus *Protocanites* is characteristic in Germany of beds equivalent to lower Tournaisian and possibly older Carboniferous beds. Other faunal data bearing on the possible correlation of the Louisiana limestone are given in several papers dealing with foreign faunas. They are inadequate as a basis for the close correlation of the Louisiana because too few species and classes are represented, identifications in the main are too uncertain, and genera are too long ranging. They do, however, suggest that the Louisiana is equivalent to beds considered Carboniferous in Europe. The stratigraphic position of the Louisiana and its consequent relation to larger and more widespread faunas, such as the Burlington limestone fauna, is sufficient to limit it to an age older than the Burlington. It is thus the probable equivalent of part of the lower Avonian of Great Britain, part of the Tournaisian (lower Dinantian) of western continental Europe, and of formations in many parts of the world correlated with these deposits.⁹¹

SOURCE OF THE LOUISIANA FAUNA

As many of the species in the Louisiana limestone also occur in the immediately underlying Saverton shale, it is probable that the Louisiana fauna originated in large part from the Saverton fauna. Species that occur in both faunas are shown in the table, pp. 32-33. The combined Saverton and Louisiana fauna is very different from the fauna of the black shales below the Saverton. It is also quite different from any Upper Devonian formation in Missouri, and it also appears

⁹¹ After this paper was submitted for publication the writer studied lower Carboniferous and Upper Devonian deposits and faunas in the Union of Soviet Socialist Republics, Germany, and Belgium. Because of the lack of many or extensive areas of marine upper Devonian in contact with marine lower Carboniferous rocks in Great Britain, deposits in Germany and Belgium have been most discussed by investigators dealing with the Carboniferous-Devonian boundary in Europe. The Louisiana limestone fauna as a fauna was not recognized among the faunas studied by the writer. Individual genera, however, suggest that it is probably about the time equivalent of the *Gattendorfia* beds along the tributaries to the lower part of the Rhine in Germany and of the lower beds of the Assise de Maredsous (Lower Tournaisian) of Belgium.

to the writer to differ considerably from any Upper Devonian faunas in nearby States. These differences are so pronounced that it does not appear at all likely that the Louisiana fauna could have originated from an Upper Devonian fauna in the immediate vicinity of its area of outcrop, or for that matter from any known Upper Devonian faunas in Missouri, Iowa, or Illinois.

The general aspect of the Louisiana fauna is more nearly like that of the Hamilton of the eastern United States than of the later Devonian faunas of that region. Closer resemblance to the Hamilton is shown by the brachiopods, trilobites, pelecypods, and gastropods. These more conspicuous resemblances may be in part due to the larger fauna of the Hamilton group, but they are nevertheless significant. Among the Louisiana genera that have been reported or described at one time or another from the eastern Hamilton are: *Pluralina*, *Camarotoechia*, *Lingula*, *Orbiculoidea*, *Rhipidomella*, *Chonetes*, *Strophalosia*, *Schuchertella*, *Productella*, *Delthyris*, *Athyris*, *Spirifer*, *Nucleospira*, *Ambocoelia*, *Cyrtina*, *Poteriocrinus*, *Grammysia*, *Parallelodon*, *Aviculopecten*, "*Leda*," *Nucula*, *Palaeoneilo*, *Loxonema*, *Pleurotomaria*, *Platyceras*, *Murchisonia*, *Bellerophon*, *Conularia*, *Cornulites*, "*Orthoceras*," *Proetus*. Added significance to the resemblances shown by the genera is given by species closely related to Louisiana species. These include a form close to, if not actually, *Conularia marionensis* Swallow; *Parallelodon hamiltoniae* (Hall), close to *P. sulcatus* (Weller); *Nucula bellistriata* (Conrad) and *N. varicosa* Hall, species close to *N. krugeri* Williams; *Loxonema delphicola* Hall, close to *L. missouriensis* Williams, n. sp.; and species of *Productella* close to *P. pyxidata* Hall.

As has been pointed out by H. S. Williams and others, faunal elements of the Hamilton "recur" together in such numbers in younger beds that so-called Hamilton faunas have been described as occurring in Upper Devonian formations at three or four horizons, extending as far upward as the Chemung. It does not seem an unreasonable hypothesis⁹² to assume that certain genera present in the eastern Hamilton migrated southward or southwestward into adjacent States, during Hamilton time or during the time of one of these "recurrences," and from these States continued in late Devonian time or very early Mississippian time into Kentucky and thence northward into northeastern Missouri during the time of the deposition of the Saverton shale. They would thus be the ancestors of many of the species in the Saverton and Louisiana formations.

The presence in the Cleveland and Bedford shales of Ohio of a number of genera found in the Louisiana limestone suggests such a course of migration. The resemblance of the Bedford fauna to those of both the Glen Park limestone and Hamilton group has been

⁹² Weller, Stuart, The fauna of the Glen Park limestone. St. Louis Acad. Sci. Trans. vol. 16, p. 470, 1906.

commented on by Girty⁹³ and is shown also by collections from the Bedford of Kentucky, made by Foerste and Butts and reported by Butts.⁹⁴

The occurrence of a few species in both the Louisiana and the so-called goniatite beds of Rockford, Ind., suggests that this latter area was in communication at one time with the seas that yielded the Louisiana fauna. The obvious resemblances between parts of the †Waverly and the Louisiana, and the presence of the rare genus *Paraphorhynchus* in the Berea (†Corry) sandstone of Pennsylvania suggests either that there was communication between the Louisiana area and these areas as late as in early †Waverly time or that the faunas were derived from a common source.

The absence of Louisiana species in some exposed upper Devonian and lower Mississippian rocks along the general course of the proposed route of migration might be explained in a number of ways. Some of the beds that crop out are black fissile shales and are nearly devoid of fossils. Others change laterally into sandstones and shales of different character. In these areas the migrants probably existed in places where the deposits are now covered or have been eroded.

The postulation here advocated for the source and migration of the ancestors of the Louisiana fauna is supported by the discovery by Savage and Sutton of beds of Genesee age as well as beds of Mississippian age within the so-called Chattanooga shale of southern Kentucky. That beds ranging in age from the early part of the late Devonian to early Mississippian are exposed within these shales suggests that, although unconformities probably occur within the shales in some areas, it is possible that the whole interval represented was occupied by black shale deposition in others, and that seas in which the ancestors of the Louisiana fauna may have lived may have also been continuous throughout that time in nearby areas whose deposits are not now exposed or have been partly eroded.

Weller,⁹⁵ in 1906, postulated that the faunas of his northern Kinderhook province were derived from a northern Chemung fauna, while those of his southern province came from the south. He included the Louisiana limestone fauna along with the Kinderhook faunas from Kinderhook and Burlington in those which he thought were derived from a northern Chemung fauna. A comparison of the number of genera common to the Louisiana fauna and the fauna of the Hamilton of New York and Pennsylvania with the number common to the Louisiana limestone and the lower Kinderhook beds at Kinderhook (beds 1-3) and Burlington (beds 1-4) shows more genera common to the Hamilton and Louisiana faunas than to the Louis-

iana and combined faunas from Kinderhook and Burlington. Furthermore, with the exception of five genera, two of which are confined to the Mississippian and another of which has been considered representative of it, all the genera common to the Louisiana and combined lower Kinderhook faunas from Burlington and Kinderhook are also common to the Louisiana and Hamilton faunas. The five excepted genera are: *Paraphorhynchus*, *Rhynchopora*, *Syringothyris*, *Crania*, and *Brachymetopus*. Genera that occur in the Louisiana and Hamilton faunas but are not included in Moore's lists from the lower beds at Burlington and Kinderhook are: *Plumalina*, *Camarotoechia*, *Strophalosia*, *Schuchertella*, *Athyris*, *Nucleospira*, *Ambocoelia*, *Cyrtina*, "Leda," *Palaeoneilo*, *Platyceras*, and *Proteus*. The occurrence of the last eight genera in the higher Kinderhook at Burlington, which no one has within late years considered as old as the Louisiana, suggests that they may have migrated into that area from the south.

The occurrence of many of the Louisiana genera also in the Chouteau might suggest that these faunas came from a common source. The presence in the Louisiana of genera that occur in the Hamilton and eastern rocks and not in the Chouteau is believed by the writer to make it more logical to assume that the Chouteau itself originated in part from the Louisiana fauna.

PALEOGEOGRAPHIC INTERPRETATIONS

Paleogeographic maps are essentially interpretive. Like hypotheses for the origin and migration of faunas, they are only as reliable as the data on which they are based, and it is to be regretted that the data only rarely approach completeness. Among the more frequent causes for their incompleteness are lack of exposures in critical areas, insecure stratigraphic boundaries, too few and inadequately studied well logs, unfossiliferous beds or imperfectly preserved fossils at important localities, imperfectly understood genera and species, and lack of adequate structural data. Often incomplete knowledge of the significance of observable data also hinders the construction of worth-while maps and the interpretation of paleogeographic relations. The interpretations here presented are restricted by several of these deficiencies. In spite of their shortcomings, they are, however, thought to be worthy of presentation, if for no other reason than that they might stimulate investigation to prove or disprove them. They will at least be helpful in summarizing the writer's concepts of the relations between the Louisiana limestone and nearby formations.

Recent work by Rubey⁹⁶ in western Illinois, across the Mississippi River from the area in which the Louisiana crops out, has given new data that aid greatly in reconstructing the paleogeography of Louisiana time.

⁹³ Girty, G. H., Geologic age of the Bedford shale of Ohio: New York Acad. Sci. Annals, vol. 22, p. 313, 1912.

⁹⁴ Butts, Charles, Mississippian series of eastern Kentucky: Kentucky Geol. Survey, 6th ser., vol. 7, p. 21, 1922.

⁹⁵ Weller, Stuart, The fauna of the Glen Park limestone: St. Louis Acad. Sci. Trans., vol. 16, p. 470, 1906.

⁹⁶ Rubey, W. W., Structural history of the Cap au Gres faulted flexure, III: Geol. Soc. America Bull., vol. 41, p. 52, 1930.

As previously mentioned, Weller,⁹⁷ in 1906, suggested that "in early Kinderhookian time there were two distinct faunal provinces within the present Mississippi Valley region, a northern province and a southern province, separated by an east and west line at a point near the mouth of the present Illinois River." Branson,⁹⁸ in 1918, considered this line as the site of a narrow peninsula which he called the St. Louis Barrier. Krey,⁹⁹ in 1924, in a report on the geologic structure of a part of the Mississippi Valley north of St. Louis, made a structural map of an anticline, which, where the writer has observed it in Missouri, is conspicuously faulted. The faulted part of the anticline had been noticed by several previous investigators and the fault described as the Cap au Gres fault. Krey called the anticline the Lincoln anticline, but Rubey has recently described it as the Cap au Gres faulted flexure. Krey's map¹ shows that this structure extends from a point near Grafton, Ill., northwestward, crossing the Mississippi River once near the mouth of the Illinois River and also near Dogtown Landing, from which point it continues into western Lincoln County, Mo. There it turns northward across Pike County and then northwestward across Ralls County. It gradually plunges to the northwest and disappears in western Marion County. Structures thought to be a continuation of it have been observed farther northwestward near Macon and near Unionville, Mo., but their relations to it are conjectural. A smaller auxiliary anticline branches off the main anticline a few miles west of Bowling Green, Mo., and extends in a northwesterly direction, the trace of its crest passing slightly south of Center, Mo. The trends of these anticlines are shown on figure 8.

Rubey has shown that this anticline was in existence in Mississippian and in pre-Mississippian time. It seems to the writer that it may well have been the site of a topographic feature as well as a structural feature in early Kinderhook time. This hypothesis is suggested by the progressive thinning of the Louisiana limestone and by the overlapping toward it of older Kinderhook formations by younger Kinderhook formations. Both of these features are well shown in Missouri but are perhaps even better shown in Illinois, where they have been described by several authors and have been rather fully treated recently by Rubey. The overlapping is especially well shown south of Hamburg, Ill., where the Louisiana limestone overlaps the Saverton (?) shale and is in turn overlapped by the Hannibal shale.

If the Cap au Gres anticline was even in part a topographic feature in Kinderhook time, it might well have

been the feature designated by Branson as the St. Louis barrier. Branson appears never to have stated to what larger land mass the peninsula forming his St. Louis barrier was attached. It appears from his figure that he did not believe it attached to the old land mass Ozarkia. His figure suggests that it may have been attached to Schuchert's postulated land mass Kankakeia. The writer believes that it was an integral part of Ozarkia in earliest Kinderhook time, and that not until medial or late Louisiana time did it have the shape of a narrow peninsula distinct from Ozarkia. The connection of the peninsula with Ozarkia rather than with Kankakeia is based on the reported absence of Mississippian beds older than the Glen Park in parts of St. Louis County, Mo., and on the reported presence of Sweetland Creek (?) shale in wells in counties in Illinois that would ordinarily be supposed to be in the line of a connection between the St. Louis barrier and Kankakeia.

The northwestward and eastward limits of the St. Louis barrier are suggested by structural, stratigraphic, and faunal data. The northwestward dip of the crest of the anticline suggests that the part of the peninsula caused by it did not extend a great distance west or northwest. This is also suggested by the faunal elements in the Louisiana, especially in the northwestern part of its area of outcrop, that are common to the faunas of the Chouteau and of the Sylamore of some authors in central Missouri. They serve as a basis for postulating a sea connection around the northwestern end of the land mass during late Louisiana time. An eastward limit to the land mass and the presence of a narrow strait between it and Kankakeia is indicated by the eastward plunging of the Cap au Gres anticline east of Grafton, Ill., and by the well data cited above. A narrow strait between these two land masses would allow the Grassy Creek, Saverton, and Louisiana seas to be derived from the south and their faunas to be southern faunas. It would thereby provide a possible common origin for the Louisiana and Glen Park faunas and thus account for some of their common species. The postulated land mass along the Cap au Gres anticline is shown in the sketches of paleogeographic interpretations (pl. 5).

Coryell² has outlined another anticline, the Pittsfield-Hadley anticline, which may have been the approximate site of a land mass in Kinderhook time. The axis of this anticline trends roughly parallel to that of the Cap au Gres anticline. The anticline is most pronounced near the towns of Pittsfield and Hadley, Ill. It trends in a northwesterly direction from a point southeast of Pittsfield to a point about 10 miles northwest of Hadley, where it branches, forming three smaller anticlines. One of these extends northwest through Quincy, Ill., entering Missouri near La Grange; another trends more north than west for a short distance

⁹⁷ Weller, Stuart, Kinderhook faunal studies, IV, The fauna of the Glen Park limestone: St. Louis Acad. Sci. Trans., vol. 16, p. 468, 1906.

⁹⁸ Branson, E. B., The geology of Missouri: Missouri Univ. Bull., vol. 19, No. 15, p. 64, 1918.

⁹⁹ Krey, Frank, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Missouri Bur. Geology and Mines, 2d ser., vol. 18, 1924.

¹ Idem, p. 52.

² Coryell, H. N., Parts of Pike and Adams Counties: Illinois Geol. Survey Bull. 40, p. 75, 1919.

and then turns northwestward and enters Missouri above Canton; and the third extends northward into northern Illinois. Two of these smaller anticlines plunge northwestward and the third, northward.

The traces of the Pittsfield-Hadley anticline and the smaller anticlines that are derived from it are shown on figure 8. The data for these features are from Krey.³ The site of Kinderhook, Ill., is shown on the map to be not far southwest of the crest of the Pittsfield-Hadley anticline. Louisiana, Hannibal, Saverton, and other places in Missouri where the Louisiana is well developed are between the Pittsfield-Hadley and Cap au Gres anticlines. The Louisiana has not, to the writer's knowledge, been recognized on the Pittsfield-Hadley anticline or in wells north or east of it.

There is little published information regarding the times of movements on the Pittsfield-Hadley anticline. Coryell⁴ believes that it was land during early Spbergen time. The interpretation of its history during Kinderhook time is made difficult by the occurrence of the Hannibal shale directly on the Saverton (or Sweetland Creek) shales in most areas along its crest and by the difficulties in distinguishing the two in wells or in the field. At other localities the Sweetland Creek shale lies directly on the Maquoketa shale and at still others, thick shales are thought to represent all three formations.

The possibility of movement during or immediately after Kinderhook time is suggested by the variation in the thickness of the Kinderhook shales, as shown by well logs.⁵ It is also suggested by the occurrence of the Hannibal shales directly on the Sweetland Creek and by the absence of Louisiana between them on the anticline. This absence of the Louisiana, it seems, can be explained by any one of three hypotheses: (1) The Louisiana was deposited and removed by erosion before the Hannibal was deposited; (2) the area of the anticline was above water during the time of deposition of the Louisiana; and (3) shales were being deposited over the region in which the anticline now occurs while the limestones of the Louisiana were being deposited farther west. The first hypothesis seems the most unlikely because no patches of Louisiana have been found, and one would think that some would be preserved at some place on the anticline or east of it, if the Louisiana had ever been deposited there. The third hypothesis is also unlikely, because one would expect the Louisiana to become more shaly toward the anticline if this hypothesis were so. The Louisiana does not appear to do so. The outcrops of the Louisiana at Hannibal and Saverton are not far enough west of the crest of the anticline, where only shales occur near this horizon, to provide for a normal gradual lateral change of facies. By elimination, then, the

second hypothesis—that the area of the anticline was land during at least a greater part of the time of Louisiana deposition—seems the most logical and suggests that there was movement along the anticline in late Saverton or early Louisiana time. Further movement in late Louisiana or early Hannibal time is suggested by the occurrence in the Hannibal at Rockport, southwest of the crest of the anticline, of a conglomerate made of Louisiana pebbles. Elevation, between Louisiana time and Glen Park time, of the region of eastern Calhoun County, Ill., which may have been in a Mississippian southerly continuation of the anticline, is suggested by the unconformable relations of the Louisiana and Glen Park formations at Hamburg and other places in this county. These relations may, however, also be explained by an uplift of the entire area or by any other phenomenon that would cause a withdrawal of the Louisiana sea and allow subaerial erosion to take place.

If a land mass did exist parallel to, and near or slightly west of, the crest of the Pittsfield-Hadley anticline, the site of Kinderhook would probably have been land during the deposition of much of the Louisiana limestone. The former existence of such a land mass would account for the absence of the Louisiana limestone in the wells near Kinderhook. It would also account for the absence of the Louisiana limestone on the Pittsfield-Hadley anticline and east of it. If the land mass extended far enough northwestward, it would also account for the absence of the Louisiana at Burlington, Iowa. If both this land mass and the postulated land mass along the Cap au Gres faulted flexure did actually exist during the time of Louisiana deposition, the Louisiana limestone was deposited in an elongate basin with a northwest-southeast trend—an interpretation that agrees with its present distribution.

Available well data are insufficient for precise determination of the northwesterly extent of the Louisiana. It has not been recognized in the few published well logs from north-central Missouri and probably does not occur there. H. S. McQueen,⁶ who has examined many well cuttings from northern Missouri, states that 8 feet of Louisiana is present in a well in sec. 10, T. 59 N., R. 10 W., north-central Shelby County, and that Louisiana limestone has not been recognized in well records from Scotland and Knox Counties. This would suggest that a land area limited its deposition in this direction in early Louisiana time. A connection with a western sea, possibly in late Louisiana time, is postulated as an explanation for certain likenesses between the so-called Sylamore in central Missouri, the Chouteau, and the Louisiana faunas.

The postulated land and sea areas are shown in sketches A to F, on plate 5. The largest land areas are Kankakeia, in northern Illinois, and Ozarkia, mainly

³ Krey, Frank, Structural reconnaissance of the Mississippi Valley area, etc.: Missouri Bur. Geology and Mines, 2d ser., vol. 18, pl. 1, 1924.

⁴ Coryell, H. N., Parts of Pike and Adams Counties: Illinois Geol. Survey Bull. 40, p. 93, 1919.

⁵ Coryell, H. N., *idem*, p. 95.

⁶ Personal communication, about October 15, 1933.

in southern and central Missouri. A land mass occupying part of the site of the Cap au Gres flexure and attached to Ozarkia is shown at an earlier stage than that of the land mass on the site of the Pittsfield-Hadley anticline, because overlaps would suggest that the Cap au Gres land was in existence before the deposition of the Saverton shale, whereas the occurrence of Saverton (Sweetland Creek) on the Pittsfield-Hadley anticline would suggest that it was an area of deposition during at least part of Saverton time. The borders of this land mass do not follow the trends of the present Cap au Gres flexure precisely, but more nearly parallel the axis of the subordinate anticline that branches from the western part of the main fold west of Bowling Green, a course suggested by the distribution of the Louisiana limestone.

The course of the land mass postulated near the Pittsfield-Hadley anticline follows the middle of the three branches given off toward the northwest by this anticline mainly because of data from wells on the thickness of the Louisiana limestone. As many of these data are uncertain, the course of the land mass in these areas is consequently more uncertain than in other areas.

Sketch A represents the time of deposition of the Saverton and equivalent beds. Shales are being deposited over relatively large areas. The principal land masses are Kankakeia, in northern Illinois, and Ozarkia and the lands attached to it in Missouri. The approximate site of the Pittsfield-Hadley anticline, now submerged, is indicated by short broken lines.

Sketch B represents a later stage, which is thought to be about the equivalent of early Louisiana deposition in the typical area. The land mass formed by the ancestral Pittsfield-Hadley anticline is rising and has about cut off the Louisiana sea from its eastern source. It is probably a low area. Shale deposition has ceased in the "Louisiana" basin and limestone is being laid down.

Sketch C shows a later stage of Louisiana deposition. A continued rising of the Pittsfield-Hadley anticline has forced the sea northwestward, and the water is either shallow or entirely gone from the southeastern part of the basin.

Sketch D shows a very late stage in the deposition of the Louisiana. The sea in the "Louisiana" basin has retreated northwestward, and erosion is taking place over most of the basin. Some Louisiana limestone is being deposited in the extreme northwestern part of the basin. The Glen Park limestone member of the Sulphur Springs is being deposited in arms of the sea, which was the original source of the Louisiana fauna and which has continued in areas east of Missouri throughout Louisiana time. Sylamore sandstone of authors is being deposited over most of central Missouri. A northerly source is supplying sandy and shaly sediments of the gradually encroaching Hannibal shale.

In sketch E, the Pittsfield-Hadley land mass has disappeared. Louisiana limestone deposition has ceased. The Hannibal sandstones and shales are advancing from the north, and the Bushberg sandstone is being deposited in enlarged arms of the eastern sea. After a period of erosion of the Sylamore sandstone of authors, Chouteau limestone is being deposited in the western sea.

A still later stage is shown in sketch F. The Pittsfield-Hadley land mass has been entirely submerged. Sulphur Springs deposition has ceased in east-central Missouri and the sea has been forced eastward out of the area where sediments of members of this formation were deposited. Deposition of the Hannibal and equivalent formations is taking place over considerable areas in northeastern Missouri and also in southeastern Iowa and in western Illinois, with different facies represented in different regions.

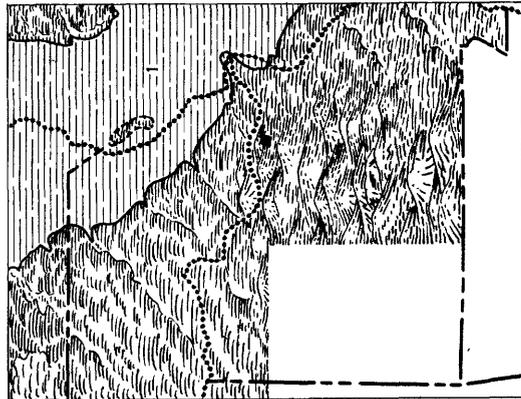
After the deposition of the Hannibal, the Chouteau seas of central and western Missouri joined the northern and eastern seas, and for a time the Chouteau limestone, including its various members in southwestern Missouri, was the only formation being deposited in Missouri. Changes in land and sea relations occurred widely in Missouri at the end of Kinderhook time.

If the sequence of events postulated above is correct, many of the problems that have long perplexed students of the Mississippian stratigraphy of the Mississippi Valley may be logically solved. Prominent among these is that of the discrepancies between the sections at Hannibal, Mo., Kinderhook, Ill., and Burlington, Iowa. The absence of the Louisiana at Kinderhook is explained by the postulation that the site of Kinderhook was a land mass during Louisiana deposition. The more distinct evidences of erosion of the Louisiana in Illinois are explained by the continuing elevation of this so-called Pittsfield-Hadley land mass. The conspicuous differences between the Hannibal and Burlington sections is explained by the postulation that the deposits at Burlington were formed in a different basin or re-entrant of the sea from that in which the deposits at Hannibal were formed. This accounts for the absence of Louisiana limestone there and at the same time is one way of allowing the formation of contemporaneous deposits of a different lithologic character.

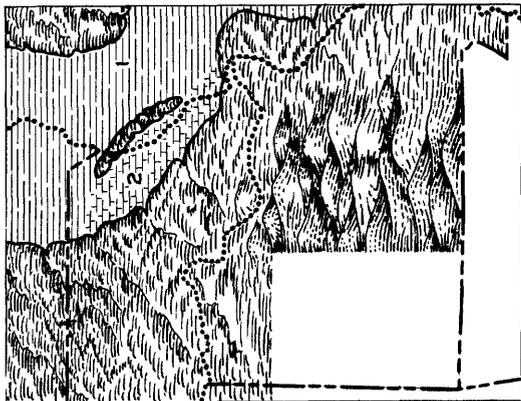
The postulated sequence also furnishes explanations for faunal similarities and dissimilarities. It accounts for the strong resemblance of the Louisiana fauna to the Hamilton faunas and for the mingling of Devonian faunal elements with Mississippian elements. It also provides a means for the migration of the Louisiana species into the other faunas in which they occur.

CONDITIONS OF DEPOSITION

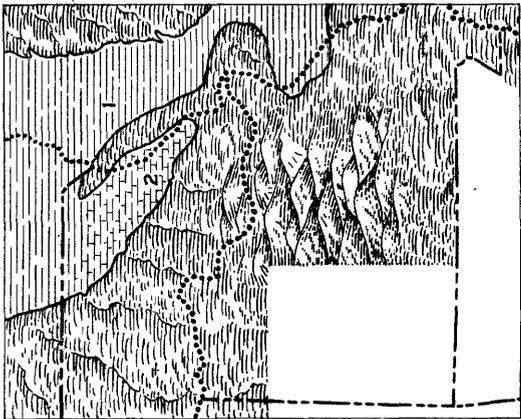
Suggestions regarding the depositional environment of the Louisiana limestone may be had from recent deposits and from consolidated deposits of like char-



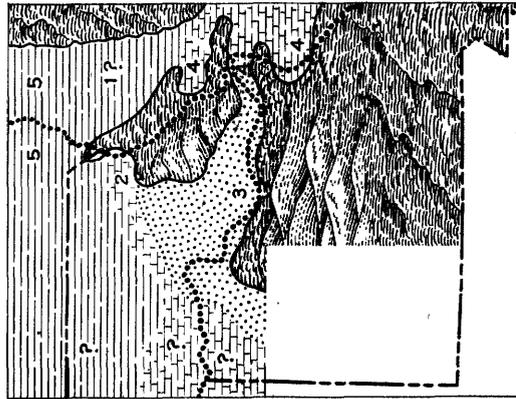
A.



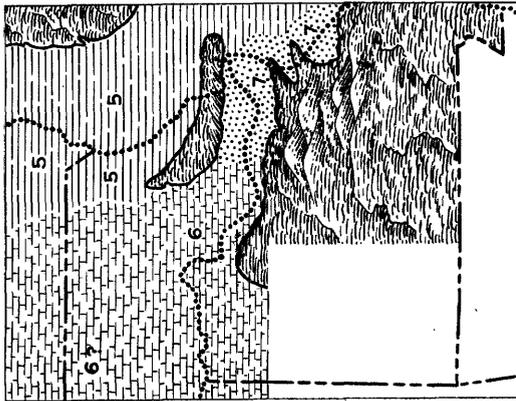
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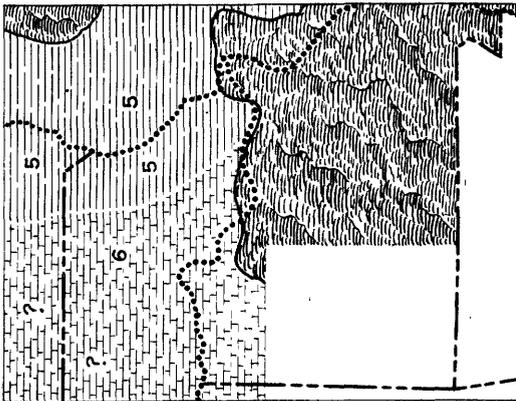
C



D



E



F

ANCIENT LAND MASSES AND BASINS OF DEPOSITION IN MISSOURI AND ADJACENT AREAS. A, SAVERTON TIME; B, EARLY LOUISIANA; C, MEDIAL LOUISIANA; D, LATE LOUISIANA; E, LATE SULPHUR SPRINGS; F, MEDIAL HANNIBAL.

Hypothetical ancient land masses are shown. The large land mass mostly in Missouri is Ozarkia, and the large mass in Illinois is Kankakeia. The small island mass that is nearly submerged in Saverton time (A) but is exposed in early Louisiana time (B) represents the rising Pittsfield-Hadley anticline. The present courses of the Mississippi and Missouri Rivers are shown by dotted lines. Areas of shale deposition are ruled; areas of sand deposition are stippled; and areas of lime deposition are indicated by rectangular blocks. The seas are indicated by numbers, as follows: 1, Saverton (Sweetland Creek) sea; 2, Louisiana limestone sea; 3, Sylamore sandstone (of authors) sea; 4, Sulphur Springs (Clen Park member) sea; 5, Hannibal and contemporary seas; 6, Chouteau sea; 7, Sulphur Springs (Bushberg sandstone member) sea. The rectangular area left blank is not considered in this report.



acter. Very fine grained muds composed almost entirely of minute particles of calcium carbonate in the Bahama region have been called "drewite" by Kindle.⁷ They occur in typical form over great areas in the shallow waters of the Great Bahama Bank west of Andros Island. The surface layer of the mud is creamy white, but below the surface layers the mud is grayish-white and has a slight odor of hydrogen sulfide. These calcareous muds are thought by Kindle to be the result of the action of a bacillus that inhabits warm shallow waters.

Kindle applies the name "vaughanite" to fine-grained limestones of the Paleozoic and Mesozoic whose particles are thought to have physical characters identical with those of drewite. These limestones "break with conchoidal fracture" and "approach rather closely the uniformity and fineness of texture seen in lithographic limestones."⁸ Though not cited as an example, there is no doubt that Kindle would include the limestones of the Louisiana among his vaughanites. He believed that the presence of mud cracks in several of such limestones proves that they were deposited in shallow waters.

Twenhofel⁹ cites references to geologic evidence suggesting that the lithographic limestones of Solenhofen, Bavaria, which resemble the limestones of the Louisiana, were formed in shallow basins surrounded by reef limestones. Such an environment would probably mean warm, shallow, little-disturbed waters, such as occur in most partly or wholly enclosed lagoons. The beds of limestone are thought to have been deposited rapidly so that delicately preserved organisms found in them were buried by lime particles or terrigenous dust before decaying.

A lagoonal origin is postulated by Dixon¹⁰ for the compact limestones (so-called Chinastone-limestones) of the Carboniferous near Gower. He believes that the lagoons were shallow and that tidal action was at a minimum.

Swartzlow¹¹ has recently argued that the most important factor in forming the finest-textured limestones of the Chouteau deposits is rapid precipitation of the calcium carbonate. He agrees with Johnston and Williamson¹² and Tarr¹³ that the most important physicochemical factors causing precipitation are increases in temperature of the water and changes in the concentration of carbon dioxide in the solution and in the air in contact with it. He is inclined to explain the origin of the fine-grained limestones of the Chouteau by the hypothesis that they formed when cold

ocean currents near saturation with calcium carbonate moved to a warm, shallow sea or basin, so that the movement of the waters, together with the higher temperature, would cause a rapid loss of calcium carbonate. Although movement may have been a factor in the precipitation of the Chouteau limestones, it seems unnecessary to attribute to it any function other than that of providing fresh supplies of cold waters saturated with calcium carbonate to explain the deposition of the Louisiana limestone. Even the supply of calcium carbonate could be contributed directly from the lands bordering the area of deposition. Changes in temperature brought about by movement of cold waters into warmer areas, or possibly by changes in outside temperature, or changes in carbon dioxide concentration caused by inorganic or organic factors could easily have been sufficient to account for its deposition.

The investigations described suggest that a common environment for the formation of dense limestones, such as compose the main part of the Louisiana, is a partly or intermittently enclosed basin that is receiving a constant or frequent supply of calcium carbonate. They also suggest that the waters of the basin of deposition are commonly shallow and warm, and that deposition of the particles which compose the dense limestone beds is rather rapid. Although some suggest otherwise, most investigators postulate that the waters are little agitated. Such environmental conditions may well be those under which the Louisiana limestone was deposited. They agree well with the paleogeographic interpretation that the Louisiana limestone was deposited in a basin partly enclosed by land barriers.

The environmental factors that cause the alternation of 3- to 6-inch beds of dense or very fine grained limestone with one-half inch to 1- or 2-inch beds of dolomitic clay and dolomite are not well understood. The fact that such alternations do occur suggests an alternation of environmental conditions or a periodic change in at least some environmental factors. The relatively large quantity of insoluble materials in the partings indicates relatively more rapid deposition of clay and fine sands during some periods. The greater relative proportion of dolomite in the partings, though possibly explainable by secondary action, would more likely seem also to indicate that a change in some environmental factors took place at more or less regular intervals. It is difficult to say, however, just what environmental changes were necessary to halt the deposition of dense limestones and to initiate the deposition or formation of dolomite and dolomitic clay partings.

Swartzlow¹⁴ believes, with Tarr,¹⁵ that at least some dolomites having the characters attributed by him to syngenetic origin were formed in shallow intermittently enclosed basins in which there might have been a con-

⁷ Kindle, E. M., Nomenclature and genetic relations of certain calcareous rocks: *Pan-American Geologist*, vol. 39, p. 368, 1923.

⁸ *Idem*, p. 370.

⁹ Twenhofel, W. H., *Treatise on sedimentation*, p. 301, 1932.

¹⁰ Dixon, E. E. L., *The Carboniferous succession in Gower*: *Geol. Soc. London Quart. Jour.*, vol. 67, p. 516, 1911.

¹¹ Swartzlow, C. R., Dolomitization and origin of granularity in Chouteau limestone: *Pan-American Geologist*, vol. 59, p. 281, 1933.

¹² Johnston, John, and Williamson, E. D., The role of inorganic agencies in the deposition of calcium carbonate: *Jour. Geology*, vol. 24, p. 738, 1916.

¹³ Tarr, W. A., Is the Chalk a chemical deposit? *Geol. Mag.*, vol. 82, p. 260, 1925.

¹⁴ Swartzlow, C. R., *op. cit.*, pp. 323-340.

¹⁵ Tarr, W. A., Contribution to the origin of dolomite: *Geol. Soc. America Bull.*, vol. 30, p. 114, 1919.

centration of magnesium and other salts above the concentration of normal sea water. Tarr attributes the alternation in the Ozark region of Missouri of beds of relatively pure limestone with beds of pure dolomite to the periodic freshening of the water after intervals of increasing concentration.

Steidtmann¹⁶ also believes that increase in salinity is important in causing dolomite to be deposited in place of calcite, but believes changes in salinity are not ordinarily great. He also shows that most dolomites contain ferrous oxide and believes that dolomites bearing a considerable percentage of ferrous oxide were formed in shallow basins of warm water, where, however, wave action did not penetrate to the bottom. He postulates that reducing conditions prevailed near the bottoms of these basins. He believes that most dolomites are marine in origin and gives a list of data which to him suggest that conclusion.

The dolomitic clay partings of the Louisiana agree in most respects with the criteria given by Swartzlow and by Steidtmann for dolomites thought to be deposited as the double carbonate (dolomite), or changed to it soon after deposition and while yet an unconsolidated mass on the sea floor. If such was the origin of the dolomitic clay partings, the waters of the Louisiana basin probably were, according to the theories of both Tarr and Steidtmann, not only warm and shallow but at times more saline than usual; and when dolomite was being deposited, they were more saline, or at least higher in magnesium content, than ordinary sea water. For some reason, dust or fine muds increased in volume relative to chemical precipitates during the times of deposition of the partings.

The probable increased salinity and the possibility that the dolomites were deposited under reducing conditions may account for the great number of relatively small species of invertebrates in the dolomitic clay partings. Dwarfing effects have been attributed to increased salinity, presence of iron in solution, presence of considerable amounts of hydrogen sulphide in the water, as frequently occurs in a reducing environment, and to many other things. Although the small species in the Louisiana cannot be said to be dwarfs, it is likely that the same factors that cause dwarfing would cause the retardation of growth of species not known to be represented by larger individuals.

DESCRIPTIVE PALEONTOLOGY

PROCEDURE FOLLOWED IN DESCRIPTION OF SPECIES

In the descriptions of species, the general procedure has been to give the original description, together with notes made during the course of examination of specimens by the writer. For the brachiopods, full descriptions are, however, given for only a few species. Most of the brachiopod species, whether or not described adequately in easily accessible publications by the

founders,¹⁷ have been adequately described by Stuart Weller in his monograph, "The Mississippian Brachiopoda of the Mississippi Valley Basin,"¹⁷ a publication that is generally available.

The original descriptions of species of other classes have been given preference because many of them are in publications that are not generally available, and because the writer has felt that those who read the descriptions would, other things being equal, prefer to have the founder's description to that of any subsequent investigator. The original description gives the founder's viewpoint, and not infrequently the manner in which it is stated gives indications of characters he had in mind that could not be derived from descriptions by subsequent investigators. The original descriptions of many of the species treated in this paper were based on material from the Louisiana limestone, a fact that lends added significance to them here. Important details brought out in subsequent descriptions are referred to under the remarks on various species.

No claim is made that the synonymies given are complete, but an effort was made to include all North American references. Foreign references are not included in the synonymy unless they change, or have important bearings on, the generic or specific reference, but those that were seen incidental to the preparation of the paper are mentioned in the remarks under each species. As customary in the description of Paleozoic fossils, entries from faunal lists, even if annotated, are not included in the synonymy except where the generic name is changed or where they bring out some important relationship not shown by other entries. The writer does not assume responsibility for all entries, but has continued in any particular synonymy entries previously placed in it unless there was some positive reason for transferring them. Where there was a reason, it is stated in the text, and, with few exceptions, the species to which an entry is transferred is given. Under the discussion of each species the writer has given the localities from which he has examined specimens, and anyone desiring to do so can, by making a comparison of that list with the synonymy, determine what entries the writer has checked by examining specimens. Space could have been saved by shorter synonymies, but recent unpleasant experience in trying to check up the disposition of forms formerly referred to certain species has emphasized to the writer the large amount of unnecessary work caused subsequent investigators when a synonymy is limited to forms examined by any one author and entries represented by forms not examined by him are not given either in the synonymy or in the text. This confusion is unnecessary, it seems, if the author states the limit of his experience with material represented by any synonymy but does not drop entries from it without just cause and without mentioning them in one way or another.

The localities given under the heading "Occurrence"

¹⁶ Steidtmann, Edward, Origin of dolomite as disclosed by stains and other methods: Geol. Soc. America Bull., vol. 28, p. 447, 1917.

¹⁷ Weller, Stuart, The Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, 1914.

are, if not otherwise stated, the localities at which the writer has collected specimens or localities from which he has examined specimens collected by others. The writer has had the privilege of examining nearly every specimen in the fine collection of Prof. R. R. Rowley, and these specimens have furnished data on a number of localities.

Comparisons given in the text are largely with Mississippian species, but some comparisons are made with Devonian species that appear more closely related to the Louisiana species than do those from the Mississippian. Comparisons of a great number of Louisiana species with descriptions and representative specimens of Devonian species were made during studies on the correlation of the Louisiana fauna, but most of these are not discussed in detail in this paper.

DESCRIPTION OF SPECIES¹⁸

PROTOZOA

Subphylum SARCODINA

Class RHIZOPODA

Subclass RETICULOSA

Order FORAMINIFERA

Foraminifera are rare in the Louisiana limestone, but the writer has collected a few by washing the clay obtained from the partings between the limestone beds. Other paleontologists have also collected a few specimens. The only identifiable specimen collected by the writer was submitted, together with some fragments that may represent other genera, to Mr. P. V. Roundy, of the U. S. Geological Survey, who reported that it was a new species which probably belonged to *Hyperamminoides* Cushman and Waters, 1928. It came from the parting above the lowest limestone bed at locality 599, 1 mile south of Louisiana, Mo.

Prof. A. K. Miller¹⁹ and one of his students at Iowa State University report that they have found two forms in Louisiana limestone collections which resemble species of *Lituotuba* Rhumbler, 1895, and *Ammodiscus* Reuss, 1861.

PORIFERA

Class SPONGIAE

Order LITHISTIDA?

Family unknown

Genus LEPTODISCUS Rowley, 1908

Leptodiscus corrugatus Rowley

Plate 6, figures 1-3

1908. *Leptodiscus corrugatus* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 70, pl. 16, figs. 74-76.

Rowley's description is given below.

Small discoidal or hemispheric masses; the underside flat or concave and with an epithelial covering, somewhat wrinkled concentrically.

¹⁸ The descriptions of species were completed in 1927, but the synonymies were brought up to date and many descriptions revised in 1933. With few exceptions, publications and other information that reached the author after the spring of 1933 are not considered in this report.

¹⁹ Personal communication, dated March 2, 1932.

The top side convex and ornamented by minute, sharp irregular ridges with deep, sharp depressions between; the surface appearing irregularly corrugate. On some specimens the ridges all leave the center of the top surface and radiate out toward the periphery but wholly unlike the lamellae of cup corals. On other specimens there is, apparently, no definite arrangement of the ridges.

On one specimen the elevations seem to start from the periphery and not only bifurcate but send off short branches that give a peculiar mosslike appearance to the ridges. The thinness of these little bodies precludes the possibility of internal tabulae and it is likely they are sponges.

Remarks: This genus was provisionally placed in the Porifera by its author, but no spicules, canals, or oscula can be made out on the specimens examined by the writer. Further study and sectioning of additional specimens is needed before its systematic position can be definitely determined.

Occurrence: Rare in the clay partings and yellow-brown calcareous mudstone of the Louisiana limestone at locality 599, 1 mile south of Louisiana, and at Louisiana, Mo.

Sponge spicules

Rowley^{19a} has figured a number of specimens that may be sponge spicules, but the writer has not identified any sponge spicules in his collections from the Louisiana limestone.

COELENTERATA

Class ANTHOZOA

Subclass TETRACORALLA

Family ZAPHRENTIDAE

Genus NEOZAPHRENTIS Grove, 1935

Recent work on the noncolonial tetracorals has made necessary a resurvey of the horn corals of the Louisiana limestone. These corals, of which there are three species, were all described as species of *Zaphrentis*. They clearly do not, however, agree with typical *Zaphrentis*, because the septa do not have carinae. The internal structures are known for only one species, and for this species somewhat imperfectly, because of a scarcity of material for sectioning. No tabulae, dissepiments, or columellae have been observed in the sections made, and none can be seen by a study of the calyces of any of the three species. Furthermore, no well-developed alar fossulae are shown in the sections or calyces. The absence of alar fossulae and the lack of well-developed tabulae and of dissepiments suggest that the species do not belong in *Triplophyllurus*, a genus to which many Carboniferous zaphrentoid corals have been referred. The absence of these structures, together with the presence of a small opening in the center in the neanic stage, which opening is surrounded by a zone of fused septal ends and which in later stages joins with a long narrow fossula, and the presence of but rudimentary secondary septa suggests that at least the species of which sections have been made

^{19a} Rowley, R. R., Geology of Pike County; Missouri Bur. Geology and Mines, 2d ser., vol. 8, pl. 16, figs. 82-86, 1908.

should be referred to the genus *Neozaphrentis*. Inasmuch as there is some doubt in the writer's mind about the distinctness of the three species and because the two species that have not been sectioned do disagree with typical *Zaphrentis* and do not, so far as is observable, disagree with *Neozaphrentis*, they also are referred to *Neozaphrentis*.

Species, as a rule, have not been satisfactorily differentiated in the family Zaphrentidae because the value of various structural characters has not been determined. Some investigators have considered to be of specific value characters that others have thought too dependent on environment for that purpose. Most species have been established on differences from previously described species in size and relative dimensions, character of epitheca, number and kinds of septa, habit of life, and shape of base. Genera have been generally differentiated on the form of the corallum, on the number and character of the fossulae, the presence or absence of and nature of tabulae, dissepiments, columellae, inner walls, septa, carinae on septa, and on other endothecal structures. Objection has been raised to the use of the shape of the corallum and especially the shape of the area of attachment at the base of the corallum for purposes of classification, but Grabau²⁰ has found that these characters are, at least in the Paleozoic, valid characters for that purpose. It is not without some misgivings that the writer recognizes as valid species based largely on the form of the base of the corallum, but in the absence of abundant material and widespread acquaintance with Paleozoic corals, it was considered best not to attempt detailed specific revisions at this time.

Neozaphrentis? acuta (White and Whitfield)

Plate 6, figures 31-33

1862. *Zaphrentis acutus* White and Whitfield, Boston Soc. Nat. Hist. Proc., vol. 8, p. 306.
 1865. *Zaphrentis acutus?* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 111.
 1894. *Zaphrentis acuta* [part] Keyes, Missouri Geol. Survey, vol. 4, p. 109 (not pl. 13, fig. 4).
 1898. *Zaphrentis acuta* Weller, U. S. Geol. Survey Bull. 153, p. 645.
 1908. *Zaphrentis acuta?* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 63, pl. 16, figs. 19 and 20.

White and Whitfield's description is given below.

Coral small, or of a medium size; subturbinate, gently curved, acutely pointed at the base, more rapidly expanding and somewhat inflated near the middle. Margin of the cup oblique to the axis, transverse section circular. Cavity of the cup of moderate depth, with from 25 to 35 thin longitudinal rays, which unite in the border of a deep subcentral fossette. Fossette large, extending from the center to the margin on the short side; elongate ovate or clavate in form, widest at the inner end; outer end occupied by a single ray. Transverse septa extending from the border of the central fossette to near the external walls, leaving

²⁰ Grabau, A. W., Palaeozoic corals of China, pt. 1, Tetraseptata: Palaeontologia Sinica, ser. B, vol. 2, fasc. 1, p. 6, 1922.

small perforations into the lower chambers. Outer walls and longitudinal septa thin and smooth; exterior surface smooth (perhaps from weathering).

This is a very rare species. The only specimen collected is incomplete and tentatively identified. The writer has not had an opportunity to examine the type, which came not from the Louisiana limestone but from the Kinderhook at Burlington, Iowa. The notes here made are based on the examination of a single specimen from the Louisiana limestone loaned to the writer by Prof. R. R. Rowley. Because only a single specimen and it one that did not belong to the writer was available, no sections could be made, and the observations are limited to those that could be made without altering the condition of the specimen.

This species was not figured by its authors, and hence its identification in the Louisiana limestone, if it were made wholly on the writer's authority, would be rather uncertain. The species was, however, identified among collections from the Louisiana by Winchell, who also worked over the White collection, which, the writer is informed, includes the type and for that reason its presence in the Louisiana is based on better authority than the mere comparison of specimens with a description without the benefit of figures. The specimen figured here is the only one seen by the writer among Louisiana forms that agrees to any extent with the specific description of *N. acuta*.

Its most conspicuous agreement is in its acutely pointed base. There are 23 primary septa and about an equal number of secondary septa. The original description does not mention secondary septa. The calyx is rather shallow, but the upper part of the corallum has seemingly been broken off of the specimen examined by the writer. The size of "fossette" on this specimen cannot therefore be definitely stated. A cardinal fossula and a suggestion of a cardinal septum can be made out on a side near the most concave side of the corallum. No carinae were observed on the septa. Indications of a few dissepiments occur on one side of the calyx, but as no sections could be made, their presence or absence, together with the presence or absence of tabulae and some other structures within the theca, could not be determined on the specimen examined. White and Whitfield's "transverse septa extending from the border of the central fossette to near the external walls" may represent what are now generally described as dissepiments. The writer has not seen in any zaphrentoid coral small perforations like those they describe. White and Whitfield also describe the external surface as smooth but state that this character may be "perhaps from weathering."

The species, as here interpreted, resembles *N. parasitica* (Worthen, 1890), also from the Louisiana, in size, general form, and in other characters but differs from it in its acutely pointed base and, if the interpretation of White and Whitfield's "transverse

septa" as dissepiments is correct, in the possession of dissepiments. Though the writer has some misgivings as to the specific significance of the pointed base of the specimen examined, the two species are recognized here as distinct because of other apparent differences and because the writer has not seen the type of *N. acuta*.

Occurrence: Yellow-brown calcareous mudstone of the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo.

This species was originally described from rocks of Kinderhook age at Burlington, Iowa, and occurs also in the Saverton shales in Missouri. The writer has examined only specimens from the Louisiana and Saverton formations.

Neozaphrentis? palmeri (Rowley)

Plate 6, figures 26, 27

1894. *Zaphrentis acuta* [part] Keyes, Missouri Geol. Survey, vol. 4, pl. 13, fig. 4. (Not description on p. 109.)

1908. *Zaphrentis palmeri* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 63, pl. 16, figs. 15-18.

The following description is based on a specimen borrowed from R. R. Rowley and labeled as type.

Corallum simple, subturbinate, rather rapidly expanding; length slightly greater than greatest width. The dimensions of the specimen (holotype?) are: Length 15 mm., average diameter of corallum at upper end 13 mm., average diameter at lower end 4.5 mm. Lower end truncate.

Calyx rather shallow, outline subcircular. Septa shown in calyx, about 28, most septa extending from outer wall nearly but not quite to center of calyx. A few irregularly distributed septa are only about one-third to one-half the length of most of the septa, but some of these short septa are clearly broken. A few septa represented by what appear to be merely thickenings of the inner thecal wall. Ends of some of the septa slightly twisted. No carinae observed on any septa. Fossulae not clearly shown. The grouping of the septa suggests a cardinal fossula with a short cardinal septum. There are also faint indications of alar pseudofossulae. Dissepiments observed near margin of cup but not abundant in a view of the calyx from above. Tabulae not observed from this view. No sections were made because of scarcity of specimens. Surface marked by concentric furrows and wrinkles and by obscure and discontinuous longitudinal epithelial ridges.

Remarks: This species is also a very rare one, and the writer has had the opportunity to examine only one specimen, loaned from the collection of R. R. Rowley and labeled the type. As Rowley figured three specimens of this species, it is not known whether the one loaned the writer is the holotype or a cotype. Rowley's description must have been based at least in part on other specimens, because he cites 42 to 46 septa in the calyx, whereas the writer could distinguish but 28 on

the specimen loaned him. As no duplicates were available, the writer did not make polished sections nor examine the interior structures. The species must therefore remain imperfectly known until other specimens are collected.

As stated by Rowley, this species differs from *N. parasitica* (Worthen, 1890) in its more rapid expansion, thinner lamellae (septa), and indistinct longitudinal epithelial furrows. The depth of the calyx of the specimen examined by the writer is not as great as that of many individuals of *N. parasitica*, but other specimens of *N. palmeri* may have deeper calyces.

This species is transferred from *Zaphrentis* to *Neozaphrentis* mainly because of the lack of carinae on the septa. The twisting of some of the septa, as shown in the figure, suggests *Pseudocaninia* but the seeming absence of dissepiments indicates stronger relationship to *Neozaphrentis*. It seems very probable that if collections of corals sufficient to show the real relationships of *N. palmeri* and *N. parasitica* are ever obtained, *N. palmeri* will be reduced to a variety of *N. parasitica*.

Keyes' figure listed in the synonymy was given for *Z. acuta* White and Whitfield, but it resembles *N. palmeri* more closely than any other Louisiana species.

Occurrence: Rare in the yellow-brown calcareous mudstone in the Louisiana limestone at Louisiana, Mo.

This species is also said to occur also in the Saverton shale.

Neozaphrentis parasitica (Worthen)

Plate 6, figures 34-40

1890. *Zaphrentis parasitica* Worthen, Illinois Geol. Survey, vol. 8, p. 79, pl. 10, figs. 5, 5a.

1898. *Zaphrentis parasitica* Weller, U. S. Geol. Survey Bull. 153, p. 648.

1908. *Zaphrentis parasitica* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 61, pl. 16, figs. 1-14.

Worthen described this species as follows:

Corallum small, truncated at the lower extremity, slightly expanded and compressed; breadth of the calice a little more than the length; surface marked with strong longitudinal striae; septal fossette comparatively large, central, extending laterally on the side of greatest curvature; about 20 strong lamellae extend from the border to the central fossette. Calice deep, and irregularly ovate in form.

Length $\frac{3}{16}$ inch; greatest breadth of calice about $\frac{1}{4}$ inch.

The specimen figured is parasitic on the ventral valve of *Productus pyxidatus*.

Remarks: Worthen described this species from a small individual. Large specimens are also common in the Louisiana limestone. Specimens collected show a considerable range in size and variation in other characters. The figures on plate 6 show the variation in size and form to a degree, but even larger specimens than the largest one figured on this plate have been collected. One of these is 34 mm. long, and about 13 mm. in diameter across the upper part of the calyx and 4 mm. in diameter near the base. The dimensions

given by Worthen in his original description are of a specimen only about 5 mm. long.

Mature and unbroken specimens have deep calices. The primary septa nearly join at the base of the calyx but do not extend inward as much as half the distance to the center from the uppermost walls of the calyx of completely preserved forms. Septa in the calyces are of two kinds, primary and secondary, and of about equal numbers.

Worther gives the number of septa in the calyx as "about 20." Although the number is variable most specimens have more than 20. A fragment from Louisiana, Mo., about 16 mm. long and about 12 mm. in diameter at its broken upper end, has about 24 septa. A smaller individual from the same locality about 12 mm. long and 8.5 mm. in greatest diameter has 24 primary septa and about the same number of secondary septa. None of the septa have any suggestions of carinae. The small size of the secondary septa suggests that they may not be recognizable on some individuals.

Longitudinal and transverse sections of several individuals were made to reveal the internal characters. The longitudinal sections were in the main unsatisfactory because of the stereotheca characteristic of the genus *Neozaphrentis*. As preserved, they show no tabulae or dissepiments. Transverse sections are shown in the photographs on plate 6. Figure 39 is of the neanic stage of a small individual, which shows a circular opening surrounded by a stereotheca composed of the fused ends of the septa and a small cardinal septum in the cardinal fossula. Figure 40 shows two stages of the corallum split longitudinally in an effort to obtain a good longitudinal section. The nearly central zone of stereotheca prevented an adequate view of the internal structures. The two parts of the corallum were later joined and a transverse section made, but before they were joined, one side had been polished down lower than the other. As a result, the transverse section really consists of approximate halves of two sections, one a millimeter or so below the calyx, and the other near the base of the calyx. The part of the lower section shows part of the zone of stereotheca formed by the fusion of the septal ends. The circular cavity in the center is now joined with the cardinal fossula, in which there is a cardinal septum. No secondary septa are visible. The part of the section near the base of the calyx shows alternating primary and secondary septa. The secondary septa appear in the section as scarcely more than spines extending inward from the thecal wall.

The relation of this species to *N. acuta* and *N. palmeri* are discussed under those species. The species is clearly not a *Zaphrentis* as it does not have carinate septa. It agrees in all essential respects with Grove's description of his genus *Neozaphrentis*, to which it is here referred.

Worther described this species from material from Clarksville, Mo., and because of its abundance in the Louisiana limestone there, it is probable that his type material came from the Louisiana. The exact horizon is, however, not definitely specified, as it is merely listed from the Kinderhook.

Keyes, in 1894, included this species in the synonymy of *Zaphrentis acuta* and gave a figure for *Z. acuta* that Rowley, in 1908, said probably was of *Z. parasitica*. There is little about the figure to justify a definite specific assignment, but it appears to be more rapidly expanding than is typical of the latter species and in that respect it resembles *N. palmeri*. It has therefore been placed in the synonymy of *N. palmeri*.

Occurrence: Limestone beds and clay partings of the Louisiana limestone at Louisiana and Clarksville, and at locality 623, 1½ miles west of Kissinger, and locality 988, 2 miles southwest of New London. This species has also been reported from the Saverton shale.

Subclass **ALCYONARIA**

Order **GORGONACEA**

Family **GORGONIDAE**

Genus **PLUMALINA** Hall, 1858

Plumalina gracilis (Shumard)

Plate 6, figure 25

1855. *Filicites gracilis* Shumard, Missouri Geol. Survey First and Second Ann. Repts., pt. 2, p. 208, pl. A, fig. 11.
 1858. *Plumalina gracilis* Hall, Canadian Naturalist, vol. 3, p. 175.
 1889. *Plumalina gracilis* Miller, North American Geology and Paleontology, p. 134.
 1898. *Filicites gracilis* Weller, U. S. Geol. Survey Bull. 153, p. 277.
 1908. *Filicites gracilis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 86, pl. 19, fig. 34.

Shumard's original description is in part as follows:

As it appears on the surface of the rock it consists of a central bifurcating axis, very slender, from which proceeds, at nearly right angles on either side, a series of very thin leaflike plates, about four lines in length; these laminae rise directly opposite each other, and they appear to be directed obliquely backwards and downwards.

Remarks: Shumard was very uncertain as to the systematic position of this species. Although he stated that it bore considerable resemblance "to the fimbriated tentaculæ of some of the crinoids," he nevertheless referred it to what was then considered a genus of plants. Hall, in 1858, concluded that it was a graptolite and referred it to the genus *Plumalina*, which genus he proposed for this species, a species from Canada and a species from the Devonian of New York that he had previously compared with *Filicites*?. Hall's species from New York was made the genotype and given the name *Plumalina plumaria*.

In 1916 Ruedemann²¹ studied *P. plumaria* and

²¹ Ruedemann, Rudolf, Account of some new or little known species of fossils, mostly from Paleozoic rocks of New York; New York State Mus. Bull. 189, p. 10, 1916.

decided that *Plumalina* was not a graptolite but that its closest relationships were with the family Gorgoniidae, subclass Alcyonaria, class Anthozoa, where it is here placed. Ruedemann had not at that time seen specimens of *P. gracilis*.

Shumard's typical material came from the "Lithographic limestone, at Louisiana and Elk Spring, Pike County; and on North River, in Marion County," Mo. As shown elsewhere, the "Lithographic limestone" was a name early applied to the Louisiana limestone. The writer has not seen Shumard's type or types and presumes that the material was destroyed by a fire that in 1892 destroyed many other types collected by Swallow and housed in the University of Missouri museum. The specimen here identified with *P. gracilis* came from the South Fork of North River in Marion County and probably was collected not far from, if not actually at, the locality from which Shumard cites some of his typical material. This conclusion is based on the facts that Swallow gives a section showing †Lithographic limestone at this locality in his report on Marion County, published in the same volume with Shumard's original description of *P. gracilis*, but gives no sections containing beds identified as †Lithographic limestone on the North Fork of North River. Several other stratigraphic sections showing †Lithographic limestone made near this one are also given in Swallow's report.

The single specimen here identified with *P. gracilis* agrees more closely with Shumard's description than with his figure. It was submitted to Ruedemann, who, in a personal communication, states that it is an undoubted *Plumalina*, and that a series of fine pores he observed on it indicate even better than his material of *P. plumaria* that *Plumalina* probably belonged to the Alcyonarians.

The stem (axis?) of the writer's specimen is about 22.6 mm. long. The pinnulae (so-called lateral branchlets) leave the main branch approximately at right angles to it and in opposing rather than alternating positions. They are not well preserved throughout the length of the stem, but on one side where they are nearly all preserved about 23 pinnulae occur in a distance of 7 mm. The pinnulae vary in length, the longest one preserved being about 8 mm. long. Twenty-five to thirty-five of the pores, which are more or less regularly spaced in linear series on the pinnulae and appear to be irregularly distributed on the stem, occur within the space of 10 mm. Little can be said of the original composition of the specimen, but its brownish cast suggests a horny material.

Occurrence: Louisiana limestone at locality 552, about 8 miles north of Monroe City, Mo., also described from the Louisiana limestone at Louisiana, and Elk Springs, Pike County, and along North River in Marion County. This species has been described from no other formation. The writer has seen a specimen from the Chouteau of Missouri that is probably conspecific, but the specimen has not been carefully studied.

Subclass unknown

Order unknown

Suborder TABULATA

Family LEPTOPORIDAE

Genus MICROCYATHUS Hinde, 1896

Microcyathus enormis (Meek and Worthen)

Plate 6, figures 9-13

1860. *Sphenopoterium enorme* Meek and Worthen, Acad. Nat. Sci. Philadelphia Proc. for 1860, p. 448.
 1866. *Sphenopoterium enorme* Meek and Worthen, Illinois Geol. Survey, vol. 2, p. 146, pl. 14, figs. 1a, b.
 1894. *Palaeacis enormis* Keyes, Missouri Geol. Survey, vol. 4, p. 118.
 1898. *Palaeacis enormis* Weller, U. S. Geol. Survey Bull. 153, p. 404.
 1908. *Palaeacis enormis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 64, pl. 16, figs. 22-28.
 1916. *Microcyathus enormis* Robinson, Connecticut Acad. Arts and Sci., Trans. vol. 21, p. 167.

Meek and Worthen's description follows:

Corallum small, subglobose, obtusely subturbinate; rounded, and apparently retaining some remains of a scar of attachment at the base. Cells four or more, rather irregularly disposed, circular, and moderately deep. Surface slightly more coarsely marked than the last, but otherwise similar.

Height, 0.45 inch; transverse diameter about 0.43 inch; breadth of cells, about 0.18 inch.

Remarks: Specimens from the Louisiana include a number of forms that vary considerably from the description given above and would furnish material for a study of the evolution of this species. They may represent some new species, but a careful study of the types of described species is necessary before the limits of the various species can be definitely fixed. The characters used by Meek and Worthen for specific differentiation included relative dimensions, shape of base, number, arrangement, and shape of calyces, thickness of intervening walls, and nature of surface markings. Each of these varies among the Louisiana specimens. Most of the specimens examined by the writer have the flattened or truncate base characteristic of *M. enormis* var. *depressus* (Meek and Worthen, 1866) but none has the regularly disposed quadrangular arrangement of corallites characteristic of that variety. A number of individuals have that part of the corallum immediately above the base drawn out into a wedged shape, but the base, even of these, is truncate. Most of the specimens are attached to shells of various kinds.

Some coralla have only one individual. Few have as many as four, the number given by Meek and Worthen in their description of the species. The coralla are all compressed, and the corallites of each corallum are nearly if not actually in a single plane. The corallites are cylindrical and have thin walls. The margins of nearly all corallites are free. The depth of an average corallite is about 45 mm. Their apertures vary slightly in outline, but average apertures are elliptical and have diameters as large as 5 mm. Vertical

striae within the calyces give the impression of poorly developed septa. No tabulae were observed. The external ornamentation of the coralla consists of small granules and anastomosing ridges separated by more continuous furrows. The finer details of the microstructure and canal system have not been worked out by the writer, who places the species in *Microcyathus* because of external features. Robinson is taken as authority for the agreement of the microstructure with that of the genus *Microcyathus*.

Some individuals here identified as *M. enormis* resemble those figured by Weller in 1910 as *M. bifidis*, but they have corallites with apertures smaller than Weller's measurements. Weller states also that *M. bifidis* has fewer corallites than *M. enormis* but this distinction does not hold as some coralla of *M. enormis* with only two corallites, the number characteristic of *M. bifidis*, occur in the Louisiana. The relationships between these two forms need more careful study.

In spite of their variation in characters ordinarily given specific value, the writer is including all the specimens from the Louisiana in one species, *M. enormis*. This course is open to criticism and may be found to be unwise, but the widely different individuals are united in series by intermediate forms. Aside from the varying number of corallites in the coralla, the variation in the angle between contiguous corallites and the different shapes of the bases of the coralla are characters that would most likely be considered of specific value, if the Louisiana specimens were to be allotted to more than one species. Both of these characters it seems might naturally be supposed to vary with the mode of growth and the number of corallites developed. The mode of growth and especially the shape of the base is in large part determined at least in the closely related genus *Palaeacis* by the size and shape of the object to which the colony was attached. Smyth,²² who has examined many specimens of *Palaeacis*, reports that where the supporting fragment is relatively large the corallum has a spreading base. Where it is relatively small, the corallum grows completely around it. The bases of coralla that have entirely enclosed foreign bodies are apt to be wedge-shaped. A wedge form, Smyth has found, is also frequently developed where an organism has attached itself near the edge of a small and flat piece of shell. He also states that "the early stages of development are naturally more affected than the later ones by the form of the supporting fragment."²³ As a result of this, the early stages of growth are often very irregular.

Occurrence: Yellow-brown calcareous mudstone and limestone beds of the Louisiana limestone at Louisiana and Clarksville, Mo.

This species also occurs in the so-called Goniaticite

²² Smyth, L. B., On the structure of *Palaeacis*: Royal Dublin Society Scientific Proc., n. s., vol. 19, No. 14, p. 131, 1929.

²³ Idem, p. 130.

beds at Rockford, Ind., and the Saverton shale in Missouri. The writer has not examined any of the specimens from Indiana.

Family FAVOSITIDAE

Genus *CONOPOTERIUM* Winchell, 1865

Conopoterium effusum Winchell

Plate 6, figures 4-8

1865. *Conopoterium effusum* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 111.
 1894. *Conopoterium effusum* Keyes, Missouri Geol. Survey, vol. 4, p. 118, pl. 14, fig. 10.
 1898. *Conopoterium effusum* Weller, U. S. Geol. Survey Bull. 153, p. 189.
 1908. *Conopoterium effusum* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 64, pl. 16, figs. 29-34.
 1916. *Conopoterium effusum* Robinson, Connecticut Acad. Arts and Sci., Trans., vol. 21, p. 173.

Winchell's description of the genus, of which this is the only species, together with the specific description is given below.

Corallum compound, generally free, sometimes adherent, but without a distinct base of attachment. Cells somewhat crowded, rapidly enlarging, inseparable, with only occasional and rudimentary diaphragms, and no radial lamellae. Walls marked internally by vertical striae, and a few pores which communicate between the cells. Exterior, where exposed, covered by an epitheca, marked only by irregular encircling striae. Cells increasing laterally and interstitially.

This genus, perhaps, approaches nearest to *Sphenopoterium*, Meek and Worthen. It differs in the absence of the cuneate form of the base even in *Sphenopoterium*—the cell mouth in this genus being turned indifferently in all directions. The cells also are smaller and more numerous; and the fewer mural pores communicate from cell to cell, instead of terminating in the intercellular substance. But one species has thus far been observed.

Corallum small, spheroidal, consisting of 20 to 50 cells, which are crowded, subcircular, or irregularly angulated in transverse section, feebly striated internally, and having a thick, feebly wrinkled epitheca. Specimens presenting cells of all sizes. Some tendency is manifest toward a proliferous growth; some of the lateral cells becoming adherent by their sides to a foreign body.

Diameter of largest mass, 0.58; diameter of mouth of largest cells, about 0.20.

Remarks: The writer has examined Winchell's types of this species through the courtesy of Prof. G. M. Ehlers, of the Geological Museum, University of Michigan. They are four in number, two of them obviously being complete coralla. The other two are parts of coralla that have been sectioned, possibly parts of a single corallum.

All of the coralla are small. The largest is sub-spherical and has a greatest diameter of about 16 mm. The smallest diameter is about 11 mm. Part of this corallum is attached to a piece of shelly material resembling a fragment of a brachiopod shell, possibly a *Spirifer marionensis* Shumard.

The corallites of this corallum are arranged so that the corallites face the surface over most of the circum-

ference. Their greatest depth is about at right angles to the surface. They vary considerably in size and shape. Fifty-two distinct corallites were counted on this corallum, and a few very small or imperfectly developed ones may not have been counted. The largest corallite has a greatest diameter of about 7 mm., but most of them have diameters of 3 mm. or less. The smallest recognizable corallites are less than 0.5 mm. in diameter. The outlines of the smaller corallites are polygonal. The larger ones are more nearly circular or subelliptical. As all have slightly sloping walls, they are more nearly subcylindrical than funnel-shaped.

The second nearly complete corallum measures 14 mm. by 15.5 mm. by 12 mm. Only a few corallites can be distinguished on it, because most of it is covered by matrix.

The two sectioned cotypes show the subcylindrical shape of the corallites. A few perforations of the walls of the corallites suggest mural pores. No tabulae can be seen. The vertical striations on the interior of the corallites plainly show as irregularities on their walls in the sectioned specimens.

The writer's specimens agree in all essential details with the cotypes. Some of them are from Clarksville, Mo., the type locality. A nearly spheroidal corallum from Louisiana, Mo., in the collection of the Missouri Bureau of Geology and Mines has a greatest diameter of about 13 mm. It has 36 corallites. Another corallum from the same locality is 20 mm. long, 12 mm. wide, and 13 mm. thick. It has about 32 corallites.

Few of the coralla are spherical. The bases of most of them are smaller than the upper surfaces and project below the greatest diameters, producing inverted pear shapes. Some, however, that have unusually small and projecting bases have shapes resembling that of a doorknob. Other more encrusting coralla are relatively longer and broader but are not very high. Most of the coralla show evidences of having been attached to foreign substances. One of them is attached to a brachiopod shell.

The corallites on the writer's specimens, like those of the cotypes, vary widely in size and outline. Some are polygonal in outline; others are subelliptical or subcircular. The smaller ones are quadrangular or polygonal. The larger ones are, in general, more nearly circular. Diameters vary from 0.5 mm. to 5 mm. The corallites are relatively deep and subcylindrical or funnel-shaped. Some of the larger corallites are 6 mm. deep. The inner surfaces of the walls of some show vertical striations, but most of the walls show no markings. Polished sections reveal an occasional tabula, but they are very rarely seen. Mural pores are present, but are also rare.

Conopoterium effusum, the type and only species of the genus, is known only from the Louisiana limestone and the Saverton shale, which occurs immediately below it. It very closely resembles the genus *Michelinia*,

but differs from the description of that genus in the smaller number and perhaps slightly different shape of its tabulae. It seems very probable that a number of species now included in *Michelinia* will ultimately either be transferred to this genus or *Conopoterium* will have to be included in *Michelinia*. *Conopoterium* also resembles species of *Pleurodictyum* Goldfuss, with which comparisons must be made before the status of *Conopoterium* can be considered satisfactory.

Robinson²⁴ included this genus in the family Lepetoporidae and it may belong there, but its close resemblance to *Michelinia* has influenced the writer to retain it in the Favositidae.

Occurrence: Yellow-brown calcareous mudstone, clay partings, and limestone beds of the Louisiana limestone at Clarksville and Louisiana, Mo. This species also occurs in the Saverton shale in Missouri.

Unidentifiable corals

Several simple coralla too fragmentary for positive identification may possibly represent new species. A specimen which is probably a coral is figured by Rowley,²⁵ and another is listed by Moore.²⁶ Several also occur in the writer's collections. The lower Mississippian corals are in need of thorough revision, and when that is done some of the species here recognized may be found to be identical with other species.

Phylum ANNELIDA

The species described under this phylum have, with one exception, generally been grouped by paleontologists under Vermes. Zoologists no longer recognize such a phylum, and species formerly included in it have been transferred (as their affinities have become better known) either to one of the long-established phyla or to one of the newer phyla erected especially to receive them. Of these latter phyla, Platyhelminthes, Nematelminthes, Trochelminthes, and Annelida are the most widely used, and together they embrace nearly all species of worms.

Paleontologists have been slow to follow the zoologists in adopting these phyla, because the worms are not common among fossils and have not recently been carefully studied and also because it is difficult, if not impossible, to classify many of them properly from the hard parts alone. Most of the Paleozoic fossils that have been described under Vermes probably are Annelids.

Class CHAETOPODA

Order TUBICOLA

Family CONULARIDAE

This family consists of a single genus *Conularia*. Its systematic position has long been in doubt. For

²⁴ Robinson, W. J., The relationship of the Tetracoralla to the Hexacoralla. Connecticut Acad. Arts and Sci. Trans., vol. 21, p. 173, 1917.

²⁵ Rowley, R. R., Geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, pl. 16, fig. 21, 1908.

²⁶ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 46, 1923.

some time it has been more or less tentatively classed among the gastropods as closely related to the pteropods. Ruedemann,²⁷ however, maintains that its closest relationship is with the worms, especially with the genus *Serpulites*, which is now generally classed as an annelid because of its many wormlike characters and which also has many characters seen in *Conularia*. Similarity between *Serpulites* and *Conularia* is shown by Ruedemann in the following: Surface sculpture; composition of the test; sessile habit, especially during very early stages; and marginal thickenings of the test.

Genus CONULARIA Miller, 1821

***Conularia marionensis* Swallow**

Plate 9, figures 27-29

1860. *Conularia marionensis* Swallow, St. Louis Acad. Sci. Trans., vol. 1, p. 656.
 1894. *Conularia marionensis*. Keyes, Missouri Geol. Survey, vol. 5, p. 217.
 1898. *Conularia marionensis* Weller, U. S. Geol. Survey Bull. 153, p. 190.

The following is Swallow's original description:

Shell pyramidal, quadrilateral. Base rhombic; obtuse lateral edges deeply sulcate; sides marked with two sets of high, granulated, transverse costae; they commence on the margins and curve towards the base, then partially back and meet or intersect in the middle, forming an obsolete mesial line where the two sets meet; the spaces between the costae twice as wide as the costae. There are 20 costae in the space equal to the width of the side, at the place counted. The sulcations are marked with obsolete, irregular striae.

This species has the general appearance of the *C. missouriensis*, but may be easily distinguished by the granulations of the costae and by the greater number of costae.

Remarks: This species has never been figured, but incomplete specimens in the collections made by the writer are easily identified with it. It was originally described from the Saverton shale, then known as the Upper Hamilton shales. Its occurrence in the Hannibal shale as reported by Keyes is probably in error, as no other collector has listed it from that formation. It is not clear whether Keyes collected the specimens from the Hannibal himself or confused Swallow's reference.

The crenulations on the transverse costae are not visible on worn surfaces, where the costae become sharp ridges. On one specimen there are 20 crenulations in 1.6 mm. at a point where the furrows between the costae are about 0.4 mm. wide. No striae were observed in the furrows. None of the specimens is well enough preserved to give dimensions of the tube.

This species does not have the triplicate costae of *C. triplicata* Swallow, 1860, which also occurs in the Upper Hamilton shales of Swallow. It is smaller and has more costae than are described from *C. missouriensis* Swallow, 1860, and its costae have crenulations, which are said to be lacking on *C. missouriensis*.

²⁷ Ruedemann, Rudolf, Account of some new or little-known species of fossils, mostly from Paleozoic rocks of New York: New York State Mus. Bull. 189, p. 85, 1916.

Another closely related species is *C. sampsoni* Miller, 1891, from the Chouteau limestone. The differences between *C. marionensis* and *C. sampsoni* appear from the literature to be very slight and comparison of authentic specimens may prove these species to be conspecific.

Occurrence: Yellow-brown calcareous mudstone of the Louisiana limestone at Hannibal and at locality 1010, 6 miles north of Withers Mills, in Marion County; and at locality 618, Clarksville, Pike County. This species also occurs in the Saverton shale in Missouri.

***Conularia* sp.**

Plate 9, figures 30-31

At least one species of *Conularia* is represented by fragments that are unidentifiable. The specimen figured probably represents a large individual. The transverse costae are minutely noded and are separated by furrows that are not quite twice the width of the costae.

Unidentifiable specimens from the Louisiana have also been reported by Rowley²⁸ and by Moore.²⁹ Rowley's figure resembles *C. marionensis* Swallow, but necessary details for accurate identification do not show.

Occurrence: The specimen here figured is from the yellow-brown calcareous mudstone of the Louisiana limestone at locality 639, 1½ miles north of Saverton.

Genus SPIORBIS Lamarck, 1801

***Spirorbis kinderhookensis* Gurley**

Plate 6, figures 23, 24

1883. *Spirorbis kinderhookensis* Gurley, New Carboniferous fossils Bull. 1, p. 9.
 1889. *Spirorbis kinderhookensis* Miller, North American Geology and Paleontology, p. 521.
 1898. *Spirorbis kinderhookensis* Weller, U. S. Geol. Survey Bull. 153, p. 599.
 1908. *Spirorbis kinderhookensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 67, pl. 16, fig. 38.

The following description was prepared after an examination of Gurley's cotypes.

Shell small, coiled almost in a plane, with second whorl scarcely elevated above first whorl, sinistral, slowing enlargement toward aperture, attached by whole of under surface. The diameter of one of the cotypes is 1.2 mm. Umbilicus wide and deep, width equal to about one-third diameter; whorls, about 1½, rounded, very slightly angular on margin of umbilicus and slightly flattened on outside. Surface smooth, or with a faint indication of spiral striae.

Remarks: This species differs from other lower Mississippian species in its well-rounded whorls and absence of distinct ornamentation or prominent angulation. It resembles *S. omphaloides* (Goldfuss, 1883) from the Devonian but is not so rapidly enlarging.

²⁸ Rowley, R. R., Geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 88, pl. 19, fig. 20, 1908.

²⁹ Moore, Raymond C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 47, 1928.

Occurrence: Yellow-brown calcareous mudstone, clay partings and limestone beds of the Louisiana limestone at Louisiana and Clarksville, and at locality 728, 3 miles northwest of Ely, Marion County, Mo.

Genus *CORNULITES* Schlotheim, 1820

The relations of this genus to *Ortonia* are somewhat in doubt. As shown by Hall,³⁰ *Cornulites* was described by Schlotheim in 1820, whereas *Ortonia* was not described until 1872. For some years it has been general practice to refer small tubes that are attached or show evidences of attachment along the whole of one side to *Ortonia* and to refer the larger forms that are at least in part free and have distinct longitudinal striae to *Cornulites*. Hall maintained in 1888 that this practice was not right, but his conclusions seem to have been overlooked. In a study of a considerable number of individuals thought to be a single species of *Cornulites* (*C. proprius* Hall, 1875) from the Silurian of Indiana, he showed that the ornamentation, the amount of coiling, and the degree of attachment as well as the size vary with the stage of growth. The degree of attachment is also influenced by the size and shape of the object to which the tube is attached. Young individuals have relatively larger coiled portions, are attached throughout their lengths, lack distinct longitudinal striae, have inner and outer walls that are not separated by vesicular tissue, and, if not too young, are distinctly annulated. As they grow older, they become partly free or, where the tip and probably the coiled portion with it has broken off, they are completely free; they become distinctly striate; the inner wall is separated from the outer wall by irregular vesicular growths, and the annulations are less distinct. The young individuals of this species thus have the generic characters of *Ortonia*, and the older ones, those of *Cornulites*. The same differences between younger and older individuals are shown in figures of the type species of *Cornulites* (*C. serpularius* Schlotheim, 1820) originally made by Sowerby, but refigured in 1888 by Hall. Hall's studies, therefore, seem to justify his conclusion that the names *Ortonia* and *Cornulites* are used for a single genus. As *Cornulites* has priority, it is the name which should be used.

Cornulites carbonarius Gurley

Plate 6, figures 28-30

1883. *Cornulites carbonarius* Gurley, New Carboniferous fossils Bull. 1, p. 8.
 1889. *Cornulites carbonarius* Miller, North American Geology and Paleontology, p. 518.
 1898. *Cornulites carbonarius* Weller, U. S. Geol. Survey Bull. 153, p. 192.
 1908. *Cornulites carbonarius* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 66, pl. 16, fig. 37.

The following description is based on the holotype.

³⁰ Hall, James, Paleontology of New York, supplement to vol. 5, pt. 2, in vol. 7, p. 8, 1888.

Tube elongate, rapidly enlarging, trumpet-shaped to elongate-conical, curved at lower end, which is attenuate; attached by under surface to shell of *Spirifer marionensis* Shumard. The dimensions of the holotype are: Length, 3.6 mm., greatest width of aperture, 1.4 mm. Annular ridges prominent over all the surface, regularly spaced but farther apart near larger end, about 5 per millimeter near larger end and 8 per millimeter near smaller end, ridges obtusely subangular on summits, separated by interspaces from 1 to 1½ times as wide as ridges. Surface also ornamented by faint interrupted longitudinal striae, which occur on annular ridges and interspaces and when discontinuous resemble short spines, about 30 striae per millimeter. No concentric striae observed.

Remarks: This species is common among the small forms from the Louisiana, and a number of variations from the type are represented. Most of the tubes are free but retain some evidence of attachment along the length of one side or near the apex. The interspaces separating the annular ridges are no wider than the ridges on most specimens, and annular ridges are more closely spaced than on the holotype. Many individuals are flexuous, some are coiled at the lower end, and many have truncate apices. An average specimen is 2.1 mm. long and has a subcircular aperture 0.9 mm. in diameter.

This genus is but sparingly represented in the Mississippian. "*Ortonia*" *blatchleyi* Beede, 1906, originally described from the Spargen limestone but also occurring in the lower part of the Amsden formation of Wyoming resembles *C. carbonarius* but is said not to have longitudinal striae. In addition, Beede's figure does not show such conspicuous annulations as are possessed by *C. carbonarius*. The only other Carboniferous species known to the writer is a questionably identified form from Coffin Island, Quebec.

Occurrence: Yellow-brown calcareous mudstones and clay partings of the Louisiana limestone at Clarksville and Louisiana and at locality 599, mouth of Buffalo Creek, 1 mile south of Louisiana, Mo.

ECHINODERMATA

Subphylum PELMATOZOA

Class BLASTOIDEA

Order EUBLASTOIDEA

Family ORBITREMITIDAE

Genus *MESOBLASTUS* Etheridge and Carpenter, 1886

Mesoblastus? sp.

Plate 6, figures 21, 22

The material here noted consists of a basal cup attached to an anterior radial plate. Deltoid plates, summit plates, spiracles, side plates, and lancet plate not preserved.

Base slightly protuberant, trilobate, with a small columnar facet. Azygous basal pentagonal, with a median triangular raised area extending and gradually

widening from the columnar facet to the radio-basal suture flanked by two flattened areas which lie about 60° from the triangular area. Large basal plates also pentagonal, each with a medium ridge extending from the columnar facet to the midpoint of opposite suture of the plate, each ridge flanked by two scarcely visible narrow furrows, which extend from the columnar facet obliquely to the ends of the opposite radio-basal suture. The radial plate is very long and narrow; body small, slightly convex, at an angle of about 90° to the sinus, with a median ridge extending from the midpoint of the lip to the midpoint on the radio-basal suture and bounded by two very narrow furrows which go from the sides of the radial lip obliquely to the lower lateral corners of the plate; limbs gradually tapering toward summit. Sinus very elongate wedge-shaped. Hydrosphere plate indistinct but recognizable. Distinct, closely spaced striae ornament the radial and basal plates. The dimensions of the specimen are as follows: Approximate length of radial plate, 19 mm.; width of limb of radial plate opposite lip of sinus, 5 mm.; width of limb near upper end, 2.3 mm.; width of sinus at lower end, 1.5 mm.; width of sinus at upper end, 2 mm.; width of radial plate at base, 7 mm.; average diameter of basal cup, 11.3 mm.; approximate depth of cup, 5 mm.; diameter of columnar cavity, 2 mm.

Remarks: There is not enough of this blastoid preserved to assign it definitely even to a genus. It furnishes the first record of any blastoid from the Louisiana, however, and is therefore worthy of notice. Though it might equally well be an *Orbitremites*, it is referred to *Mesoblastus* because its deltoid plates were probably short, which is not true of most species of *Orbitremites*.

Occurrence: Limestone beds of the Louisiana limestone at locality 552, about 8 miles north of Monroe City, Mo.

Class CRINOIDEA³¹

Order ADUNATA

Family PLATYCRINIDAE

Genus PLATYCRINUS Miller, 1821

Platycrinus dodgei Rowley

Plate 6, figures 16-18

1908. *Platycrinus dodgei* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, pp. 68-69.

Rowley's original description is given below.

The basal disk is low but having an elevated ring about the stem pit. The suture lines are indicated by slender depressions between low double ridges * * *. The radials are about as high as the greatest breadth of the basal disk and but little broader at the top than below. The brachial scar is quite half the upper width.

There is a slight elevation of the central portions of the radial into an elongate, quadrangular figure, not noticeable on smaller plates.

³¹ The units of classification of the Crinoidea above the rank of family are, with the exception of the order Adunata, after Wachsmuth and Springer. These units are adopted for convenience and without prejudice as to their use or the use of other units

³² Bather, Jaekel, and others.

The side of the restored calyx is almost perpendicular. Higher plates, vault, and arms unknown. The column leaves the calyx as a round stem but becomes elliptical and most extraordinarily twisted and tuberclose or spiny. The axial canal is minute as usual with this genus. This species in the elevated basal ring about the column base and the sutural ridges recalls *P. huntsvillae* of the St. Louis group and *P. truncatulus* of the Lower Burlington limestone but outside of these features there are no resemblances. The specific name is in honor of my valued friend and coworker, Mr. E. A. Dodge of Louisiana, Mo.

While stem joints of this species are not uncommon in the clay seams at the base of the limestone, the separate radials and basal disks are rare.

Remarks: The calyx is not complete in any of the specimens examined, and most of the material is in the form of separate plates and stems. The basal cup is very shallow and saucer-shaped. In one specimen three nodes or tubercles around the columnar facet mark the termination of the sutures between the basals. The radial plates examined have a slightly convex surface, length about one and a quarter times width, radial facet occupying about half of width of radial plate, reaching about one-sixth length of plate. Radial facet supported by a raised ridge on the plate, which extends downward as a single ridge below the facet for about half the length of the plate and then bifurcates, one branch going to each lower angle of the plate. The largest basal disk examined had a diameter of 4 mm. at the rim of the lower truncated end and 10 mm. at the top of the basals.

Rowley apparently described this species from basal disks, free radials, and stem fragments. A more complete specimen is needed before the specific relationships can be definitely determined.

Occurrence: Clay partings, yellow-brown calcareous mudstone, and limestone beds of Louisiana limestone at Louisiana, Mo.

Order INADUNATA

Suborder LARVIFORMIA

Family ALLAGECRINIDAE emend. Wright

Genus ALLAGECRINUS Etheridge and Carpenter, 1881

Allagecrinus americanus Rowley

Plate 6, figures 14, 15

1895. *Allagecrinus americanus* Rowley, Am. Geologist, vol. 16, p. 219, figs. 3-10.

1898. *Allagecrinus americanus* Weller, U. S. Geol. Survey Bull. 153, p. 75.

1908. *Allagecrinus americanus* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 67, pl. 16, figs. 39-41.

1916. *Allagecrinus americanus* Wilson, Jour. Geology, vol. 24, p. 507, text fig. 5, no. 6.

1929. *Allagecrinus americanus* Wanner, Nederlandsch-Indië, Dienst van den Mijnbouw Wetensch-Appelijke Mededeelingen, no. 11, p. 13.

1930. *Hybochilocrinus americanus* Weller, Illinois Geol. Survey Rept. Investigations no. 21, p. 13, pl. 1, figs. 1a-c.

1932. *Allagecrinus americanus* Wright, Geol. Mag., vol. 69, no. 818, p. 363.

1933. *Allagecrinus americanus* Wright, idem., vol. 70, no. 827, p. 204.

Rowley's original description is quoted below.

Crinoid minute. Calyx conical. Basals form a low rounded cup. Number unknown, as the suture lines are not visible under a hand glass. Radials 5, elongate, each with 1 or 2 distinct articular facets above for the attachment of arms. The scars directed upward but not noticeably outward. Arms unknown. The dome or ventral surface composed apparently of 3 single pieces, though the depressions around the vault suggest 5. The left upper corner of one of the radials in several of the larger specimens meets the edge of the adjacent radial below the right upper corner of that plate and at first sight suggests an accidental break, but this may represent the anal area of other Paleozoic crinoids. The larger specimens with this feature present have scars for the attachment of 9 arms, while the smaller examples have but 5 facets. A few thin round joints of a column have been observed attached to some of the specimens, and small, round stems are common in the clay. Plates apparently smooth. Most of the specimens are highly calcified so that features are made out with difficulty. The collection contains over 300 specimens of all sizes, from those almost microscopic to those one-sixteenth by one-thirtieth of an inch, all possessing the vault in place.

The writer can add but little to the facts given in the descriptions by Rowley and by J. M. Weller. Furthermore, Dr. Edwin Kirk, of the Geological Survey, is making an extensive study of this and related species and genera. It is therefore necessary to give here only a few comments.

Specimens in the writer's collection are all small but represent quite a range in size. Three individuals have the following respective dimensions: Height of calyx 1.5, 1.3, and 0.5 mm.; greatest width of calyx taken at about top of RR, 0.84, 0.69, and 0.25 mm. Most of the specimens examined are about the size of the second specimen measured. Some few are larger than the first. The sides of the calyces of the larger individuals are more nearly in one plane than are the curved sides of the smaller ones, and their shapes are as a consequence more nearly conical. Most specimens show the sutures between the radials rather distinctly, but those that separate the orals are not so plain, and only rarely can the sutures separating the basals be made out. The surfaces of all plates are, on most specimens, minutely pitted, but some are nearly smooth.

Rowley could not make out the sutures between the basals and was not therefore able to give their number. Wilson in 1916, however, distinguished the basal plates and gave a drawing showing their number and arrangement. According to Wilson, there are three basals, the posterior smaller than the other two, which are of approximately equal size. The present writer was able to make out only fragments of sutures between basal plates on all except two specimens, on which all the sutures could not be traced throughout their length. On each of these individuals a small basal could be made out and incomplete sutures indicated that there were two other larger basals. The writer's observations, then, although not worthy of positive conclusions, would seem to substantiate Wilson's conclusions.

The radials are somewhat variable in size and shape, some being higher and narrower than those adjacent. The left posterior radial is higher than the other radials on most specimens, but others also vary in height. Some variations in shape are clearly the result of crushing. Two adjacent radials on the largest specimen whose measurements are given above have the following respective dimensions: Height 0.52 and 0.6 mm., width 0.33 and 0.25 mm.

Considerable variation also exists among the characters of the upper part of the radial plates. Some individuals have rather large notches in each corner of each radial plate into which the orals extend; others, especially larger individuals, have radial plates that, as seen in side view, have only small notches, if any. On some individuals hardly any two notches are the same depth. Most mature individuals have a rounded or angular notch on the upper left-hand corner of what is said to be the right posterior radial that is larger than the other notches. The upper extremity of the left side of this plate thus meets the right side of the left posterior radial considerably below its upper right-hand corner. This notch is said to indicate the position of an anal plate. The notch is relatively much larger on some specimens than on others, but on some specimens all the notches are of approximately the same size and are shared by two adjacent radials. The writer has not been able to distinguish an anal plate distinct from the orals and radials on any individual but does not doubt that one occurs on mature forms. Some of the smaller individuals clearly do not have distinct anal plates. In them the orals can be seen to fill all the notches in the radial plates. In most of the mature specimens there is unfilled space in the notch that could accommodate a small anal plate. In some of the larger specimens, however, the notches are shallow, and the orals do not extend very far between the radials. As preserved, they have spaces between the orals, and some of the radials and an anal plate may have occupied these areas. On these the tegmen appears to have been at least partly broken away from the dorsal cup.

The smaller individuals have only one radial facet or opening on each radial plate, and it is subcentral. Larger individuals may have two openings on most radial plates, or most radial plates on the single large individual may have one opening, and a few others may have two. On one large individual the writer observed eight openings and one or two additional ones may have been covered by foreign material. Most radial plates on this specimen had a large opening and a smaller opening. It is possible that some few of the smaller openings were small notches and not arm openings, but at least two of them had definite rings around them, and their significance can hardly be questioned.

Primibrachs were observed on three or four individuals. These observed primibrachs are relatively

narrow, being about half as wide as a radial plate. Some of them at first appear relatively higher than others, but the higher ones were found to consist of two plates. The first of these pairs of plates observed was at first interpreted as an anal plate, but further examination showed that it arises from the center of a radial plate and is connected to the arm facet.

Another specimen shows two of these seemingly high plates, which are in reality two plates. The first primibrach is flat and disklike, or appears so from a side view. The second primibrach is high and narrow. If the smaller basal plate is posterior the two pairs of plates are on the right and left anterior radials. The writer was unable to orient the specimen by the use of the notch on the right posterior radial, because it was not distinctly larger than other notches. Moreover, the sutures between the orals are indistinct, and the posterior oral cannot be distinguished from the other orals.

Five orals can be made out on most of the domes. On young individuals and on some nearly mature individuals they differ but slightly in size. On other mature forms one oral is larger than the others. This large plate has been generally considered to be posterior. On some specimens it has a single subcentral depression. On others, two depressions may be made out. On one specimen it has a subcentral hole.

The genus to which this species should be referred is in dispute and has recently been the subject of papers with divergent conclusions. The writer is following the course generally taken by those who must classify species among disputed genera without having had the opportunity to investigate the merits of the genera fully and is adopting without prejudice the genus used by the last investigator. The reader is referred to the more recent entries in the synonymy for details of the controversy.

Occurrence: Clay partings and yellow-brown calcareous mudstone of the Louisiana limestone at Louisiana and at locality 599, 1 mile south of Louisiana, Mo.

Suborder FISTULATA

Family POTERIOCRINIDAE

Subfamily POTERIOCRININAE

Genus POTERIOCRINUS Miller, 1821

Poteriocrinus jeffriesi Rowley

Plate 6, figures 19, 20

1908. *Poteriocrinus jeffriesi* Rowley, Missouri Bur. Geology and Mines, 2d. ser., vol. 8, p. 69, pl. 16, figs. 71-73.

Rowley's remarks in the original notice of the species follows:

From the arrangement of the angles at the lower part of the basal plates, our little specimen had a low under basal cup of five plates. The basal plates are longer than wide, three of them being hexagonal, one (the largest) heptagonal of equal

width and length and the fifth hexagonal without an angle below.

The radial plates a little wider than long, four of them being pentagonal and one quadrangular. The scars for the attachment of the first costals almost as wide as the upper edge of the radials. The radial opposite the anal area is much less in size than the other four radials and apparently without scar for costal attachment, the crinoid thus appearing to be four-armed. The two anal plates are pentagonal, the right being somewhat larger than the left and lying lower in the calyx. Smaller disconnected plates lie just above the anals and in the opening of the cup but their places in the calyx cannot be determined. Plates apparently smooth. Arms, under basals and column unknown.

Remarks: This species was described without the infrabasals, brachials, or any of the plates of the tegmen, and the generic reference is consequently uncertain. The radials are very irregular in shape and in the width of their facets. The height of the dorsal cup of the holotype, without the infrabasals, is 2.5 mm., and the greatest width is 3 mm. The species is not represented in the writer's collections.

It is possible that this species is closely related to some of the small species of *Poteriocrinus* described by Miller and Gurley from the Kinderhook at LeGrand, Iowa, but comparisons are hardly possible because of the incomplete description of these species and the incomplete preservation of *P. jeffriesi*.

Occurrence: Clay partings in the Louisiana limestone at Louisiana, Mo.

Unidentifiable crinoids

Crinoid stems and plates are common in the Louisiana and occur at practically all horizons and localities. Some of these are figured by Rowley,³² and others are represented by numerous specimens in the collections studied. The writer also has two or three series of brachials with pinnules attached that cannot be identified.

MOLLUSCOIDEA

Class BRYOZOA

Species of bryozoa belonging to the genera *Streblotrypa* Ulrich, 1890, *Lioclema* Ulrich, 1882, and *Tabulipora* Young, 1883, have been listed by Rowley³³ and by Moore.³⁴

Branching bryozoans are common in the clay partings and in the yellow-brown calcareous mudstone at the base of the Louisiana, and they also occur in the limestone beds. Most of them have been collected at Louisiana, at locality 599, 1 mile south of Louisiana, and at Clarksville. Markings resembling the thread-like excavations of the genus *Rhopalonaria* Ulrich, 1879, occur on some shells, having been particularly noticed on specimens of *Productella pyxidata* Hall, 1858. These bryozoans will be described in a later paper.

³² Rowley, R. R., Geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, pl. 16, figs. 49-70, 87-89, 1908.

³³ Rowley, R. R., Geology of Pike County: Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 72, 1908.

³⁴ Moore, E. C., Early Mississippian formations in Missouri: idem., 2d ser., vol. 21, p. 46, 1928.

Class BRACHIOPODA

Order ATREMATA

Superfamily LINGULACEA

Family LINGULIDAE

Genus LINGULA Bruguière, 1792

The species here referred to *Lingula* are distinguished mainly by differences in shape, size, and ornamentation. The muscular impressions are not distinctly shown on any of them, and internal structures are shown on only one. An impression of a slight median internal ridge is visible on the mold of the dorsal (?) valve of one species. Two of the species have concentric markings much coarser than typical of the genus, but they come within the range of variation of *Lingula* as currently interpreted. These concentric markings are separated by interspaces scarcely as wide as the markings themselves and are therefore not the type of ornamentation characteristic of *Trigonoglossa* Dunbar and Condra.

One of the species here referred to *Lingula* has for some time been placed in *Glossina* and some doubt attends its transfer back to *Lingula*. *Glossina* Phillips (= *Paleoglossa* Cockerell) was proposed for an Ordovician species that Phillips thought differed from typical *Lingulas* only in being inequivalved. As interpreted by Weller in 1914 the genus differs from typical *Lingula* "in the subtrigonal outline of the shell." Dunbar and Condra report that the shell outline of *Lingula attenuata* Sowerby, the genotype of *Paleoglossa*, differs little from that of typical *Lingula*, and its ornamentation differs not at all. Therefore, as typical *Lingula* is itself slightly inequivalve, there seems no utility in recognizing *Paleoglossa* in the Carboniferous, and the writer is accordingly referring the Louisiana species *L. lineolata* Rowley, 1908, to *Lingula*. This species does not belong in the group of species referred to *Trigonoglossa* Dunbar and Condra, which was erected for forms having a subtriangular outline and sharply raised concentric lirae separated by much broader, flat interspaces.

Lingula fleenori Williams, n. sp.

Plate 6, figure 48

Shell subelliptical to subovate in outline, not quite twice as long as wide, greatest width about midlength. The dimensions of the holotype are: Length, 14 mm.; width, 7.5 mm.

Valve moderately convex, greatest convexity near margin of the valve: lateral margins gently convex, anterior margin subsemicircular, more convex than lateral margins, posterolateral margins sharply rounded, posterior not well preserved, slightly narrower than anterior.

Surface seemingly marked by concentric costae, about 13 of which occupy the space of 1 mm., and by distinct radiating striae, which are about 0.3 mm. apart. The concentric costae are shown as impressions of the

external surface where the shelly material has been broken away. The radiating striae show plainly on the interior of the shell, and although not distinct in the mold of the external surface because the shell is broken, they may possibly have been visible on the external surface because the shell is so thin. However, they may be only markings caused by setae similar to the markings on some living species. These markings cannot be seen from the exterior.

Remarks: This species resembles *L. gorbyi* Miller, 1892, from the Chouteau limestone, but *L. gorbyi* is not known to have distinct radiating striae. As indicated in the description, this character may not, however, be specific. *L. fleenori* is larger than *L. louisianensis* Weller, 1914, and has concentric costae instead of irregular lines of growth. It also differs from most other species of *Lingula* in having radiating striae and regular concentric costae rather than concentric striae or growth lines. The species has characters that differ somewhat from those typical of *Lingula*, but they are within the limits of the genus as interpreted by most workers. The greatest deviation is shown by the concentric markings, which in the most typical forms of *Lingula* are very fine. The beak is not preserved but the most convex part of the shell seems to have been a slight distance from the shell margin. The composition and structure of the shell, the elongate outline of the growth lines, and the absence of any indication of rudimentary articulating structures all agree with *Lingula*.

The holotype is a mold of a single valve preserved in mudstone but with most of the shelly material attached to it. The essential specific characters are, however, well shown by the specimen.

This species is named for Miss Coral Fleenor, who has retouched the photographs used in this paper.

Occurrence: Yellow-brown calcareous mudstone, at its contact with the blue (Saverton) shale, of the Louisiana limestone at locality 798, 2½ miles west of Frankford, Mo.

Lingula lineolata Rowley

Plate 6, figure 41

1908. *Lingula lineolata* [part] Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, pp. 87, 100, pl. 19, fig. 35; pl. 20, fig. 19 (not pl. 19, fig. 36; pl. 20, figs. 20, 21).

1914. *Glossina lineolata* [part] Weller, Illinois Geol. Survey Mon. 1, p. 38, pl. 1, fig. 12.

This species was described from two specimens, one of which is much larger and relatively much longer than the other, and differs also in outline. The larger specimen is here described as a new species, *L. krugeri*.

As restricted to the smaller of Rowley's two types *L. lineolata* resembles descriptions of *L. meeki* Herrick 1888, from the Cuyahoga shale of Ohio, and *L. irvinensis* Foerste, 1909, from the so-called Berea-Bedford of Kentucky. Foerste's description of *L. irvinensis* is brief, and the writer does not have specimens for comparison.

Though the figure of his species is smaller and differs slightly in outline from that of *L. lineolata*, the two species appear very closely related. *L. meeki* is much larger than *L. lineolata* and relatively longer. The length-width ratio of *L. meeki*, as given by Herrick, is about 13 to 7, and that of *L. lineolata* is about 8 to 7.5. Herrick's figures, however, show that the length-width ratio of the two figured specimens of *L. meeki* differ from the ratio given in the text of his paper. Measurements of the two figures shown give length-width ratios of approximately 11 to 8 and 12 to 9. Moreover, *L. meeki* is said to have a prominent beak, while that of *L. lineolata* is not prominent.

This species is here returned to *Lingula* for reasons stated in the discussion of the genus.

Occurrence: Basal limestone bed of Louisiana limestone at locality 599, mouth of Buffalo Creek, Pike County, Mo. This species is confined to the Louisiana limestone.

***Lingula louisianensis* Weller**

Plate 6, figure 52

1914. *Lingula louisianensis* Weller, Illinois Geol. Survey Mon. 1, p. 34, pl. 1, fig. 3.

This species to a certain degree resembles *L. membranacea* Winchell, 1863, from the *Chonopectus*-bearing sandstone of Burlington, Iowa, *L. gannensis* Herrick, 1885, from the so-called †Waverly of Ohio, and *L. gorbyi* Miller, 1892, from the Chouteau limestone of Missouri. The first species is larger than *L. louisianensis* and is not known to have a median internal ridge. The second species is also much larger than *L. louisianensis* and from its description appears to have more prominent concentric ornamentation. The outline of its posterior margin is shown by the figures to be slightly more angular. It resembles *L. louisianensis* in having an internal ridge, but the two ridges may not be homologous. The description of *L. gorbyi* shows that it does not have the subtruncate anterior margin and narrowly rounded posterior margin of *L. louisianensis*. The few patches of shell preserved on the holotype of *L. louisianensis* do not show the concentric costae characteristic of *L. gorbyi*. The faint radiating striae mentioned by Weller were not observed by the writer.

Occurrence: Limestone beds of the Louisiana limestone at Louisiana, Mo.

***Lingula krugeri* Williams, n. sp.**

Plate 6, figures 49-51

1908. *Lingula lineolata* Rowley [part], Missouri Bur. Geology and Mines, 2d ser., vol. 8, pp. 87, 100, pl. 19, fig. 36; pl. 20, figs. 20, 21. (Not pl. 19, fig. 35; pl. 20, fig. 19.)

1914. *Glossina lineolata* Weller [part], Illinois Geol. Survey Mon. 1, p. 39. (Not pl. 1, fig. 12.)

Shell elongate, subelliptical in outline, the length not quite twice the width. The dimensions of the type are: Length 15.6 mm., width 9 mm.

Valves moderately convex, greatest convexity near center of shell; lateral margins straight, anterior margin subsemicircular, posterior and posterolateral margins not preserved.

Surface of shell marked by concentric costae, about 15 of which occupy the space of 1 mm.

Remarks: The holotype of this species is the larger of the two specimens designated as cotypes for *Lingula lineolata* by Professor Rowley. The posterior of the shell is not preserved, but enough of the shell margins is preserved to show that the shell outline is not ovate-subtriangular, as is that of the smaller specimen. *L. krugeri* is relatively much longer and is also much larger than the cotype to which the writer is here restricting *L. lineolata*.

This species does not have the distinct radiating striae of *L. fleenori*, but as there is doubt that this is a specific character these two species may be the same. If these are conspecific, *fleenori* should be retained as the species name. The subtruncate anterior margin of *L. louisianensis*, the only other species of *Lingula* here described from the Louisiana limestone, distinguishes it from *L. krugeri*.

L. krugeri is of about the same size as *L. atra* Herrick, 1888, from the Cuyahoga shales of Ohio, but it has a more nearly circular anterior margin, is relatively narrower, and its posterior outline, though only partly preserved, appears not to be the same.

The name is in honor of Frederick Kruger, who assisted the writer in the field.

Occurrence: Clay partings in the Louisiana limestone at locality 614, about 7 miles west of Louisiana, Mo

Order NEOTREMATA

Superfamily DISCINACEA

Family DISCINIDAE

Subfamily ORBICULOIDEINAE

Genus ORBICULOIDEA D'Orbigny, 1847

***Orbiculoidea limata* Rowley**

Plate 6, figure 53

1908. *Orbiculoidea limata* Rowley [not Beede, 1911], Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 72, pl. 17, figs. 1, 2.

Shell small, subcircular in outline. The dimensions of the holotype, a brachial valve, are: Length, 9 mm., width 8 mm., convexity about 5 mm.

Pedicle valve unknown. Brachial valve depressed conical, apex eccentric posteriorly and inclined toward the posterolateral margin, situated about one-third the length of the valve from the posterior margin; surface of valve sloping abruptly from apex to posterior margin, gently convex to anterior margin, where it is flat or slightly concave, more convex from apex to lateral margins, but flattened near lateral margins. Surface marked by concentric lines of growth with a

few larger concentric ridges at irregular intervals but most abundant near margin.

Remarks: Distinguishing characters of this species are its small size, subcircular shape, relatively high convexity, prominent beak, which is one-third the length of the shell from the posterior margin, and steeply sloping convex area extending from the beak posteriorly. The ornamentation has been the main character used to distinguish *O. limata* from some species, but its use as a sole character to distinguish species of *Orbiculoidea* is rarely advisable. The holotype is crushed, and it is difficult to determine the true inclination of the apex.

Orbiculoidea limata has the same outline as a group of lower Mississippian species that includes *O. herzeri* Hall and Clarke, 1892, *O. newberryi* (Hall, 1863), and *O. magnifica* (Herrick, 1891), from the so-called †Waverly beds of Ohio; *O. capax* (White, 1862), from the *Chonopectus*-bearing sandstone at Burlington, Iowa; *O. patellaris* (Winchell, 1863), also listed from the Kinderhook at Burlington; and *O. sampsoni* (Miller, 1891), from the Chouteau limestone of Missouri. It is, however, smaller than any of these species and differs from each in other characters. As described, *O. capax* and *O. sampsoni* do not have the strong concentric ridges of *O. limata*. *O. patellaris* is much larger, and its apex is more nearly subcentral than that of *O. limata*. The ornamentation of *O. limata* seems to agree with that given in the descriptions of *O. herzeri* and *O. magnifica* and with that shown on the illustrations of *O. newberryi*. Its beak is more nearly central than that of any of them, however, and it is a very much smaller species than either *O. herzeri* or *O. magnifica*.

O. parva Rowley, 1901, from the so-called Knobstone of Indiana, *O. saffordi* (Winchell, 1869), from the lower Mississippian of Tennessee, and *O. gallaheri* Winchell, 1865, from the lower Mississippian of Ohio and Pennsylvania, also are described as having subcircular outlines. *O. parva* is much smaller than *O. limata* and has a more nearly central apex and finer ornamentation. *O. saffordi* has not been figured, its dimensions have never been given, and the writer has not had specimens for study. It is said to have a subcentral apex. *O. gallaheri* is based on a pedicle valve, and therefore its type cannot be directly compared with *O. limata*. It is a much larger species than *O. limata*. The differences between *O. limata* and some of the species with which it is here compared may prove to be individual differences rather than specific differences, but material to justify that interpretation is not at hand.

Both species of *Orbiculoidea* from the Louisiana limestone are referred to that genus solely on the external configuration and ornamentation of the dorsal valve. As some closely related genera are distinguished from *Orbiculoidea* on characters other than these, the generic reference of these two species cannot be considered incontestable.

O. limata Beede, 1911,³⁵ is a homonym.

Occurrence: Yellow brown calcareous mudstone of the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo. This species also occurs in the Sever-ton shale.

Orbiculoidea elongata Williams, n. sp.

Plate 6, figure 42

Shell subelliptical in outline, longer than wide. The dimensions of the holotype are: Length 8 mm., width 6 mm., convexity 3.2 mm., distance of beak from posterior margin 2.4 mm.

Pedicle valve not known.

Brachial valve depressed conical; apex excentric and inclined to posterior margin, situated approximately one-third the length of the shell from the posterior margin; surface marked by concentric striae.

The holotype is an internal mold with parts of the shell clinging to it.

Remarks: This species is characterized by its small size, subelliptical outline, posteriorly situated apex, and concentric surface markings. It is very closely related to *O. limata* Rowley, 1908, also of the Louisiana, but it has a greater length-width ratio and a less conspicuous, posteriorly directed beak.

Its outline also approaches that shown in figures of *O. hardinensis* Moore, 1928, from the Hannibal shale of Illinois, but *O. elongata* is relatively much longer than *O. hardinensis*, and it is also a larger species.

Occurrence: Yellow-brown calcareous mudstone of the Louisiana limestone at locality 615, along Mississippi River, Louisiana, Mo.

Superfamily CRANIACEA

Family CRANIIDAE

Genus CRANIA Retzius, 1781

This genus, which extends from the Ordovician to the Recent, is one of the longest ranging genera known. Attempts have been made at different times to divide it into genera with more restricted ranges, but no combinations of biocharacters suitable for a widespread subdivision have yet been found.

Genera and subgenera founded on species formerly referred to *Crania* have, however, been erected from time to time. Most of these have been established on combinations of characters that include evidences of attachment or lack of it, the punctate or impunctate structure of the shell, the outline of the valves, the relative convexity of the valves, and the internal characters of the valves, especially the presence or absence of a border, the ornamentation of the border where present, the shape and relative size of the muscles, and the internal ridges. Subdivisions proposed as genera by King in 1849 and based on the

³⁵ Beede, J. W., The Carbonic fauna of the Magdalen Islands: New York State Mus. Bull. 149, pp. 161, 177, 1911.

probable degree of attachment of the ventral valve have never been generally adopted.

Three distinct types of Carboniferous brachiopods are currently referred to *Crania*. On one of these types the ornamentation of the dorsal or upper valve consists of continuous or discontinuous radiating costae, with which inconspicuous concentric striae may occur; on the second type the ornamentation consists of concentric growth lines, which may or may not have fine radiating striae associated with them; and on the third type it consists of fine papillae or spines and concentric growth lines. Some of the second type of *Cranias* attached to plicate fossils have a superficial appearance of radiating ornamentation impressed upon them by the ornamentation of the form to which they are attached; but seldom is it difficult to distinguish such ornamentation from the true ornamentation of the *Crania* itself.

All three types of *Crania* occur in the Louisiana limestone, where, as in other faunas, they appear not to be united by mature gradational forms. The genotype, *Anomia craniolaris* Linné, 1760, belongs to the first type, which is represented in the Louisiana limestone by *Crania rowleyi* Gurley.

Three subgenera based on the three types of ornamentation just described are here proposed. The first type includes the genotype and therefore must bear the name of the genus. It is accordingly designated as the subgenus *Crania*. For the second type the subgeneric name *Lissocrania* is proposed with *Crania dodgei* Rowley of the Louisiana limestone as its type. The name *Acanthocrania* is proposed for the third type, with *Crania spiculata* Rowley, also of the Louisiana limestone, as the type.

The genus *Crania* is here interpreted essentially as by Weller in 1914. Exception is made, however, to include forms with subquadrate or elongate outlines. Three species referable to this genus occur in the Louisiana limestone. They are all represented by attached individuals, and the external characters of the ventral valves, as well as the internal characters of both valves, are unknown. Because of the scarcity of specimens, no sections were made for the study of the shell structure, which has been described by some previous authors as punctate.

The genus *Choniopora*, proposed by Schaubert in 1854 for a Permian fossil thought by him to be a bryozoan but later said by Geinitz to have the external appearance of a *Crania*, has not been generally recognized. The writer has not had an opportunity to see this form or an illustration of it. The description is not clear to the writer, and its position is disputable. If it is a *Crania* and if the ornamentation consists mainly of papillae, it will have priority over the subgenus *Acanthocrania* here proposed. Other genera and subgenera based on species of *Crania* are distinguished by

characters other than the ornamentation of the dorsal valve.

Subgenus CRANIA s. s.

This subgenus is distinguished from other subgenera of *Crania* by its radial costae, which may be continuous or discontinuous, and by a subcircular or subquadrate outline. Its internal characters are those of the genotype. Of the American Carboniferous species, the following belong in this subgenus: *C. blairi* Miller, 1892, *C. cincta* Bell, 1929, and *C. rowleyi* Gurley, 1883.

Crania (Crania) rowleyi Gurley

Plate 6, figures 43, 44

1883. *Crania rowleyi* Gurley, New Carboniferous fossils, Bull. 1, p. 3.
 1892. *Crania rowleyi* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 44, fig. 13.
 1898. *Crania rowleyi* Weller, U. S. Geol. Survey Bull. 153, p. 194 (not references to *C. blairi*).
 1908. *Crania rowleyi* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 73, pl. 17, figs. 3, 4.
 1914. *Crania rowleyi* Weller, Illinois Geol. Survey Mon. 1, p. 46, pl. 1, figs. 37-39.

This species is closely related to *C. blairi* Miller, 1892, from the Chouteau but differs from it in its smaller size and in its coarser plications. Both of these species have about 3 plications per millimeter, but the plications of *C. rowleyi* are wider and are separated by narrower interspaces than those that separate the plications of *C. blairi*. The plications of *C. rowleyi* average slightly over 0.15 mm. in width, and those of *C. blairi* are not so wide and are sharper. Toward the margins of the shells of *C. blairi* very fine plications are implanted between the larger, regular plications giving more plications per millimeter than in *C. rowleyi*. The plications of *C. blairi* are more flexuous than those of *C. rowleyi*.

Weller states that the apex of *C. rowleyi* is more eccentric than the apex of *C. blairi*, but measurements of the cotypes of *C. blairi* and of specimens of *C. rowleyi* do not show this to be so. The apex in a cotype with a maximum diameter of 12 mm. is 4.5 mm. from the margin; and in another cotype having a maximum diameter of 16 mm., it is 6 mm. from the margin. The holotype of *C. rowleyi* has the following measurements: Maximum diameter 10 mm., closest distance from beak to margin 3.8 mm. Two other specimens of *C. rowleyi* have maximum diameters of 8 mm. and 10.6 mm., and convexities of 3 mm. and 2 mm., respectively. The closest distance from the beak to margin in the first shell is 3.2 mm., in the second, 3.5 mm. A specimen in the R. R. Rowley collection has a central beak. Weller's figures are apparently mixed. His figure 39 is of the specimen numbered Walker Museum 6316 and marked as the type.

This species is easily distinguished from the other two species of *Crania* in the Louisiana by its ornamentation.

Occurrence: Yellow-brown calcareous mudstone, clay partings, and limestone beds of the Louisiana limestone at Louisiana, Mo.; locality 618, Clarksville, Mo.; and locality 599, 1 mile south of Louisiana, at the mouth of Buffalo Creek. This species is confined to the Louisiana limestone. The holotype is from the limestone beds at Louisiana, Mo.

Subgenus ACANTHOCRANIA Williams, n. subgen.

Cranias with dorsal valves ornamented by fine papillae or fine spines. Concentric growth lines and fine radial striae may be present, but radial costae do not occur. The type of this subgenus is here designated as *Crania spiculata* Rowley.

The name combines the Greek, *akantha* (spine), with the generic name *Crania* and refers to the ornamentation of the dorsal valve. As stated in a previous paragraph, the name may be preoccupied by *Choniopora*.

Ornamentation somewhat similar in appearance to that of these species occurs on specimens whose punctae have been filled with a deposit and whose shells have been partly removed leaving the fillings in relief. Where an opportunity to study the specimens is provided, these fillings may be easily distinguished from finely spinose ornamentation.

***Crania (Acanthocrania) spiculata* Rowley**

Plate 6, figures 46, 47, 54

1908. *Crania spiculata* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 74, pl. 17, figs. 7-10.
1914. *Crania spiculata* Weller, Illinois Geol. Survey Mon. 1, p. 47, pl. 1, fig. 31.

This species may be easily distinguished from other Cranias of the Louisiana limestone by its ornamentation. The greatest diameter of the distorted specimen shown as figure 46 of plate 6, is 9 mm., and the apex is about two-fifths the greatest diameter from the nearest margin. A species from the Burlington, *C. laevis* Keyes, 1894, is closely related to *C. spiculata*, but it is said to be less circular in outline and to have finer papillae.

Occurrence: Clay partings and limestone beds in the lower part of the Louisiana limestone at locality 599, mouth of Buffalo Creek, 1 mile south of Louisiana, Mo.; and at Louisiana. This species occurs only in the Louisiana formation. The specimen, shown in figure 46 of plate 6, was marked by Rowley as the holotype, but it is not the same specimen as the one figured by Weller as the holotype.

Subgenus LISSOCRANIA Williams, n. subgen.

Cranias with dorsal valves devoid of radial costae or spines. Ornamentation, if any, consists of concentric growth lines or of fine radiating striae or of both.

The type of this subgenus is *Crania dodgei* Rowley. The name is a combination of the Greek, *lissos* (smooth)

with the generic name *Crania*, and refers to the lack of pronounced ornamentation on the surface of the dorsal valve.

The following American Carboniferous species appear to belong to this subgenus: *C. brookfieldensis* Bell, 1929; *C. chesterensis* Miller and Gurley, 1897; *C. lemori* Rowley, 1901; *C. missouriensis* Weller, 1909; *C. modesta* White and St. John, 1868; *C. pertenuis* Girty, 1926; and *C. robusta* Rowley, 1901.

If only a small piece of the shell is present, some species referable to this subgenus which of themselves have no radial ornamentation have the appearance of radial ornamentation where they have conformed to the ornamentation of the shell to which they are attached. Very little difficulty is experienced in distinguishing this modification from the true ornamentation, however, if more than a fragment of shell is present, as the so-called radial costae would then be seen to be parallel rather than radial.

***Crania (Lissocrania) dodgei* Rowley**

Plate 6, figure 45

1908. *Crania dodgei* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 73, pl. 17, figs. 5, 6.
1914. *Crania dodgei* Weller, Illinois Geol. Survey Mon. 1, p. 44, pl. 1, fig. 32.

The following description is based on the holotype.

Shell subcircular in outline, the holotype attached to shell of *Productella pyxidata* Hall. Dimensions of holotype are: Greatest diameter 8.5 mm., least diameter 8 mm., distance of beak from nearest margin 2.75 mm.

Pedicle valve not exposed.

Brachial valve subconical, apex eccentric, erect, the surface sloping abruptly from the beak to posterior (?) margin and with less convex curvature to other margins. Surface ornamented with concentric lines of growth, some of which are stronger than others.

Remarks: This is a rare form in the Louisiana, but may be easily distinguished from other Louisiana Cranias by its ornamentation. The obscure radiating striae mentioned by Weller are not apparent on Rowley's figured holotype, which is not Weller's figured specimen. The maximum diameter of the holotype is 8.5 mm., not 17 mm. as given by Weller. The apex is approximately 2.75 mm. from the closest margin.

Species that resemble *C. dodgei* are *C. cincta* Bell, 1929, from the Upper Windsor series of Nova Scotia, *C. missouriensis* Weller, 1909, from the Fern Glen limestone of Missouri, and *C. robusta* Rowley, 1901, from the †Knobstone group of Indiana. Other species having the same type of ornamentation differ from *C. dodgei* in shape, convexity, or relative position of the beak. The writer has not seen *C. cincta*. Its description indicates that it is very close to *C. dodgei*, differing only in the greatly thickened margins of *C. cincta*. *C. missouriensis* is a larger species than *C. dodgei* and has a less convex dorsal valve. *C. robusta* is described as

having a subtriangular area posterior to the beaks that *C. dodgei* does not have, and the figure shows that its beak is nearer to the posterior margin.

Occurrence: Limestone beds and yellow-brown calcareous mudstone of the Louisiana limestone at locality 600, Eighth Street quarry, Louisiana, Mo.; locality 593, Town Branch, Louisiana; and locality 599, mouth of Buffalo Creek, 1 mile south of Louisiana. This species occurs only in the Louisiana limestone. The holotype is from the limestone beds at locality 599.

Superfamily ORTHACEA

Family RHIPIDOMELLIDAE

Genus RHIPIDOMELLA Oehlert, 1891

Rhipidomella missouriensis (Swallow)

•Plate 6, figures 55-66

1860. *Orthis missouriensis* Swallow, St. Louis Acad. Sci. Trans., vol. 1, p. 639.
 1892. *Orthis missouriensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 6A, figs. 16, 17.
 1898. *Rhipidomella missouriensis* Weller, U. S. Geol. Survey Bull. 153, p. 524.
 1908. *Rhipidomella missouriensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 78, pl. 17, figs. 43-47
 1914. *Rhipidomella missouriensis* Weller, Illinois Geol. Survey Mon. 1, p. 148, pl. 20, figs. 1-8.

This is the only *Rhipidomella* in the Louisiana. It is characterized by its medium to small size, by its greater width than length, by the small and inconspicuous beak of the pedicle valve which is relatively much extended beyond the hinge line, and by strong radiating costae.

The beak of the pedicle valve is not as prominent or as extended in any of the specimens as in *R. burlingtonensis* (Hall, 1858), which it resembles, and *R. missouriensis* is proportionately broader, and most individuals are smaller. It is a smaller species than *R. oweni* Hall and Clarke, 1892, and has proportionately larger muscular impressions on the pedicle valve.

Specimens from the Louisiana have a considerable range in size. Most of them are wider than long, but a few are as long as wide. One large individual is 25 mm. long and 25 mm. wide. The dimensions of two others are: Greatest length, 17 mm. and 13 mm., respectively; greatest width, 23 mm. and 15 mm.

Six specimens secured by washing the clay from the partings in the Louisiana limestone are much smaller than the average. The dimensions of the largest and a smaller one of these six are as follows: Greatest width of pedicle valve 2.7 mm. and 2.4 mm., respectively; length of pedicle valve 2.1 mm. and 2 mm.; length of hinge line 1.3 mm. and 1.2 mm.; length of brachial valve 1.9 mm. and 1.8 mm. The smallest individual in the collections is 1.6 mm. wide and 1.3 mm. long.

These small individuals resemble specimens of *R. diminutiva* Rowley, 1900, but they are wider than long, have no sinus on the pedicle valve, and do not have the peculiar modifications of the cardinal process and the

socket plates that are described by Weller as being characteristic of *R. diminutiva*.

Many of the *Rhipidomellas* of the Mississippian are hard to distinguish and vary greatly, but typical specimens of the different species can be distinguished. Some species may prove to be varieties of other species.

Occurrence: *Rhipidomella missouriensis* is common in the Louisiana at nearly all collecting localities in the yellow-brown calcareous mudstone, the clay partings, and in the limestone beds. It also occurs in the Chouteau limestone, in the Hannibal (?) shale, and in the Saverton shale in Missouri. It has also been reported in fossil lists from bed 3 at Burlington, Iowa, from beds in Illinois referred to the Hannibal, and from beds described as Chattanooga in western Kentucky, and it or a closely related species occurs in the so-called Sylamore sandstone in Missouri.

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

Subfamily ORTHOTETINAE

Genus SCHUCHERTELLA Girty, 1904

This genus, which has been fully described and adequately figured, can be easily recognized where both the internal and external characters are observable and typically developed. The distinctive characters consist of the combination of the relatively fine radial ornamentation of the exterior of the valves with the rudimentary or incompletely developed dental plates and lack of a median septum of the interior of the ventral valve. These characters, however, do not suffice to distinguish it from *Streptorhynchus* King, 1850, and many species might be tentatively referred to either genus. *Streptorhynchus* typically has a much higher and much narrower pedicle valve with a correspondingly narrower hinge line than *Schuchertella*. *Streptorhynchus* also typically has some evidence of a scar of attachment on the pedicle valve. Many specimens do not, however, have scars of attachment and have shapes intermediate between those typical of *Schuchertella* and *Streptorhynchus*. Such specimens are usually referred to *Streptorhynchus*, if there appears to be evidence that the shell is distorted. Some forms of *Schuchertella* resemble *Schellwienella*, because there are gradations between the rudimentary dental plates of *Schuchertella* and the short dental plates of *Schellwienella*.

Schuchertella lens (White)

Plate 7, figures 1-7

1862. *Streptorhynchus lens* White, Boston Soc. Nat. Hist. Proc., vol. 9, p. 28.
 1892. *Orthotheses lens* Hall and Clarke, New York State Geologist Eleventh Ann. Rept., pl. 16, figs. 12-16.
 1892. *Orthotheses lens* Hall and Clarke, Paleontology of New York vol. 8, pt. 1, pl. 11A, figs. 16-22.
 1894. *Streptorhynchus lens* Keyes, Missouri Geol. Survey, vol. 5, p. 67, pl. 39, figs. 2 a, b.
 1898. *Orthotheses lens* Weller, U. S. Geol. Survey Bull. 153, p. 403.

1904. *Schuchertella lens* Girty, U. S. Nat. Mus. Proc., vol. 27, p. 734.
1908. *Orthothes lens* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 78, pl. 17, figs. 37-42.
1914. *Schuchertella lens* Weller, Illinois Geol. Survey Mon. 1, p. 55, pl. 3, figs. 1-8, 9?
1915. *Schuchertella lens* Butts, Kentucky Geol. Survey, 4th ser., vol. 3, pt. 2, pl. 49, figs. 29, 30.
1917. *Schuchertella lens* Butts, idem, Mississippian series in western Kentucky, pl. 4, figs. 29, 30.
1931. *Schuchertella lens* J. M. Weller, idem, 6th ser., vol. 36, pl. 33, figs. 8, 9.
1932. *Schuchertella lens* Dunbar and Condra, Nebraska Geol. Survey Bull. 5, 2d ser., p. 70, pl. 15, figs. 11, 12.

There are only two species of *Schuchertella* in the Louisiana, and they may easily be distinguished by their difference in size and by other features. *S. lens*, the genotype may be distinguished from other Mississippian species by its relatively small size and by the nearly uniform size and spacing of its lirae, by the absence of wide spaces between the lirae, by the small size of the lirae, about three of which occupy the space of 1 millimeter, and by the relatively small width-length ratio. It is much larger, however, than *S. louisianensis* and differs from it in other respects. These differences are discussed under that species.

S. lens is common in the limestone beds, the clay partings, and the yellow-brown calcareous mudstone of Louisiana. An average brachial valve in the collections of the University of Missouri is 19 mm. wide and 16 mm. long. One small individual is 7 mm. wide and 4 mm. long.

Occurrence: All horizons in the Louisiana formation in Pike and Ralls Counties. It occurs also in the Saverton shales in Missouri.

White's original material is said to have come from Burlington, Iowa, Clarksville, Mo., and Hamburg, Ill. Large collections from Burlington do not contain it, and no subsequent author has described it from there. It is difficult to ascertain which of the species now recognized there White had in mind. It is said that he actually based his description on material from the Louisiana limestone. The writer has not had an opportunity to examine the material included in White's typical lot and to attempt to discover from an examination which of the Burlington species he had, if the assumption that *S. lens* does not occur at Burlington is correct. The Louisiana limestone occurs at Hamburg, and Moore³⁶ lists this species from there and also from the Louisiana at Hardin, Ill.

S. lens has also been listed from the so-called Marshall group of Ohio by Winchell³⁷ and described from the Carboniferous limestone of the Kousnetz Basin of the Union of Soviet Socialist Republics by Tolmatchoff.³⁸

³⁶ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 46, 1928.

³⁷ Winchell, Alexander, Description of new species of fossils from the Marshall group of Michigan, etc.: Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 117.

³⁸ Tolmatchoff, S. P., Fauna du calcaire carbonifère au bassin houiller de Kousnetz, pt. 1; Comité géologique Matériaux pour la géologie générale et appliqué, livr. 25, p. 234, pl. 12, figs. 10, 11, 1924.

Neither of these has been here included in the synonymy. Winchell's specimen was not figured and not described and he was not sure of his identification. Tolmatchoff's reference deals with material that was collected outside North America, and the synonymies of this article include only material collected from North America. The writer has not seen specimens of *S. lens* from the New Providence shale of Kentucky, the horizon and locality for the two references by Butts and the reference by J. M. Weller in the synonymy, and as neither figured his material but took his illustrations from S. Weller, these entries are included solely on their identifications.

Schuchertella louisianensis Williams, n. sp.

Plate 7, figures 76-81

Shell small, broader than long, greatest width near midlength in most specimens. The dimensions of three individuals are; Length 1.5, 1.44, 1.2 mm.; length of hinge line 2.3, 2.1, 1.2 mm.; width 2.4, 1.68, 1.5 mm.; height of cardinal area on the first specimen 0.9 mm.

Pedicle valve convex, highest point at or slightly in front of beak, surface sloping evenly from highest point to anterior and lateral margins, slightly if at all depressed at cardinal extremities, in some shells there is a slight mesial sinus near front; beak slightly incurved or not incurved; cardinal area high, some cardinal areas being over one-half as high as broad, standing about 90° to the plane of the valve in undistorted specimens; delthyrium one-third to two-thirds as broad as high, covered by a convex deltidium, which almost closes it and which is slightly sinuate on its lower margin. Hinge teeth unsupported by distinct dental plates; muscular scars not observed; inner margin of valve crenulate from front to umbonal region.

Brachial valve plane to depressed convex, some individuals concave near front, highest in umbonal region which is distinctly raised above the rest of the valve in typical specimens; beak inconspicuous not extended beyond hinge line; cardinal area long and narrow. Upper surface of cardinal process bifid from anterior to posterior, without recognizable chilidium; interior of valve crenulate almost to beak.

Surface of shell marked by lirae, which increase mainly by implantation; and which are of nearly equal size and equally spaced; lirae wider than intervening spaces, about eight occupying the space of 1 millimeter; lines of growth more prominent near front.

Remarks: This species is much smaller than average specimens of *S. lens*, and there is a great difference in size between the smallest specimens of *S. lens* of the Louisiana and the largest specimens of *S. louisianensis*. Its pedicle valve differs from that of *S. lens* in having a less convex anterior slope, a cardinal area higher compared to its length and directed at 90° to the plane of

the valve, a deltidium less concave at the cardinal margin, and a delthyrium not as broad as high. Its brachial valve has no chilidium, and the cardinal process is completely bifid on the upper surface and has no suggestion of the median ridge that attaches to the cardinal process of *S. lens*.

Its small size and surface ornamentation provide a means of readily distinguishing it from most lower Mississippian Schuchertellas. Its closest resemblance is to *S. morsei* Foerste, 1909, from the so-called Bedford-Berea of Kentucky, and it may prove to be conspecific with it. The writer has not seen specimens of Foerste's species, and its internal characters are not known. As described, *S. morsei* is a larger species than *S. louisianensis* and has relatively much wider interspaces on the surface between the radial lirae, and somewhat coarser lirae.

There is considerable variation among the individuals of *S. louisianensis* in the position of the cardinal areas. Most of the cardinal areas stand about 90° to the plane of the valve, but some are nearly in the plane of the valve.

This species might possibly represent the young of *S. lens*, but as specimens grading from one form into the other are not present in the Louisiana, and as this form differs in several respects from any specimens of *S. lens* seen by the writer, he considers it best to describe it as a new species.

Occurrence: Yellow-brown calcareous mudstone and clay parting above the lowest limestone bed of the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. The syntypes came from the yellow-brown calcareous mudstone.

Family CHONETIDAE

Genus CHONETES Fischer, 1837

Chonetes geniculatus White

Plate 7, figures 8-11

1862. *Chonetes geniculata* White, Boston Soc. Nat. Hist. Proc. vol. 9, p. 29.
 1865. ?*Chonetes geniculata* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 116.
 1870. ?*Chonetes geniculata*? Winchell, Am. Philos. Soc. Proc., vol. 11, p. 250.
 1894. *Chonetes geniculatus* Keyes, Missouri Geol. Survey, vol. 5, p. 53, pl. 38, fig. 3.
 1898. *Chonetes geniculatus* Weller, U. S. Geol. Survey Bull. 153, p. 176.
 1905. ?*Chonetes geniculatus* Weller, Jour. Geology, vol. 13, p. 619.
 1908. *Chonetes geniculatus* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 75, pl. 17, figs. 15-19.
 1914. *Chonetes geniculatus* Weller, Illinois Geol. Survey Mon. 1, p. 92, pl. 8, figs. 35-42.

This species may easily be distinguished from *C. ornatus* Shumard, with which it is associated, by its greater length-width ratio, its smaller average size, its shorter hinge line and much more poorly developed aurications, its much finer lirae, which are absent near the posterior of the shell, and the elongate prominence on the brachial valve just anterior to the cardinal

area. It is also relatively more convex than average specimens of *C. ornatus*. Young individuals of *C. ornatus* and *C. geniculatus* are not so easily distinguished, but the young *C. ornatus* are less convex, more distinctly auriculate, and relatively more coarsely costate. An elongate prominence occurs on the brachial valves of small individuals of both species.

The Mississippian species that resembles *C. geniculatus* most is *C. gregarius* Weller, 1901, which occurs in beds 2 to 6 of Weller's section of the Kinderhook at Burlington, Iowa. *C. geniculatus* may be distinguished from it by its coarser lirae, which in contrast to those of *C. gregarius* are not well developed in the umbonal region, and by its greater convexity and more elliptical outline.

This species was listed in the original description from the "Chemung Group" of Burlington, Iowa; Hamburg, Ill.; and Clarksville, Mo. The identification from Burlington was, however, made with a query, and therefore the types presumably came from the other localities. Inasmuch as the Louisiana limestone is exposed at both of the other localities and also as the species occurs abundantly in it at both of them, it seems reasonable to conclude that the types probably came from that formation. The writer has not seen the type specimens.

Included in the synonymy are three references that may be found to be better placed in other species. The writer has not seen the specimens on which the identifications were based nor any from the localities cited. These references are those by Winchell in 1865 and 1870 from units that he called the Marshall and Waverly groups of Rockford, Indiana, and Ohio, respectively, and of Weller, in 1905, from the unit he called the sandstone of the Kinderhook age at Kinderhook, Ill. As the writer cannot dispose of them otherwise, they are tentatively carried in the present synonymy with the qualifications mentioned. They may be found to be better placed in *C. gregarius* Weller, 1901. Winchell,³⁹ in 1870, suggested that his forms were more closely related to forms from Burlington, the type locality of *C. gregarius*, than to those from Louisiana.

Occurrence: All horizons in the Louisiana. This species has been collected in Missouri from Louisiana and vicinity, from Clarksville, and from locality 798, about 2½ miles west of Frankford, in Pike County.

This species has been identified by the writer in the Hannibal (?) shale and in the Saverton shale in Missouri. Its reported occurrences in Indiana and Ohio and at Kinderhook, Ill., have been discussed above. This species is also listed in Moore's recent paper from bed 2 at Burlington, from beds in Illinois referred to the Hannibal, and tentatively from the Hannibal shale at Louisiana, Mo.

³⁹ Winchell, Alexander, Notices and descriptions of fossils from the Marshall group of the western States, with notes on fossils from other formations: Am. Philos. Soc. Proc., vol. 11, p. 250, 1870.

Chonetes ornatus Shumard

Plate 7, figures 12-19

1855. *Chonetes ornata* Shumard [part], Missouri Geol. Survey First and Second Ann. Repts., p. 202, pl. C, figs. 1a-c.
 1894. *Chonetes ornata* Keyes [part], Missouri Geol. Survey, vol. 5, p. 53, pl. 38, fig. 2.
 1898. *Chonetes ornatus* Weller, U. S. Geol. Survey Bull. 153, p. 178.
 1908. *Chonetes ornatus* Rowley, Missouri Bur. Geology and Mines, 2d. ser., vol. 8, p. 75, pl. 17, figs. 20-23.
 1914. *Chonetes ornatus* Weller, Illinois Geol. Survey Mon. 1, p. 86, pl. 8, figs. 21-29.

An average individual of *C. ornatus* is 13 mm. long and 9 mm. wide. A very small individual is 5 mm. long and 6 mm. wide. Costae occur on the auricular portions of most specimens seen by the writer.

This is a very common form in the Louisiana. Average individuals can easily be distinguished by their size and ornamentation from *C. geniculatus* White, 1862, the only other species of *Chonetes* in the formation. Young individuals of the two species are, however, not so easily distinguished. The differences between them are discussed under *C. geniculatus*.

The form described as *C. glenparkensis* Weller, 1906, is here considered a variety of *C. ornatus*. Specimens from the Louisiana limestone show almost continuous gradation from individuals typical of *C. ornatus* to those typical of *C. glenparkensis*.

Other lower Mississippian forms closely related to *C. ornatus* are *C. logani* Norwood and Pratten, 1855, originally described from lower Mississippian (probably Kinderhook) at Burlington, Iowa, but also recognized in the lower Mississippian formations at other places in the Mississippi Valley basin and in the so-called †Waverly of Ohio and the Madison limestone of the West; *C. batesvillensis* Girty, 1929, from the middle part of the Boone limestone near Batesville, Arkansas; possibly *C. tumidus* Herrick, 1888, originally described from the †Waverly group of Ohio; and a species now in manuscript by G. H. Girty and the writer, from the Kinderhook at Burlington, Iowa. *C. ornatus* has coarser radial ornamentation than any of the above species except the manuscript species. It does not have large "spines" such as tend to interrupt the lirae of *C. batesvillensis* or the numerous oval pores described by Herrick from *C. tumidus*. *C. ornatus* closely resembles *C. logani* which has finer and lower costae and greater relative convexity of the pedicle valve than *C. ornatus*. These differences may not be of specific rank, however. The manuscript species mentioned above occurs in the *Chonopectus*-bearing sandstone and the overlying bed in the Kinderhook section at Burlington. It is smaller than *C. ornatus*. It has more slender costae, which are separated by narrower interspaces; and the sinuses which pass from each side of the beak obliquely to the lateral margins are not as distinct as those of *C. ornatus*.

Shumard cited *C. ornatus* from his Chenung group

from Cooper and Moniteau Counties (central Missouri) and from Louisiana and Hannibal, Mo. (northeastern Missouri). The rocks from which it was collected in central Missouri have since become known as the Chouteau limestone. Shumard's material from northeastern Missouri probably came from the Louisiana limestone because he mentioned that *C. ornatus* was very abundant in the †Lithographic limestone. The form from the Chouteau is probably the variety *glenparkensis*. The specimens illustrated by Girty⁴⁰ in 1899 from the Madison limestone of Yellowstone Park as *C. ornatus* have been examined through his courtesy and are now tentatively placed in *C. logani*, but they may be finally referred to *C. ornatus* var. *glenparkensis* or to a new species.

Frech,⁴¹ in 1916, identified a form from Persia tentatively with *C. ornatus*. The writer has not seen Frech's material. As it did not come from North America, the reference is not included in the synonymy.

Occurrence: Yellow-brown calcareous mudstone, clay partings, and limestone beds of the Louisiana at nearly all collecting localities.

This species has also been collected by the writer and described by others from the Saverton shale of northeastern Missouri. It was also identified tentatively by Weller in 1905 from the thin-bedded sandstones of the Kinderhook at Kinderhook, Ill., and in a list by H. S. Williams in 1900 from black Kinderhook (?) shales in Arkansas, and it has also been identified from the so-called Sylamore of central Missouri.

Chonetes ornatus var. glenparkensis Weller

Plate 7, figure 20

1855. *Chonetes ornata* Shumard [part], Missouri Geol. Survey First and Second Ann. Repts., p. 202.
 1895. *Chonetes ornata* Keyes [part], idem, vol. 5, p. 53.
 1906. *Chonetes glenparkensis* Weller, St. Louis Acad. Sci. Trans., vol. 16, p. 441, pl. 6, fig. 7.
 1914. *Chonetes glenparkensis* Weller, Illinois State Geol. Survey Mon. 1, p. 87, pl. 8, figs. 30, 47-49.

When described, this form had not been recognized among individuals of *C. ornatus* in the Louisiana limestone. During this investigation the writer discovered specimens from the Louisiana that had no observable differences from individuals of *C. glenparkensis* from the type formation, the Glen Park, and from the Chouteau limestone.

Weller distinguished *C. glenparkensis* from *C. ornatus* by much greater convexity of the pedicle valve and the greater concavity of the brachial valve, by the greater extension of the shell along the hinge line, and by the more conspicuous auriculations. Although these differences obtain between typical individuals, there is in the Louisiana almost complete gradation in numerous specimens from typical forms of *C. ornatus* to those having all the morphological characters of

⁴⁰ Girty, G. H., Devonian and Carboniferous fossils of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, p. 527, pl. 68, figs. 4a-d, 1899.

⁴¹ Frech, Fr., Geologie Kleinasiens in Bereiche der Bagdadbahn: Deutsche geol. Gesell. Zeitsch., Band 68, p. 238, pl. 6, figs. 5a-c, 1916.

C. glenparkensis. Because of this gradation, *C. glenparkensis* is reduced from specific to varietal rank.

This variety resembles *C. logani* Norwood and Pratten, 1855, even more closely than do typical forms of *C. ornatus*. It is, however, relatively more transverse than *C. logani*, and it has a more triangular outline and slightly coarser radial markings, which are said to be separated by wider interspaces. As both *C. logani* and *C. glenparkensis* are said to occur in the Chouteau and are so closely related it is probable that the synonymies of the two forms have entries that may have to be transferred from one species to the other.

One specimen of *C. ornatus* var. *glenparkensis* is on the same slab of rock with a specimen of *C. geniculatus* White.

Occurrence: Limestone beds of the Louisiana at locality 625, 1 mile south of Annada, and at locality 798, 2½ miles west of Frankford, Pike County, Mo.

This variety has been described from the Glen Park and Chouteau limestones in Missouri and has been also listed by Moore from his Northview, Sedalia, Pierson, St. Joe, and Burlington formations from Missouri, and from bed 5 at Burlington, Iowa, and occurs in collections examined from the so-called Sylamore sandstone of central Missouri.

Family PRODUCTIDAE

Subfamily PRODUCTELLINAE

Genus PRODUCTELLA Hall, 1867

Productella pyxidata Hall

Plate 7, figures 61-67

1858. *Productus pyxidatus* Hall, Iowa Geol. Survey, vol. 1, pt. 2, p. 498, pl. 3, figs. 8a-e.
1858. *Productus shumardianus* Hall [part], idem, vol. 1, pt. 2, p. 499, pl. 3, fig. 9 (not pl. 7, fig. 2).
1867. ?*Productella shumardiana* Hall [part], Paleontology of New York, vol. 4, p. 157 (not pl. 23, figs. 6-8).
1883. *Productella pyxidata* Hall, New York State Geologist Rept. for 1882, pl. (17) 48, fig. 34.
1884. *Productus pyxidatus* Walcott, U. S. Geol. Survey Mon. 8, p. 130.
1892. *Productella pyxidata* Hall and Clarke, New York State Geologist Eleventh Ann. Rept., pl. 21, figs. 20, 23.
1892. *Productella pyxidata* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 17, fig. 34; pl. 17A, fig. 14.
1894. *Productella pyxidata* Keyes, Missouri Geol. Survey, vol. 5, p. 52, pl. 38, figs. 4a-d.
1898. *Productella pyxidata* Weller, U. S. Geol. Survey, Bull. 153, p. 481.
1908. *Productella pyxidata* Rowley, Missouri Bur. Geol. and Mines, 2d ser., vol. 8, p. 77, pl. 17, figs. 5, 30-36.
1914. *Productella pyxidata* Weller, Illinois Geol. Survey Mon. 1, p. 100, pl. 19, figs. 1-21.
1915. *Productella pyxidata*? Girty, U. S. Geol. Survey Bull. 598, p. 34.
1926. *Productella pyxidata* Shimer, Canadian Geol. Survey Bull. 42, p. 37.
1926. *Productella pyxidata* Cooper, Oklahoma Geol. Survey Circ. 9, p. 21.
1928. *Productella pyxidata* Moore, Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 265.

There is considerable variation among individuals of *Productella pyxidata* Hall in the collections, and some of them may represent grades toward other genera. Chao⁴² derives seven of the genera of Producti represented in the Carboniferous of China directly or indirectly from *Productella*, which he considers a Devonian genus. Thomas⁴³ and Muir-Wood⁴⁴ do not record Productellas from the Carboniferous of Great Britain, but the genus does occur in the Mississippian in North America. The dental sockets, mentioned as one of the essential characters of the genus by Hall,⁴⁵ can be made out on the only two brachial interiors examined by the writer (pl. 7, fig. 66). The cardinal area is low and linear but can be distinguished on a few specimens under a magnification of 20 diameters. No interiors of ventral valves were available for examination. Davidson⁴⁶ included in *Productus* forms having teeth and sockets as well as those not having them. *Productella* Hall, 1867⁴⁷ was made to include "shells having the general form of *Productus*, but uniformly with a narrow area on each valve, a foramen or callosity on the ventral area, small teeth, and more or less distinct teeth-sockets." It differs from *Productus* "in the constant presence of an area, hinge-teeth and sockets." It has been generally recognized as occurring in North American Mississippian faunas, and *Productella pyxidata* seems a valid representative of it. Some of the other species of *Productella*, as suggested by Girty,⁴⁸ and by Moore,⁴⁹ may be found to belong to other genera recently established or redefined by Thomas, Chao, and others. Girty⁵⁰ has noted resemblances between *Productella pyxidata* and *Overtonia fimbriata* (Sowerby), the genotype of *Overtonia* Thomas. The brachial ridges figured by Hall and Clarke⁵¹ are similar to those figured on *Overtonia fimbriata* by Thomas⁵² and also to the brachial ridges on a specimen figured on plate 7. The preservation is not good enough to show the brachial ridges well, and the other internal characters described by Thomas as present in *Overtonia fimbriata* are not well shown in specimens of *Productella pyxidata*. *Productella pyxidata* may have the generic characters of *Overtonia*, but as the writer has no specimen of *Overtonia* for comparison and the preservation

⁴² Chao, Y. T., Productidae of China, pt. 2: Palaeontologia Sinica, ser. B, vol. 5, fasc. 3, 1928.

⁴³ Thomas, Ivor, The British Carboniferous Producti: Geol. Survey Great Britain Mem., Paleontology, vol. 1, pt. 4, pp. 197-366, 1914.

⁴⁴ Muir-Wood, H. M., The British Carboniferous Producti, pt. 2: Geol. Survey Great Britain Mem., Paleontology, vol. 3, pt. 1, pp. 1-217, 1928.

⁴⁵ Hall, James, Paleontology of New York, vol. 4, pt. 1, p. 153, 1867.

⁴⁶ Davidson, T., The Carboniferous Brachiopoda: Mon. British Fossil Brachiopoda, vol. 2, pt. 5, London, 1858-1863.

⁴⁷ Hall, James, Paleontology of New York, vol. 4, pt. 1, p. 153, 1867.

⁴⁸ Girty, G. H., Invertebrate paleontology, in Hinds and Greene, The stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 8, pp. 344-350, 1915.

⁴⁹ Moore, R. C., Early Mississippian formations of Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 264, 1928.

⁵⁰ Idem, p. 349.

⁵¹ Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 1, pl. 17, fig. 34, 1892.

⁵² Thomas, Ivor, The British Carboniferous Producti: Geol. Survey Great Britain Mem., Paleontology, vol. 1, pt. 4, pl. 20, fig. 15, 1914.

of the diagnostic characters is not good, no definite conclusion seems possible. The median septum of *Productella pyxidata* is longer than that of *Overtonia fimbriata* and there may be differences in ornamentation or other differences, as well as likenesses, that do not show clearly in the figures or on some of the specimens.

The variations in surface ornamentation of specimens of *Productella pyxidata* are rather wide. Young specimens are ornamented by a few irregularly placed spines and by concentric growth lines. Some mature specimens are without spines or pustules, and the ornamentation consists wholly of concentric striae. Some have a few pustules; others scattered spines, and still others have the pustules arranged to form almost continuous plicae, and there are many intermediate stages.

There is also a considerable range in size of individuals. All but a very few are wider than long. The dimensions of three large specimens are: Width 23, 23, and 21 mm.; length 19, 17, and 19 mm., respectively. A smaller specimen has a width of 9 mm. and is 7.7 mm. long. A very small individual is 3 mm. long and 3 mm. wide. There is almost a complete gradation in size from the smallest individuals in the collections to the largest.

It is difficult to distinguish some specimens of *P. pyxidata* from specimens of *P. concentrica* (Hall, 1857), that have the anterior part of the ventral valve broken off. Most specimens of *P. pyxidata* are less convex than these broken specimens, and they also have smaller and less incurved beaks, fewer and less conspicuous concentric wrinkles in the umbonal region, and more concave brachial valves. Some specimens cannot, however, be distinguished, and this circumstance has perhaps led to the identification of *P. pyxidata* in the Chouteau limestone and in other formations. *P. concentrica* is a widespread lower Mississippian species.

The form from the Chouteau described by Weller⁵³ in 1895 has been transferred to the synonymy of *P. concentrica*.

Occurrence: Yellow-brown calcareous mudstone, limestone beds, and clay partings of the Louisiana limestone at nearly all collecting localities in Missouri.

The writer has also collected this species from the Saverton shale. The references in the synonymy show it also from the Hannibal shales in Missouri, the St. Joe member of the Boone formation in Arkansas, the Sycamore limestone of Oklahoma, and lower Mississippian or Upper Devonian in Alberta and Nevada. The writer has seen none of the specimens on which these references are based. Weller did not list it from the Hannibal in 1914. Moore, in 1928, includes it in lists from bed 3 at Kinderhook and from beds at Pleasant Hill, Ill., that he refers to the Hannibal.

⁵³ Weller, Stuart, A circum-insular Palaeozoic fauna: Jour. Geology, vol. 3, p. 913, 1895.

Subfamily STROPHALOSIINAE

Genus STROPHALOSIA King, 1844

Strophalosia beecheri Rowley

Plate 7, figures 68-71

1893. *Strophalosia beecheri* Rowley, Am. Geologist, vol. 12, p. 308, pl. 14, figs. 18, 19.
 1898. *Strophalosia beecheri* Weller, U. S. Geol. Survey Bull. 153, p. 612.
 1908. *Strophalosia beecheri* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 76, pl. 17, figs. 24, 25.
 1914. *Strophalosia beecheri* Weller, Illinois Geol. Survey Mon. 1, p. 146, pl. 19, figs. 37, 38.

The following description is based on the holotype and another more complete specimen, a plesiotype, collected by the writer.

Shell subelliptical in outline, productoid, unsymmetrical, wider than long, hinge line less than greatest width. The dimensions of the holotype and the plesiotype are, respectively: Length 13.2 and 12.7 mm., width 14.8 and 14 mm., length of hinge line 11 and 13 mm., convexity 6 and 4.3 mm. The holotype is a pedicle valve. The plesiotype has both valves well preserved.

Pedicle valve convex, greatest convexity near middle, slightly compressed toward cardinal extremities, umbonal region projecting slightly beyond the hinge line, the cicatrix small and inconspicuous or not distinguishable; cardinal area very broadly triangular, nearly in the plane of the valve, flat or slightly concave; delthyrium distinct, small, covered by a convex deltidium. Surface of valve marked by concentric lines of growth and irregularly distributed spines, most of which are near the cardinal margin; spines hollow, cylindrical, averaging about 0.2 to 0.3 mm. in diameter, either erect or bent over, those near the cardinal margin being curved over the margin and entwined together.

Brachial valve concave, greatest concavity near middle, posterolateral margins flattened; beak indistinct; cardinal area low and linear, cardinal process covered by a convex chilidium. Surface ornamented by growth lines, spines being very rare or absent.

Remarks: This species may be easily distinguished from *Productella pyxidata* Hall, with which it is associated in the Louisiana, by its distinct, broadly triangular cardinal area and by its large, long, hollow spines, which are more abundant near the posterior margin of the shell and curve over the cardinal area. The cicatrix is visible on the holotype but cannot be made out on the plesiotype.

Of the lower Mississippian species, *S. cymbula* Hall and Clarke, 1892, from the New Providence shale of Kentucky most resembles *S. beecheri*. It is, however, a larger species than *S. beecheri* and has more spines, and its spines are not so erect as those of *S. beecheri*.

Paeckelmann⁵⁴ doubts the wisdom of establishing

⁵⁴ Paeckelmann, Werner, Die Brachiopoden des deutschen Unterkarbons: P. u. s. geol. Landensanstalt Abh., Neue Folge, Heft. 136, p. 55, 1931.

genera among productelloid shells on the habit of life and proposes to consider *Strophalosia* a subgenus of *Productella*. The writer is inclined to agree that this character is of doubtful utility in such shells, especially where the attachment was only for a short period in youth, but because he has not been able to make an extensive study of *Strophalosia* and *Productella*, he is making no changes in the nomenclature in this paper. If, however, it is found advisable to refer these two genera to a single genus, *Strophalosia* would have priority.

Occurrence: Yellow-brown calcareous mudstone and clay partings of the Louisiana limestone at locality 593, along Town Branch, Louisiana, Mo., and at Louisiana. This species is confined to the Louisiana limestone. The holotype is from the yellow-brown mudstones at locality 593.

Genus LEPTALOSIA Dunbar and Condra 1932

Leptalosia scintilla (Beecher)

Plate 8, figures 33-38

1890. *Strophalosia scintilla* Beecher, Am. Jour. Sci., 3d ser., vol. 40, p. 243, pl. 9, figs. 10-13.
 1892. *Strophalosia scintilla* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 15B, figs. 32-34.
 1898. *Strophalosia scintilla* Weller, U. S. Geol. Survey Bull. 153, p. 613.
 1908. *Strophalosia scintilla* Rowley, Missouri Bur. Geology and Mines, 2d. ser., vol. 8, p. 76, pl. 17, figs. 26-29.
 1914. *Strophalosia scintilla* Weller, Illinois Geol. Survey Mon. 1, p. 144, pl. 18, figs. 19-23.
 1920. *Etheridgina scintilla* Greger, Geol. Mag., vol. 57, p. 536, pl. 14, figs. 12-14.
 1932. *Leptalosia scintilla* Dunbar and Condra, Nebraska Geol. Survey, 2d ser., Bull. 5, p. 260.

This species, which was originally described under the genus *Strophalosia* and later referred to *Etheridgina*, is the genotype of Dunbar and Condra's proposed genus *Leptalosia*,⁵⁵ which is said by its founders to be distinguished from *Strophalosia* by "its more completely adnate habit, its spineless dorsal valve, and its more obsolete cardinalia"⁵⁶ and from *Etheridgina* by the structure of its cardinal process and conjoined ridges of the dorsal valve and by the possession of a cardinal area. The cardinal process of *Etheridgina* is said to differ from that of *Leptalosia* by being 'relatively large'⁵⁷ and "joined at the base by a pair of ridges that run laterally just below the hinge line and a second pair that run forward and fuse a short distance in front of the process." The fused ridges continue forward as a median septum. Dunbar and Condra⁵⁸ characterize the cardinal process of *Leptalosia* as "very small and bifid, being composed of two narrow, posteriorly facing, and closely oppressed muscular apophyses, supported in front by a pair of very short diverging ridges separated

by a depression." They do not mention a median septum in their generic description, but, as will be shown later, a septum occurs on species referred by them to *Leptalosia*. The writer here is recognizing Dunbar and Condra's genus as distinct from *Strophalosia* and *Etheridgina*, but this course must be considered merely tentative because of the uncertainty regarding the status and variability of some of the generic differences mentioned. The confusion is most obvious in the differences between *Etheridgina* and *Leptalosia* and mainly concerns the possible presence of a cardinal area on *Etheridgina* and the internal characters of the dorsal valve of *Leptalosia*.

The confusion regarding the presence of a cardinal area on *Etheridgina* largely comes from uncertainty regarding the cardinal area of the genotype. The genus *Etheridgina* was founded by Oehlert⁵⁹ in 1887, but by typographical error it is dated by Oehlert 1877. It was originally described as a subgenus of *Productus*, and the genotype was designated by its author as *E. complectens* (Etheridge)—*Productus complectens* Etheridge, 1876. Oehlert did not describe a cardinal area in his rather short generic description. In Etheridge's original description of *P. complectens*,⁶⁰ the presence or absence of a cardinal area is not mentioned, but his figures do not clearly show the absence of cardinal areas. His type specimens were collected by James Bennie in "East Lothian" (Haddington County), Scotland. Two years later, Etheridge⁶¹ noted that Bennie had recently found *Productus complectens* at localities other than those mentioned in the original description, among them was a locality in Fife, which is across the Firth of Forth from Haddington County. In this same article Etheridge described a form which also came from Fife, and which he seemed to think might be different from *P. complectens*. This form had a distinct cardinal area. It appears to have come from rocks of the same age as those that contained *P. complectens*. Greger,⁶² in 1920, obtained specimens from Fife identified as *Etheridgina complectens*. His examination of these specimens showed that they had cardinal areas and covered delthyria. Hall and Clarke,⁶³ in 1892, had stated that *Etheridgina* did not have a cardinal area, and Muir-Wood,⁶⁴ in 1928, made the same statement, but in neither of the two papers was it made clear whether the statement was based on personal observation of the genotype or on observation of other species or on implications in the literature. Certainly the impli-

⁵⁹ Oehlert in Fischer, Manuel conchyliologie, p. 1278, fig. 1039, 1887.

⁶⁰ Etheridge, R., On an adherent form of *Productus* and a small *Spiriferina* from the Lower Carboniferous limestone group of the east of Scotland: Quart. Jour. Geol. Soc. London, vol. 32, p. 462, 1876.

⁶¹ Etheridge, R., Further remarks on adherent Carboniferous *Productidae*: Geol. Soc. London Quart. Jour., vol. 34, p. 498, 1878.

⁶² Greger, D. K., North American species of the brachiopod *Etheridgina*: Geol. Mag., vol. 57, p. 535, 1920.

⁶³ Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 1, p. 335, 1892.

⁶⁴ Muir-Wood, H. M., The British Carboniferous *Producti*, II. *Productus* (sensus stricto): *semireticulatus* and *longispinus* groups: Great Britain Geol. Survey Mem., Paleontology, vol. 3, pt. 1, p. 38, 1928.

⁵⁵ Dunbar, C. O., and Condra, G. E., Brachiopoda of the Pennsylvania system in Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 5, p. 260, 1932.

⁵⁶ Idem, p. 261.

⁵⁷ Idem, p. 262.

⁵⁸ Idem, p. 260.

cation one gets from Etheridge's descriptions is that he did not consider that his species had a cardinal area. This is also the implication one has from Oehlert's description of *Etheridgina* as a subgenus of *Productus*. As against those implications, however, there are these facts: Greger has examined specimens identified with the genotype and these specimens have cardinal areas; these specimens came from a region in which Etheridge had identified his species; a form with a cardinal area was collected from beds of the same age and from the same general locality in Fife as those that yielded the specimens identified or accepted by Etheridge as his species, and as it was also collected by Mr. Bennie this form may have been in the same collection with the specimens identified or accepted by Etheridge as *P. complectens*: the small (?) size of the species would doubtless make the presence of a cardinal area difficult to determine on many individuals and if present at all, the area would be indistinct on others. Dunbar and Condra would include in *Leptalosia* forms with distinct cardinal areas and forms said to have narrow cardinal areas and nearly obsolete hinge teeth and sockets. Unless the confusion regarding the cardinal area of the genotype of *Etheridgina* has been cleared up in foreign or other publications not seen by the writer, it still remains an uncertain point in the distinctions between the two genera.

The other important difference cited between *Leptalosia* and *Etheridgina* concerns the cardinal process and internal ridges of the dorsal valve. Although these features have been adequately described and figured from *E. complectens*, the genotype of *Etheridgina*, they cannot be said to be well known on the genotype or any other of the American Carboniferous species referred to *Leptalosia*. The writer has not seen any brachial interiors of the genotype, and Beecher is the only author represented in the literature examined by the writer who has described the interior of its brachial valve. He did not include in his description any reference to the cardinal process or internal ridges. Rowley, in 1908, figured a specimen which, if a dorsal valve, seems to have had diverging lamellae, but Rowley shows no cardinal process, and it is not certain that he had a dorsal valve. He did not so designate it in his explanation of plates, and because of the small size of the figured specimen the possibility of its being after all a ventral valve with the sides of the delthyrium preserved cannot be dismissed with any degree of assurance. Weller,⁶⁵ in 1914, gave a brief description of the interior of the dorsal valve of *L. scintilla* but did not mention the cardinal process or internal ridges and said that "the brachial impressions have not been observed." Greger did not describe or figure the interior of the dorsal valve, and the writer has not been able to determine whether Dunbar and Condra's descrip-

tion of the interior of the dorsal valve of their genus was based on their own observation of the genotype or on their observation of other species referred to the genus or on the observations of others.

Other Carboniferous species referred by Dunbar and Condra to *Leptalosia* are *L. keokuk* (Beecher, 1869), *L. spondyliiformis* (White and St. John, 1867), *L. ovalis* Dunbar and Condra, 1932, and *L. rarispina* (Beecher). The writer has been unable to locate the last-named species in the literature of the American Carboniferous. Devonian species mentioned by them are *L. truncata* (Hall, 1857) and *L. radicans* Winchell, 1866. Another species that probably belongs with these is *Etheridgina incondita* Greger, 1920, from the Pennsylvanian of Kansas and Missouri.

With the exception that a cardinal process is said to be present in *L. keokuk*, the interior of the dorsal valve has not been described or figured in the literature of any of the Carboniferous species listed above. A narrow elongate, bifid cardinal process is described from the Devonian species, *L. radicans*. Beecher also described and figured a short median septum from this species. He did not, however, mention the presence of any other lamellae in the interior of the dorsal valve, but two very short lines or elongate dots in his figures are designated by him as dental sockets, and if dental sockets are present, they probably were bordered by short lamellae. The writer is inclined to doubt that *S. truncata* should be grouped with the species referred to *Leptalosia*. None of the specimens of this species examined by the writer are attached, and all the references examined in the literature state that it preserves only a comparatively small scar or area of attachment. A series of specimens of this species has been studied by Raymond.⁶⁶ The dorsal interiors show that the young individuals had a cardinal process that was wider than long and was continued below and anteriorly into two short diverging lamellae, essentially the condition described by Dunbar and Condra for *Leptalosia*. In more mature specimens the cardinal process has grown longer compared to the width, and the other structures have approached the condition described on the genotype of *Etheridgina*. The lamellae joining the cardinal process have grown longer and have changed until they are almost parallel to the hinge line to form the dental sockets. A slight sub-rounded depression has appeared immediately anterior to the beak, and a median septum, which if continued posteriorly would bisect the depression, is visible in the central part of the valve. The writer has not been able to make an exhaustive and complete search of the literature on these two Devonian species nor has he been able to examine a great number of specimens, but the observations described seem to reliably depict the true conditions.

⁶⁵ Weller, Stuart, Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, p. 114, 1914.

⁶⁶ Raymond, P. E., The *Tropidoleptus* fauna at Canandaigua Lake, New York with the ontogeny of twenty species: Carnegie Mus. Annals, vol. 3, p. 123, pl. 7, fig. 3, 1904.

The above discussion of the cardinal processes and internal structures of the dorsal valves of *Etheridgina* and *Leptalosia* may be summarized as follows: The cardinal process and internal structures of the genotype of *Etheridgina* are known; if Dunbar and Condra's remarks about the dorsal interior of *Leptalosia* are not based on an investigation of the genotype, the cardinal process of the genotype of that genus is not known at all, and the internal ridges of the genotype are known only from one drawing of a specimen that may not be a dorsal valve; the cardinal process of *Leptalosia* is known at all from only one Carboniferous species, *L. keokuk*, and it has merely been mentioned and has never been described; aside from the mere mention of the cardinal process of *L. keokuk*, none of the internal characters of the dorsal valves of Carboniferous species of *Leptalosia* have been described in the literature seen by the writer; a figure of one Devonian species referred to *Leptalosia*, *L. radicans*, has dental sockets, and as these are elongate at about 45° to the hinge line, and as they probably had ridges on their interior sides, *L. radicans* probably had short diverging ridges on the dorsal valve. It also has a median septum. The other Devonian species referred by the founders of *Leptalosia* to their genus, has in youth lamellae and other characters of the interior of the dorsal valve that conform to the description of *Leptalosia*, but these characters in mature specimens seem to agree more closely with those described on the genotype of *Etheridgina*. The cardinal process even on mature forms is relatively narrow, a character attributed to *Leptalosia*.

But the confusion regarding the value of the differences said to exist between the interiors of dorsal valves of *Etheridgina* and *Leptalosia* is not owing solely to the deficiency in the knowledge of the characters of *Leptalosia*. Some confusion arises also from the evaluation of these differences. This uncertainty comes from the small size of the individuals and from the variability in the cardinal process and dorsal internal ridges and in the cardinal areas within productoid and producteloid species. Some of these variations are undoubtedly referable to age or stage of development; others are not. The cardinal areas are, within limits, more completely developed in older individuals than in young individuals in most species. The writer has seen characters on the dorsal valve of *Productella* that agree with those described on the genotype of *Etheridgina*, and almost identical characters also were seen on *Productus*.

Because of these uncertainties regarding the facts and interpretation of the facts of the dorsal interiors of American Carboniferous species of *Leptalosia* and because of the uncertainty of the existence of a cardinal area on the genotype of *Etheridgina*, the recognition of the genus *Leptalosia* is here considered tentative.

Leptalosia scintilla is a common form in the Louisiana and is easily identified in the collections from it. Most of the specimens collected are attached to *Productella*

pyxidata Hall, 1858, but they also occur on *Spirifer marionensis* Shumard, 1855, and on other species. Most of the specimens are longer than wide but some are nearly equal in length and width. The dimensions of two specimens are: length, 2 mm., width, 2.3 mm.; length, 1.8 mm., width, 2.5 mm.

Leptalosia keokuk (Beecher, 1890), of the Keokuk of Indiana is the only other Mississippian species that closely resembles *L. scintilla*. It is said by Weller⁶⁷ to differ from *L. scintilla* by its larger size, proportionately more elongate outline, and more numerous, more elongate, and more crowded spines of attachment which occur as commonly along the cardinal margin as elsewhere.

Occurrence: Yellow-brown calcareous mudstone, clay partings, and limestone beds of Louisiana at Louisiana and Clarksville, Mo., and at locality 599, about 1 mile south of Louisiana. This species also occurs in the Saverton shale.

Order TELOTREMATA

Superfamily RHYNCHONELLACEA

Family CAMEROPHORIIDAE

Subfamily CAMEROPHORIINAE

Genus CAMEROPHORIA King 1844

Camerophoria pikensis Williams, n. sp.

Plate 8, figures 26-28

Shell lenticular, triangularly subovate in outline, wider than long, greatest width at about midlength. The dimensions of the holotype are: Length 12 mm., width 14 mm., thickness 7 mm.

Pedicle valve gently convex, umbo narrowly convex, greatest convexity at front and in the sinus. Beak small, extending beyond and incurved over that of opposite valve but not in contact with it. Mesial sinus originating in anterior half of valve, becoming more prominent toward the front, where it is deflected nearly at right angles to the plane of the valve, broad, shallow, and producing only a slight deflection in the anterior margin. Delthyrium and deltidial plates not observed. Plications few, small, rounded, obsolete near umbo and toward lateral margins, more prominent on sinus, about 1 millimeter in width. Five plications are in the sinus, which is bordered by one or two faint plications, the rest of the valve being smooth.

Brachial valve convex but not gibbous, greatest convexity posterior to the middle, greatest depth at middle. Mesial fold originating anterior to midlength, slightly elevated above the surface of the shell, occupied by about six low rounded plications, which originate anterior to the umbonal region and are about 1 millimeter wide. One or two faint plications border the fold, the rest of the valve and the umbonal region not plicate. Fine concentric lines of growth cross the plications.

⁶⁷ Weller, Stuart, Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, p. 145, 1914.

The only internal character of the shell that was observed is a median septum in the ventral valve.

Remarks: Only one specimen of this species has been found. Its generic reference is not absolutely certain, as it was not sectioned. A median septum is visible in the umbonal region of the pedicle valve, where the shell is not fully preserved, but the presence or absence of a dorsal median septum could not be determined because umbonal region of the dorsal valve is much better preserved. As serial sections were not made because of the scarcity of material, the presence or absence of a spondylium, a cruralium, and a continuous hinge plate is not known. Despite these deficiencies, the generic reference is considered very probably correct, because this is the only Mississippian genus that combines the external ornamentation of such genera as *Shumardella*, *Liorhynchus* and *Pugnax* with a well-developed ventral median septum.

Lower Mississippian species of *Camerophoria* are *C. bisinuata* (Rowley), 1900, found in the limestone of Boone age in Texas and in the Fern Glen and Burlington formations of Missouri; *C. hamburgensis* Weller, 1910, from the Glen Park (†Hamburg oolite) of Illinois; *C. obesa* Clark, 1917, from the Madison limestone of Montana; *C. thera* (Walcott), 1884, from the Eureka District, Nevada; *C. ringens* (Swallow), 1860, found in the Burlington limestone of Missouri and the Madison limestone of Yellowstone National Park; and *C. simulans* Girty, 1915, from the St. Joe member of the Boone limestone of Arkansas. *Camerophoria pikensis* may be easily distinguished from all of the above species except *C. hamburgensis* and *C. simulans* by its shape, relative dimensions, and ornamentation. These same characters serve to distinguish it from *C. hamburgensis* and *C. simulans*, but the resemblance to them is closer. *C. hamburgensis* has more plications than *C. pikensis*, but does not have such a pronounced sinus and, if one may judge from Weller's figures, does not have a well-developed median septum. *C. simulans* has no lateral plications.

The name of this species is from Pike County, Mo.

Occurrence: Limestone beds of the Louisiana limestone at locality 618, near Clarksville, Pike County, Mo.

Family CAMAROTOECHIIDAE

Subfamily CAMAROTOECHIIDAE

Genus ALLORHYNCHUS Weller, 1910

Allorhynchus? curriei (Rowley)

Plate 7, figures 36-39

1901. *Trigeria? curriei* Rowley, Am. Geologist, vol. 27, p. 350, pl. 28, figs. 40-42.
 1908. *Trigeria? curriei* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 80, pl. 17, figs. 54-56.
 1914. *Trigeria? curriei* Weller, Illinois Geol. Survey Mon. 1, p. 245, pl. 30, figs. 30-33.
 1926. *Trigeria? curriei* Girty, U. S. Geol. Survey Prof. Paper 146, p. 30.

The internal characters of this species and the punctate shell structure have not been observed, and it was questionably referred to the genus *Trigeria*. Girty believes that it should be referred to some rhynchonelloid genus, probably *Camarotoechia*. His statement, which is the basis for the writer's changing the generic reference is given below.

"*Centronella louisianensis* and *Trigeria curriei* so far as known lack every distinctive character of terebratuloid shells—they are apparently impunctate, they have an erect pointed beak in the pedicle valve with a triangular pedicle opening and they are finely plicated, a character which in Mississippian Terebratuloids is extremely uncommon to say the least. This last character is well developed only in *Trigeria curriei*, but it is apparently incipient in *C. louisianensis* (See Weller's Figure 27). Though alien to terebratuloid shells these characters are in a measure distinctive of rhynchonelloids, and the peculiar configuration which has probably prevented authors from considering the latter relationship would be almost equally adverse to the former. The configuration, however, which is so unlike rhynchonelloid shells in their mature stages is, one might say, characteristic of them when very young. In their early stages the valves are compressed and the general shape spatulate, the characteristic fold and sinus are lacking and instead the brachial valve is more or less concave from side to side, and the pedicle valve convex, while plications may be entirely absent or marginal. Altogether these considerations establish a high probability that both species are rhynchonelloids, though they probably are distinct from one another and may belong to different genera. From the strength of its plications *T. curriei* may well be a young *Camarotoechia*; *C. louisianensis* may also be a *Camarotoechia*."

The writer has made serial sections of several individuals of this species from the Louisiana. These sections have not shown any structures in the interior of the dorsal valve. What appear to be rudimentary dental lamellae are shown in a few ventral valves. In view of the absence of lamellae in the dorsal valve, it seems more reasonable to refer this species to *Allorhynchus* than to *Camarotoechia*, but after all, the absence of lamellae may be owing to poor preservation or incomplete development of young individuals.

Three specimens in the collections have the following respective dimensions: Length of pedicle valve 1.3, 2, and 3.4 mm.; length of brachial valve 1.1, 1.6 mm., and 3 mm.; width 1.2, 1.8, and 2.8 mm. Some specimens are nearly subcircular in outline and are not strongly carinate on the pedicle valve. The sinus is nearly obsolete on some specimens and deep and angular on others. The greatest width in nearly all the specimens is less than one-fourth the length of the shell from the anterior margin. Most specimens are distinctly plicate, but some have plications only on the anterior half of the shell, and some of these have them only in and near the fold and sinus.

Occurrence: Rare in the yellow-brown calcareous mudstone and clay partings of the Louisiana at Louisiana, Mo., and common at locality 599, 1 mile south of Louisiana.

Allorhynchus? louisianensis (Weller)

Plate 7, figures 47-50

1914. *Centronella louisianensis* Weller, Illinois Geol. Survey Mon. 1, p. 241, pl. 30, figs. 26-29.
 1926. *Centronella louisianensis* Girty, U. S. Geol. Survey Prof. Paper 146, p. 30.

This is a rare form in the Louisiana, and only a few specimens have been collected. The internal structures have never been described, and because of the scarcity of specimens no sections to determine them were made during this study. The generic reference of this species is therefore very uncertain. It was referred to the genus *Centronella* by Weller solely on the basis of its external form. Girty, however, believes it is more closely related to the rhynchonelloids than to the terebratuloids and has suggested that it is congeneric with *Camarotoechia* or some closely related genus. The features favoring this conclusion are discussed under *Allorhynchus curriei* (Rowley). The writer is here transferring it to *Allorhynchus* merely because no internal structures have been observed, and because it seems to be a rhynchonelloid. It might as well be placed under *Camarotoechia*.

Some individuals of *Selenella pediculus* (Rowley, 1901), resemble individuals of this species so closely that it is difficult to distinguish them by an examination of the exteriors. Most specimens of the two species can be distinguished by the rostrate pedicle valve of *A. louisianensis* and by its more distinct fold and sinus and greater number of concentric growth lines. The brachidium of *Selenella* has been observed only by Weller and by him only on one specimen, but he says it "seems to agree with that of the genus *Selenella*." *Selenella* should have punctate shell structure, but it has not been observed on available specimens.

Occurrence: Yellow-brown calcareous mudstone(?) and clay partings of the Louisiana limestone at Louisiana, Mo., and at locality 599, 1 mile south of Louisiana, Mo.

Genus **CAMAROTOECHIA** Hall and Clarke, 1893***Camarotoechia* cf. *C. tuta* (Miller)**

Plate 7, figures 51-54

1881. *Rhynchonella tuta* Miller, Cincinnati Soc. Nat. History Jour., vol. 4, p. 315, pl. 7, figs. 11-11b.
 1914. *Camarotoechia tuta* Weller, Illinois Geol. Survey Mon. 1, p. 179, pl. 24, figs. 9-28.

Complete specimens have not been secured from the Louisiana, but separate valves in sufficient numbers to preserve all external details of the shell are available for study. Most of the specimens are molds. The Louisiana specimens are similar in all respects to specimens from the Chouteau limestone, with which they were compared and on which basis they were identified.

The writer has not been able to study material from the type locality. In both the Chouteau and the Louisiana specimens the number of plications in the sinus ranges from 3 to 6, with probably one-third of the Louisiana forms having only three. The plications on the fold also range from 3 to 6. None of the plications are longitudinally grooved.

In some of the specimens the fold on the brachial valve is very inconspicuous even at the front of the shell and can hardly be differentiated. The slight mesial depression extending from the beak of the brachial valve forward about one-fourth the length of the shell is a constant character in the Louisiana specimens.

As the internal characters of the Louisiana specimens are not well known, the specific and even the generic reference cannot be fully substantiated. Dental plates were observed in a section of a ventral valve. The shelly material was preserved on parts of only a few of the dorsal valves that were ground. Most of these specimens were found to be molds and therefore showed no internal lamellae. A faint impression of a median septum can be seen on one specimen that was not sectioned. Because so little shelly material is preserved, it is also impossible to state with assurance the nature of the shell structure. It appears to be impunctate.

One specimen, from the Hannibal (?) shale, has some indications of punctate structure. This specimen is figured as figures 51 and 52 of plate 7. Like the Louisiana specimens, it retains very little shelly material. Punctae could not be definitely made out on any of the patches of shell, but an impression of granularity that one gets from some of them when rotating the specimen may indicate punctation. Punctate structure is further suggested on this specimen by rounded incrustations or infiltrations of a red mineral, but as the mineral also occurs on areas where no shelly material is preserved, its value as evidence for punctate structure is uncertain. This specimen is somewhat larger than average specimens, being 10 mm. long and 10 mm. wide. If it is punctate, it will of course have to be referred to another genus, probably to *Rhynchopora*.

Occurrence: Limestone beds of the Louisiana at locality 798, 2½ miles west of Frankford; locality 1009, 2½ miles north of Ely; and locality 552, about 8 miles north of Monroe City.

This species is also reported from the Chouteau, the Compton, and the Burlington formations of Missouri and the Lake Valley limestone of New Mexico, and a conspecific or closely related form occurs at Bowling Green and near Rensselaer, Mo., in beds here referred to Hannibal (?). Aside from the Louisiana and Hannibal (?) forms the writer has seen specimens only from the Chouteau.

Genus *PARAPHORHYNCHUS* Weller, 1905*Paraphorhynchus striatocostatum* (Meek and Worthen)

Plate 8, figure 32

1868. *Rhynchonella missouriensis* Meek and Worthen, Illinois Geol. Survey, vol. 3, p. 450, pl. 14, figs. 7a-d. (Not *Rhynchonella missouriensis* Shurgard, 1855).
1868. *Rhynchonella striato-costata* Meek and Worthen, idem, p. 452.
1870. ?*Rhynchonella missouriensis* Winchell, Am. Philos. Soc. Proc., vol. 11, p. 253.
1893. ?*Pugnax missouriensis* Hall and Clarke [part], Paleontology of New York, vol. 8, pt. 2, fasc. 2, p. 204 (Advance distribution in fascicles).
1893. ?*Pugnax striato-costata* Hall and Clarke, idem., p. 204.
1895. ?*Pugnax missouriensis* Hall and Clarke [part], Paleontology of New York, vol. 8, pt. 2, p. 204, pl. 60, figs. 33, 34 (not pl. 62, figs. 44, 45).
1895. ?*Pugnax striato-costata* Hall and Clarke, idem., p. 204.
1901. *Pugnax striatocostata* Weller, St. Louis Acad. Sci. Trans., vol. 11, no. 9, pp. 150, 154, pl. 13, figs. 14-16.
1905. *Paraphorhynchus striatocostatum* Weller, idem., vol. 15, p. 262, pl. 1, figs. 6-11.
1914. *Paraphorhynchus striatocostatum* Weller, Illinois Geol. Survey Mon. 1, p. 189, pl. 26, figs. 15-22.

Only one incomplete specimen has been collected by the writer, and it came from the yellow-brown calcareous mudstone at its contact with the blue Saverton shale below.

This specimen is an internal mold, but enough of the original shell is preserved to show that the shell surface and plications are striated. Its dimensions are: Length 25 mm., approximate width 27 mm., thickness, 19 mm. This species differs from *P. transversum* Weller and *P. elongatum* Weller mainly in size and proportions. The dimensions of a typical *P. transversum* are: Length 25 mm., width 31 mm., thickness 23 mm. Those of a typical *P. elongatum* are: Length 37 mm., width 28.8 mm., thickness 22.5 mm. Weller gives the dimensions of a nearly perfect *P. striatocostatum* as: Length 25 mm., width 26 mm., thickness 17.8 mm.

The generic name was originally spelled by Weller *Paraphorhynchus*. Later he changed it to *Paryphorhynchis*. G. H. Girty states that he imperfectly remembers that Weller wrote him that he made the change because he had discovered an error in transliteration. The changing of the spelling of generic names on that basis has been upheld in opinion 36 of the International Commission of Zoological Nomenclature. However, as *para* is a common combining form and *pary* is not, it seems best to return to the original spelling.

Occurrence: Yellow-brown calcareous mudstone of the Louisiana limestone at locality 618, Clarksville, Mo.

The types of this species came from the Kinderhook at Kinderhook, Ill. The species has also been described from beds 3 and 4 of the Kinderhook at Burlington, Iowa; from the so-called †Waverly of Sciotoville, Ohio; and from the Chouteau of Pike County, Mo. In addition,

Moore lists it from bed 3 at Kinderhook. Aside from the Louisiana specimens, the only other ones examined were from the Kinderhook of Burlington, Iowa.

Genus *RHYNCHOPORA* King, 1856*Rhynchopora? rowleyi* Weller

Plate 7, figures 72-75

1908. *Pugnax missouriensis?* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 81, pl. 17, figs. 60-62.
1914. *Rhynchopora? rowleyi* Weller, Illinois Geol. Survey Mon. 1, p. 237, pl. 30, figs. 18-21.

This is a rare form in the Louisiana, but it may be easily distinguished from any other brachiopod in the formation. Its generic reference is not certain, as the punctate shell structure has not been observed. It is placed in the genus mainly because of its external resemblance to other species of *Rhynchopora*. This species is very closely related to *R.? cooperensis* (Shurgard, 1855) and to *R. persinuata* (Winchell, 1865), but, it is proportionately wider than Weller's specimens of these two species and has the beak of its pedicle valve more closely incurved over the beak of the brachial valve and nearly in contact with it.

Specimens *R. cooperensis* from the Chouteau examined by the writer have approximately the same dimensions as the holotype of *R.? rowleyi* and agree in all external characters with *R.? rowleyi* except in the curvature of the pedicle beak, which is more closely incurved in *R.? rowleyi*. This may not constitute a specific difference, but as the internal structures of *R.? rowleyi* are not completely known, the species is not here identified with *R. cooperensis*. There is no difference between the type of *R.? rowleyi* and some specimens of *R. cooperensis* in coarseness of plications or character of the lingual extension at the anterior of the pedicle valve.

Considerable difference of opinion exists regarding the systematic position of *Rhynchopora*. Dunbar and Condra⁶⁸ have recently suggested that its real affinity is with the terebratulids rather than with the rhynchonellids, where it has for a long time been placed.

Occurrence: Louisiana limestone at Louisiana, Mo.

Superfamily SPIRIFERACEA

Family SPIRIFERIDAE

Subfamily DELTHYRINAE

Genus *DELTHYRIS* Dalman, 1828*Delthyris clarksvillensis* (Winchell)

Plate 8, figures 29-31

1862. *Spiriferina? subtexta* White [part], Boston Soc. Nat. Hist. Proc., vol. 9, p. 25 (not specimens from Burlington limestone).

⁶⁸ Dunbar, C. O., and Condra, G. E., Brachiopoda of the Pennsylvanian system in Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 5, p. 290, 1932.

1865. *Spiriferina clarksvillensis* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 119.
 1894. *Spiriferina clarksvillensis* Keyes, Missouri Geol. Survey, vol. 5, p. 85.
 1898. *Spiriferina clarksvillensis* Weller, U. S. Geol. Survey Bull. 153, p. 594.
 1908. *Spiriferina clarksvillensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 83, pl. 18, figs. 10-12.
 1914. *Delthyris clarksvillensis* Weller, Illinois Geol. Survey Mon. 1, p. 301, pl. 36, figs. 6, 7.

This species is rare in the Louisiana limestone and may be easily distinguished from other brachiopods in its fauna. It is very closely related to *D. missouriensis* Weller, 1906, from the Glen Park limestone member of the Sulphur Springs, but at least some specimens of *D. missouriensis* have more convex pedicle valves and fewer plications on the lateral slopes of the valves. The writer has not examined the cotypes of *D. missouriensis*, but from Weller's description and figures it is very difficult to make out constant characters which distinguish them from *D. clarksvillensis*. This species is relatively wider than *D. suborbicularis* Weller, 1906, from the Glen Park limestone and has a relatively longer hinge line, a more convex pedicle valve, a slightly more incurved pedicle beak, and longer, better defined plications than the holotype of that species.

Muir-Wood⁶⁹ has suggested that this and other lower Mississippian species may belong to *Tylothyris* rather than to *Delthyris*. The writer has not examined specimens of *Tylothyris*, but from North's description one would suppose it was erected for species that are much larger and relatively much broader than this species, and that it had relatively smaller and more numerous costae. The concentric lamellae of *D. clarksvillensis* agree with *Tylothyris* in not being spinose, but the lamellae of *Delthyris* have been said by some investigators not to be spinose, and probably both spinose and non-spinose lamellae occur within the genus as accepted at present.

Occurrence: Limestone beds of the Louisiana limestone at Louisiana, Mo. Also reported from the yellow-brown mudstone at Louisiana and from the limestone beds at Clarksville, Mo.

Genus ACANTHOSPIRINA Schuchert and LeVene 1929

Acanthospirina aciculifera (Rowley)

Plate 7, figures 55-60

1893. *Spirifera aciculifera* Rowley, Am. Geologist, vol. 12, p. 307, pl. 14, figs. 13, 14.
 1898. *Spiriferina aciculifera* Weller, U. S. Geol. Survey Bull. 153, p. 593.
 1908. *Spiriferina aciculifera* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 84, pl. 18, figs. 13-15.
 1914. *Acanthospira aciculifera* Weller, Illinois Geol. Survey Mon. 1, p. 418, pl. 35, figs. 64-72.

⁶⁹ Muir-Wood, H. M., Notes on the Silurian brachiopod genera *Delthyris*, *Uncinulina*, and *Meristina*: Annals and Mag. Nat. History, ser. 9, vol. 15, p. 86, 1925.

1929. *Acanthospirina aciculifera* Schuchert and LeVene, Am. Jour. Sci., 5th ser., vol. 17, p. 119.
 1930. *Acanthospirina aciculifera* King, Texas Univ. Bull., No. 3038, p. 122.
 1933. *Acanthospirina aciculifera* Rowley and Williams, Washington Acad. Sci. Jour., vol. 23, No. 1, p. 46, figs. 1-4.

This is the genotype and only species of the genus *Acanthospirina*. This genus was described by Weller in 1914 as *Acanthospira*. The name was changed to *Acanthospirina* in 1929 by Schuchert and LeVene⁷⁰ who showed that *Acanthospira* was a homonym.

Weller's essential generic character is the presence of fine spines on the surface which, he stated, were arranged in regularly radiating series along the summits of the plications and in similar rows on the fold and in the sinus. This distinctive character of *Acanthospirina* was inferred from the presence of minute tubercles or papillae, which Weller thought "doubtless supported slender spines in the living shell." Three such spines, which were obviously broken off the summits of tubercles, were noted on specimens in the writer's collection. They were sufficiently close to the tubercles and their broken bases corresponded with the tops of the tubercles that they were close to so well that one could hardly doubt that they were once mounted on the tubercles and projected at right angles to the shell surfaces. The tubercles are not preserved over all the surface of all the specimens and some tubercles do not show in detail the regular arrangement described by Weller, but these inconsistencies are probably the result of the failure of some tubercles to be preserved. The internal structures, except for some in the delthyrium, are not known for *Acanthospirina*. On one specimen where the pseudodeltidium is broken, a delthyrial plate can be seen in the delthyrium. A median ridge on the delthyrial plate very much resembles the ridges on the delthyrial plates of many species of *Syringothyris*. Whether this actually represents a syrinx or some other structure was not determined, owing to the lack of sufficient specimens to permit sectioning.

Two specimens of this species have an unusual color differentiation that is very striking. The surfaces of both valves have streaks of light brownish red material on them. These streaks, which average about 0.16 mm. in length and 0.02 mm. in width are on the fold, sinus, plications, and intervening furrows and radiate in broken lines from the beak, roughly paralleling the plications. Some of the red areas are slightly raised above the surface and appear as though they might occupy the places of flat spines, but no small flat spines have been noted on this genus. Others are beneath the level of the surface, and some appear to be covered by a thin shelly layer. The colored areas may be the remains of an original color pattern or may merely represent differential replacement of parts of the shell

⁷⁰ Schuchert, Charles, and LeVene, C. M., New names for brachiopod homonyms: Am. Jour. Sci., 5th ser., vol. 17, p. 119, 1929.

differing in texture or structure from the body of the shell.

The structure of the shell is, as Weller stated, impunctate, unless the areas occupied on the two specimens by coloring material are punctae. The pattern shown on the two specimens by the coloration also occurs on an uncolored specimen. On this specimen it consists of a series of small depressions which are of approximately the same size and shape and have the same arrangement as the colored areas on the other specimens. Very similar uncolored patterns occur on young specimens of *Syringothyris hannibalensis* (Swallow, 1860) also from the Louisiana limestone. This pattern and the ridge on the delthyrial plate suggest a close relationship between the two genera. No spines or tubercles have been seen on young specimens of *S. hannibalensis*, however.

Young individuals of *Cyrtina acutirostris* (Shumard, 1855), which species also occurs in the Louisiana limestone, are of about the same size and shape as individuals of *A. aciculifera* and may be confused with them. The shells of the Cyrtinas are regularly perforated by subrounded punctae, whereas the Acanthospirinas are either not punctate or are perforated by elongate punctae. The Cyrtinas lack the radial rows of tubercles that occur on the plications and on the fold and sinus of *Acanthospirina*. Instead of the rounded ridge on the delthyrial plate, they have a sharp ridge in the delthyrium. This sharp ridge is the posterior continuation of a narrow median septum. No delthyrial plate is present on *C. acutirostris*.

Occurrence: Clay partings in the Louisiana limestone at locality 599, mouth of Buffalo Creek, 1 mile south of Louisiana, Mo., and at locality 600, Eighth Street quarry, Louisiana.

Subfamily SPIRIFERINAE

Genus SPIRIFER Sowerby, 1815

A number of new genera and subgenera have been proposed for forms previously included in *Spirifer*. By far the greatest number of these were proposed by Fredericks in 1918 and 1919. Fredericks' genera were based on both internal and external characters, but most of them were actually founded on differences in external characters. Few of his genera have been recognized in this country. The one species here described would, it appears, belong in the genus *Spirifer* as interpreted by Fredericks. Other spiriferoid genera have been recently proposed by Chao, North, and others.

As here considered, the genus *Spirifer* includes forms that have plications on the fold, in the sinus, and on the lateral slopes. In addition there are more or less distinct radiating striae and concentric growth lines. In the ventral valve, the dental plates are short but rather thick. They go almost vertically to the floor of the

valve or diverge slightly. Between the dental plates on the floor of the valve is an oval muscle scar divided by a low median ridge, which extends forward from this area toward the anterior margin of the valve.

Most of the plications on the lateral slopes are simple, but a few bifurcate. The character of the plications or costae has been used to differentiate genera in spiriferoid forms, but its validity as a sole generic character is not universally accepted. Fredericks' proposed genus *Neospirifer* differs from *Spirifer*, s. s., in the fasciculate character of its plications. Dunbar and Condra⁷¹ state that *Spirifer* has simple plications, but Chao⁷² includes in *Spirifer* forms with simple plications and forms having plications that bifurcate. Because some specimens of this one species of *Spirifer* in the Louisiana limestone have only simple plications and others have a few plications that bifurcate, it seems best to interpret the genus to include both forms.

Chao's proposed genus *Tangshanella*⁷³ is characterized by the dichotomous bifurcation of most of the plications of the lateral slopes, but it is also differentiated from typical *Spirifer* by the configuration of the shell.

Spirifer marionensis Shumard

Plate 8, figures 39-50

1855. *Spirifer marionensis* Shumard [part], Missouri Geol. Survey First and Second Ann. Repts., p. 203, pl. C, figs. 8a-b (not fig. 8c).
1858. *Spirifer marionensis* Hall, Iowa Geol. Survey, vol. 1, pt. 2, p. 511, pl. t, figs. 1a-c.
1883. *Spirifera marionensis* Hall, New York State Geologist Second Ann. Rept., pl. (31) 56, fig. 15.
1893. *Spirifer marionensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 26, 38, pl. 31, fig. 15. (Advance distribution in fascicles.)
1894. *Spirifer marionensis* Hall and Clarke, New York State Geologist Thirteenth Ann. Rept., vol. 2, pl. 27, fig. 3.
1894. *Spirifera marionensis* Keyes [part], Missouri Geol. Survey, vol. 5, p. 78, pl. 40, figs. 1a-b. (Not specimens from Cooper County, Mo.)
1895. *Spirifer marionensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 26, 38, pl. 31, fig. 15.
1898. *Spirifer marionensis* Weller, U. S. Geol. Survey Bull. 153, p. 586.
1905. *Spirifer marionensis* Weller, Jour. Geology, vol. 13, p. 621.
1908. *Spirifer marionensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 81, pl. 18, figs. 1-5; p. 88, pl. 19, figs. 3-6.
1914. *Spirifer marionensis* Weller, Illinois Geol. Survey Mon. 1, p. 308, pl. 37, figs. 1-7.

This species may be distinguished from most other Mississippian Spirifers by the linear cardinal area of the pedicle valve, which has parallel margins extending almost to the lateral extremities and giving the cardinal area the shape of a parallelogram.

⁷¹ Dunbar, C. O., and Condra, G. E., Brachiopoda of the Pennsylvania system in Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 5, p. 317, 1932.

⁷² Chao, Y. T., Carboniferous and Permian spiriferids of China: Palaeontologia Sinica, ser. B, vol. 11, fasc. 1, p. 5, 1929.

⁷³ Chao, Y. T., *idem*, p. 57.

There is a considerable variation among specimens from the Louisiana. Young specimens have relatively longer hingelines, and on some of them they are extended into mucronate points. The dimensions of a small individual are: Length 6 mm., width 13 mm., length of hinge-line 16 mm. In some of the adult specimens the hingeline is shorter than the greatest width, but in most of them it is longer than the width anterior to the hingeline. Most specimens have the cardinal area shaped like a parallelogram, but on some, especially on young individuals, it is very broadly triangular. There is also a great variation in the convexity of the brachial valve and the elevation of the fold, which in some young specimens is below the level of the valve near the anterior of the valve. Many specimens have only 12 plications on each lateral slope, and on some specimens 4 plications bordering the sinus on each of the lateral slopes bifurcate. Many individuals have 5 plications in the sinus. A few fine radial striae were observed, but the finer ornamentation is chiefly concentric. A pseudodeltidium closes the upper part of the delthyrium of some specimens.

Internally, the hingeteeth are supported by short dental lamellae; the muscular area is deeply impressed, obcordate in form, and divided by a low median longitudinal ridge. The cardinal area of the brachial valve is low and linear, with parallel margins; the cardinal process is low, and the socket plates are well developed. Spiralia were not observed.

This species very much resembles *S. centronatus* Winchell, 1865, a widespread Mississippian species. Where the fine sculpture is preserved, it can be distinguished from Winchell's species by its finer and fewer radial striae and relatively more strongly developed concentric lamellae. Where the cardinal areas of the two species are fully preserved, that of *S. marionensis* is more nearly rectangular. The plications of most specimens of *S. marionensis* are lower, relatively broader, and more rounded and are separated by relatively narrower furrows than are those of *S. centronatus*. Most specimens of *S. centronatus* have higher folds and more rapidly enlarging and more anteriorly produced sinuses. They also have relatively smaller and less prominent plications bounding the folds and sinuses.

This species has been described from a number of widely separated localities. Some of these identifications have, however, been found to be in error, and the forms on which they were based transferred to other species. Most of these transfers were suggested by Weller in 1914. Others are suggested here for the first time. As *S. marionensis* is not among the hundreds of Chouteau brachiopods examined, it seems logical to conclude that it probably does not occur in that formation. Synonymic entries describing *S. marionensis* from that formation probably should go to *S. missouriensis* Swallow, 1860, or to *S. centronatus*

Winchell, 1865. They include in part the reference of Shumard, 1855, in part the reference of Keyes, 1895, and the reference of Weller, 1895. The reference of Weller, 1899, has been transferred by him to *S. osagensis* Swallow, 1860. The reference of Weller, 1901, from the Northview shale should probably go to *S. osagensis*; from the Pierson limestone of authors to *S. shepardii* Weller, 1914, from beds 5 and 6 of the Kinderhook at Burlington, Iowa, to *S. platynotus* Weller, 1914. References in the synonymy of *S. marionensis* from the so-called †Waverly beds should go either to *S. striatiformis* Meek, 1875, or to *S. centronatus*. They include the references of Winchell, 1870, and of Herrick, 1888 and 1895. Girty's identification, in 1899, of *S. marionensis* in the Madison limestone of Yellowstone Park should be put in the synonymy of *S. centronatus*, it would seem from an examination of the literature only. Nettleroth's identification, in 1889, is of a form said to occur in Devonian rocks, and the writer will not attempt a reference of it.

The foregoing shows the need of an even more comprehensive study of the lower Mississippian Spirifers than that given them by Stuart Weller.

Occurrence: Widely distributed and at all horizons in the limestone beds, clay partings, and the yellow-brown mudstones of the Louisiana limestone.

The writer has also collected this species from the Saverton shale. It has been questionably identified by R. C. Moore in beds referred to the Hannibal shale. Its reported occurrence by Stuart Weller in the fine-grained sandstones of the Kinderhook at Kinderhook, Ill., is also credited here, but the writer has not seen specimens from there. A form said to be *S. marionensis* has also been described by Lebedew⁷⁴ from the Carboniferous of Siberia, but the writer regards the identification as uncertain. This species was listed in 1900 by H. S. Williams from shales called the Chattanooga in Arkansas, but the identification may not conform to a modern interpretation of the species.

Subfamily SYRINGOTHYRINAE

Genus SYRINGOTHYRIS, Winchell, 1863

Syringothyris hannibalensis (Swallow)

Plate 8, figures 51-56

1860. *Spirifer* (*Cyrtia*?) *hannibalensis* Swallow, St. Louis Acad. Sci. Trans., vol. 1, p. 647.
1863. *Syringothyris halli* Winchell [part], Acad. Nat. Sci. Philadelphia Proc. for 1863, p. 7 (not specimens from Burlington, Iowa).
1890. *Syringothyris carteri* Schuchert [part], New York State Geologist Ninth Ann. Rept., p. 30.
1894. *Syringothyris carteri* Keyes [part], Missouri Geol. Survey, vol. 5, p. 87 (not pl. 40, fig. 10).
1895. *Syringothyris hannibalensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 25, figs. 33-35.
1898. *Syringothyris carteri* Weller [part], U. S. Geol. Survey Bull. 153, p. 619.

⁷⁴ Lebedew, Spiriferidae aus dem Karbon des Donetzbeckens und einiger anderer Gebiete von Russland: Deutsche geol. Gesell. Zeitschr., Band 81, Heft. 6, p. 258, 1929.

1908. *Syringothyris hannibalensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 82, pl. 18, figs. 6-9; p. 88, pl. 19, figs. 4-5.
1914. *Syringothyris hannibalensis* Weller, Illinois Geol. Survey Mon. 1, p. 388, pl. 68, figs. 1-7.

This species was formerly identified with *Syringothyris carteri* (Hall), 1857, a species which Weller⁷⁵ rejects on account of its being described from brachial valves "which do not show the specific or even the generic characters." A number of Mississippian forms now described as separate species were formerly placed in this species. Some of them are no doubt distinct species, but others vary greatly and apparently intergrade and if distinct, have few distinguishing characters. The characters that Weller⁷⁶ uses to distinguish them are mainly "in the pedicle valve and consist in the proportional height of the cardinal area, its degree of curvature, whether flat, concave, or convex, and especially in the size of the angle between the flatter portion of the area and the plane of the valve." He also considers the proportions of the delthyrium, length of the delthyrial plate, and the free extension of the syrinx to be important specific characters.

There is quite a variation in the above characters in specimens of *Syringothyris hannibalensis* from the Louisiana. Many specimens have essentially the proportions of Weller's specimen, but most specimens in collections studied are smaller. A modal specimen is 21 mm. long and 40 mm. wide. There is also a considerable variation in the heights of the cardinal areas, the specimen cited having a cardinal area 16.5 mm. high. A specimen 48 mm. wide and 27 mm. long has a cardinal area 18 mm. high. One 46 mm. wide and 28 mm. long has a cardinal area 15 mm. high. The angle between the cardinal area and the plane of the valve also differs in different specimens. Weller's revised description⁷⁷ states that the cardinal area slopes posteriorly at an angle of 60° to 65°. On a later page,⁷⁸ he says the cardinal area of *S. hannibalensis* has essentially the same slope as *S. newarkensis* Weller, 1914, which slopes anteriorly at an angle of about 60°. Most of the specimens in the collections studied have cardinal areas which slope anteriorly at 75° to 85° to the plane of the valve. On some specimens the angle is however, about 60°, and the slope is backward. In some specimens the delthyrial plate extends nearly to the base of the delthyrium; in others it extends only about half the distance from the top to the base. A pseudodeltidium covers most of the delthyrium of some specimens; others have only a small area near the top of the delthyrium covered; and others have no pseudodeltidium preserved. The lateral slopes of most of the

valves have fewer than 20 plications. Though the specific characters are variable *S. hannibalensis* seems to be distinct from other Mississippian species.

Punctate shell structure was not seen on any of the specimens examined, unless a number of elongate oval-shaped depressions which form a radial pattern on some young individuals are punctae. These depressions do not appear to penetrate the innermost shell layers, and they were not seen on any large individuals. They occur alike on the fold and sinus and on the plications and in the furrows. They are easily seen under a magnification of about 15 diameters.

The characteristic difference in ornamentation between the inner and outer parts of each half of the cardinal area is shown by a number of specimens. The lamellae of the syrinx curve toward each other but do not join. On some specimens they are widely separated and approach the condition shown in Frederick's proposed genus *Prosyringothyris*. On other specimens, they come almost together. These specimens suggest that Frederick's generic character is either variable or one that can be produced by incomplete preservation or growth. The syrinx is a large tube and occupies nearly the total width of the delthyrium on most specimens, but it varies in width.

The writer has collected many fragments that probably belong to this species, but complete specimens are rare. Most are brachial valves from the limestone beds. Nearly all are exfoliated. A specimen figured by Branson⁷⁹ as *S. hannibalensis* does not show a syrinx, but its absence is probably because of lack of preservation.

Occurrence: Limestone beds and yellow-brown calcareous mudstones of the Louisiana limestone at numerous collecting localities.

This species also occurs in the Saverton shale of Missouri. It has been included in the synonymy of *S. carteri* by Tolmatchoff,⁸⁰ who identified that species in the Lower Carboniferous of the Kousnetzko Coal Basin. The writer has not seen specimens from there. It or a closely related species occurs also in the so-called Sylamore sandstone of central Missouri.

Syringothyris newarkensis Weller

Plate 8, figures 57, 58

1914. *Syringothyris newarkensis* Weller, Illinois State Geol. Survey Mon. 1, p. 394, pl. 68, figs. 8-15.

The dimensions of three specimens are: Width 45.5, 44, and 35 mm., respectively; length 19, 19.5 and 21.5 mm.; height of cardinal area 20, 19.5, and 22 mm. The proportions of the first two are nearer *S. newarkensis* than *S. hannibalensis* (Swallow), 1860, and all of them have higher cardinal areas than is typical of *S. hannibalensis*; the cardinal areas slope anteriorly at angles ranging from 55° to 70°.

⁷⁵ Weller, Stuart, Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, p. 396, 1914.

⁷⁶ Weller, Stuart, Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, p. 386, 1914.

⁷⁷ Weller, Stuart, Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois Geol. Survey Mon. 1, p. 389, 1914.

⁷⁸ Idem, p. 395.

⁷⁹ Branson, E. B., The Devonian of Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 17, fig. 10, p. 105, 1923.

⁸⁰ Tolmatchoff, I. P., Faune du calcaire carbonifère du bassin houiller de Kousnetzko: Com. geol. [Russial], Matériaux pour la géologie générale et appliquée, livr. 25, pt. 2, p. 156, pl. 7, figs. 34-36, pl. 8, figs. 1, 2, 1924.

One specimen of this species was also collected from the Hannibal (?) beds. The lateral slope of one side of its pedicle valve rounds into the cardinal area but it is sharply differentiated from the cardinal area on the other side. This specimen has, however, been crushed so that one side of the shell is narrower and higher than the other side.

None of the specimens is well preserved, and the finer details of ornamentation and shell structure cannot be made out. The syrinx has been partly destroyed on the most complete specimen, and its characters are not fully known from any of them.

Although the writer is recognizing *S. newarkensis* as distinct from *S. hannibalensis* and in so doing is accepting the characters used by Weller as specific characters, he is not without doubt as to their validity. It may be found to be more satisfactory and hence less reactionary to return to broader specific concepts in this genus.

Occurrence: Limestone beds of the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo.; and locality 1022, about 6 miles west of Withers Mills, Marion County, Mo.

This species has been figured from the Chouteau limestone in Missouri and is listed by Moore from the Burlington and Hannibal formations. Weller gives its horizon as Kinderhook but does not state in what formations it occurs. The writer has seen only specimens from the Louisiana, the Chouteau, and the Hannibal (?).

Subfamily AMBOCOELIINAE

Genus AMBOCOELIA Hall, 1860

George⁸¹ has attempted to divide *Ambocoelia* into three genera—*Ambocoelia*, s. s., *Ambothyris* George, 1931, and *Crurithyris* George, 1931. His distinctions were made mainly on the character of the ornamentation, the interior structures of the dorsal valve, and the configuration of the shell. He transferred to *Crurithyris* a number of smooth or spinose American species that are said to differ from typical *Ambocoelia* in shape or in the character of the muscle scars and the structures in the posterior of the dorsal valve. George placed some species whose interiors were not well known in *Crurithyris*, because they had spinose ornamentation, and because he thought that in this subfamily spines are associated only with interiors differing from that of typical *Ambocoelia*. Dunbar and Condra⁸² have recently compared interiors of dorsal valves of a spinose species, *A. planoconvexa* (Shumard, 1855), with interiors of *A. umbonata* (Conrad, 1842), the type species of *Ambocoelia*, from the Hamilton group. Their comparison satisfied them that the dorsal interiors are, in all essential features, alike, and that forms with spinose ornamentation may have interiors like those

typical of *Ambocoelia*. However, their description indicates that the dorsal interiors of *A. planoconvexa* and *A. umbonata* are not identical but differ somewhat in the cardinal areas and muscle scars. These differences suggest that *A. planoconvexa* is in some respects gradational between *Ambocoelia* s. s. and *Crurithyris*.

The dorsal interiors of the two species here referred to *Ambocoelia* are not known. The ornamentation of well-preserved specimens is spinose, but, if Dunbar and Condra's observations are correct, the spinose ornamentation is not sufficient to justify the transfer of the species to *Crurithyris*, and they are left in *Ambocoelia*, at least temporarily. A redescription of *A. umbonata* and a more complete description of the dorsal interior, especially of the muscle scars, of *A. planoconvexa*, would aid in a better understanding of the relations of *Ambocoelia* and *Crurithyris*.

Ambocoelia louisianensis Williams, n. sp.

Plate 8, figures 7-12

Shell subplano-convex to concavo-convex, subelliptical to subcircular in outline, hinge line much shorter than the greatest width of the shell, greatest width near midlength. The dimensions of four individuals are respectively: Length of pedicle valve 1.7, 1.1, 0.79- and 0.6 mm.; width 1.9, 1.3, 0.9, and 0.6 mm.; thickness 0.68, 0.6, 0.25, and 0.33 mm.; length of hinge line 1.35, 0.75, 0.68, and 0.34 mm.; width of cardinal area 1.3, 0.6, 0.68, and 0.34 mm.; height of cardinal area 0.45, 0.23, 0.25, and 0.12 mm.

Pedicle valve wider than long, or length and width subequal, moderately convex, greatest height in front of beak, height of most pedicle valves about one-third the width; umbo raised but not prominent; beak distinct but not conspicuously differentiated from rest of shell, slightly, if at all incurved; cardinal area slightly concave or plane at approximately 90° to the plane of the valve, about one-third as high as wide, lateral margins poorly defined; delthyrium open or partly closed by deltidial plates, about four-fifths as high as wide; mesial sinus absent or in some individuals, poorly developed.

Brachial valve depressed convex, plane, or slightly convex in umbonal region and concave anteriorly; beak inconspicuous; mesial sinus not present or poorly defined near front of shell; cardinal area poorly defined, much wider than high; delthyrium open or partly closed by chilidial plates.⁸³

Surface partly or completely covered by minute spines.

Interior structures not observed.

Remarks: This species differs from *A. minuta*, also

⁸¹ George, T. N., *Ambocoelia* Hall and certain similar British Spiriferidae: Geol. Soc. London Quart. Jour., vol. 87, pt. 1, pp. 30-61, 1931.

⁸² Dunbar, C. O., and Condra, G. E., Brachiopoda of the Pennsylvanian system in Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 5, p. 347, 1932.

⁸³ It is here proposed to use the term "chilidial plates" to designate those plates which grow from the sides or the delthyrium of the dorsal valve toward the center, tending to close it. These plates are analogous to but probably not homologous in origin with the deltidial plates of the pedicle valve. The term is used in the same morphologic sense by Schuchert and Cooper (Peabody Mus. Nat. Hist., Mem., vol. 4, pt. 1, p. 7, 1932).

of the Louisiana limestone, in its greater width compared to length, its relatively shorter hinge line, its moderately convex pedicle valve and its less conspicuous pedicle beak, its lesser relative height of the pedicle valve, its average relatively wider delthyrium, and the absence of a sinus on most specimens. Spines are more abundantly preserved on most specimens of this species than on most specimens of *A. minuta*.

This form does not have all the typical generic characters of *Ambocoelia*, but the genus was described from larger individuals. Young specimens of this species can hardly be distinguished from young of *A. minuta*, and gradational forms from young to mature individuals of each are present in the Louisiana limestone. Gradational forms between mature individuals of the two species are not present in the collection.

Occurrence: Yellow-brown calcareous mudstones and clay partings in the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. The cotypes are from the yellow-brown mudstone.

Ambocoelia minuta White

Plate 8, figures 1-6

1862. *Ambocoelia* (*Spirifer*?) *minuta* White, Boston Soc. Nat. Hist. Proc., vol. 9, p. 26.
 1894. *Ambocoelia minuta* Keyes, Missouri Geol. Survey vol. 5, p. 90.
 1898. *Ambocoelia minuta* Weller, U. S. Geol. Survey Bull. 153, p. 81.
 1908. *Ambocoelia minuta* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 85, pl. 18, figs. 21-24.
 1914. *Ambocoelia minuta* Weller, Illinois Geol. Survey Mon. 1, p. 423, pl. 77, figs. 44-54.
 1915. *Ambocoelia minuta* Girty, U. S. Geol. Survey Bull. 598, p. 40.

This species has been described by several investigators. It is common in the Louisiana limestone. Mature individuals may be distinguished from most other small brachiopods in the formation by their high pedicle valves with prominent umbonal regions, obtuse, elevated pedicle beaks, high cardinal areas, narrow groove-like sinuses, and open delthyria that include parts of both valves. In some specimens, however, the delthyria are partly closed by deltidial plates. The characters that distinguish this species from *A. louisianensis* are given in the remarks on that species. Young specimens of *A. minuta* have pedicle valves that are relatively less convex than the pedicle valves of mature individuals. Most of them also have relatively shorter hinge lines and smaller height-width ratios. Their width-length ratios are larger, the sinuses of their pedicle valves less well developed, the beaks of the pedicle valves less prominent and less incurved, and their ornamentation more spinose. The measurements of a large individual, a modal individual, and two small individuals, one a grade toward *A. louisianensis*, from the writer's collections are, respectively, as follows: Length of pedicle valve

2.1, 1.35, 0.9, and 1.0 mm.; length of brachial valve 2.0, 1.2, 0.9, and 1.13 mm.; greatest width 2.25, 1.25, 0.9 and 1.15 mm.; thickness 1.6, 0.9, 0.5, and 0.45 mm.; length of hinge line 1.95, 0.9, 0.7, and 0.9 mm.; width of cardinal area 1.9, 0.9, 0.7, and 0.9 mm.; height of cardinal area 0.6, 0.45, 0.25, and 0.3 mm.

The cardinal area of the brachial valve is longer compared to its height than that of the pedicle. The delthyrium on the brachial valve is open or partly closed by chilidial plates.

Closely related species are *A. levicula* Rowley, 1910, described from the Burlington limestone, and *A. parva* Weller, 1899, from the Northview shale. The latter is said by Weller to differ from *A. minuta* in its larger size, shell configuration, and absence of fine surface spines. The same features distinguish *A. levicula* from *A. minuta*, but *A. levicula* is also said to be proportionately wider and to have a fainter mesial sinus than *A. parva*. The interior features of the brachial valve of *A. levicula* differ from those of typical *Ambocoelia* so much that George has referred it to his genus *Crurithyris*. The interior of the brachial valve of *A. minuta* is not known.

Occurrence: Yellow-brown calcareous mudstone and clay partings of the Louisiana limestone at locality 599, 1 mile south of Louisiana; at locality 728, 3 miles northwest of Ely; and at Louisiana and Clarksville, Mo. This species has also been described from the St. Joe member of the Boone limestone of Arkansas by Girty. The writer has not seen Girty's specimen.

Family SPIRIFERINIDAE

Subfamily CYRTININAE

Genus CYRTINA Davidson, 1858

Cyrtina acutirostris Shumard

Plate 7, figures 23-35

1855. *Cyrtina acutirostris* Shumard, Missouri Geol. Survey First and Second Ann. Repts., p. 204, pl. C, figs. 3a-c.
 1894. *Cyrtina acutirostris* Hall and Clarke, New York State Geologist Thirteenth Ann. Rept., vol. 2, pl. 29, fig. 18.
 1894. *Cyrtina acutirostris* Keyes, Missouri Geol. Survey, vol. 5, p. 89, pl. 39, figs. 10a-b.
 1895. *Cyrtina acutirostris* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 28, figs. 38-42, 44, 54.
 1898. *Cyrtina acutirostris* Weller, U. S. Geol. Survey Bull. 153, p. 208.
 1908. *Cyrtina acutirostris* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 84, pl. 18, figs. 16-20; p. 87, pl. 19, fig. 2.
 1914. *Cyrtina acutirostris* Weller, Illinois Geol. Survey Mon. 1, p. 286, pl. 35, figs. 6-21.

This species is easily recognized among the Louisiana brachiopods by the large plications on either side of the fold and sinus, with much smaller plications on the sides. Small individuals representing several distinct growth stages are present in the formation. The smallest specimen obtained is 2 mm. wide and 1.1 mm. long. Young specimens are smooth and have folds and sinuses

that do not reach the beaks. Deltidial plates are either not present or not preserved, and the dental plates and angular ridge at their junction on first examination resemble the ridge posterior to the syrx on the delthyrial plate of *Syringothyris*. Sections of these young individuals show, however, that the angular ridge is a median ventral septum united with converging dental plates, a typical arrangement in *Cyrtina*.

The synonymy as here given does not include two references that have been made to the species. The figure given of the specimen from the so-called Waverly of Ohio by Herrick⁸⁴ does not show the characters of *C. acutirostris*. A reference by Weller⁸⁵ of an incomplete brachial valve to this species was made tentatively; although the writer is unable to definitely assign it at present, it probably does not belong in *C. acutirostris*.

If the proposed genus *Davidsonina* Schuchert and LaVene, 1929 (*Davidsonella* of Fredericks, 1926) is a valid genus, *C. acutirostris* may be found to belong in it. Although the writer is not fully acquainted with *Davidsonina*, he believes the reference to *Cyrtina* is the better one because the plications of the exterior affect the interior of most specimens, a feature seen on *Cyrtina* but not on *Davidsonina*.

Occurrence: Yellow-brown calcareous mudstone, clay partings, and limestone beds of the Louisiana at many collecting localities.

This species also occurs in the Saverton shale in Missouri, and it or a closely related form occurs in the so-called Sylamore sandstone of central Missouri. Moore lists it from bed 5 at Burlington, and it was listed by Williams in 1900 from so-called Chattanooga beds in Arkansas. The writer has seen only specimens from the Louisiana and Saverton and so-called Sylamore formations.

Superfamily ROSTROSPIRACEA

Family MERISTELLIDAE

Subfamily NUCLEOSPIRINAE

Genus NUCLEOSPIRA Hall 1859

Nucleospira rowleyi Weller

Plate 8, figures 13-20

1901. *Nucleospira barrisi* Rowley [not White], Am. Geologist, vol. 27, p. 350, pl. 28, figs. 46-48.
 1908. *Nucleospira barrisi* Rowley [not White], Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 85, pl. 18, figs. 25-27.
 1914. *Nucleospira rowleyi* Weller, Illinois Geol. Survey Mon. 1, p. 454, pl. 82, figs. 43-48.

This is a rare form in the Louisiana. It may be distinguished from other small brachiopods in the formation by the nearly equal convexity of the valves, the absence of plications, its subcircular to subelliptical

outline, average subequal length and width, relatively short hinge line, short slightly incurved pedicle beak, well-defined small, relatively low concave cardinal area and relatively small delthyrium of the pedicle valve with no corresponding opening on the dorsal valve, and poorly defined sinuses on pedicle and brachial valves. The pseudodeltidia and details of the delthyria cannot be made out on the cotypes. The spiralia have not been observed by the writer. The dimensions of two of the cotypes are: Length 1.4 and 1.4 mm., width 1.2 and 1.4 mm.

A number of lower Mississippian species of this genus are so closely related that there appears from the literature little more than difference in size and outline to distinguish them. Among these, in addition to *N. rowleyi*, are *N. barrisi* White, 1860, from the Kinderhook at Burlington, Iowa; *N. minima* Weller, 1906, from the Glen Park limestone member of the Sulphur Springs; and *N. obesa* Rowley, 1900, from the Burlington limestone. *N. barrisi*, however, is said to differ from the other species in having a deeper sinus and a more prominent fold near the front of the shell.

Occurrence: Partings in the Louisiana limestone at Louisiana and Clarksville, Mo., and yellow-brown mudstone and partings at locality 599, 1 mile south of Louisiana.

Family ATHYRIDAE

Subfamily ATHYRINAE

Genus ATHYRIS McCoy 1844

Athyris hannibalensis (Swallow)

Plate 8, figures 21-24

1860. *Spirigera hannibalensis* Swallow, St. Louis Acad. Sci. Trans., vol. 1, p. 649.
 1865. *Spirigera hannibalensis* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 118.
 1893. *Athyris hannibalensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 90, pl. 46, figs. 13-15. (Advance distribution in fascicles.)
 1894. *Athyris hannibalensis* Keyes, Missouri Geol. Survey, vol. 5, p. 91, pl. 41, fig. 9.
 1895. *Athyris hannibalensis* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 46, figs. 13-15.
 1898. *Athyris hannibalensis* Weller, U. S. Geol. Survey Bull. 153, p. 102.
 1908. *Athyris hannibalensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 86, pl. 18, figs. 28-30.
 1914. *Athyris hannibalensis* Weller, Illinois Geol. Survey Mon. 1, p. 467, pl. 78, figs. 10-14.
 1915. *Athyris hannibalensis* Girty, U. S. Geol. Survey Bull. 598, p. 40.
 1915. *Athyris hannibalensis* Butts, Kentucky Geol. Survey, ser. 4, vol. 3, pt. 2, pl. 49, figs. 13, 14.
 1917. *Athyris hannibalensis* Butts, idem, Mississippian series in western Kentucky, pl. 4, figs. 13, 14.
 1931. *Athyris hannibalensis* J. M. Weller, idem., Paleontology of Kentucky, p. 268, pl. 33, fig. 10.

This species is closely related to *A. lamellosa* (L'Éveillé, 1835), but typical specimens of *A. hannibalensis* are smaller, have a greater length-width ratio and a more subcircular outline, and have the concen-

⁸⁴ Herrick, C. L., Geology of Licking County, Part IV: Denison Univ., Sci. Lab., Bull., vol. 4, pl. 11, figs. 20a-c, 1888.

⁸⁵ Weller, Stuart, Kinderhook faunal studies, III. The faunas of beds 3 to 7 at Burlington, Iowa: St. Louis Acad. Sci., Trans., vol. 11, No. 9, p. 167, pl. 14, fig. 5, 1901.

tric lamellae closer together. However, it is possible that the assembling of a large number of individuals would furnish many gradational forms between the two species and prove them to be the same. Some specimens from the Fern Glen formation that have been referred to *A. lamellosa* cannot be distinguished from specimens of *A. hannibalensis* from the Louisiana. A specimen that is a grade between the two species is 18 mm. long and 24 mm. wide.

Weller's identification⁸⁶ of this species in the Chouteau in 1895 was probably in error, as he does not include it in his synonymy in 1914. A reference to Winchell's description⁸⁷ in 1870 is not included in the synonymy because his description suggests a larger species.

Occurrence: Yellow-brown, calcareous mudstone, clay partings, and limestone beds of the Louisiana at locality 593, Louisiana, Mo.; locality 599, 1 mile south of Louisiana; and locality 617, Clarksville, Mo.

This species has been reported from a formation of Kinderhook age at Sulphur Springs, Mo., but recent collectors have not reported it from that region. It has been described from the St. Joe limestone member of the Boone formation of Arkansas and the New Providence shale of Kentucky and occurs in the Saverton shale in Missouri. Williams in 1900 listed it from a so-called Chattanooga shale in Arkansas. The writer has seen only specimens from the Louisiana and Saverton formations.

***Athyris lamellosa* (L'Éveillé)**

Plate 8, figure 25

1835. *Spirifer lamellosa* L'Éveillé, Soc. géol. France Mém., t. 2, p. 39, figs. 21-23.
 1861. *Athyris intervarica* McChesney, Description new species of fossils, etc., p. 78.
 1861. *Athyris ultravarica* McChesney, idem, p. 79.
 1875. *Athyris lamellosa?* Meek, Paleontology of Ohio, vol. 2, p. 283, pl. 14, figs. 6a, b.
 1888. *Athyris lamellosa* Herrick, Denison Univ. Bull., vol. 3, p. 49, pl. 2, fig. 7.
 1888. *Athyris ashlandensis* Herrick, idem, vol. 4, p. 24, pl. 3, fig. 6.
 1893. *Athyris lamellosa* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 90, pl. 46, figs. 16-20. (Advanced distribution in fascicles.)
 1894. *Athyris incrassatus* Keyes, Missouri Geol. Survey, vol. 5, p. 91, pl. 41, fig. 10.
 1895. *Athyris ashlandensis* Herrick, Ohio Geol. Survey, vol. 7, pl. 23, fig. 10.
 1895. *Athyris lamellosa* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 46, figs. 16-20.
 1899. *Athyris lamellosa* Weller, St. Louis Acad. Sci. Trans., vol. 9, p. 21, pl. 4, fig. 8.
 1901. *Athyris lamellosa* Weller, Jour. Geology, vol. 9, pp. 141, 146.
 1909. *Athyris lamellosa* Weller, Geol. Soc. America Bull., vol. 20, p. 312, pl. 14, figs. 5, 6.

⁸⁶ Weller, Stuart, A circum-insular Palaeozoic fauna: Jour. Geology, vol. 3, p. 911, 1895.

⁸⁷ Winchell, A., notices and descriptions of fossils from the Marshall group of the western States with notes on fossils from other formations: Am. Philos. Soc. Proc., vol. 11, p. 253, 1870.

1914. *Athyris lamellosa* Weller, Illinois State Geol. Survey Mon. 1, p. 465, pl. 78, figs. 1-5, 15-20.
 1915. *Athyris lamellosa* Girty, U. S. Geol. Survey Bull. 598, p. 19.
 1925. *Athyris lamellosa* Thomas, Iowa Geol. Survey, vol. 30, pl. 4, fig. 21.
 1926. *Athyris lamellosa* Butts, Alabama Geol. Survey, Special Rept. 14, p. 170, pl. 54, figs. 17-18.

One specimen from the Louisiana has the characters of this species. Its dimensions are: Length 22.5 mm., greatest width 32 mm., average distance between concentric lamellae 2.5 mm. Some concentric lamellae are 3 mm. apart.

The form identified by Girty in 1899 from the Madison limestone has been found by him to belong in *Cliothyridina incrassata* (Hall, 1858).

Occurrence: Parting between beds of Louisiana limestone at locality 593, Town Branch, Louisiana, Mo.

This species is widespread in lower Mississippian formations. The writer has examined specimens from the Louisiana and Fern Glen formations.

Subfamily CAMAROPHORELLINAE

Genus CAMAROPHORELLA Hall and Clarke 1893

***Camarophorella buckleyi* (Rowley)**

Plate 7, figures 21, 22

1865. *Spirigera missouriensis* Winchell [not Swallow], Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 117.
 1898. *Athyris missouriensis* Weller [not Swallow], U. S. Geol. Survey Bull. 153, p. 103.
 1908. *Seminula buckleyi* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 79, pl. 17, figs. 48-53.
 1914. *Camarophorella missouriensis* Weller, Illinois Geol. Survey Mon. 1, p. 460, pl. 82, figs. 70-79.

This is a rare form in the Louisiana limestone. The internal characters, without which the generic reference cannot be definitely made, do not show on the specimens examined by the writer, and because only two specimens were available no sections were made. The dimensions of the specimen figured as figures 21 and 22 of plate 7, Rowley's holotype, are: Length 14.5 mm., width 13 mm., thickness 8.8 mm.

This species was described as *Spirigera missouriensis* by Winchell. This name was however a homonym, as Swallow had described a species by that name in 1860. Rowley described *Seminula buckleyi* in 1908, as a new species. Weller found it to be the same as Winchell's form, but as Winchell's species name was eliminated as soon as proposed because it is a homonym, the species name *buckleyi* was valid and is here substituted.

Occurrence: Yellow-brown calcareous mudstones and limestone beds of the Louisiana limestone at locality 593, Town Branch, Louisiana; locality 600, Eighth street quarry, Louisiana; and at locality 599, mouth of Buffalo Creek, 1 mile south of Louisiana, Mo.

This species was identified by Winchell also in the unit which he called the Marshall group of Ohio. Aside from this, it is limited to the Louisiana limestone. The writer has seen only specimens from the Louisiana.

Superfamily TEREBRATULACEA

Family CENTRONELLIDAE

Genus SELENELLA Hall and Clarke, 1893

Selenella pediculus (Rowley)

Plate 7, figures 40-46

1901. *Dielasma? pediculus* Rowley, Am. Geologist, vol. 27, p. 350, pl. 28, figs. 43-45.
 1908. *Dielasma? pediculus* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 80, pl. 17, figs. 57-59.
 1914. *Selenella pediculus* Weller [figured as *Trigeria? pediculus*], Illinois Geol. Survey Mon. 1, p. 244, pl. 30, figs. 34-39.

This species resembles *Allorhynchus louisianensis* (Weller, 1914) also of the Louisiana limestone, but does not have the subcarinate pedicle valve or the fold and sinus of that form. There is quite a variation among the individuals of *Selenella pediculus* in the Louisiana. A very small individual is 0.25 mm. long and 0.2 mm wide. The dimensions of four other individuals are respectively: Length 0.55, 1.5, 2, and 3.2 mm.; width 0.4, 1.3, 1.2, and 2.4 mm. Some individuals are nearly flat; others are very convex. Growth lines are absent on most specimens. A few specimens have what appear to be very faint radial striae, but their exact nature is unknown, and they may be secondary. No specimen in the collections examined has the brachidium preserved, but Weller has observed it on one specimen in his collection. The shell structure should be punctate but no specimen examined by the writer shows punctation.

A closely related species, *Selenella? subcircularis* Girty, 1926, occurs in limestone of Boone age at San Saba, Texas. Like that of *S. pediculus*, its generic reference is insecure. It is said to be somewhat broader than *S. pediculus* and to have the widest part somewhat farther forward.

Occurrence: Yellow-brown calcareous mudstones, clay partings, and limestone beds of the Louisiana limestone at locality 593, Town Branch, Louisiana; at locality 599, along Buffalo Creek, 1 mile south of Louisiana; at locality 728, 3 miles northwest of Ely; and at locality 552, about 8 miles north of Monroe City, Mo. This species was collected only from the Louisiana.

Unidentifiable brachiopods

A number of brachiopods that are not specifically identifiable have been collected from the Louisiana. Moore⁸⁸ lists undetermined species of *Dielasma* and *Spirifer*, and the writer has specimens that may possibly belong to two other genera.

MOLLUSCA

Class PELECYPODA

The pelecypods of the Louisiana limestone, like those of many other Carboniferous formations, are mainly internal molds. Many of the characters con-

sidered of generic and specific value, such as details of the hinge structure, ornamentation, musculature, and even true configuration, can be ascertained with confidence from but few specimens preserved in this manner. Because many Paleozoic species, known mainly from internal molds, have been placed in genera that extend into much younger rocks, many of the generic, sub-generic, and specific units in use in the Paleozoic are in dispute or are poorly understood. Some of the uncertainties will no doubt be removed when revisional studies that have been undertaken by various paleontologists are completed.

Order PRIONODESMACEA

Family GRAMMYSIIDAE

Genus GRAMMYSIA de Verneuil, 1847

Grammysia hannibalensis (Shumard)

Plate 9, figures 41-44

1855. *Allorisma hannibalensis* Shumard, Missouri Geol. Survey First and Second Ann. Repts., pt. 2, p. 206, pl. C, fig. 19.
 1865. *Sanquinolites hannibalensis* Winchell, Acad. Nat. Sci. Philadelphia Proc., p. 128.
 1870. *Allorisma (Sedgwickia) hannibalensis* Winchell, Am. Philos. Soc. Proc., vol. 11, p. 256.
 1870. *Grammysia hannibalensis* Hall, Preliminary notice of lamellibranch shells, p. 62.
 1875. *Grammysia? hannibalensis* Meek, Ohio Geol. Survey, Paleontology, vol. 2, p. 300, pl. 16, figs. 5 a-c.
 1884. *Grammysia hannibalensis* Walcott, U. S. Geol. Survey Mon. 8, p. 244, pl. 20, fig. 4.
 1885. *Grammysia hannibalensis* Hall, Paleontology of New York, vol. 5, pt. 1, p. 381, pl. 61, figs. 29, 30, 33.
 1886. *Grammysia hannibalensis* Claypole, Wyoming Hist. and Geol. Soc. Proc. vol. 2, pt. 2, p. 248.
 1888. *Grammysia hannibalensis* Herrick, Denison Univ., Sci. Lab., Bull. vol. 3, p. 75, pl. 4, fig. 13.
 1888. *Grammysia? hannibalensis* Herrick, idem, vol. 4, pl. 6, fig. 11.
 1889. *Grammysia hannibalensis* Miller, North American Index Fossils, p. 483, fig. 831.
 1894. *Allorisma hannibalensis* Keyes, Missouri Geol. Survey, vol. 5, p. 127.
 1895. *Grammysia? hannibalensis* Herrick, Ohio Geol. Survey, vol. 7, pl. 17, fig. 11.
 1898. *Grammysia hannibalensis* Weller, U. S. Geol. Survey, Bull. 153, p. 297.
 1908. *Grammysia hannibalensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 94, pl. 19, figs. 3, 6.
 1909. *Grammysia hannibalensis* Grabau and Shimer, North American index fossils, vol. 1, p. 383.
 1931. *Grammysia hannibalensis* Williams, Missouri Bur. Geology and Mines Biennial Rept. State Geologist for 1929-30, app. 2, p. 134, pl. 1, figs. 1-4.

The original description of this species is short and does not adequately describe many important characters. The species was more fully described by Meek in 1875, but his description was not based on specimens from the type formation or locality. The specimens in the writer's collections are from the type formation. They correspond satisfactorily to most of Meek's description, but one of the Louisiana limestone specimens

⁸⁸ Moore, R. C., Early Mississippian formations in Missouri. Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 46, 1928.

has a definite sulcus, the other has a definite suggestion of one, and neither has any indication of a posterior gape.

Williams and Breger⁸⁹ have sought to eliminate the genus *Grammysia* from the Carboniferous. They would refer all those species from Carboniferous rocks that were formerly included in *Grammysia* to other genera because they "are not only without the radial and sulcus or any strictly corresponding structure, but most of the species are gaping posteriorly." As an example of a Carboniferous species that is gaping posteriorly they cite *G. hannibalensis* as figured by S. A. Miller in 1889.

From an examination of the literature alone, one might be inclined to agree with Williams and Breger. An examination of specimens, however, casts doubt on their conclusions.

The types of *Grammysia hannibalensis* are from the Louisiana limestone at Hannibal, Mo. They were in the Shumard collection, at the University of Missouri and probably were destroyed by fire. The specimens here described are from the type formation but from a different locality.

One of these specimens has a very distinct sulcus, and the other has a sulcus clearly indicated. Neither has a fold associated with the sulcus, as does the type species of the genus, but the fold on a number of species of *Grammysia* is inconspicuous and indistinguishable from the slope of the valve. The general practice has been to include all species otherwise agreeing with *Grammysia* in that genus if they have a distinct sulcus. The fold is such a variable character that it seems reasonable to allow a certain degree of variation within the genus, as has been the custom. Certainly the specimens here figured are sufficient to prove that a sulcus does occur in Carboniferous forms.

The two specimens here figured are not sufficiently well preserved to enable one to determine whether they gape posteriorly or not. The more complete specimen has one valve almost fully preserved. There is no indication in the configuration of the posterior end of the valve that it was gaping, but the associated valve is not preserved, and the junction with it is not therefore observable. The posterior margin seemed to be in the same plane from above to below. Such circumstances do not of course preclude a gaping posterior margin, because a number of gaping forms have little indication of it in the configuration of the posterior part of the valve or in the deviation of parts of the posterior margin from the plane in which the parts above and below rest. They do, however, favor more the hypothesis that there was no gape than one that presupposes a gape. The less complete specimen has an entire, closely appressed anterior margin, but the posterior part of the specimen is broken.

Of the forms figured in the literature as *G. hannibalensis*, only one appears to have a gape in the posterior margin. The specimen was figured by Meek in 1875 from the so-called Waverly sandstone of Medina, Ohio. The only view that shows anything that might be interpreted as a gape is a view of the hinge line, and from it one cannot definitely determine whether the apparent gape was actually a gape or a filling of material in a break in the shell. Meek,⁹⁰ himself, appears not to have been sure, for in his description he says "apparently sometimes a little gaping." Meek's figure has been copied by several authors, and Williams and Breger cite a copy of it as proof that *G. hannibalensis* was a gaping form.

The writer was not able to secure specimens from Medina, Ohio, the place that yielded Meek's figured form, but he was able to examine specimens from the same rocks, the so-called Waverly group, from Cuyahoga Falls. Meek, in the same article in which he described the figured form here discussed, also recognized *G. hannibalensis* from Cuyahoga Falls, which, incidentally, is only about 20 miles east of Medina and where the same beds as at Medina are exposed. Three internal molds from Cuyahoga Falls had the posterior part of the shell well enough preserved to show that there was no gape. No other internal mold had the posterior fully preserved. It may be that compression of these specimens has forced the posterior margins together, but there was no evidence that it had. On the whole, it seems more logical that the forms were not gaping and that the gaping appearance of Meek's figured form was because it was not fully preserved, or because it had been deformed.

None of the specimens from Cuyahoga Falls had the pallial line visible and none of them had distinct sulci extending from the beak to the lower margins, but a few had definite indications of them.

From the above discussion it will be seen that there are forms from the Carboniferous referred to *G. hannibalensis* that have definite sulci and that no form referred to this species is known definitely to have been gaping. Some specimens, however, were almost surely not gaping. In view of these facts, it seems that *G. hannibalensis* is at least one exception to Williams and Breger's statement that *Grammysia* does not occur in the Carboniferous. The above conclusion of course rests on the interpretation of *Grammysia* as it has been generally interpreted and with variations that have been generally included in it, and on the specific identity of the †Waverly form with the Louisiana form. Careful and comprehensive revisional studies may show either of these premises to be insecure.

The writer has seen specimens from but a few of the localities represented by references in the synonymy of

⁸⁹ Williams, H. S., and Breger, C. L., The fauna of the Chapman sandstone of Maine: U. S. Geol. Survey Prof. Paper 89, p. 133, 1916.

⁹⁰ Meek, F. B., A report on some of the invertebrate fossils of the Waverly group and Coal Measures of Ohio: Ohio Geol. Survey, vol. 2, pt. 2, Paleontology, p. 300, 1875.

this species. He has not seen specimens from localities mentioned in the reference by Winchell in 1865 from Michigan, that of Claypole in 1886 from Pennsylvania, and that of Walcott from Nevada, and has seen specimens from only one Ohio locality. Inasmuch as the Carboniferous forms referred to *Grammysia* are so much in need of comparative study, and the specific characters so much in doubt, it has seemed best to retain all entries in the synonymy pending further study. One result of such a study will probably be to transfer the references from the "yellow sandstone" at Burlington, Iowa, to *G. plena* Hall. Another will no doubt be the elimination of Claypole's reference from this synonymy.

Occurrence: Both of the identifiable specimens came from the limestone beds of the Louisiana. One is from locality 634, near Saverton, Ralls County, Mo., and the other is from Louisiana, Mo. Professor Rowley's specimens also came from Louisiana.

This species is rather widely distributed in Mississippian formations in the United States. The writer has examined specimens only from the Louisiana and from the so-called †Waverly. The latter are but tentatively identified.

Superfamily NUCULACEA

Family NUCULIDAE

Genus NUCULA Lamarck, 1801⁹¹

Subgenus PALAEONUCULA Quenstedt, 1930

Nucula (*Palaeonucula*) *krugeri* Williams

Plate 9, figures 17, 18.

1931. *Nucula krugeri* Williams, Missouri Bur. Geology and Mines Bienn. Rept. State Geologist for 1929-30, app. 2, p. 135, pl. 1, figs. 14, 15.

Shell small, subquadrate to subcircular in outline, depressed convex. The dimensions of two of the cotypes are: Length 17.5 and 17 mm., height 15.5 and 14 mm., distance of beaks from posterior 9 and 8.5 mm.; thickness approximately 3 mm. Another specimen is more convex but is apparently distorted. Beaks inconspicuous, projecting slightly above the hinge line, posteriorly directed, situated about midway between anterior and posterior margins.

Anterior margin truncate, forming a straight line from anterior dorsal margin, which it joins at an angle of approximately 95°, to ventral margin; ventral margin gently rounded to almost straight, merging into the rounded posterior margin; posterior margin gently rounded to posterior dorsal margin, which intersects it about one-fifth the distance from beak to ventral margin; anterior dorsal margin slightly convex; posterior dorsal margin concave.

⁹¹ Since this report was submitted for publication, several papers treating of *Nucula* and related genera have appeared. One of these (Schenck, H. G., Classification of nuculid pelecypods; Musée royal d'histoire naturelle de Belgique Bull., tome 10, No. 20, 1934) gives a tentative subdivision of the family Nuculidae and treats of Paleozoic species commonly referred to *Nucula*. Schenck (p. 33) states that he has seen no Paleozoic species that is closely related to *Nucula*, s. s. Most Paleozoic species commonly referred to *Nucula* would be referred by Schenck to *Nuculopsis*.

Valves gently convex, greatest convexity about one-third the distance from dorsal to ventral margin. Umbones flattened, posterior umbonal slope terminating dorsally in a ridge, which is concave dorsally; anterior umbonal slope with a discernible, but only slightly developed ridge, which is straight and follows the anterior dorsal outline of the shell, intersecting anterior margin one-fifth the distance from beak to lower margin. No lunule. Escutcheon poorly defined. Posterior and anterior umbonal ridges diverging at an angle of 130°. A flattened area extends from beak to anterior margin and is delimited ventroposteriorly by the slight anterior umbonal ridge.

Surface marked by fine indistinct concentric lines of growth. Pallial line and muscle scars not preserved. Hinge taxodont. Teeth preserved on only one specimen. In this specimen there are three teeth posterior to the beak and nine teeth anterior to the beak. Teeth beneath beak and for a short distance on either side are not preserved. The specimens are all internal molds.

Remarks: This species may be distinguished from most other Mississippian species referred to *Nucula* by its subquadrate outline, truncate anterior margin, and the flat area extending from the beak to the anterior margin. The dentition immediately beneath the beaks is not preserved, and a chondrophore could not be made out. The species is placed in *Nucula* mainly on the basis of taxodont dentition and somewhat on its general form, though it varies from the shape of typical *Nuculas*. The anterior umbonal ridge is not found on most *Nuculas*, but the specimens on which this species is based are internal molds and the preservation may accentuate the ridge.

Much confusion has for sometime existed regarding the orientation of shells referred to *Nucula*. Following the usage of Hall and Clarke,⁹² the writer described the three valves here considered as right valves. It has been shown, however, by Quenstedt⁹³ that Recent and other *Nuculas* have their beaks directed posteriorly, and that, in at least the forms he examined, the short side is posterior. Although there are some examples of orthogyrate or slightly prosogyrate fossil *Nuculas*, most of them are, like the Recent ones, opisthogyrate. The description has, therefore, been changed to conform to the usage of Quenstedt and of other workers who have for sometime maintained a like position.

The configuration of this species is quite different from that of typical *Nucula* and in many respects is similar to *Cypricardella*. Features more suggestive of the latter than the former are the truncate margin which, however, on *Cypricardella* is the posterior

⁹² Hall, James, and Clarke, J. M., Paleontology of New York, pl. 44, figs. 1-6, etc., 1885.

⁹³ Quenstedt, Werner, Die Anpassung an die grabende Lebensweise in der Geschichte der Selenonyiden und Nuculaceen: Geol. and Paleont. Abh., neue Folge, Band 18, Hef. 1, pp. 43, 112, taf. 2, figs. 8-11, 1930.

margin, the subquadrate outline, and the umbonal ridge. The taxodont dentition, however, definitely removes these specimens from *Cypricardella*.

Williams and Breger⁹⁴ have attempted to distinguish most of the Paleozoic shells formerly classified as *Nuculas* from the Tertiary and Recent shells referred to that genus by their lack of a denticulate ventral margin. They would place the Paleozoic forms lacking such a margin in a new subgenus erected by them and named *Nuculoidea*. Girty⁹⁵ has consulted conchologists who have worked with Recent forms and they have informed him "that this character is absent in many living species also: that in some species it is present or absent at different stages of growth, and that it is regarded by conchologists as a group character but no more."

Quenstedt⁹⁶ appears to be in essential agreement with those conchologists consulted by Girty, because he includes in typical *Nucula* forms with denticulate margins as well as forms with smooth margins. He reduces Williams and Breger's *Nuculoidea* to the rank of a section. In interpreting *Nuculoidea*, he emphasizes the curvature of the beak more than the smooth ventral margin. Quenstedt, himself, proposes to divide *Nucula* into two subgenera: *Nucula*, s. s., to which he attributes a range from Jurassic to present, and *Palaeonucula*, which he says ranges from Devonian to Jurassic. He distinguishes his two subgenera by differences in the direction and configuration of the ligament groove (chondrophore?) and structures immediately surrounding it, and in the direction of the beaks, the degree of curvature of the anterior row of teeth and also of the ventral margin, and the presence of a delimited area posterior to the beaks. He would also limit Paleozoic forms of *Nucula* to forms with smooth ventral anterior margins, but does not say where he would put the Paleozoic forms that have crenulated margins and are now included in *Nucula*. Although many of the characters by which the distinction between his two subgenera are made are not preserved on the specimens in hand, those characters that are preserved agree with Quenstedt's subgenus *Palaeonucula*. The writer is therefore tentatively adopting it here.

Few species of *Nucula* have the configuration of this one. Two that approach it are *N. insularis* Walcott, 1884, from the Mississippian of the Eureka district, Nevada, and the form figured by Hall and Clarke⁹⁷ in 1885 as *Nucula bellistriata* (Conrad 1841) from the Hamilton of New York. The latter form does not have the abruptly truncate anterior margin of *N.*

krugeri and is not said to have a distinct umbonal ridge. It also has a shorter posterior dorsal margin. *N. insularis* also appears from its figure to have a shorter posterior dorsal margin, and its beaks are relatively nearer the posterior margin.

The species is rare in the Louisiana limestone, only 3 specimens having been collected. All are molds of left valves. It is named for Fred Kruger, who collected one of the cotypes.

Occurrence: Three specimens from the yellow-brown calcareous mudstones at locality 634, Ralls County, Mo.

Family LEDIDAE

Genus PALAEONEILO Hall, 1870

Palaeoneilo ignota Herrick

Plate 9, figure 15

1888. *Palaeoneilo ignota* Herrick, Denison Univ., Sci. Lab., Bull., vol. 4, p. 44, pl. 4, fig. 15.
 1889. *Palaeoneilo ignota* Herrick, Am. Geologist, vol. 3, pl. 2, fig. 15.
 1895. *Palaeoneilo ignota* Herrick, Ohio Geol. Survey, vol. 7, pl. 16, fig. 15.
 1898. *Palaeoneilo ignota* Weller, U. S. Geol. Survey Bull. 153, p. 407.
 1931. *Palaeoneilo ignota* Williams, Missouri Bur. Geology and Mines, Bienn. Rept. State Geologist for 1929-30, app. 2, p. 136, pl. 1, fig. 15.

Herrick's original description is as follows:

Shell of medium size, moderately convex, rather thick, height two-thirds the length, the greatest height a little posterior to the beaks which are one-third the distance from the front, basal margin semi-elliptical, terminating before and behind at nearly one-half the height; anterior margin sub-parabolic; posterior outline rather acutely terminating at about one-third the height from the somewhat oblique hinge; posterior projection compressed; surface most ventricose near the middle, marked only by very fine, numerous crowded concentric striae. Hinge with five moderate teeth in front and fifteen or more very fine denticles behind which diminish toward the beak. * * * Length, 14 mm., height, 9 mm.

Remarks: Three specimens in the collection of the University of Missouri belong to this species. One of them is 17.5 mm. long and 12 mm. high; another, a small individual, is 11 mm. long and 9 mm. high. The dentition beneath the beak is not preserved in any of the specimens, there is no sinus below the posterior umbonal slope, and the generic reference is therefore uncertain. However, the arrangement of teeth on either side of the beak and the general form of the shell suggest that this species belongs to *Palaeoneilo*.

On one specimen there are 3 anterior teeth and 11 posterior teeth, but there is an area on each side of the beak in which no teeth are preserved. Another specimen has 3 anterior and 9 posterior teeth, but this specimen also has an area in which no teeth are preserved.

The basal margin in the specimens collected terminates nearer to two-thirds the distance from the base

⁹⁴ Williams, H. S., and Breger, C. L., The fauna of the Chapman sandstone of Maine: U. S. Geol. Survey Prof. Paper 89, p. 173, 1916.

⁹⁵ Girty, G. H., Fauna of the Wewoka formation of Oklahoma: U. S. Geol. Survey Bull. 544, p. 109, 1915.

⁹⁶ Quenstedt, Werner, op. cit., p. 112.

⁹⁷ Hall, James, and Clarke, J. M., Paleontology of New York, vol. 5, pt. 1, pl. 46, figs. 1-9, 1885.

to the dorsal surface than to one-half this distance, as in the type. A distinguishing character of this species is the gentle slope of the posterior umbonal ridge.

The posterior part of the shell is not preserved in any of the specimens, which are all internal molds.

Occurrence: One specimen from the yellow-brown mudstone at locality 615, along the Mississippi River at Louisiana, and one specimen from the yellow-brown mudstone at locality 634, Ralls County, Mo. This species has been described from the so-called Waverly in Ohio, but the writer has not examined the type or other specimens from there.

Genus "LEDA," Schumacher, 1817

Three species in the Louisiana limestone fauna belong to that group of Paleozoic shells widely known under the generic name *Leda*. The use of the name *Leda* has on several occasions been challenged by paleontologists who maintain either that *Nuculana* has priority and should be used or that neither *Leda* nor *Nuculana* can be used for the genus. Prominent among those who maintain that *Nuculana* should be used instead of *Leda* are Iredale⁹⁸ and Stewart.⁹⁹

The writer is here using *Leda* in preference to *Nuculana*, without prejudice to future action, because *Leda* is more widely used in the Paleozoic and because it is used for a group of Paleozoic shells whose characters are fairly well agreed upon. This course is also supported by the widespread disagreement as to which name should be used and the possibility that action by the International Commission on Zoological Nomenclature may be needed before the controversy is ended. Additional support comes from the fact that some conchologists maintain that *Nuculana* did not exist before the Miocene. If this is true, it might be possible to use *Nuculana* for the Miocene and post-Miocene forms and by special action of the Commission still use *Leda* for the Paleozoic forms. Until the opinions of paleontologists and zoologists on this question much more nearly approach unanimity, it appears best to follow what appears to be the most common usage. It should be noted, however, that *Nuculana* has been and is now being used by some paleontologists for Paleozoic species.

Leda diversoides (Weller)

Plate 9, figures 1-4

1906. *Nuculana diversoides* Weller, St. Louis Acad. Sci. Trans., vol. 16, No. 7, p. 448, pl. 2, figs. 4, 5.
 1928. *Leda diversoides* Moore, Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 137.
 1931. *Leda diversoides* Williams, idem, Bienn. Rept. State Geologist for 1929-30, app. 2, p. 137, pl. 1, figs. 8-11.

⁹⁸ Iredale, Tom, A commentary of Suter's "Manual of the New Zealand Mollusca;" New Zealand Institute Trans. and Proc., vol. 47, p. 483, 1915.

⁹⁹ Stewart, R. B., Gabb's California Cretaceous and Tertiary type lamellibranchs: Acad. Nat. Sci. Philadelphia, Spec. Pub. 3, p. 49, 1930.

The following is Weller's original description:

Shell small, elongate-subovate in outline, subcuneate behind, the width a little more than one-half the length. Beaks prominent, incurved above the hinge line, situated about one-third the length of the shell from the anterior extremity. Cardinal margin slightly convex from the beak anteriorly, and concave posteriorly to the posterior margin which is very short and sharply rounded; ventral margin slightly convex posteriorly, becoming gradually more curved anteriorly where it passes into the regularly rounded anterior margin. Valves rather strongly convex anteriorly, the umbo prominent, becoming gradually more depressed posteriorly, the umbonal ridge subangular, following the postero-cardinal margin of the shell, the cardinal slope from the ridge nearly vertical, in larger specimens even undercut so that in a direct view of the valve the slope cannot be seen. Surface marked with very fine, regular, concentric lines, about five or six occupying the space of one millimeter. The dimensions of two specimens, one right and one left valve, are: length 16 and 10.5 mm., width 9 and 6.2 mm., convexity 3.75 and 3 mm.

Remarks: The specimens studied are about the same size as the cotypes. Some of them are slightly more concave dorsally than the cotypes and, possibly, are a little more acuminate posteriorly and less convex. The lesser convexity is partly because they are internal casts. The ornamentation is preserved on only two of the specimens.

This species may be compared with *L. saccata* Winchell, 1863, from bed 5 of the Kinderhook at Burlington, and *L. spatulata* Herrick, 1888, and *L. similis* Herrick, 1888, both originally described from the so-called Waverly of Ohio, but the acute angle made by the divergence of the anterior umbonal ridge from a line drawn from the beak vertically to the ventral margin is smaller in this species than in any of the above, and it differs from them in size and shape. It is not so large as *L. similis* and has a greater height-length ratio. *L. spatulata* is more acuminate posteriorly, somewhat more strongly curved along the posterior cardinal margin, and its most anterior part is near midheight. *L. saccata* is a smaller species, which was not figured by its maker. Herrick's figure suggests that it is less curved along the posterior cardinal margin and more acuminate posteriorly. *L. diversoides* is also related to *L. diversa* Hall, 1883, but is larger and has more abrupt cardinal slopes from the umbonal ridges. The true differences of these and other closely related species of the genus are somewhat obscure, and a careful study of all the types or of large collections might result in the consolidation of some of the species. Identification of the writer's specimens was made mainly on the basis of size and general form. Two of the specimens have the following measurements: length 15 and 13.5 mm., height 8.5 and 8 mm.

Occurrence: Three specimens from the yellow-brown mudstone at locality 634, southwest of Severton, Ralls County; and two from locality 615, along the Mississippi River, Louisiana, Mo.

This species also occurs in the Glen Park limestone.

"Leda" rowleyi Williams

Plate 9, figure 13

1931. *Leda rowleyi* Williams, Missouri Bur. Geology and Mines Bienn. Rept. State Geologist for 1929-30, app. 2, p. 138, pl. 1, fig. 7.

Shell large for the genus, inequilateral, subovate to subcircular in outline, somewhat contracted and produced posteriorly. The dimensions of the holotype are: Length 17 mm., height 14 mm., convexity about 2.5 mm.

Beaks distinct, posteriorly directed, situated near the midlength of the shell. Umbones depressed, inconspicuous. Anterior dorsal margin convex, sharply rounding into the rounded anterior margin. Ventral margin gently curved, merging into the posterior margin, which is short, more abruptly rounded than the ventral margin, subtruncate above, and forms an acute angle with the dorsal margin. Greatest posterior extension at junction of posterior-dorsal and posterior margins, which is about one-third the distance from beak to ventral margin. Posterior-dorsal margin concave.

Valves depressed convex, greatest convexity near the beaks. Umbones flattened; anterior and posterior umbonal slopes gently convex. A broad flattened to gently convex area extends from the beaks to the ventral margin and is delimited anteriorly and posteriorly by the points where the ventral margin merges into the anterior and posterior margins respectively. The anterior-posterior convexity of the shell is much greater in front of this area and somewhat greater behind it.

Surface of the shell marked by fine concentric lines of growth, which differ in strength and are more conspicuous and stronger near the ventral margin.

Muscle scars oval, imperfectly preserved, probably subequal. Pallial line not entirely preserved. No hinge teeth preserved. The type is an internal mold.

Remarks: Only one specimen of this species has been collected, and it is an internal mold. The preservation is not perfect but sufficient to distinguish it from any described species. The reference to the genus is made mainly on general form and muscular impressions; no hinge teeth are preserved.

This species is closely related to such forms as *L. nasuta* Hall, 1856, *L. curta* Meek and Worthen, 1861, and *L. chesterensis* Weller, 1920. It is much larger than *L. nasuta*, the anterior margin is shorter and more abruptly rounded; the shell is less transverse, and its most posterior point is higher. From *L. curta* it differs in its larger size, in the greater convexity of its posterior-dorsal margin, and in its more subcircular shape. Its closest relation seems to be with *L. chesterensis*, from which it differs mainly in its smaller size, more abruptly curved and less extended anterior margin, its greater height-length ratio, and the greater relative

height at which the posterior margin intersects the posterior-dorsal margin.

The species is named for Professor R. R. Rowley of Louisiana, Mo., who accompanied the writer on many of his collecting trips.

Occurrence: Yellow-brown mudstone at locality 634, near Saverton, Ralls County, Mo.

"Leda" spatulata Herrick

Plate 9, figures 5, 6

1888. *Nuculana (Leda) spatulata* Herrick, Denison Univ., Sci. Lab., Bull., vol. 3, p. 79, pl. 9, fig. 11; pl. 7, fig. 35.

1898. *Nuculana spatulata* Weller, U. S. Geol. Survey Bull. 153, p. 382.

1931. *Leda spatulata* Williams, Missouri Bur. Geology and Mines Bienn. Rept. State Geologist for 1929-30, p. 138, pl. 1, figs. 12, 13.

The following is Herrick's original description:

Shell elongate oval, broadly expanded anteriorly, acute behind; beaks small, slightly prominent, acute, about seven-twentieths the entire length from the anterior margin; hinge line rather strongly concave; teeth (if present) small; anterior margin forming a bold, uniform curve, reaching nearly as high as the beaks, with its greatest anterior projection above or near the middle; lower outline gently convex, nearly attaining the hinge posteriorly, but separated from it by a short truncate posterior margin. Greatest convexity about one-third the height of shell from the beaks; umbonal ridge with a sudden, but gentle slope. The surface is marked by very numerous, fine lines of growth—about six occupying the space of 1 mm., in the shells measured. Length (1) 20, (2) 17, (3) 16.5; height (1) 9, (2) 7, (3) 8; distance from beak to front (1) 4, (2) 3, (3) 3; height of beak above longest transverse axis (1) 7, (2) 6, (3) 5.

Remarks: One well-preserved and two imperfectly preserved specimens from the Louisiana probably belong to this species. All are internal molds. The anterior margin of this species is less oblique than that of *L. diversoides* (Weller, 1906), and its most anterior part is higher. It is more acuminate posteriorly and the cardinal margin is somewhat more curved posteriorly. It is not as large as *L. similis* Herrick, 1888, which it resembles closely, and the greatest convexity of its anterior margin is higher. Herrick states that its hinge line is more concave and its ventral margin more convex, but his figures do not show this to be true.

Herrick's measurements of the distances of the beaks from the fronts of the shells seem to be wrong, and his statement made in the first few sentences of the description that the beaks are about seven-twentieths the length of the shell from the anterior is right, if one may judge from measurements of his figures. The dimensions of the one well-preserved specimen from the Louisiana are as follows: Length 15 mm.; height 8.2 mm.; distance of beaks from anterior margin, 6 mm. The other two specimens are too incomplete for satisfactory measurement.

Specimens described in 1928 by Girty¹ from the

¹ Girty, G. H., The Pocono fauna of the Broad Top coal field, Pennsylvania: U. S. Geol. Survey, Prof. Paper 150-E, p. 121, pl. 23, figs. 19, 20, 1928.

Pocono of Pennsylvania have been compared with this species. These specimens are imperfect and distorted, and the identification, as indicated by Girty, is uncertain. They appear to be more closely related to *L. saccata* Winchell, 1863, if that species is valid, than to *L. spatulata*.

Occurrence: Yellow-brown mudstone at locality 615, along the Mississippi River, and at locality 593, Town Branch, Louisiana; and at locality 634, near Saverton, Ralls County, Mo.

This species also occurs in the co-called Waverly beds in Ohio, but the writer has not examined specimens from there.

Superfamily **ARCACEA**

Family **PARALLELODONTIDAE**

Genus **PARALLELODON** Meek and Worthen, 1866

Parallelodon louisianensis Williams

Plate 9, figures 7, 8

1931. *Parallelodon louisianensis* Williams, Missouri Bur. Geology and Mines Bienn. Rept. State Geologist for 1929-30, app. 2, p. 139, pl. 1, figs. 5, 6.

Shell of medium size, subovate in outline, highest posteriorly, height slightly over one-half the length. The dimensions of a left valve, the holotype, and a right valve, a paratype, are respectively: Length 16.5 and 13.5 mm., height from beak to ventral margin normal to hinge line 9 and 7.5 mm., greatest height, measured normal to hinge line and about four-fifths the distance from anterior to posterior marginal, 10.5 and 8 mm. convexity 2.5 and 2 mm. Beaks anterior, situated one-fifth to one seventh the distance from anterior to posterior margins, distinct but not prominent, incurved, extending over the hinge line, anteriorly directed; umbonal region well-defined, oblique.

Dorsal margins of types broken, probably straight. Hinge line straight, about three-fifths to three-fourths the total length of shell. Anterior shell margin shorter than posterior margin. Dorsal portion of anterior margin not preserved; ventral-anterior margin sharply rounded, merging into the ventral margin. Ventral margin nearly straight, curving into anterior and posterior margins, diverging from hinge line at an angle of about 20°, slightly sinuate medially. Posterior margin broadly rounded, more gently rounded above but not truncate, greatest posterior extension of shell below middle of posterior margin.

Valves moderately convex, greatest convexity in the umbonal region, flattening toward margins, with least convexity along the posterior margin. Cardinal slopes from umbonal ridges concave on either side of beak, becoming gently convex posteriorly. Anterior and posterior umbonal ridges forming an obtuse angle; posterior ridge much the longer, merging into the general convexity of the shell posteriorly. Anterior umbonal ridge describing a curved line in passing from beak to ventral margin, the midpoint being nearer the posterior

of shell than are its dorsal or ventral extremities. Posterior umbonal ridge paralleling hinge line for one-third the distance from beak to posterior margin and thence turning abruptly toward ventral-posterior extremity and forming an angle of approximately 30° with the hinge line and flattening into the general convexity of the shell, intersecting posterior margin at about one-third the distance from ventral to dorsal margins. A broad flattened or gently convex area bounded by the umbonal ridges and bisected by a very shallow, somewhat indistinct sinus extends obliquely from beak to the ventral margin.

Surface of valves marked by concentric lines of growth. One of the specimens has two elongate posterior teeth nearly parallel to the hinge line. No anterior teeth are preserved. Pallial line simple. Muscle scars not preserved. Both specimens are internal molds.

Remarks: This species is closely related to *P. sulcatus* (Weller, 1906), from the Glen Park limestone, but adult specimens can be easily distinguished from the cotypes of that species by differences in shape. These differences result mainly from differences in convexity and in the directions of the umbonal ridges.

It is difficult to determine whether many Carboniferous species that are known only from internal molds should be referred to *Parallelodon* or to *Cypricardinia* Hall, 1859. The reference of this species to *Parallelodon* is not without some question, but its close resemblance to *P. sulcatus* Weller outweighed other considerations and was the deciding factor. Because of its preservation, one cannot definitely determine the true ornamentation or, for that matter, the true thickness or configuration.

Occurrence: The holotype is from the yellow-brown mudstone at locality 615, along the Mississippi River, at Louisiana, Mo. The one paratype is from the yellow-brown mudstone at locality 623, near Kissenger, Pike County, Mo. Another specimen, which is incomplete, is from the Louisiana limestone at locality 623.

Parallelodon sulcatus (Weller)

Plate 9, Figures 9-13

1906. *Macrodon sulcatus* Weller, St. Louis Acad. Sci. Trans., vol. 16, no. 7, p. 450, pl. 2, figs. 6-9.
 1928. *Parallelodon sulcatus* Moore, Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 137.
 1931. *Parallelodon sulcatus* Williams, idem., Bienn. Rept. State Geologist for 1929-30, app. 2, p. 140, pl. 1, figs. 16-20.

Weller's original description of this species is as follows:

Shell equivalved, of medium size, subovate to subelliptical in outline, widest posteriorly, width one-half or a little more than one-half the length, beaks situated anteriorly but not terminal, prominent, elevated above the hinge-line; hinge-line three-fifths to three-fourths the total length of the shell. Dorsal margin straight along the hinge-line, obtusely subangular at each end where it joins the anterior and posterior margins; posterior margin broadly rounded, sometimes obliquely subtruncate above, the greatest posterior extension of the shell below the middle;

ventral margin usually straight through the greater portion of its length, curving upward in front and behind, sometimes slightly convex throughout; anterior margin short, regularly rounded. Valves gibbous in the umbonal region, the umbonal ridge merging into the general convexity of the valve posteriorly; the cardinal slope from the umbonal ridge concave, very abrupt near the beak, becoming more gentle posteriorly; the ventral slope longer and more gentle than the dorsal, with a flattened area or a broad, shallow sinus extending obliquely from the umbo to the middle of the ventral margin. Surface marked by regular, concentric lines separated along the posterior half of the umbonal ridge by intervals of one-half to one millimeter, or occasionally by wider intervals, and towards the beak by smaller intervals; also marked in unworn specimens, upon the posterior half of the shell and especially on the cardinal slope, with very fine, radiating costae which are interrupted at concentric lines. Hinge straight, with two or three small oblique teeth anterior to the beak, and one or two posterior teeth subparallel to the hinge-line; ligament external, attached to a narrow, elongate, flattened area which is longitudinally striate.

The dimensions of three specimens are: length, 16, 13, and 11.3 mm.; width, 8, 7.5 and 6 mm.; length of hinge-line, 11, 7.5 and 8 mm.; convexity, 4.5, 3.5 and 3 mm.

Remarks: Three specimens of this species have been collected from the Louisiana limestone. Only one of them has a sinus, but the flat area extending from the umbo to the middle of the ventral margin is distinct on all of them. The specimens are all internal molds and are not quite as convex as the cotypes, with which they were compared. Two of them are right valves and the other is a left valve. The radiating striae mentioned by Weller are not preserved, and concentric lines of growth are but faintly preserved. The specimens from the Louisiana are about the same size as those from the Glen Park. A small individual has a length of 11 mm. and a height of 6 mm. Another has a length of 13 mm. and is 7 mm. high. Two elongate posterior teeth approximately parallel to the hinge line are preserved on the smaller specimen. The hinge line on this specimen is relatively longer than that of the cotype of about the same size, but the relative length is within the limits set by Weller for the species.

This species is closely related to *P. hamiltoniae* Hall, 1870, and to *P. ovatus* Hall, 1870, both of which have been identified in the so-called † Waverly of Ohio. It differs from the former, as described by Hall, in size and in the flattened area and sinus that extends obliquely from the beaks to the ventral margin. *P. ovatus* differs from it in having a greater height compared to length, a curved hinge line and a truncate dorsal posterior margin. The dorsal part of the posterior margin in *P. sulcatus* is subtruncate to rounded.

P. sulcatus has also been compared with *Elymella missouriensis* Miller and Gurley, 1896, from the Chouteau limestone of Missouri, but it differs in several respects from that species. *E. missouriensis* is more globose, its umbonal area more tumid, its beaks elevated higher above the hinge line, and its length-height ratio greater. The hinge line of *P. sulcatus* is shorter compared to the length of the shell, its posterior umbonal slope more sharply rounded, the lack of par-

allelism between the hinge line and the basal margin more pronounced, its shell much wider posteriorly, and its dorsal posterior margin more oblique. The types of *E. missouriensis* have no hinge teeth preserved.

Occurrence: One specimen from the yellow-brown mudstone at locality 615, along the Mississippi River, at Louisiana, Mo.; one specimen from the yellow-brown mudstone at locality 593, Town Branch, Louisiana; and one poorly preserved specimen from the Louisiana limestone at locality 623, near Kissenger, Pike County, Mo.

This species also occurs in the Glen Park limestone, and a questionably identified specimen occurs in the Saverton shale.

Superfamily PECTINACEA

Family PECTINIDAE

Genus AVICULOPECTEN McCoy, 1851

Aviculopecten marbuti (Rowley)

Plate 9, figures 61-63

1908. *Pernopecten? marbuti* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 93, pl. 19, fig. 23.

1928. *Aviculopecten marbuti* Moore, idem, 2d ser., vol. 21, p. 47.

1930. *Aviculopecten marbuti* Williams, idem, Bienn. Rept. State Geologist for 1929-30, app. 2, p. 141, pl. 1, figs. 22-24.

The following description was prepared by the writer from an examination of the holotype:

Shell of moderate size, thin, subovate-alate, slightly inequilateral, height greater than length. Dimensions of the holotype are: Height 40.5 mm., greatest length, measured about half the distance from beak to ventral margin, 31.5 mm. (shell broken); width of hinge line 18.5 mm. (incomplete); thickness 4.5 mm.

Beak of left valve distinct, extending slightly beyond the hinge line. Umbones distinct, lateral slopes diverging at the beak at an angle of approximately 80°, anterior umbonal slope more abrupt than posterior slope, reaching the anterior margin at about two-fifths the distance from the beak to the ventral margin; posterior umbonal slope more gradual, intersecting the posterior margin about one-half the distance from the beak to ventral margin. Anterior margin of shell broken, probably gently rounded; posterior margin broken, probably straighter than the anterior margin; dorsal part of posterior margin probably straight. Anterior ear incomplete, smaller and more convex than posterior ear, with a suggestion of a slight sinus; posterior ear nearly flat.

Shell structure lamellose; ornamentation poorly preserved over most of the shell, consisting of fine radiating somewhat discontinuous costae alternating in strength, crossed by concentric striae, giving a reticulate appearance; where the striae cross the costae slight knobs occur. About 2 costae occupy the space of 1 mm. Concentric striae are spaced approximately the same distance apart as the plications.

Right valve nearly plane, covered by rock and not accessible for description.

Interior shell structures not observed.

Remarks: This species was referred to *Pernopecten* by Rowley mainly on the basis of general form, as the dentition is not preserved. *Pernopecten* was erected in 1865 by Winchell for several forms intermediate between *Aviculopecten* and *Perna*. It embraces those forms externally like *Aviculopecten* but having "a central ligamental pit with accessory ligamental pits on either side." It differs from *Perna* in general shape and in having subcentral beaks and pits on both sides of the beak. Winchell's type was *P. limaeformis*. He did not figure the species. However, Hall² in 1884 examined Winchell's type specimen and confirmed Winchell's description of the hinge structure. *Crenipecten* was proposed by Hall in 1883 to include some forms which have been referred to *Pernopecten*, but which have no central ligament pit. Several species now included under *Pernopecten* were formerly placed under *Entolium*, which differs from *Pernopecten* in the angle at which the ears diverge from the beaks and in the lack of a straight hinge. Most species now referred to both *Entolium* and *Pernopecten* lack radiating striae.

Most *Pernopectens* differ in shape from most *Aviculopectens*. In practically all the figured specimens of *Pernopecten* the hinge line is shorter and ears smaller than in typical *Aviculopectens*. The posterior ear meets the posterior margin of the shell at a higher angle in *Pernopecten* than in *Aviculopecten*, the ear and posterior margins being nearly parallel in *Pernopecten*. Most *Pernopectens* are higher compared to length than typical *Aviculopectens*. These things, however, do not constitute generic differences, though they may indicate a possible means of tentatively classifying species. Winchell,³ the founder of the *Pernopecten*, used the differences in shape of the ears in placing *P. limatus* among the *Pernopectens* rather than among the *Aviculopectens*.

Rowley suggests that the species might belong to *Aviculopecten* or to *Crenipecten*. The writer believes it is an *Aviculopecten*. The ears, hinge line, and anterior and posterior margins are incomplete, and hence the form one assumes for the shell is a matter of its logical restoration. An incomplete left valve in the collections probably belongs to this species. It is more convex in the umbonal region, somewhat smaller, and has none of the surface markings preserved, but its anterior margin and its anterior ear are well preserved, and its ventral posterior margin can also be made out. If it were broken in the same places in which the holotype is broken, it would, aside from its greater convexity, resemble the holotype very closely. If the anterior and posterior margins of the holotype were restored to correspond with the anterior and posterior margins of this specimen, the shape of the holotype would be similar to that of most *Aviculopectens*. The length of the

anterior part of the hinge line of this specimen indicates that the hinge line is nearly, if not quite, as long as the shell.

This species differs from other *Aviculopectens* in ornamentation and general shape. It is closely related to *A. crenistriatus* Meek, 1871, from the so-called †Waverly, but that species is larger and its posterior ear is not so distinctly set off from the shell. It is also closely related to *A. granvillensis* Herrick, 1888, *A. hardinensis* Worthen, 1890, and *A. indianensis* Meek and Worthen, 1868, but differs from the first in size and from the other two in its finer plications. Two species from the Carboniferous of Nova Scotia, *A. lyelli* Dawson, 1868, and *A. reticulatus* Dawson, 1868, have similar ornamentation. The incompleteness of the holotype of *A. marbuti* makes it difficult to compare it with other forms.

The holotype consists of two valves. The one figured is probably a left valve, as it is more convex and is without any indication of a byssal notch. A byssal notch is plainly shown on the right valve of another specimen in the writer's collection.

Occurrence: Limestone beds of the Louisiana limestone along Town Branch, Louisiana, Mo., and at locality 552, Marion County.

Fragmentary pelecypods

Unidentifiable fragments represent probably eight or nine other species of pelecypods. At least three species that probably belong to *Parallelodon* are in the collections. There are also probably three species of *Aviculopecten*, one specimen of *Sanguinolites*?, another of *Palaeoneilo*?, and one that probably represents another species of *Nucula*. None of these specimens are complete enough for specific determination. The specimen tentatively placed in *Sanguinolites* is figured on plate 9.

Class AMPHINEURA

Order POLYPLACOPHORA

Suborder EOPLACOPHORA

Family GRYPHOCHITONIDAE

Genus GRYPHOCHITON Gray, 1847

Gryphochiton? *anomalus* (Rowley)

Plate 9, figures 19, 20

1908. *Platyceras?* *anomalum* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 90, pl. 19, figs. 15-17, 18?, 19?.

Rowley described *Platyceras?* *anomalum* from two cotypes, but the writer has examined only the larger of these. There seems to be little doubt that it is a posterior valve of a chiton. The following description is based on this single cotype and is formulated on this interpretation.

Posterior valve strongly elevated, subtrapezoidal in outline; anterior margin subtruncate; posterior margin wider and regularly rounded; length 5.2 mm., width near anterior margin 3.2 mm., width at juncture be-

² Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 81, 1884.

³ Winchell, Alexander, Descriptions of new species of fossils from the Marshall group of Michigan, etc.: Acad. Nat. Sci. Phila. Proc. for 1865, p. 126, 1865.

tween central and posterior areas 4.6 mm., height at beak 2.6 mm.; beak or mucro acutely pointed, curved backward, and strongly posterior in position, about four-fifths distance from anterior to posterior margin in median line and at juncture between posterior and central areas. Dorsal area is a well-defined ridge extending from beak forward and gradually expanding toward anterior margin, where it is about 1.3 mm. wide and where it causes a slight sinus in the anterior outline; it is flanked by narrow sulci, which also expand gradually in passing forward to the anterior margin. Diagonal line separating central from posterior areas a conspicuous groove, lateral parts of this groove being immediately posterior to elongate, triangular depressed areas, which extend and rapidly expand from beak to lateral margins. These elongate triangular depressed portions and the sulci bordering the dorsal ridge give relative elevation to the areas between them, which appear as two expanding ridges extending from the beaks anterolaterally to the margins of the valve. Posterior area regularly semielliptical in outline, with no suggestion of a sinus; concave, greatest concavity immediately beneath beak.

Under margin of posterior area distinctly crenulated; under margins of central area (lateral and anterior margins) smooth. Insertion plates absent. Broken ends of sutural laminae observed on either side of jugal sinus indicate that they were about 1 mm. wide.

Shell structure finely punctate. No megalopores, canals, or chambers observed.

Remarks: The generic reference of this species is very uncertain and must be considered merely tentative. Generic descriptions of many Carboniferous chitons are too meager to permit recognition or delimitation, and different writers have interpreted them so differently that a complete study of all the Carboniferous genera with types at hand seems to be the only method of arriving at satisfactory definitions.

The specimen here described very closely resembles specimens from the Spergen limestone of Indiana described as *Gryphochiton? parvus* (Stevens, 1858), and may prove to be conspecific with them.

Occurrence: Clay partings in the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo.

Class GASTROPODA

Subclass STREPTONEURA

Order ASPIDOBANCHIA

Suborder DOCOGLOSSA

Family BELLEROPHONTIDAE

Genus BELLEROPHON Montfort, 1808

Bellerophon? sp.

Plate 9, figures 25, 26.

One or possibly two species probably belonging to *Bellerophon* are represented in the Louisiana fauna by

fragments that are not specifically identifiable. Some fragments have raised narrow slit bands and are ornamented by fine, closely spaced axial lamellae or growth lines. Others have depressed or concave slit bands that are relatively wider than the convex bands of the other specimens. Their ornamentation also consists of concrescent or axial lamellae, but the lamellae are not so closely spaced. Important specific and generic characters such as the shape and rate of expansion of the whorls, the outline of the aperture, the size and development of callosities and of the umbilical depressions, cannot be determined from the specimens, and there consequently remains some doubt even as to their generic relationships.

Occurrence: Limestone beds of Louisiana limestone at locality 552, about 1 mile south of Warren, Marion County, Mo.

Suborder RHIPIDOGLOSSA

Family PLEUROTOMARIIDAE

Genus BEMBEXIA Oehlert, 1888

Bembexia minima (Rowley)

Plate 9, figure 24

1895. *Pleurotomaria minima* Rowley, Am. Geologist, vol. 16, p. 222, fig. 19.

1898. *Pleurotomaria minima* Weller, U. S. Geol. Survey Bull. 153, p. 457.

1908. *Pleurotomaria minima* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 91, pl. 19, fig. 8.

The following is Rowley's original description:

Outline of shell, low trochiform, minute. Volutions preserved rarely more than three, increasing rapidly in size. A narrow spiral band quite noticeable around the middle of the first volution. Suture well defined. Umbilicus small. Surface apparently ornamented by transverse lines, visible only on a single specimen. Aperture subcircular. Length and breadth of specimens about equal. One-seventeenth of an inch in diameter.

Remarks: Most of the mature specimens in the writer's collection are attached to or embedded in limestone matrices, and the writer was not successful in removing any specimens in a complete condition. None of the attached specimens had the aperture or any considerable part of that portion of the whorl near it visible, and none of them was preserved so as to show the umbilicus. Rowley says the species has a small umbilicus and a subcircular aperture. A raised transversely lirate slit band bordered by two revolving lirae is visible at the periphery of the last whorl and can be seen on most specimens on all whorls. Above and below the slit band are transverse lirae, which are directed almost straight across the whorl until they nearly reach the slit band, where they curve rather gently backward. A rather large individual is 2.2 mm. high and 2.1 mm. wide at the base. The base is slightly convex or nearly flat.

A number of immature forms secured by washing

clay from weathered outcrops show more details than the mature but embedded forms. These forms present quite a variation, and some of them may actually represent undescribed species that would be better assigned to genera closely related to *Bembexia*. At the moment, however, the best interpretation arrived at from a comparison with the younger parts of mature forms seems to be that they are the variable young of *P. minima*. These forms have very small umbilici, which may be almost entirely closed by calluses. The peritreme is not fully preserved on any but is almost completely preserved on a few. On these specimens it appears subcircular. The slit band continues nearly to the aperture, and there is only room in the unobserved areas for a very shallow slit or sinus in the outer lip. The greatest variation is in the shape of the whorls and the position of the slit band. On most of the immature specimens it is above the periphery. On some it is at the lower margin of a gently convex area that might be termed a slight shoulder and distinct from a lower, more extensive, and more convex part of the whorl. On others there is very little difference in convexity between that part of the whorl above the slit band and the part below it. Aside from the revolving lirae that delimit the narrow slit band, the ornamentation, so far as observed, consists of transverse growth lines. The position of the slit band above the periphery and the ornamentation is similar to those features on the immature parts of mature specimens, except that some of the immature forms have their slit bands higher than any seen on the immature parts of the mature individuals. They also have more distinct shoulders.

As this species has the characters commonly associated, at least in this country, with *Bembexia*, it is here transferred to that genus. It may be distinguished from other lower Mississippian *Bembexias* by its combination of small size, small number of whorls, fine transverse lirae, and absence of revolving lirae, other than those that border the slit band.

Occurrence: Yellow-brown mudstone, clay partings, and limestone beds of the Louisiana limestone at Louisiana, and at locality 599, one mile south of Louisiana, and locality 728, three miles northwest of Ely, Mo.

Genus **PLEUROTOMARIA** Sowerby, 1821

Pleurotomaria? sp.

Plate 9, figure 32

A specimen too imperfect for specific or even for positive generic determination belongs among the *Pleurotomariidae*. In the absence of distinctive characters that would enable it to be referred to some of the genera that have been erected from species formerly

placed in *Pleurotomaria*, it may result in least confusion to designate it as *Pleurotomaria?* sp.

The slit band is distinct on the periphery of the penultimate whorl. There is a faint and very uncertain indication of a revolving costa above the costa that delimits the slit band, but it is very faint and may have resulted from compression during fossilization. No other suggestions of ornamentation are present. The specimen is an internal mold. It consists of two whorls, but the apex has been broken away, and the aperture is not preserved. The whorls are rounded. The height of the specimen, apex not preserved, is 14.3 mm. and the width at the base is 16.5 mm.

Occurrence: Clay parting in the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo.

Pleurotomaria sp.

An unnamed specimen of *Pleurotomaria* is listed by Moore⁴ from the Louisiana limestone at Louisiana, Mo. It has not been described or figured, and the writer has not examined it.

Occurrence: Louisiana limestone at Louisiana, Mo.

Genus **MURCHISONIA** D'Archiac and Verneuil, 1841

Murchisonia? *pygmaea* Rowley

Plate 9, figures 21, 22

1895. *Murchisonia* (?) *pygmaea* Rowley, Am. Geologist vol. 16, p. 222, fig. 20.
 1898. *Murchisonia pygmaea* Weller, U. S. Geol. Survey Bull. 153, p. 359.
 1908. *Murchisonia?* *pygmaea* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 91, pl. 19, fig. 7.

Rowley's description follows.

Shell minute, elongate, slender, tapering very gradually. Volutions rounded, the lowest being quite as long as the two whorls above. Suture well defined. No surface ornamentation visible, probably on account of the pyritized condition of the specimens, which after all may be but casts. Natural size of the figured specimen, one-sixteenth by one-fortieth of an inch. A rare specimen.

Remarks: Rowley's type is a poorly preserved specimen, an internal mold, and the generic reference is therefore very uncertain, and many characters that would add to the specific description are of course not preserved. The only other specimen that the writer has examined is also an internal mold and it therefore can be only tentatively identified, if it may be said to be at all identifiable. A very faint indication of a slit band occurs on one whorl. The peritreme is not preserved. The type material and the writer's material of this species is so poor that it is hardly worth while to continue this name in the literature.

Occurrence: Clay partings of the Louisiana limestone at Louisiana and at locality 599, 1 mile south of Louisiana, Mo.

⁴ Moore, R. C., Early Mississippian formations in Missouri. Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 47, 1928.

Order CTENOBANCHIATA

Suborder PLATYPODA

Superfamily GYMNOLOSSA

Family LOXONEMATIDAE

Genus LOXONEMA Phillips, 1841

Loxonema missouriensis Williams, n. sp.

Plate 9, figure 23

Shell turreiform, spire ascending with a probable apical angle of about 24°; apex and aperture not preserved. Height of specimen 27.5 mm.; whorls four; body whorl convex, greatest convexity a short distance above basal margin, flattened below, not ventricose; other whorls with greatest convexity a short distance above lower suture: a slight flattened depressed area, which may be termed a subsutural band, occurs on each whorl, including the body whorl, below the upper suture. Below this abruptly depressed band the lateral surface of each whorl is flattened, convex, and gently oblique to near the lower suture, where it turns at almost a right angle toward the columella and forms an almost horizontal ledge that overhangs the lower suture; below the ledge is a very narrow concave area, which extends down to the suture. No indication of an umbilicus but shell not well enough preserved so that it is certain there is none. Surface marked by distinct slightly rounded axial lirae, which curve backward from the upper suture on the sutural band and on the elevated part of the whorl to about the middle of the whorl, where the lirae curve forward in a broad curve and become obsolete on the ledge just above the lower suture, about 10 lirae in the space of 5 mm. on the body whorl.

Remarks: This species is closely related to *L. delphicola* Hall, 1862, but a careful comparison of specimens of *L. delphicola* from the Hamilton of New York and *L. missouriensis* shows that *L. missouriensis* has more convex whorls, with the maximum convexity below the middle of the whorl, giving a distinct ledge above the lower suture, and coarser, more rounded lirae. An examination of a number of specimens showing the range in variation of Hall's species may prove this to be conspecific with it, for they are very closely related.

Although *L. delphicola* was described from the Hamilton, it has been also recognized by Herrick in the Bedford shale in Ohio. *Loxonema difficile* Sardeson, 1902, appears from its description to be a much larger form with more whorls and with a greater part of each whorl impressed. Its figure does not show the subsutural band of *L. missouriensis*, and the outline of the whorl differs from that of *L. missouriensis*. A species of *Loxonema* from the Chouteau near Springfield, Mo., was briefly described by Weller in 1895 as *L. cf. hamiltonae*. It was never figured, and the description is too meager to permit comparison with *L. missouriensis*.

The species is placed in *Loxonema* mainly on the basis of form and ornamentation, since the nucleus and

peritreme are not preserved, and the lower surface is so concealed as not to show the presence or absence of an umbilicus.

Doubt has been expressed by some investigators that typical *Loxonema* occurs in the Carboniferous. Mrs. Longstaff⁵ has recently stated that none of the British Carboniferous species formerly referred to *Loxonema* actually belongs in that genus. She has placed several English species formerly included in *Loxonema* in newly erected genera. Of these latter, *Platyconcha* Longstaff, 1913, seems most nearly to resemble our *L. missouriensis*, but *L. missouriensis* seems, as preserved, to agree fully as well with the description of *Loxonema* and it is left in that genus.

Occurrence: Limestone beds of the Louisiana limestone at locality 623, 1½ miles west of Kissenger, Pike County, Mo.

Superfamily TAENIOGLOSSA

Family CAPULIDAE⁶

Genus PLATYCERAS Conrad, 1840

Platyceras paralium White and Whitfield

Plate 9, figure 14

1862. *Platyceras paralium* White and Whitfield, Boston Soc. Nat. Hist. Proc., vol. 8, p. 302.
1865. *Platyceras paralium* Winchell, Acad. Nat. Sci. Philadelphia Proc. for 1865, p. 131.
1888. *Platyceras* sp. (*cf. P. paralium*) Herrick, Denison Univ., Sci. Lab., Bull., vol. 3, p. 92, pl. 1, fig. 22?, 23.
1889. *Platyceras paralium* Keyes, Acad. Nat. Sci. Philadelphia Proc. for 1889, p. 294.
1890. *Capulus paralius* Keyes, Am. Geologist, vol. 6, p. 9.
1890. *Capulus paralius* Keyes, Acad. Nat. Sci. Philadelphia Proc. for 1890, p. 166, pl. 2, figs. 1a-b.
1894. *Capulus paralius* Keyes, Missouri Geol. Survey, vol. 5, p. 174, pl. 53, figs. 1a-d.
1898. *Capulus paralius* Weller, U. S. Geol. Survey Bull. 153, p. 165.
1901. *Capulus paralius* Weller, St. Louis Acad. Sci. Trans., vol. 11, p. 201, pl. 20, figs. 13-14.
1903. *Platyceras paralium* Girty, U. S. Geol. Survey Prof. Paper 16, p. 311.
1909. *Platyceras paralius* Grabau and Shimer, North American index fossils, vol. 1, p. 686, fig. 969.
1909. *Platyceras paralius* Weller, Geol. Soc. America Bull., vol. 20, p. 319, pl. 15, figs. 17, 18.
1926. *Platyceras paralius* Shimer, Canadian Geol. Survey Bull. 42, p. 82.

White and Whitfield's original description follows.

Shell rather below the medium size, composed of but little more than one loosely-coiled volution. Apex minute, laterally compressed; the upper half of the shell somewhat angular on the dorsum, more rapidly expanding and less angular in the outer part. Body of the shell marked by several proportionally strong, irregular plications, which give a deeply undulating or dentate

⁵ Longstaff, Jane, A revision of the British Carboniferous members of the family Loxonematidae, with descriptions of new forms. Geol. Soc. London Quart. Jour., vol. 89, pt. 2, p. 87, 1932.

⁶ In a paper that reached the writer after this paper had been submitted for publication, J. Brookes Knight adopts Hall's family Platyceratidae for the genera, *Platyceras*, *Orthonychia*, *Diaphorostoma*, and his new genus *Helictostylus*. He would place this family in the order Aspidobranchia. (The gastropods of the St. Louis, Missouri, Pennsylvanian outlier, VII, The Euomphalidae and Platyceratidae: Jour. Paleontology, vol. 8, No. 2, pp. 139-166, 1934.)

character to the margin of the aperture. General form of the aperture irregular ovate. Peristome much prolonged on the anterior portion, and a little more expanded on the right side.

Surface marked by strong, concentric lamellose lines of growth, which are strongly undulated as they cross the plications.

Remarks: This species was identified by Winchell in the White collection from the †Lithographic (Louisiana) limestone at Clarksville, but it has been found in the Louisiana by no subsequent collector. The writer has not seen the specimen identified by Winchell, and it is included in the Louisiana fauna solely on the authority of Winchell's identification. The figure is copied from Keyes' figure, said to be of the type specimen from the Kinderhook of Burlington, Iowa. A full synonymy has been included for this species, but the writer has not examined specimens on which any of the entries are based.

Occurrence: Louisiana limestone, Clarksville, Mo.

This species is widespread in Kinderhook and Osage formations in the Mississippi Valley and occurs in the so-called Waverly in Ohio, Leadville limestone in Colorado, and in lower Mississippian rocks near Banff, Alberta.

Platyceras pulcherrimum Rowley

Plate 9, figures 56-59.

1908. *Platyceras pulcherrimum* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 89, pl. 19, figs. 11-14.

The following description was prepared from one of the cotypes.

Shell somewhat obliquely subovoid, arcuate. Apex extremely attenuate, minute, spirally enrolled for about one volution, with a gently enlarging diameter, and beyond this for three-fourths of a volution the shell is so rapidly enlarging that the lateral diameter of the aperture is 20 mm. Whorls scarcely in contact. Dorsum flattened to slightly convex, right and left sides strongly convex, at an angle of 45° or more to dorsum. Aperture oblique, nearly circular. The lateral diameter of aperture of one of the cotypes is 20 mm. and its anterior-posterior diameter is 19.3 mm. Peristome irregularly undulating, not well preserved, sinuses indicated by growth lines, modified by attachment. Surface ornamented by fine concentric wavy striae, which are grouped into fascicles at intervals of about 1 mm., giving the surface a lamellose appearance, and by very faint indications of longitudinal plications. Two very shallow sulci are on either side of dorsum, the sulcus on the right side being a narrow groove extending over one-half the distance to the apex, but the sulcus on the left side is not so definite.

Remarks: This species is characterized by its sub-circular aperture, its flattened, rounded dorsum and the two sulci on either side of it, and by the absence of well-developed longitudinal ornamentation or spines.

Occurrence: Yellow-brown mudstone and limestone beds of the Louisiana limestone at locality 615, along Mississippi River, at Louisiana; locality 600, on Eighth

Street, Louisiana, and at locality 599, one mile south of Louisiana, Mo. This species also occurs in the Saverton shale in Missouri.

Class CEPHALOPODA

Subclass TETRABRANCHIATA

Order NAUTILOIDEA

Suborder ORTHOCHOANITES

Family ORTHOCERATIDAE

Genus "ORTHOCERAS" Bruguière, 1789

The status of the genus *Orthoceras* is so uncertain that it cannot at present be used with the definiteness that should characterize a good genus. Much of the uncertainty is caused by confusion regarding the availability of the name for a genus of cephalopods and by doubt as to its proper genotype. There is also uncertainty as to whom the genus should be credited.

The uncertain points have been discussed by several authors. Most of them are treated in papers written by Foerste⁷ and more recently by Troedsson,⁸ Schuchert,⁹ and Galloway.¹⁰ The reader is referred to these papers for details regarding them. The main questions involved seem to be: (1) Is *Orthoceras* a genus distinct from *Orthocera* and *Orthoceratites*, or are the three merely different ways of spelling the same name? (2) If *Orthoceras* is a distinct genus, should it be credited to Bruguière, who it appears was the first to describe it after the accepted starting point of zoological nomenclature, or to Breynius to whom it has been generally credited, or to others who have described it? (3) What is its genotype? (4) Should the name be used for a genus of cephalopods, of foraminifers, or some other class? A study of the papers cited above will show conflicting views of each of these questions. The writer has not made an exhaustive study either of the above questions or of the genus *Orthoceras*. The investigation that he has made, however, suggests that the following are the facts as now known. The three names have been considered by some as synonyms, but seem to Troedsson and Galloway to be distinct or at least seem to have been considered distinct by those who first used them. This is a conclusion with which the writer can agree. A consideration of the philology of the words gives no real reason to believe that *Orthocera*, *Orthoceras*, and *Orthoceratites* originally represented different spellings of the same word, even though they did come from the same root. As is well known, quite a few generic names

⁷ Foerste, A. F., Notes on American Paleozoic cephalopods: Denison Univ., Sci. Lab., Jour., vol. 20, p. 218, 1924; Cephalopods of the Red River formation of southern Manitoba: Idem, vol. 24, p. 159, 1929; Three studies of cephalopods: Idem, vol. 24, p. 279, 1929; Black River and other cephalopods from Minnesota, Wisconsin, Michigan, and Ontario, (pt. 1): Idem, vol. 27, p. 70, 1932.

⁸ Troedsson, G. T., Studies on Baltic fossil cephalopods, I. On the nautiloid genus *Orthoceras*: Lund Universitet, Arsskrift, neue Folge, avdelningen 2, Band 27, No. 16, pp. 1-31, 4 pls., 1931; Studies on Baltic fossil cephalopods, I. Vertically striated or fluted orthoceracones in the *Orthoceras* limestone: Idem, Band 28, No. 6, p. 31, 1932.

⁹ Schuchert, Charles, Review of studies on Baltic fossil cephalopods, I. On the nautiloid genus *Orthoceras*: Am. Jour. Sci., 5th ser., vol. 24, p. 89, 1932.

¹⁰ Galloway, J. J., A manual of Foraminifera, pp. 246, 453, 457, 458, 1933.

in present use differ only slightly in spelling from other names. The intent of every person who has used one or more of the three names cannot be known. However, it appears that Breynius, who used two of them, used *Orthoceras* for recent forms and *Orthoceratites* for fossil forms. As he gave different descriptions for each it seems he would thus, at least theoretically have had different genotypes. If the three names are, merely because of their derivation from the same root and spelling thought to be synonyms, then other generic names that no one seems to have discussed must be considered. At least one of them antedates *Orthoceras*. They include *Orthoceros* Da Costa, 1776, *Orthocerus* P. Latreille, 1796, and others.¹¹

It seems the first to describe *Orthoceras* after the establishing of binary nomenclature was Bruguière, 1789. Since Breynius was pre-Linnean, he cannot be credited with it. Blainville and Lamarck are both later than Bruguière. It has been advocated, however, that since Bruguière did not indicate the scope of his genus or refer species to it, he should be passed over in favor of a later author.

No genotype was designated by Bruguière and no species were referred by him to *Orthoceras*. According to the rules of nomenclature, the first species subsequently described becomes the genotype. This appears to have been a foraminifer. It is not known what species or what class Bruguière had in mind.

The fundamental question involved, it seems to the writer, is whether or not established usage is to be upset in favor of a strict interpretation of the rules based on uncertain data. Surely, no one would maintain that all the facts are surely and completely known, or that those known are adequate. Almost all reputed facts are in dispute or are represented by personal interpretations of uncertain basis. Any attempt to establish the genus *Orthoceras* by legalistic arguments on such bases are sure to be challenged by other interpretations. This will serve to continue the uncertainty and to prevent the precise use of the genus. There is, however, a way to terminate the uncertainty, circumvent a mass of profitless argument, and establish *Orthoceras* as a useful genus. That way was pointed out by Troedsson, when he suggested that the genus should be established and a genotype designated by the International Commission on Zoological Nomenclature.

Strongly a believer in the strict application of the laws of priority when the facts regarding date of description, type species, type specimens, and other necessary data can be certainly determined and when the application of the laws does not unnecessarily upset old established and widespread usage and thereby cause wholly unnecessary confusion, the writer nevertheless believes that there are frequently instances where some of these conditions are not met, and the rule of priority

should be set aside. This instance seems to be one of them. In the writer's opinion *Orthoceras* should be retained for a genus of cephalopods because of its widespread and common use as such for forms that have characters that are in a general way well known. Not only has the name been widely used in a generic sense but it has also been used for families and other divisions higher than genera. Its use in a descriptive sense by paleontologists has also been extensive, and it has also been used widely in stratigraphic and descriptive geology. It would be very unfortunate to restrict the name *Orthoceras* to a genus of Foraminifera, in which class it appears not to be in common use, and to cause thereby untold confusion merely to uphold the laws of priority. It must be borne in mind that the fundamental purpose of the rules themselves is to avoid confusion and that they are useful only to the extent that they do so. Their function in assuring proper credit for work is subordinate. With the mechanism for setting aside the rules where adherence to them would cause confusion rather than lessen it, provided for by the establishing of the International Commission on Zoological Nomenclature, the way seems open to firmly establish *Orthoceras* as a genus of cephalopods with a genotype that is representative of the genus as commonly and widely known.

Until definite action is taken by the International Commission, the only authority having the power to set aside or vary any of the rules of nomenclature, the use of *Orthoceras* for cephalopods is, so far as the facts are now known and interpreted, not according to the rules. To indicate this fact, the name is enclosed in quotation marks wherever used in this paper. The name is still retained, however, because it is hoped that it will be firmly established for cephalopods of the same general type as it has been used for in the past when revisional studies are made by some specialist in cephalopods.¹²

"*Orthoceras*" *chemungense* Swallow

1860. *Orthoceras chemungense* Swallow, St. Louis Acad. Sci. Trans., vol. 1, p. 660.
 1889. *Orthoceras chemungense* Miller, North American Geology and Paleontology, p. 447.
 1894. *Orthoceras chemungense* Keyes, Missouri Geol. Survey, vol. 5, p. 228.
 1898. *Orthoceras chemungense* Weller, U. S. Geol. Survey Bull. 153, p. 394.
 1899. *Orthoceras chemungense* Weller, St. Louis Acad. Sci. Trans., vol. 9, p. 45, pl. 5, fig. 16.

¹² After this paper was submitted for publication an article on "*Orthoceras*" by Teichert and Miller (Teichert, Curt, and Miller, A. K., What is *Orthoceras*? Am. Jour. Sci., vol. 31, pp. 352-362, 1936) appeared. In their paper they present data to support the theses (1) that *Orthoceras* can only be used as a generic name for a genus of pelecypods, (2) that *Orthocera* is valid for a genus of Foraminifera, (3) that *Orthoceratites* is valid for a little-known genus of Devonian cephalopods, and (4) that *Orthoceros* is available for cephalopods of the same general type as those generally known under *Orthoceras*. In view of the many diverse conclusions regarding the use of *Orthoceras* that have been reached within the last few years as additional data became known, or as known data became differently interpreted, it still seems to the present writer that the most direct and permanent method of stabilizing "*Orthoceras*" would be to apply to the International Commission on Zoological Nomenclature to set aside the Rules and establish *Orthoceras* as a valid genus of cephalopods, with a genotype that possesses the characters most generally attributed to *Orthoceras*.

¹¹ For references to these and other genera see Nomenclator animalium generum et subgenerum, Band 4, Lief. 17, p. 152, 1933.

1901. *Orthoceras indianense* Weller, Jour. Geology, vol. 9, p. 143.

Swallow's original description of this form is rather unsatisfactory. It is quoted in full below.

Shell small, tapering moderately; transverse section elliptical; septa very concave; distant nearly half the shorter diameter; siphuncle small, central.

Longest diameter, .64; shorter diameter, .51; distance of septa, .24; diameter of siphuncle, .06.

This fossil is very like *O. ovalis* of Phillips (Geol. York., Vol. II., p. 238); but the siphuncle is more central in our species.

Rare in the Lithographic Limestone of Marion and Pike counties.

Remarks: The type of this species, with most of Swallow's types, was destroyed by a fire which destroyed the main building of the University of Missouri in 1892 and, as the author did not figure it, details not covered in his description cannot now be supplied.

The writer has collected only one specimen from the Louisiana limestone that has any resemblance to it. That specimen is here described as a new species, "*Orthoceras*" n. sp. A.

The synonymy given for *O. chemungense* is merely compilation. The writer assumes no responsibility for its being correct, but, with the present state of his knowledge regarding the species, there is no justification for changing it.

Occurrence: Swallow's specimens were collected from the Louisiana limestone from unlisted localities in Marion and Pike Counties. No subsequent writer has reported its being collected from the Louisiana.

This species has also been identified from the North-view and Chouteau formations. The writer has not studied the specimens upon which these identifications were made.

"*Orthoceras*" minimum Rowley

1908. *Orthoceras minimum* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 92, pl. 19, fig. 25.

Rowley's original description follows.

The type consists of an outer or living chamber, somewhat crushed and a few simple closed chambers with their partition walls. The shell is round and the closed chambers of moderate width. The siphuncle is so small that it defies a pocket magnifier to locate it.

Remarks: This species is very small. It was described from a poorly preserved specimen, which has since been temporarily misplaced by its author. No specimens that can be referred to it have been collected by the writer.

Occurrence: Clay partings of Louisiana limestone at locality 599, mouth of Buffalo Creek, Pike County, Mo.

"*Orthoceras*"? n. sp. A.

Plate 9, figure 55

A single specimen preserved as a natural longitudinal section is so different from any described form that it is probably a new species and may represent a new genus.

As the living chamber, apex, and external surface are not preserved on this specimen, the form is not here described as a new genus or even as a formally named species.

The most unique character of the section is a series of deposits within the camerae. In most other observed characters the shell agrees with those shells rather generally included in "*Orthoceras*" and because the origin and significance of the deposits are not known, it is here tentatively included in "*Orthoceras*" despite the fact that the deposits in many respects resemble the deposits in the camerae of *Pseudorthoceras* Girty. The siphuncle is not the same as that of *Pseudorthoceras*, however, and until more of the shell than is here preserved is available for study it seems better to place it tentatively in the larger group "*Orthoceras*" than to extend unduly the range of *Pseudorthoceras*.

Conch orthoconic, small, gradually expanded orad. Specimen, a natural longitudinal section near the center, consisting of an incomplete living chamber and an incomplete phragmocone, with six distinct camerae and about three other camerae that are indicated but cannot be definitely made out. Length of specimen, 46.5 mm. An average diameter at the larger end is 11 mm., at the smaller end it is 4.3 mm. Apical angle about 6°. The section is so crystallized near the adoral end that one cannot determine where the phragmocone leaves off and the living chamber begins. Apex and aperture not preserved. Cross section, as indicated by a section through the specimen at the adapical end, where about half the circumference is preserved, subcircular.

Camerae near the adapical end of the specimen about half as long as wide; where the diameter of the section is 5 mm., the distance between septa is about 2.5 mm. Septa simple discs, concave orad (convex apicad); concavity ranging from 1 to 1.7 mm. Sutures not observed.

Siphuncle slender, average diameter about 0.5 mm., as seen in polished section, slightly eccentric or subcentral, about 1.5 mm. from one side of section and 2 mm. from other side at adapical end; cross section of siphuncle at adapical end of specimen slightly more elliptical than circular; walls of siphuncle not preserved in the adapical cross section; interior of siphuncle apparently without deposits; structure orthoconitic. Segments cylindrical or tubular; walls nearly straight, neither concave nor convex, scarcely if at all constricted where siphuncle passes through the septa. Septal necks not distinguishable from connecting rings; poorly preserved; in some of the camerae shelly material can be seen for about one-fifth the distance from the adoral to the adapical septum; in other camerae no shelly material is preserved about the segments of the siphuncle; septal necks, where observed, are vertical; connecting rings not observed.

Inner surface of outer wall of camerae thickened to

form a distinctive and regular structure that is observable in section on one side of five camerae. This structure consists of a gradual thickening of the inner surface of the outer wall of each camera from the adoral septum toward the adapical septum. At about two-thirds this distance the thickening expands abruptly into what appears in cross section to be a semicircular node. In some camerae the thickening appears to expand also immediately below the adoral septum and to form a triangular area in the angle formed by the septum and the outer wall. This area in the camerae in which it is visible continues under the septum as a gradually decreasing thickening about half the distance from the outer wall of the siphuncle. In other camerae no extension of the thickened area beyond a nearly vertical line is visible in this part of the camerae. The thickening of the wall is greater in the older camerae and the nodelike expansion is not so prominent in these camerae. The presence or absence of such a thickening on the other side of the specimen cannot be determined because of recrystallization. It is also impossible to determine whether the thickening on the walls throughout their circumference or merely a thickening of one side or an irregular thickening. The cross section at the adapical end suggests that it is present on one side only, and that the swellings just above the adapical septa are nodes, but because the shell wall is not fully preserved in the section, this suggestion may be wrong.

External ornamentation unknown.

Remarks: The writer is much in doubt as to the exact shape and origin of the structures on the inner walls of the shell. Although the cross section at the adapical end shows the thickenings of the outer wall to be irregular, the wall or the material that has replaced it or accumulated against it is not present in some places and is so altered by recrystallization over most of the circumference that its structure cannot be made out. The thickenings may actually represent annulations around the inner surface of the outer walls of the camerae.

The origin of the structure is also unknown. It may represent replacement of the outer wall, or it may be an added deposit within the wall. If any outer wall is present in the specimen as now preserved, which seems doubtful, it cannot be distinguished from the structures thought to represent thickening. The hypothesis that the structure represents an added deposit is strengthened by the fact that the older (adapical) camerae appear to have thicker deposits, as one would expect if it were owing to deposition about the walls. It is also strengthened by the increasing number of orthoconic cephalopods that are being found to have deposits within their camerae. Most of these deposits are, however, different in position from the deposits here described, because most of them are around the siph-

uncle rather than around the walls of the camerae.¹³

This species differs from all other Carboniferous species in the possession of the structures along the inner surface of the outer wall. In many respects, it rather closely agrees with the description of "*Orthoceras*" *chemungense* Swallow, 1860, also of the Louisiana limestone, but Swallow's species is larger. As before stated, Swallow's type specimens have been destroyed by fire; and as some details regarding their structure were not given in his description and as the nature of some of the features described by Swallow cannot be determined on the holotype of this species, even though they may later prove to be synonyms. Swallow makes no mention in the description of *O. chemungense* of the peculiar thickening observed on the species here described, and it should be assumed until proven otherwise that it was not present on *O. chemungense*.

As has been stated above, the thickened wall of the camerae of this species suggests the genus *Pseudorthoceras* Girty but the thickening in this species is not so extensive as in *Pseudorthoceras* and the shape of the structure formed is quite different. Furthermore, the siphuncle of *Pseudorthoceras* is definitely constricted where it passes through the septa and expanded within the camerae, whereas the siphuncle of this species is scarcely if at all constricted where it passes through the



FIGURE 9.—Diagrammatic representation of part of a section of "*Orthoceras?*" n. sp. A. showing shape of deposit within the camerae.

septa. The siphuncle of this species is much slenderer than that of *Pseudorthoceras*.

Occurrence: Limestone beds of the Louisiana limestone at locality 798, about 2½ miles west of Frankford, Pike County, Mo.

¹³ In addition to the description of deposits within the camera of *Pseudorthoceras*, Miller, Dunbar, and Condra (Miller, A. K., Dunbar, C. O., and Condra, G. E., The nautiloid cephalopods of the Pennsylvanian system in the midcontinent region: Nebraska Geol. Survey, 2d ser., Bull. 9, p. 80, 1933) mention somewhat similar deposits within the camera of representatives of the genera *Ormoceras* Stokes and *Trematoceras* Whitfield, but these genera differ in other characters from *Pseudorthoceras* and from the genus of which this species is a representative. Miller, Dunbar, and Condra appear to believe that the deposits of *Pseudorthoceras* are of organic origin and accept them as a diagnostic generic character at least for that genus.

Since this paper was submitted for publication, Flower and Caster (Flower, R. H., and Caster, K. E., The stratigraphy and paleontology of northwestern Pennsylvania, part 2, Paleontology: Bull. Am. Paleontology, vol. 22, p. 32, 1935) have described under *Bradfordoceras* as a new genus, cephalopods having deposits within the camera, and Sardeson (Sardeson, F. W., Ordovician complete *Gonioceras*: Pan.-Am. Geologist, vol. 61, No. 4, pp. 251-263, 1934) has attributed deposits within the camera of *Gonioceras* to pathologic factors.

"Orthoceras" sp.

1908. *Orthoceras* sp? Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 92, pl. 19, fig. 24.

Remarks: Fragmentary materials that may belong to this genus have been collected by R. R. Rowley and by the writer, but none of them is suitable for identification.

Order AMMONOIDEA

Suborder EXTRASIPHONATA

Family CHEILO CERATIDAE

Genus AGANIDES (Montfort, 1808) Fischer¹⁴*Aganides compressus* Moore

Plate 9, figures 51-54

1928. *Aganides compressus* Moore, Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 283, pl. 13, figs. 7, 8.

Moore's description of the type follows.

Shell discoidal, involute, laterally compressed, the whorls high and impressed to about one-half their height by the inner volution. The height of the last whorl is nearly two-thirds the total diameter of the shell. The sides of the whorl are flattened, convex and smooth, curving gently to the narrower, rounded venter. The umbilical shoulders are abruptly rounded and the opening almost closed. The dimensions of a nearly complete specimen are as follows: diameter 37.5 mm., height of last whorl 23 mm., height of last whorl from the preceding 13 mm., width of last whorl 15.8 mm., involution 10 mm., width of the umbilicus 2 mm.

The surface of the shell is ornamented by gently curving sigmoidal growth constrictions with a rather broad posteriorly directed sinus at the ventral margin.

The septa are of the usual *Aganides* type with a slightly spatulate, tongue shaped ventral lobe, deep and narrow and a sharply rounded lateral lobe. The external saddle is evenly rounded but directed slightly toward the venter, the lateral saddle is very broadly rounded.

Remarks: Measurements made by the writer of the holotype are: Diameter measured from extreme adoral part of holotype across umbilicus to the opposite side of shell 34.5 mm., diameter at 90° to preceding and across umbilicus 31 mm., estimated height of last whorl 20 mm., height of penultimate whorl 13 mm., estimated maximum width of last whorl 12 mm., width of umbilicus 4 mm.

The most distinctive character of this species is the external suture. It has a deep narrow tongue-shaped ventral lobe, which is constricted anteriorly. The most posterior part of the ventral lobe is partly chipped off of the only suture on the type that shows the posterior part of the ventral lobe and this part cannot therefore be clearly made out. There is, however, a suggestion of its being extended to a point. The lateral lobe is rather deep and sharply rounded, and is situated about one fifth the distance from venter to

¹⁴ O. H. Schindewolf would discard *Aganides* for species such as the one described here and substitute the name *Imitoceras* for them. (See Neues Jahrb. Beilage-Band 49, p. 325, 1923.) H. Schmidt and others have not, to the writer's knowledge, accepted Schindewolf's new name. The writer has not yet been able to investigate the merits of Schindewolf's proposal.

umbilicus. The external saddles are directed slightly toward the venter.

No sections were made of this species, which is represented by only one identifiable specimen, the holotype, the property of Walker Museum. The internal characters are not therefore known. The internal suture also could not be observed. A fragmentary mold from the Louisiana limestone at Louisiana, Mo., has about the same size and outline as *A. compressus*, but it is too poorly preserved for satisfactory determination.

This species resembles *A. discoidalis* Smith, 1903, from the Chouteau limestone; but that species does not have so deep or narrow a lateral lobe, its lateral lobe is farther dorsad, and its ventral lobe is not constricted anteriorly.

Occurrence: The holotype is from the limestone beds of the Louisiana limestone near Hamburg, Ill. The fragmentary and very tentatively identified specimen is also from the limestone beds but comes from Louisiana, Mo.

Family PROLECANITIDAE

Subfamily PROLECANITINAE

Genus PROTOCANITES H. Schmidt, 1922?

Protocanites louisianensis (Rowley)

Plate 9, figures 33-40

1895. *Goniatites louisianensis* Rowley, Am. Geologist, vol. 16, p. 221, figs. 15-18.

1898. *Goniatites louisianensis* Weller, U. S. Geol. Survey Bull. 153, p. 293.

1903. *Prolecanites?* *louisianensis* Smith, U. S. Geol. Survey Mon. 42, p. 54, pl. 4, figs. 6-8.

1908. *Goniatites louisianensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 93, pl. 19, figs. 26, 27.

1925. *Protocanites louisianensis* H. Schmidt, Preuss. Geol. Landesanstalt, Jahrb., Band 45, p. 537.

Rowley's original description is as follows:

Shell compressed, very small. Umbilicus large and rather deep, but the condition of the specimens is such that the inner whorls are not visible. Volutions rather slender and rounded on the dorsal side. Septa distinct only in a very few specimens, probably on account of the pyritized condition of the shells. Dorsal lobe long, tongue-shaped and rounded at the end. Dorsal saddle hardly as long as the dorsal lobe, but wider, and rounded at the extremity. Upper lateral lobe shallow and rounded at the end. Lateral saddle shallow, broad and rounded. Lower lateral lobe broad, obtuse. From the umbilicus to the dorsal side of a volution, three well defined, equidistant furrows extend. Body chamber not present in the specimen figured. The average size of the twelve or more specimens in the collection is little more than half that of the example figured.

The generic reference was first changed by Smith, who based the following remarks on a specimen from the Gurley collection.

The whorls are evolute, depressed, little embracing. The shell has one or two constrictions to a revolution. The general shape reminds one strongly of *Anarcestes*, but the septa show that the transition to the stock of the Prolecanitidae has already been made. The ventral lobe is long, tongue-shaped, and

undivided; the lateral lobe is lanceolate, and the second lateral or auxiliary lobe is shallow, broad, and lies just outside of the umbilicus. The internal septa consist of a pointed antisiphonal lobe, flanked by a pair of shallow laterals. All the saddles are rounded.

Remarks: This species is common in the washings from the clay partings in the Louisiana. Specimens collected range in diameters, measured across the umbilicus, from 0.75 to almost 4 mm. Three individuals have the following respective dimensions: Diameter measured from extreme adoral part of specimen to the opposite side of shell crossing the umbilicus 2, 2, and 2.8 mm.; width of umbilicus 1, 1 mm., and indeterminate. The width of the outer whorls of the specimens is about twice their height. About three volutions are present in each of the specimens whose dimensions are given.

The external sutures are not completely preserved on any specimen in the writer's collection. Fragments indicate that the external sutures resemble typical representatives of the genus. The ventral lobe is relatively small and V-shaped but not so relatively small as it is in some larger species. The first lateral saddle is rounded and U-shaped; the first lateral lobe is deeper and wider than the ventral lobe and is tongue-shaped rather than V-shaped. The second lateral saddle is narrower than the first lateral saddle but, like it, is rounded. The second lateral lobe is shallower and relatively wider than the first lateral lobe. The third lateral saddle is interrupted by the umbilical wall. As a comparison will show, the suture of this specimen differs quite decidedly from the suture figured by Smith.

Other individuals questionably placed in this species appear to have sutures more nearly approaching the suture represented by Smith. Most of these specimens are crushed or otherwise distorted, and no one of them shows more than a small part of an external suture and for these reasons and because the species is such a small one they are left in *P. louisianensis* though they may represent a new species or even another genus. Representations of sutures constructed by piecing together pieces of sutures on two or more individuals are likely to be in error. They suggest, however, that some of these individuals had only one lateral lobe and part of another lobe on the lateral slope of the shell, and that the umbilical wall intersects the suture a slight distance beyond the base of the second lateral saddle. On these specimens both the lobes and the saddles are shallower and hence relatively wider than on the specimen described above as having two lateral lobes completely shown on the lateral slope.

The internal suture was not observed on any of the individuals in the collections and the living chamber is not completely preserved on any. The penultimate and earlier whorls can be distinguished in the umbilicus on all but a few specimens. Umbilical shoulders are rounded; umbilical walls sloping at about 60°; umbilicus shallow. The later whorls are wider relative to their heights than the earlier formed whorls.

Cross sections of the whorls are mushroom-shaped. The whorls are impressed for not over one fifth of their height. Character of siphuncle not observable in sections made. The writer was unable to examine the types of this species.

Occurrence: Clay partings of the Louisiana limestone at Louisiana and at locality 599, mouth of Buffalo Creek, one mile south of Louisiana, Mo.

Genus *PROLECANITES* Mojsisovics, 1882

Prolecanites? sp.

Specimens of this genus that are specifically unidentifiable have been collected from the Louisiana limestone by R. C. Moore.¹⁵

As the identifications were probably made when the genus *Prolecanites* was more broadly considered than it is now, it is probable that Moore would now refer the specimens to one of the new genera made by the dismemberment of *Prolecanites* rather than to *Prolecanites* itself. As restricted, *Prolecanites* is characteristically found in much younger beds. The writer has not examined any of these specimens, and the reference is introduced here merely for completeness.

ARTHROPODA

Class CRUSTACEA

Subclass TRILOBITA¹⁶

Order OPISTHOPARIA

Family PROETIDAE

Genus *PROETIDES* Walter, 1926

This genus was proposed by Walter¹⁷ for Proetidae having short glabellas and three pairs of lateral furrows that cross the median area of the glabella. The short glabella distinguishes it from *Proetus*, *Phillipsia*, and *Griffithides*, and the lateral furrows, from *Brachymetopus*. A further and probably more important difference from *Brachymetopus* is the presence of a facial suture on *Proetides*.

Only one species in the Louisiana limestone is here referred to *Proetides* and its reference is only tentative. Although it has a short glabella and a well-defined facial suture, it does not have transverse glabellar furrows that cross the median part of the glabella. It may perhaps represent a new genus, but because one of Walter's figures does not clearly show such furrows, the writer is, for the time being, including it in his genus despite the absence

¹⁵ Moore, R. C., Early Mississippian formations in Missouri: Missouri Bur. Geology and Mines, 2d ser., vol. 21, p. 47, 1928.

¹⁶ The details of classification of the trilobites are controversial, and many different viewpoints must be harmonized before a stable and usable classification can be had. As the writer desires not to enter into the controversy, he is using the old established classification and consequently is omitting some recently proposed units. The chief contributors to recent discussions on the higher units of classification of the trilobites are Raymond, Warburg, Raw, Swinnerton, and Ulrich. The reader is referred to the works of these investigators for detailed discussion.

This part of the study of the Louisiana limestone fauna was completed before the publication of recent revisional studies of Carboniferous trilobites made by V. Weber, O. Toumansky, and J. M. Weller, and opportunity was not had to incorporate the work of these or of any other authors whose papers reached the writer after the spring of 1933 into the descriptions here presented.

¹⁷ Walter, O. T., Trilobites of Iowa and some related Paleozoic forms: Iowa Geol. Survey, vol. 31, p. 316, 1926.

of transverse furrows other than those that delimit the basal lobes. When more detailed studies are made, this course may be found to be in error, but it can then easily be altered.

Proetides? stratton-porteri (Rowley)

Plate 9, figures 65, 66

1908. *Phillipsia stratton-porteri* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 94, pl. 19, figs. 28, 29.

1928. *Brachymetopus stratton-porteri* Moore, idem., 2d ser., vol. 21, p. 47.

Rowley's original description is as follows:

A rather small species. Cephalic shield semicircular, about twice as broad as long and with the postero-lateral angles produced into slender elongate spines that extend back, probably to the middle of the thoracic margin. A poorly defined rim, with little upward deflection, borders the front and sides of the head shield.

The glabella has but little convexity and a length but half that of the head shield and a width one-fifth as great. The length of the glabella is once and a half as great as the width. Neck segment narrow, depressed. Only the posterior lateral lobes of the glabella observable. Eyes round, more than one-third as long as the glabella and quite as prominent. Reticulations not visible under a hand glass.

Facial sutures traceable with difficulty, meeting the anterior margin of the cephalic shield almost in front of the eye. Thorax not known. Pygidium almost semicircular, a little wider than long and fully as long as the head shield. Mesial lobe convex, much less wide anteriorly than the lateral lobes, tapering backward to a blunt point at the broad posterior margin of the pygidium and having thirteen segments. Lateral lobes somewhat convex and with a broad flattened margin, ten segments each ending with a marginal blunt spine giving the outline a toothed appearance.

There are five or six other rows of nodes on the lateral lobe, the central row being much the strongest. Seven rows of nodes cross the middle lobe, longitudinally, the middle row being very much the strongest. Less distinct nodes cover the cephalic shield including the glabella.

The spinose or toothed character of the outer ends of the pygidial segments, unusually small glabella and prominent rounded eyes readily separate this trilobite from other species of the genus.

Remarks: Some distinctive characters of the cephalon of this species are: the short glabella, the absence of more than one pair of lateral furrows on the glabella, the long genal spines, the short length of cephalon compared to the width, the narrow, convex, elevated, uniform nontuberculated border, the small irregularly arranged pustules, the posterior position of the strongly elevated conical eye, and the large basal lobes of the glabella. The glabella is slightly over one-half the length of the cephalon and is somewhat conical, the highest point being near the middle. The facial suture cannot be definitely traced posterior to the eye. Some measurements of the cephalon of one of the cotypes are as follows: Length of cephalon, exclusive of occipital ring, 6 millimeters; width of cephalon, 12 millimeters; length of genal spine, 4.7 millimeters; length of glabella, 3.5 millimeters.

The median row of nodes on the axis of the pygidium

is composed of much larger nodes than the lateral rows. The lateral rows are discontinuous and irregular and of irregularly sized nodes. Seven rows, a median row and three lateral rows on either side of it, can, however, be made out on the axis. The strongest nodes on the pleural segments are at the place where the segments bend down before recurving to the spinose border. The abrupt recurving of the pleural segments to the upturned spinose margin is characteristic of the species. There are 13 segments on the axis and 10 segments on each pleural lobe of the cotype examined by the writer. The dimensions of this pygidium are: Length 7 mm., width 9.5 mm., and width of axis at anterior of pygidium 2.5 mm.

There is considerable doubt as to which, if any, of the established Carboniferous genera this species should be referred, and the reference made here is merely tentative. Its closest resemblances seem to be to *Brachymetopus* and to *Proetides*. The presence of a distinct facial suture and basal lobes and absence of tubercles on the marginal rim of the cephalon would at first glance appear to prohibit its reference to *Brachymetopus*, because McCoy, in his original description of that genus, states that "eyelines" (facial sutures?) are unknown and he does not mention basal glabellar lobes but does describe as one of the generic characters a marginal row of tubercles. Furthermore, McCoy based his genus on very small, almost minute forms. The very fact that the specimens were very small would lessen the importance of the presence or absence of facial sutures, for they may not, because of possible immaturity of the specimens, have yet been developed on the dorsal side of the form he had in mind. Although he does not mention basal lobes in his description, he does say "one pair of small, basal, cephalothoracic furrows or none" in his generic description, and it is probable, especially as the figure of one of his species shows them, that he meant to imply that these furrows delimited basal lobes. The principal character that McCoy had in mind is establishing *Brachymetopus* seems to have been the short glabella. However, most forms referred by subsequent authors have not shown facial sutures, and their absence has been cited by some who have made revisional studies as of generic importance. It is mainly in deference to this viewpoint that the writer is transferring this species to *Proetides*.

The species does not, however, conform in at least one important respect to *Proetides* and seems but slightly better placed under this genus than under *Brachymetopus*. *Proetides* is said to differ from *Brachymetopus* in possessing facial sutures and three pairs of lateral furrows that cross the median area of the glabella. His figure of one of the type specimens shows only faint indications of transverse glabellar furrows, but they are clearly shown on the figure of the other specimen. If Walter's genus *Proetides* is to be strictly interpreted as described, this species cannot be included

in it and as it does not agree with *Brachymetopus*, it must be placed in a new genus or in one not heretofore recognized in the Carboniferous. Because the transverse furrows are not clearly shown on one of Walter's figures, however, the writer is taking the liberty to include also in it temporarily at least forms that are without transverse glabellar furrows except those that delimit the basal lobes. This appears to be the more conservative course to follow until more complete studies of these two genera and related forms can be made.

Of the Mississippian trilobites, the following species rather closely resemble *P. stratton-porteri*, *Brachymetopus occidentalis* (Herrick, 1888), *B. lodiensis* (Meek, 1875), and *B. spinosus* (Herrick, 1888). From the description of the first species, *P. stratton-porteri* differs in the relatively shorter glabella and round eyes of its cephalon and the much narrower axis of its pygidium. It also has fewer axial segments on its pygidium. A comparison of *P. stratton-porteri* with the description of *B. lodiensis* shows that *P. stratton-porteri* differs in having a much shorter glabella and larger basal lobes and in lacking a marginal row of tubercles around the cephalon. It also has a relatively longer pygidium with seven rows of nodes on the axis, whereas the pygidium of *B. lodiensis* is said to have but five rows. The axis of its pygidium is also narrower. The cephalon of *B. spinosus* is said to have a relatively longer glabella than that of *P. stratton-porteri* and smaller basal lobes. Moreover, the tubercles on the glabella of *B. spinosus* are described as being arranged in rows, whereas those of *P. stratton-porteri* are not so arranged. The pygidium of *B. spinosus* is more highly arched and has an axis that is relatively wider than that of *P. stratton-porteri*. It has 5 rows of nodes on the axis as against 7 for *P. stratton-porteri*, and 1 to 4 rows on the pleura as against 5 or 6 for *P. stratton-porteri*. Furthermore, the pleural segments of its pygidium bifurcate near the margin. None of the species here compared with *P. stratton-porteri* have been described as having facial sutures.

This species was described from a cephalon and two pygidia, which were found close together at the same horizon. They may, however, represent two distinct species.

Occurrence: Louisiana limestone at Louisiana, Mo.

Genus BRACHYMETOPUS McCoy, 1847

One species in the Louisiana limestone is doubtfully referred to *Brachymetopus*. As previously discussed under *Proetides? stratton-porteri*, the possible immaturity of the genotype casts doubt on the significance of the characters on which *Brachymetopus* is based. As generally used in America it embraces forms with short glabellae, without transverse glabellar furrows except those that delimit the basal lobes, and without facial sutures. The use of this last character is rather pre-

carious, because facial sutures are not distinctly shown on some specimens on which they exist, and also because there is considerable confusion regarding their ontogenetic significance and development. In actual practice, however, the facial sutures are used fully as much as the transverse lateral furrows in distinguishing *Proetides* and *Brachymetopus*. The writer here is following current American usage and retaining in *Brachymetopus* all forms possessing the other characters generally attributed to it and not known to have facial sutures.

Brachymetopus? spinosiformis Williams, n. sp.

Plate 9, figure 68

This species is based on a single external mold of a pygidium that resembles *B. spinosus* (Herrick, 1888).

Pygidium subsemielliptical, convex, rather highly arched, of moderate size; length 10 mm., width at anterior 14 mm., width of axis at anterior 5 mm.

Axial lobe distinctly set off from pleural lobes by sharp longitudinal dorsal furrows. Axis highly elevated, convex, tapering to a blunt extremity at about one-sixth the length of pygidium from posterior of pygidium, slightly more than one-third the width of pygidium at anterior end; composed of 13 segments. Seven longitudinal rows of nodes ornament the axis, the central row being composed of nodes that are stronger and more distant from the lateral nodes than the lateral nodes are from each other.

Pleural lobes composed each of about 10 segments, which are not continuous with the segments of the axial lobe. Segments separated by deep and distinct furrows and divided longitudinally into an anterior carinate portion and a posterior depressed portion by furrows that extend from near the axis to the margin. The anterior carinate portion of each segment is ornamented by three to five rather small nodes or pustules.

Margin of pygidium probably not fully preserved. No area that can be differentiated as a margin from the rest of the pygidium is shown on the specimen. If it is fully preserved, the margin might be described as irregular or slightly denticulate but not in any sense spinose.

Remarks: As stated above, this pygidium rather closely resembles that of *B. spinosus*, but because of a few rather pronounced differences from it, it was thought best to describe it as new, even though the material is not very satisfactory. These differences are largely found in the tuberclose ornamentation, but other features also differ. *B. spinosus* has more axial and fewer pleural segments. It has five rows of nodes on the axis, whereas *B. spinosiformis* has seven rows. It has, according to the description and figures given by its founder, fewer and relatively larger nodes on the pleural segments than *B. spinosiformis*.

The pygidium of *B. spinosiformis* differs from that of *P. stratton-porteri*, which also occurs in the Louisiana limestone, because of its greater convexity, relatively

much narrower and more convex axis, flatter pleural lobes, smaller nodes on the axial and pleural segments, and longitudinally divided pleural segments. Furthermore, the margin of *P. stratton-porteri* is strongly and coarsely spinose, whereas that of *B. spinosiformis* is not known to have that character.

The reference of this species to *Brachymetopus* is merely provisional and was made largely because of its resemblance to *B. spinosus*. The writer has not examined typical specimens of *B. spinosus*, but the description of its cephalon does not mention facial sutures. General practice is to include forms resembling *B. spinosus* and without facial sutures in *Brachymetopus*.

The name of the species recalls its resemblance to *B. spinosus*.

Occurrence: Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo.

Genus **PROETUS** Steininger, 1830

Proetus missouriensis Shumard

Plate 9, figures 45-50

1855. *Proetus missouriensis* Shumard, Missouri Geol. Survey, First and Second Ann. Repts., p. 196, pl. B, figs. 13 a, b.
 1862. *Proetus auriculatus* Hall, New York State Cab. Nat. Hist. 15th Ann. Rept., p. 107.
 1863. *Phillipsia meramecensis* Winchell, Acad. Nat. Sci. Philadelphia, Proc. p. 24.
 1865. *Proetus missouriensis* Winchell, idem, p. 133.
 1887. *Phillipsia shumardi* Herrick, Denison Univ., Sci. Lab., Bull. vol. 2, pp. 58, 69, pl. 7, figs. 14, 14a.
 1887. *Proetus missouriensis* Vogdes, New York Acad. Sci. Annals, vol. 4, p. 75, pl. 3, figs. 1?, 2 (not fig. 16).
 1888. *Proetus missouriensis* Hall and Clarke, Paleontology of New York, vol. 7, p. 133, pl. 23, fig. 32.
 1888. *Phillipsia shumardi* Herrick, Denison Univ., Sci. Lab., Bull. vol. 3, p. 29, pl. 2, fig. 22; pl. 3, fig. 32.
 1888. *Phillipsia (Proetus) auriculatus* Herrick, Denison Univ., Sci. Lab., Bull. vol. 4, p. 54, pl. 1, fig. 14.
 1889. *Phillipsia (Proetus) auriculatus* Herrick, Am. Geologist, vol. 3, pl. 1, fig. 14.
 1889. *Proetus missouriensis* Miller, North American Geology and Paleontology, p. 562.
 1889. *Phillipsia auriculatus* Miller [part], North American Geology and Paleontology, p. 560.
 1890. *Proetus missouriensis* Vogdes, U. S. Geol. Survey Bull. 63, p. 137.
 1894. *Proetus missouriensis* Keyes, Missouri Geol. Survey, vol. 4, p. 233.
 1895. *Proetus auriculatus* Herrick, Ohio Geol. Survey, vol. 7, pl. 14, figs. 14, 15.
 1898. *Proetus missouriensis* Weller, U. S. Geol. Survey Bull. 153, p. 506.
 1900. *Proetus missouriensis* Lane and Cooper, Michigan Geol. Survey, vol. 7, pt. 2, p. 266, pl. 11, figs. 14, 15.
 1908. *Phillipsia missouriensis* Rowley, Missouri Bur. Geology and Mines, 2d ser., vol. 8, p. 95, pl. 19, figs. 30, 31.
 1910. *Proetus missouriensis* Grabau and Shimer, North American index fossils, vol. 2, p. 301.
 1925. *Proetus* cf. *P. missouriensis* Walter, Iowa Geol. Survey, vol. 31, p. 318, pl. 26, fig. 10.

Shumard's original description of this species is as follows:

Glabella tumid, greatest height about the center, ovoid, obtusely rounded in front, truncated posteriorly, length a little

greater than the width, widest behind, three furrows on either side, posterior pair strongly marked: these commence at the dorsal sinus, about one-third the distance from base to front, pass in a curve backwards, and bifurcate about midway between the center and sides of the glabella; one branch, very shallow, is continued for a short distance almost transversely; the other bends backwards nearly to the occipital sinus, and with the main branch partially encloses a large oval lobe on each side, the lobes separated by a space about half the width of the glabella; middle pair of furrows, shallow, curving backwards in a direction nearly parallel with the posterior ones, but considerably shorter; anterior pair feebly impressed, a little oblique; occipital sinus a little convex towards the front, shallowest in the middle; occipital ring wide, flattened, much lower than the plane of the glabella. Pygidium semi-circular, flattened convex, width double the length, margin broad and slightly concave; axial lobe almost as wide as the lateral lobes, rounded at the extremity, segments ten, separated by strongly marked furrows; lateral lobes flattened, with six or seven segments, separated by shallow, but well-marked furrows; surface thickly studded with granulae, which are rather smaller than those of the glabella.

Dimensions: Length of head, 8½ lines; greatest width of glabella, 7½ lines; length of pygidium, 6½ lines, width of ditto, 1 inch.

Cheeks and thorax unknown.

Remarks: Seven pygidia and three glabellae in the writer's collections belong to this species. The pygidia have a considerable range in size and vary in other ways. The following are the approximate dimensions of four specimens: No. 3773, length 14 mm., width 22.4 mm., segments on axis 9, segments on pleura 7; no. 3774, length 13.5 mm., width 24.3 mm., segments on axis 10, segments on pleura 8; no. 3775, length 6 mm., width 8.7 mm., segments on axis 9, segments on pleura 8; no. 3776, length 5.5 mm., width 9.4 mm., segments on axis 9, segments on pleura 7.

Most of the pygidia have granulated surfaces. The two larger specimens given in the above table are slightly smaller than the type and are not quite twice as wide as long. Herrick¹⁸ says, however, that Shumard's type specimen was broken, and that the species is one-third wider than long instead of twice as wide as long. The relative dimensions may vary between the two. The axis in the specimens collected is about as wide as the pleural lobes anteriorly but narrows to an obtuse point and terminates about one-fourth its length from the posterior of the pygidium. The pleural lobes are not distinctly segmented posteriorly, and the exact number of segments on them is not easily determined. The axis is separated from the posterior of the pygidium by a distinct border. The border is one-fifth to one-third as wide as the rest of the pleural lobe anteriorly and increases very slightly, if at all, in width posteriorly. Shumard's original description states that the margin is concave. Herrick corrected this in a later description. The margin is slightly convex. Shumard's specimen was probably exfoliated at the margin. This is indicated by the fact that one of the specimens in the collections has one margin exfoliated and the other preserved. The exfoliated part is much flatter than the part that retains the test.

¹⁸ Herrick, C. L., A Waverly trilobite: Denison Univ., Sci. Lab., Bull. vol. 2, p. 69.

The pygidia in the writer's collections are characterized by the semicircular shape, the abrupt, almost vertical bending down of the pleural segments about one-half their distance from the longitudinal dorsal furrow, the convex uniform margin, the granulated surface, and the furrows which go from the longitudinal dorsal furrows to the margins of the pygidia and divide each pleural segment into an anterior carinate ridge and a posterior flattened area.

One glabella is much larger than the other two, but all three are smaller than the type. Two of them have four pairs of lateral furrows. The anterior furrow is shorter than the others and somewhat less oblique. Granules are much coarser on the largest specimen but are present on all. The dimensions of the largest and one of the smaller glabellae are: Length, exclusive of occipital segment, 12.5 and 7.1 mm. respectively; length, including occipital segment, 15 and 8.3 mm.; width at posterior of glabella, 12 and 7 mm. The two smaller glabellae may represent a new species, but as they only differ from the type in size and in size of granules, the writer believes they are small forms of *P. missouriensis*. The largest glabella in the collections studied is intermediate in size and in size of granules between the type and the smaller glabellae.

Shumard's type glabella, which is in the collection of Washington University, St. Louis, appears from the matrix to have come from the Louisiana limestone and bears the label said to be in Shumard's handwriting, "Lithographic ls., Louisiana, Mo." It has the following measurements: Length of glabella, exclusive of occipital segment, 17 mm.; width of occipital segment, 2.5 mm.; approximate width of glabella, 16.5 mm.; width of margin in front of glabella, 2 mm. Three lateral furrows are well marked on the glabella, and a fourth, which is in front of the other three, can be made out. It does not curve and is less oblique than the other furrows. Granules on the occipital ring are finer than those on the glabella.

This species was first described by Shumard from a glabella and a pygidium. Owing to the somewhat obscure nature of the differences between *Proetus* and *Phillipsia*, it has been placed in each of these genera at various times. Winchell, in 1865, was the first to propose that *Proetus missouriensis* be referred to *Phillipsia*. Vogdes, in 1887, included the form under *Proetus*, and in 1888 Hall and Clarke referred it to *Proetus* and identified *P. auriculatus* Hall with it. Hall and Clarke's reference was based mainly on the small number of segments in the pygidium and its relatively short pygidium. In 1908 Rowley called this form *Phillipsia missouriensis* but did not state why he thought it was a *Phillipsia* rather than a *Proetus*. The Louisiana form was placed in the genus *Proetus* by Grabau and Shimer in 1910. In 1924 Walter, largely on the basis of a communication from Dr. G. H. Girty, identified glabellae collected from the yellow sandstone at Burlington, Iowa, and doubtfully referred by A. Winchell to *Phillip-*

sia meramecensis as *Proetus missouriensis*. The cephalon described by Vogdes in 1887 from Cameron, Missouri, is probably from the Pennsylvanian rocks and is probably not *Proetus missouriensis* Shumard. The writer has not, however, examined Vogdes' specimen. All the references cited above are included in the synonymy.

Occurrence: Louisiana limestone in Pike, Marion, and Ralls counties, Mo. This or a closely related species occurs also in the so-called Sylamore sandstone of Missouri.

This species has also been described or reported from lower Mississippian formations in Ohio, Michigan and Iowa and from the Chouteau limestone of Missouri. The Chouteau reference is probably in error, as no specimens of *Proetus missouriensis* are said to have been found in the material used by Shumard from the Chouteau, and none has since been collected from that formation. The writer has not checked any of the synonymic references by examining specimens other than those from the Louisiana limestone.

Proetus tenuituberculus Williams

Plate 9, figure 67

1930. *Proetus tenuituberculus* Williams, Am. Jour. Sci., 5th ser. vol. 20, p. 63, fig. 1.

Pygidium subsemicircular in outline, moderately convex, length slightly over half the width. Axis distinct but not prominent, depressed, convex, highest near midlength, rounded posteriorly, gradually tapering to a blunt extremity and terminating at the narrow border of the pygidium about one-fourth its anterior width from the posterior of the specimen. The width of the axis at the anterior of the pygidium is 6.5 mm., which is somewhat greater than the width of the pleural lobes. Segments 10, separated by distinct but not deep intersegmental furrows.

Anterior part of the pleural lobe not quite equal in width to the anterior part of the axial lobe. Pleural lobes gently convex, sloping gently from the longitudinal dorsal furrow for about half their widths, at which place they curve abruptly downward. Each lobe divided into eight segments, which are distinct to the border of the pygidium. Each pleural segment is divided into an anterior slightly raised part and a posterior slightly depressed part by a furrow that extends from the longitudinal dorsal furrow to the smooth margin of the pygidium. A narrow, moderately convex, uniform border surrounds the pygidium.

The entire pygidium is covered by very fine pustules, which are visible only under a magnification of about 20 diameters.

The following are the dimensions of the holotype: Length of pygidium, 9.5 mm., width of pygidium 16.5 mm., width of axis at anterior end 6.5 mm., length of axis, 8.5 mm., width of axis at posterior end 2.4 mm., distance of posterior end of axis from posterior of the pygidium 1.6 mm., width of pleural lobe at anterior end 5.0 mm., greatest width of margin 1.6 mm.

Remarks: This species is very closely related to *P.*

missouriensis Shumard, 1855, but it is much more finely pustulose, the pustules of even small individuals of *P. missouriensis* being visible to the naked eye. It is also flatter than typical specimens of *P. missouriensis*, and the anterior part of each pleural segment is only slightly elevated above the posterior part. In *P. missouriensis* the anterior part is distinctly elevated above the posterior part. *P. tenuituberculus* is also closely related to *P. swallowi* Shumard, 1855, but differs from it in shape and in its more distinct segmentation of the pleural lobes.

The holotype of *P. tenuituberculus* is especially interesting because of its unusual markings. They consist of two rows of dark-brown subcircular spots extending along the sides of the axis close to the longitudinal dorsal furrows from near the termination of the axis nearly to the anterior of the pygidium. These markings are about equal in number to the segments of the axis, but some of them extend across the intersegmental furrows and occupy parts of two segments. Two rows of faint short transverse lines of dark brown color extend from the posterior of the axis parallel with and between the rows of rounded markings, which probably to some extent show the original pattern of the coloration. Between them is a long narrow space devoid of color markings which occupies the highest part of the axis of the pygidium.

Occurrence: Limestone beds of the Louisiana limestone at locality 728, 3 miles northwest of Ely, Marion County, Mo.

Subclass EUCRUSTACEA

Superorder OSTRACODA

Ostracodes are rather common among the small forms secured by washing the clay partings in the Louisiana limestone. Some ostracodes were figured by Rowley,¹⁹ but he did not give them generic or specific names. Mr. P. V. Roundy, of the U. S. Geological Survey, identified the following from material submitted to him by the writer: *Bassleria* n. sp., *Beyrichiella*? n. sp., *Amphissites*, two species, *Jonesina* sp., *Bairdia* sp., *Cytherella* sp., *Bythocypris*? sp. He also noted fragments of shells that suggested other ostracod genera. The material came from the clay parting above the lowest limestone bed at locality 599, 1 mile south of Louisiana, Mo.

VERTEBRATA

Class ARTHRODIRA²⁰

Order ARTHROTHORACI

Family DINICHTHYIDAE

Genus DINICHTHYS Newberry, 1868

Dinichthys sp.

Plate 9, figures 69, 70

Two dinichthid fragments of uncertain position suggest a form comparable in size to *D. curtus* Newberry.

¹⁹ Rowley, R. R., Geology of Pike County Missouri Bur. Geology and Mines, 2d ser., vol. 8, pl. 16, figs. 77, 78; pl. 19, figs. 32, 33, 1908.

M. G. Mehl, who examined them, stated that they probably represent an anterior margin and a lower margin of a left infero-gnathal. This is apparently the first record of a dinichthid in rocks so young as the Louisiana.

Occurrence: Limestone beds or clay partings of the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo.

Class ELASMOBRANCHII

Subclass HOLOCEPHALI

Order CHIMAEROIDEI

Family PTYCTODONTIDAE

Genus PTYCTODUS Pander, 1858

Ptyctodus calceolus Newberry and Worthen

Plate 9, figure 64

1866. *Rinodus calceolus* Newberry and Worthen, Illinois Geol. Survey, vol. 2, p. 106, pl. 10, figs. 10a-c.
1870. *Ptyctodus calceolus* Newberry and Worthen, idem, vol. 4, p. 374.
1875. *Ptyctodus calceolus* Newberry, Ohio Geol. Survey, vol. 2, pt. 2, p. 59, pl. 59, figs. 13, 13a.
1897. *Ptyctodus calceolus* Calvin, Iowa Acad. Sci. Proc., vol. 4, p. 18.
1898. *Ptyctodus calceolus* Eastman, Iowa Geol. Survey, vol. 7, p. 114, text fig. 10a (p. 115).
1898. *Ptyctodus calceolus* Eastman, Am. Naturalist, vol. 32, p. 476, figs. 1-17, on p. 477.
1899. *Ptyctodus calceolus* Weller, Jour. Geology, vol. 7, p. 484.
- ?1906. *Ptyctodus* sp. Dean, Carnegie Inst. Washington Pub. 32, p. 137, text fig. 115.
1906. *Ptyctodus calceolus* Norton, Iowa Geol. Survey, vol. 16, p. 356.
1907. *Ptyctodus calceolus* Eastman, New York State Mus. Mem. 10, p. 71.
1908. *Ptyctodus calceolus* Eastman, Iowa Geol. Survey, vol. 17, p. 133, pl. 5, figs. 1-17.
1911. *Ptyctodus calceolus* Cleland, Wisconsin Geol. Survey Bull. 21, p. 150, pl. 48, figs. 1-17.
1914. *Ptyctodus calceolus* Branson, Missouri Univ. Bull., vol. 15, No. 31; Science ser., vol. 2, No. 4, p. 64, pl. 3, figs. 3, 4.
1918. *Ptyctodus calceolus* Branson, idem, vol. 19, No. 15, engineering experiment station ser. 19, p. 103, pl. 4, fig. 16.
1918. *Ptyctodus calceolus* Hussakof and Bryant, Buffalo Soc. Nat. Sci. Bull., vol. 12, p. 109, pl. 34; pl. 36, figs. 1, 2, 10; pl. 37, fig. 9.
1922. *Ptyctodus calceolus* Branson, Missouri Bur. Geol. and Mines, 2d ser., vol. 17, p. 126, pl. 31, figs. 1, 2.

Meek and Worthen's original description follows:

Teeth laterally compressed, forming an unequal and irregular frustrum of a cone; the summit truncated, compressed and deeply furrowed longitudinally; base more or less excavated beneath. The general form is very much that of a low shoe, a resemblance which has suggested the specific name given to it. The sides of the tooth are marked with a series of more or less interrupted and inosculating, horizontal, raised lines and furrows, of nearly equal breadth. The summit is occupied by a plate of dense enamel marked like the sides, but across this the lines run transversely, giving it a file-like surface. In the specimens before us this enameled crown is hollowed into a broad, longitudinal sulcus; when examined under a powerful glass, the roughening of the triturating surface is seen to be affected by the arrangement of the enameled tubes, which are placed in rows side by side, forming sulci which are separated by ridges of

²⁰ The units of classification below the rank of phylum are taken from Jordan, D. S., A classification of fishes: Stanford Univ. Pub., Univ. ser., Biol. Sci., vol. 3, No. 2, 1923.

harder material. The base is deeply excavated longitudinally, and the under surface shows the same peculiar structure as the upper; length 2 inches; greatest breadth 8 lines.

A more recent description, made by Eastman in 1907, is also given for comparison.

Dental plates compressed into a thin cutting edge shortly behind the symphysis, but widening gradually, becoming more or less outwardly curved, and the oral surface occupied for nearly its entire width by the tritoral area, the inner margin of which is more strongly curved than the other. Laminar structure of the tritors indicated superficially by fine punctae arranged in parallel rows running obliquely across the functional surface. The compressed edge in advance of the tritor in the lower dental plate slopes rapidly upward and terminates in a strong anterior beak. Upper dental plates similar to the lower, except that the symphysial border is rounded and not produced into a beak.

Remarks: Worn teeth are common in the yellow-brown shale at the base of the Louisiana limestone, and two specimens have been collected from the limestone beds by the writer.

Occurrence: Limestone beds of the Louisiana at locality 800, near Spencersburg, Pike County, and at Louisiana (Branson's and Peabody Museum (doubtful) records); yellow-brown mudstone in Louisiana limestone at locality 618, Clarksville; and mudstones and clay partings of limestone beds at locality 593, Town Branch, Louisiana, Mo.

This species is widely distributed in Middle and Upper Devonian faunas, and specimens also occur in the so-called Sylamore sandstone, Saverton (Mississippian), and Grassy Creek (Mississippian or Upper Devonian) shales in northeastern Missouri. Specimens have been described by Weller from the Glen Park member of the Sulphur Springs formation and cited by Moore from the Bushberg sandstone member in southeastern Missouri.

Conodonts²¹

A few fragmentary conodonts were collected from the clay partings in the Louisiana limestone by washing the clay obtained from them. The writer has collected a few from locality 599, 1 mile south of Louisiana, Mo., where they are associated with ostracodes and other small forms. The only fragment that could be identified was said by P. V. Roundy, of the Geological Survey, to "clearly belong to an undescribed genus which occurs in the Sycamore limestone of Oklahoma."

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²¹ Since this report was prepared, conodonts from the Louisiana have been described or mentioned by E. B. Branson, M. G. Mehl, and other investigators.

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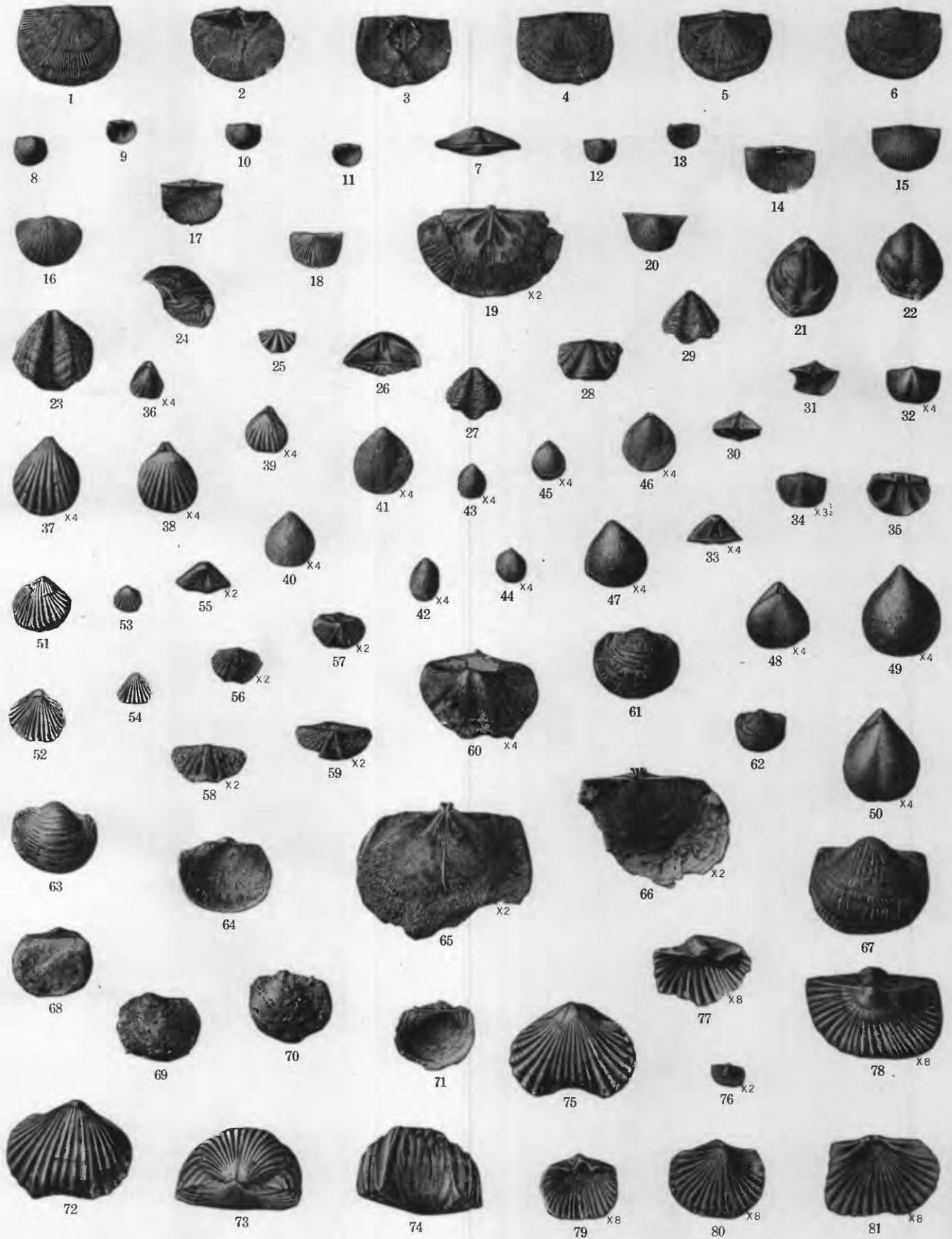
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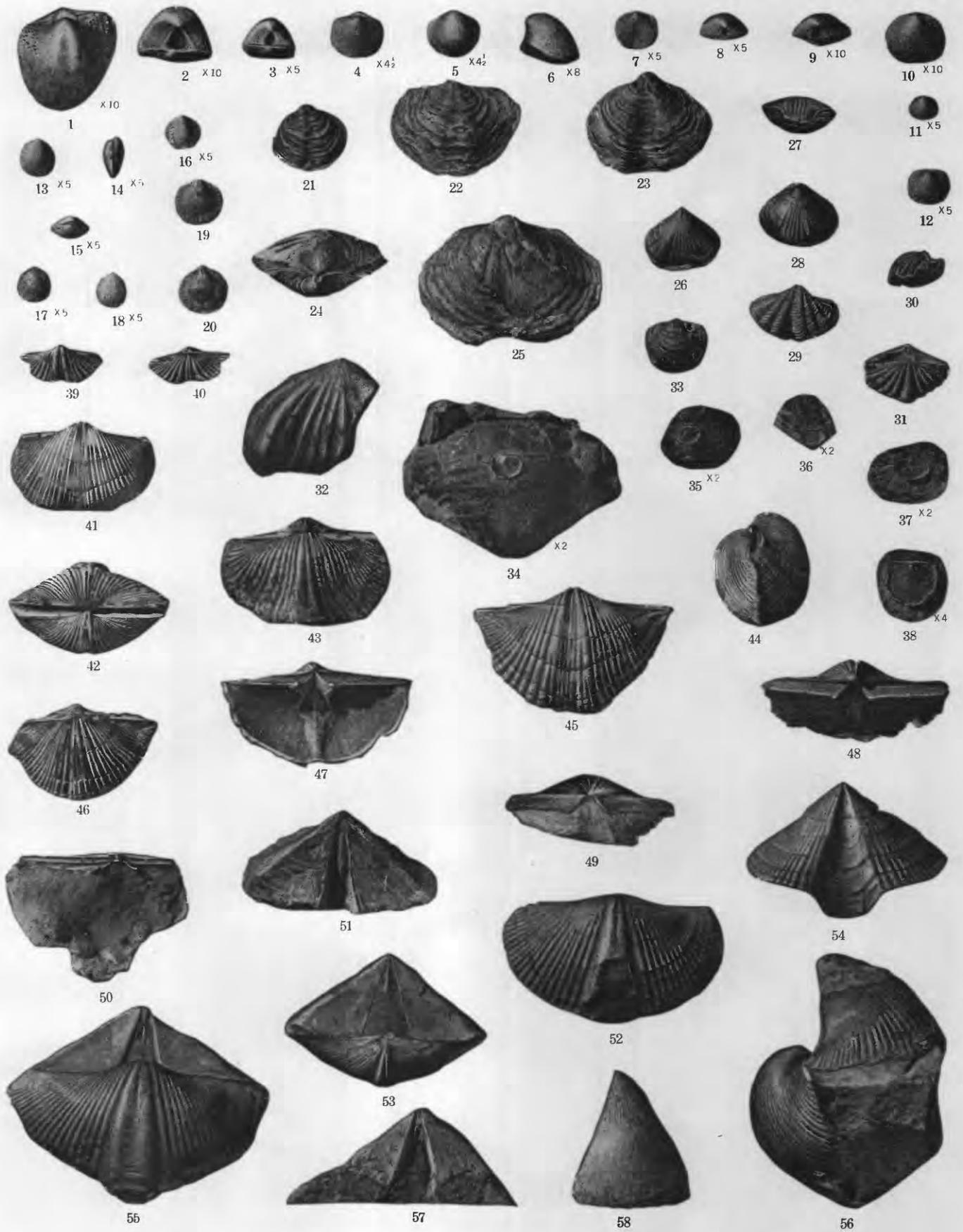


FAUNA OF THE LOUISIANA LIMESTONE OF MISSOURI.





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PLATES 6-9



PLATE 6

- FIGURES 1-3. *Leptodiscus corrugatus* Rowley (p. 55). Clay partings and yellow-brown mudstone of the Louisiana limestone at or near Louisiana, Mo. R. R. Rowley collection.
1. One of the cotypes enlarged to show details of structure.
 2. Another cotype.
 3. Specimen shown in figure 1, natural size.
- FIGURES 4-8. *Conopoterium effusum* Winchell (p. 60). Specimens 4-7 are from yellow-brown mudstone or limestone beds of the Louisiana at Louisiana, Mo., R. R. Rowley collection; 8 is from the Louisiana limestone at Louisiana, Mo., Univ. Mo. 5503.
4. Average specimen.
 5. View of under surface showing peritheca.
 6. Individual with corallites partly filled with foreign material.
 7. View of upper surface of specimen shown in figure 5.
 8. Section showing mode of development of corallites and mural pores and rarity of tabulae.
- FIGURES 9-13. *Microcyathus enormis* (Meek and Worthen) (p. 59). Yellow-brown mudstone or limestone beds of the Louisiana at Louisiana, Mo. R. R. Rowley collection.
9. Corallum composed of three corallites.
 10. Another view of same specimen.
 11. Individual that is truncate below.
 12. Another individual enlarged to show surface markings.
 13. Side view of a corallum that has four corallites.
- FIGURES 14, 15. *Allagecrinus americanus* Rowley (p. 64). Two individuals figured to show approximate size and general form of species. Clay partings of the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 5527.
- FIGURES 16-18. *Platycrinus dodgei* Rowley (p. 64). Two basal cups and a radial plate. Probably the types. Clay partings of the Louisiana limestone, Louisiana, Mo. R. R. Rowley collection.
- FIGURES 19, 20. *Poteriocrinus jeffriesi* Rowley (p. 66). Dorsal and lateral views of holotype. Clay partings of the Louisiana limestone at Louisiana, Mo. R. R. Rowley collection.
- FIGURES 21, 22. *Mesoblastus?* sp. (p. 63).
21. View showing basal plates. Limestone beds of the Louisiana limestone, locality 552. Univ. Mo. 4950.
 22. Side view of same specimen showing radial plate, which is attached to basals figured above.
- FIGURES 23, 24. *Spirorbis kinderhookensis* Gurley (p. 62). Labeled from the "Kinderhook at Louisiana, Missouri." Syntypes are Walker Mus. 6322.
23. Syntype.
 24. Three syntypes on a pedicle valve of *Spirifer marionensis* Shumard.
- FIGURE 25. *Plumalina gracilis* (Shumard) (p. 58). Specimen figured on a piece of limestone. Limestone beds of the Louisiana at locality 552. Univ. Mo. 4999.
- FIGURES 26, 27. *Neozaphrentis? palmeri* (Rowley) (p. 57). Two views of a specimen labeled "the type." Yellow-brown mudstone of the Louisiana at Louisiana, Mo. R. R. Rowley collection.
- FIGURES 28-30. *Cornulites carbonarius* Gurley (p. 63).
- 28, 29. Two average specimens, the larger one showing scar of attachment. Clay partings of the Louisiana limestone, locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 5510.
 30. The holotype labeled from the Kinderhook, from Louisiana, Mo. Walker Mus. 6321. This specimen is attached, but the object to which it is attached is not shown.
- FIGURES 31-33. *Neozaphrentis? acuta* (White and Whitfield) (p. 56). Three views of a specimen. Yellow-brown mudstone of the Louisiana, locality 593, Louisiana, Mo. R. R. Rowley collection.
- FIGURES 34-40. *Neozaphrentis parasitica* (Worthen) (p. 57).
- 34, 35. Two views of a specimen. Louisiana limestone, Louisiana, Mo. R. R. Rowley collection.
 36. A large individual showing probable scar of attachment. Louisiana limestone at Louisiana, Mo. Univ. Mo. 1242.
 37. Another specimen from Louisiana limestone, Louisiana, Mo. R. R. Rowley collection.
 38. A small individual from the Louisiana limestone at Louisiana, Mo. Univ. Mo. 1242.
 39. Photograph of section of neanic stage of an individual from the clay partings of the Louisiana at Louisiana, Mo. This section shows the circular opening in the center formed by the merged ends of the septa. U. S. Geol. Survey Carboniferous Collection 5112 b.
 40. Photograph of a composite section of adult stage of individual shown in figure 39. The upper left half of the section was taken a millimeter or so below the base of the calyx. It shows the fossula merged with the circular opening in the center formed by merging of the ends of the septa. No secondary septa are present. The lower right half of the photograph is of part of a section taken through the calyx a short distance above its base. It shows rudimentary secondary septa. U. S. Geol. Survey Carboniferous collection 5112b.
- FIGURE 41. *Lingula lineolata* Rowley (p. 67). The ventral? valve of the lectotype. Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. R. R. Rowley collection.
- FIGURE 42. *Orbiculoidea elongata* Williams, n. sp. (p. 69). The holotype, an internal mold of a brachial valve. Yellow-brown mudstone of the Louisiana at locality 615, along Mississippi River, Louisiana, Mo. Univ. Mo. 4937.

FIGURES 43, 44. *Crania (Crania) rowleyi* Gurley (p. 70).

43. A well-preserved brachial valve. Yellow-brown mudstone of the Louisiana at Clarksville, Mo. Univ. Mo. 4938.

44. View of about half of the holotype, which is attached to a *Spirifer marionensis* Shumard and conforms to the curvature of that shell. Louisiana limestone at Louisiana, Mo. Walker Mus. 6316.

FIGURE 45. *Crania (Lissocrania) dodgei* Rowley (p. 71). A brachial valve, the holotype. Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. R. R. Rowley collection.

FIGURES 46, 47, 54. *Crania (Acanthocrania) spiculata* Rowley (p. 71).

46. A distorted brachial valve from a clay parting in the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. R. R. Rowley collection.

47. Same specimen as figure 46 enlarged to show surface ornamentation.

54. Another brachial valve together with a *C. dodgei*, showing mode of attachment. Same locality and horizon as specimen shown in figure 46. R. R. Rowley collection.

FIGURE 48. *Lingula fleenori* Williams, n. sp. (p. 67). External mold with parts of shell of holotype. Yellow-brown mudstone of the Louisiana at locality 798, 2½ miles west of Frankford, Mo. Univ. Mo. 4936.

FIGURES 49-51. *Lingula krugeri* Williams, n. sp. (p. 68).

49, 51. Both valves of the holotype. Clay parting in the Louisiana limestone at locality 614, about 7 miles west of Louisiana, Mo. R. R. Rowley collection.

50. Part of the surface of the holotype, showing concentric costae.

FIGURE 52. *Lingula louisianensis* Weller (p. 68). The holotype. Limestone beds of the Louisiana at Louisiana, Mo. Peabody Mus. collection, Yale Univ.

FIGURE 53. *Orbiculoidea limata* Rowley (p. 68). The holotype, a brachial valve. Yellow-brown mudstone of the Louisiana limestone at locality 593, Town Branch, Louisiana, Mo. R. R. Rowley collection.

FIGURES 55-66. *Rhipidomella missouriensis* (Swallow) (p. 72).

55, 56. Two views of a small specimen. Clay partings of the Louisiana limestone at locality 599, one mile south of Louisiana, Mo. Univ. Mo. 4807.

57. Interior view of brachial valve of a small specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4765.

58. Brachial valve of an average specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4808.

59, 60. Exterior and interior views of a pedicle valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4768.

61. Exterior view of a brachial valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4764.

62, 63. Pedicle and brachial views of a specimen below average size. Yellow-brown mudstone of the Louisiana, locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4810.

64. Lateral view of an average specimen from the Louisiana limestone at Louisiana, Mo. Univ. Mo. 4763.

65. Interior view of a rather large pedicle valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4766.

66. Interior view of brachial valve shown in figure 61.

PLATE 7

FIGURES 1-7. *Schuchertella lens* (White) (p. 72).

1. A brachial valve of an average individual. Louisiana limestone at Clarksville, Mo. Univ. Mo. 4800.
2. Interior of a pedicle valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4798.
- 3, 4. Interior and exterior views of a brachial valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4797.
- 5, 6. Brachial and pedicle views of a specimen. Yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4799.
7. Posterior view of an average specimen. Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4803.

FIGURES 8-11. *Chonetes geniculatus* White (p. 74).

8. A pedicle valve of an average specimen. Yellow-brown mudstone of Louisiana limestone at locality 615, Louisiana, Mo. Univ. Mo. 4850.
9. An interior of a pedicle valve. Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4853.
10. A wide pedicle valve. Yellow-brown mudstone of the Louisiana at locality 615, along the Mississippi River, Louisiana, Mo. Univ. Mo. 4851.
11. A brachial view of a specimen from a clay parting in the Louisiana limestone at locality 593, Louisiana, Mo. Univ. Mo. 4855.

FIGURES 12-19. *Chonetes ornatus* Shumard (p. 75).

- 12, 13. Pedicle and brachial views of a small specimen. Clay parting of the Louisiana limestone at locality 615, Louisiana, Mo. Univ. Mo. 4881.
- 14, 15. Brachial and pedicle views of an average specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4857.
16. Pedicle view of a specimen that represents a grade toward the var. *glenparkensis*. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4858.
17. Brachial view, showing cardinal area and deltidium, of a specimen. Yellow-brown mudstone of the Louisiana at locality 618, Clarksville, Mo. Univ. Mo. 4856.
18. Pedicle valve of a specimen of *C. ornatus* that is gradational to the var. *glenparkensis*. Limestone beds of the Louisiana at locality 728, 3 miles northwest of Ely; Mo. Univ. Mo. 4876.
19. An interior of a brachial valve. Louisiana limestone of Louisiana, Mo. Univ. Mo. 4859.

FIGURE 20. *Chonetes ornatus* var. *glenparkensis* Weller (p. 75). A pedicle valve. Limestone beds of the Louisiana at locality 798, 2½ miles west of Frankford, Mo. Univ. Mo. 4879.

FIGURES 21, 22. *Camarophorella buckleyi* (Rowley) (p. 91). Brachial and pedicle views of Rowley's holotype for his *Seminula buckleyi*. Louisiana limestone at Louisiana, Mo. R. R. Rowley collection.

FIGURES 23-35. *Cyrtina acutirostris* Shumard (p. 89).

- 23, 24. Pedicle and lateral views of a large specimen with a highly concave cardinal area. Louisiana limestone at locality 618, Clarksville, Mo. Univ. Mo. 4916.
25. Brachial valve of a small individual. Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4917.
26. Posterior view of a large specimen. Louisiana limestone at locality 617, Clarksville, Mo. Univ. Mo. 4915.
27. Pedicle view of an average specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4918.
- 28, 29. Brachial and pedicle views of an average specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4919.
- 30, 31. Posterior and pedicle interior views of a small individual. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4947.
- 32, 33. Pedicle and posterior views of a very small specimen. Yellow-brown mudstone at locality 599, Louisiana, Mo. Univ. Mo. collection.
34. Brachial view of a small specimen. Same locality and horizon as specimen shown in figures 32 and 33. Univ. Mo. collection.
35. Interior view of a brachial valve. Louisiana limestone, Louisiana, Mo. Univ. Mo. 4948.

FIGURES 36-39. *Allorhynchus? curriei* (Rowley) (p. 81). Yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4926.

36. Brachial view of a small individual.
- 37, 38. Pedicle and brachial views of a large individual.
39. Brachial view of a rather small individual.

FIGURES 40-46. *Selenella pediculus* (Rowley) (p. 92). Yellow-brown mudstone of the Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4924.

40. Pedicle view of an average specimen.
41. Pedicle view of a specimen having what appears to be faint radial striae.
42. A long narrow pedicle valve.
43. A small pedicle valve.
44. A pedicle valve with a slight sinus.
45. Brachial view of a small individual.
46. Brachial view of an average individual.

- FIGURES 47-50. *Allorhynchus? louisianensis* (Weller) (p. 82). Clay partings of the Louisiana limestone at Louisiana, Mo. Walker Mus. 6730.
- 47, 48. Pedicle and brachial views of the smaller of the two cotypes.
- 49, 50. Pedicle and brachial views of the larger cotype.
- FIGURES 51-54. *Camarotoechia* cf. *C. tuta* (Miller) (p. 82).
- 51, 52. Pedicle and brachial views of a large distorted specimen, shown for comparison. Dolomite beds in the Hannibal (?) shale at locality 526, near Rensselaer, Mo. Univ. Mo. 4894.
53. A brachial valve. Limestone beds of the Louisiana at locality 798, near Frankford, Mo. Univ. Mo. 4892.
54. Pedicle view of a specimen from the same zone and locality as that shown in figure 53. Univ. Mo. 4893.
- FIGURES 55-60. *Acanthospirina aciculifera* (Rowley) (p. 84).
- 55-57. Posterior, brachial, and pedicle views of an average specimen. Clay partings of the Louisiana limestone at Louisiana, Mo. R. R. Rowley collection.
- 58, 59. Brachial and pedicle views of a large specimen. Same locality and horizon as specimen shown in figures 55-57. R. R. Rowley collection.
60. A large specimen showing radiating streaks, which are bright red on the specimen. Parting in the Louisiana limestone at Louisiana, Mo. Univ. Mo. 5200.
- FIGURES 61-67. *Productella pyxidata* Hall (p. 76).
61. A mature pedicle valve with irregular spines and short tubercles. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4884.
62. An immature pedicle valve with irregular spines. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4897.
63. A mature pedicle valve ornamented only by concentric striae. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4885.
64. Brachial valve of an average specimen. Louisiana limestone at locality 593, Louisiana, Mo. Univ. Mo. 4887.
65. Interior of a brachial valve. Yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4886.
66. Another view of specimen shown in figure 65 showing cardinal process and dental sockets on either side of it.
67. A mature pedicle valve with tubercles arranged to form discontinuous radiating plicae. Yellow-brown mudstone of the Louisiana at locality 618, Clarksville, Mo. Univ. Mo. 4888.
- FIGURES 68-71. *Strophalosia beecheri* Rowley (p. 77).
- 68, 69. Brachial and pedicle views of the holotype. Yellow-brown mudstone of the Louisiana at locality 593, Louisiana, Mo. R. R. Rowley collection.
- 70, 71. Pedicle and brachial views of the plesiotype. Clay partings of the Louisiana limestone at Louisiana, Mo. Univ. Mo. 4941.
- FIGURES 72-75. *Rhynchopora? rowleyi* Weller (p. 83). Brachial, posterior, anterior, and pedicle views of the holotype. Louisiana limestone, probably from Louisiana, Mo. R. R. Rowley collection.
- FIGURES 76-81. *Schuchertella louisianensis* Williams, n. sp. (p. 73). Yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4882.
- 76, 78. Pedicle views of the syntype.
- 77, 79-81. Pedicle interior, pedicle interior, brachial, and brachial interior views of four syntypes.

PLATE 8

- FIGURES 1-6. *Ambocoelia minuta* White (p. 89). Yellow-brown mudstone of the Louisiana at locality 599. Univ. Mo. 4929.
1. A pedicle valve enlarged to show spines.
 2. A posterior view of a specimen showing deltidial and chilidial plates.
 3. A posterior view of a specimen that is less enlarged.
 - 4, 5. Brachial and pedicle views of individual shown in figure 3.
 6. Side view of same specimen.
- FIGURES 7-12. *Ambocoelia louisianensis* Williams, n. sp. (p. 88). Yellow-brown mudstone of the Louisiana at locality 599. Univ. Mo. 4930.
- 7, 8. Brachial and posterior views of a cotype.
 9. A cotype enlarged to show deltidial and chilidial plates.
 10. A brachial valve of a cotype enlarged to show fine spines.
 11. Same individual as shown in figure 10.
 12. Pedicle view of specimen shown in figure 7.
- FIGURES 13-20. *Nucleospira rouleyi* Weller (p. 90). Specimens shown in figures 13-18 are from Louisiana limestone (probably from partings) at Louisiana, Mo. Walker Mus. 6733.
13. Pedicle view of a cotype.
 14. Side view of a cotype.
 15. Posterior view of specimen shown in figure 14.
 16. Pedicle view of one of the cotypes.
 17. Brachial view of individual shown in figure 13.
 18. Pedicle view of a cotype.
 19. Pedicle view of a large specimen, natural size. Yellow-brown mudstone of the Louisiana at locality 599. Univ. Mo. 4945.
 20. Brachial view of specimen shown in figure 19.
- FIGURES 21-24. *Athyris hannibalensis* (Swallow) (p. 90).
21. A small individual, probably from the yellow-brown mudstone of the Louisiana, at locality 599. Univ. Mo. 4923.
 22. Brachial view of a wide specimen. Limestone beds of the Louisiana limestone at locality 593. Univ. Mo. 4921.
 23. An average pedicle valve. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4922.
 24. Posterior view of above specimen, brachial valve partly restored.
- FIGURE 25. *Athyris lamellosa* (L'Éveillé) (p. 91). A pedicle valve. Parting between the limestone beds of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. 4920.
- FIGURES 26-28. *Camerophoria pikensis* Williams, n. sp. (p. 80). Pedicle, anterior, and brachial views of the holotype. Limestone beds of the Louisiana at locality 618, Clarksville, Mo. Univ. Mo. 4889.
- FIGURES 29-31. *Delthyris clarksvillensis* (Winchell) (p. 83). Pedicle, lateral, and brachial views of two plesiotypes. Limestone beds of the Louisiana at Louisiana, Mo. Walker Mus. 6699.
- FIGURE 32. *Paraphorhynchus striatocostatum* (Meek and Worthen) (p. 83). An incomplete specimen. Yellow-brown mudstone of the Louisiana at its contact with the Saverton shale, locality 618, Clarksville, Mo. Univ. Mo. 4890.
- FIGURES 33-38. *Leptalosia scintilla* (Beecher) (p. 78).
33. Two specimens adhering to shell of *Productella pyxidata* Hall. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4902.
 34. An average specimen on a pedicle valve of *Productella pyxidata* Hall, showing long flat spines along lateral and anterior margins. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4949.
 35. A specimen from the yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4899.
 36. A small specimen from the limestone beds of the Louisiana at locality 618, Clarksville, Mo. Univ. Mo. 4901.
 37. A specimen on part of a *Spirifer marionensis* Shumard, showing spines at anterior margins. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4900.
 38. A specimen from the limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4927.
- FIGURES 39-50. *Spirifer marionensis* Shumard (p. 85).
- 39, 40. Pedicle and brachial views of an immature specimen. Louisiana limestone at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4912.
 - 41, 42, 44. Pedicle, posterior, and lateral views of a well-preserved specimen. Limestone beds of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. 4910.
 43. A brachial valve. Limestone beds of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. 4910.
 45. Pedicle valve of a large specimen. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4911.
 46. Brachial valve of a specimen from the limestone beds of the Louisiana at locality 728, 3 miles north of Ely, Mo. Univ. Mo. 4909.
 - 47, 48. Pedicle interior and posterior views of a specimen from the Louisiana limestone at Louisiana, Mo. Univ. Mo. 4946.
 49. Posterior view of a specimen with pseudodeltidium. Louisiana limestone at Louisiana, Mo. Univ. Mo. 4913.
 50. Interior of a brachial valve slightly over natural size. Yellow-brown mudstone of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 4914.

FIGURES 51-56. *Syringothyris hannibalensis* (Swallow) (p. 86).

51. Posterior view of a small specimen from the limestone beds of the Louisiana at locality 1010, Marion County, Mo. Univ. Mo. 4907.

52-54. Brachial, posterior, and pedicle views of an average specimen. Louisiana limestone at locality 593, Louisiana, Mo. Univ. Mo. 4906.

55, 56. Brachial and lateral views of a large specimen. Louisiana limestone at locality 728, 3 miles northwest of Ely. Univ. Mo. 4908.

FIGURES 57, 58. *Syringothyris newarkensis* Weller (p. 87). Posterior and lateral views of the only specimen collected by the writer that is worthy of illustration. It is not from the Louisiana but from dolomite beds in the Hannibal (?) shale at locality 526, near Rensselaer, Mo. Univ. Mo. 4903.

PLATE 9

- FIGURES 1-4. "*Leda*" *diversoides* (Weller) (p. 96).
 1, 2. A left and a right valve, cotypes. Glen Park limestone. Walker Mus. 11330.
 3. A left valve. Yellow-brown mudstone of the Louisiana at locality 615, Louisiana, Mo. Univ. Mo. 3650.
 4. A right valve. Yellow-brown mudstone of the Louisiana at locality 634. Univ. Mo. 3652.
- FIGURES 5, 6. "*Leda*" *spatulata* Herrick (p. 97).
 5. A left valve. Yellow-brown mudstone of the Louisiana at locality 615, Louisiana, Mo. Univ. Mo. 3654.
 6. An incomplete left valve. Yellow-brown mudstone of the Louisiana at locality 634. Univ. Mo. 3655.
- FIGURES 7, 8. *Parallelodon louisianensis* Williams (p. 98).
 7. The holotype, a left valve. Yellow-brown mudstone of the Louisiana at locality 615. Univ. Mo. 3656.
 8. A right valve (paratype). Yellow-brown mudstone of the Louisiana at locality 623. Univ. Mo. 3657.
- FIGURES 9-13. *Parallelodon sulcatus* (Weller) (p. 98).
 9-11. Three of Weller's cotypes. Glen Park limestone. Walker Mus. 11335.
 12. A right valve. Yellow-brown mudstone of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. 3660.
 13. A small right valve. Yellow-brown mudstone of the Louisiana at locality 615, Louisiana, Mo. Univ. Mo. 3659.
- FIGURE 14. *Platyceras paratium* White and Whitfield (p. 103). Side view, after Keyes.
- FIGURE 15. *Palaeoneilo ignota* Herrick (p. 95). An internal mold showing dentition. Yellow-brown mudstone of the Louisiana at Louisiana, Mo. Univ. Mo. 3646.
- FIGURE 16. "*Leda*" *rowleyi* Williams (p. 97). A right valve, the holotype. Yellow-brown mudstone of the Louisiana at locality 634. Univ. Mo. 3649.
- FIGURES 17, 18. *Nucula* (*Palaeonucula*) *krugeri* Williams (p. 94). Two left valves, the cotypes. Yellow-brown mudstone of the Louisiana at locality 634. Univ. Mo. 3642.
- FIGURES 19, 20. *Gryphochiton?* *anomalus* (Rowley) (p. 100). View from above and lateral view of posterior valve of the larger of Rowley's types. Clay partings of the Louisiana limestone at locality 599. R. R. Rowley collection.
- FIGURES 21, 22. *Murchisonia?* *pygmaea* Rowley (p. 102). Two views of a specimen of about the same size as Rowley's species. Clay parting in the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 5519.
- FIGURE 23. *Loxonema missouriensis* Williams, n. sp. (p. 103). The holotype. Limestone beds of the Louisiana at locality 623. Univ. Mo. 4996.
- FIGURE 24. *Bembexia minima* (Rowley) (p. 101). A specimen from the limestone beds of the Louisiana, locality 728. Univ. Mo. 5524.
- FIGURES 25, 26. *Bellerophon?* sp. (p. 101). Two indeterminate specimens that probably belong to this genus but may represent two different species. Limestone beds of the Louisiana at locality 552. Univ. Mo. 5525.
- FIGURES 27-29. *Conularia marionensis* Swallow (p. 62). Yellow-brown mudstone of the Louisiana limestone at Clarksville, Mo.
 27. A lateral face with shelly material preserved. Univ. Mo. 4993.
 28. An external mold. Same locality and horizon as specimen shown in figure 27. Univ. Mo. 4994.
 29. Part of another external mold showing impressions made by crenulations on costae on the surface of lateral face. Univ. Mo. 4905.
- FIGURES 30, 31. *Conularia* sp. (p. 62). Two fragments of lateral areas. Yellow-brown mudstone of the Louisiana at locality 609. Univ. Mo. 4998.
- FIGURE 32. *Pleurotomaria?* sp. (p. 102). An indeterminate specimen probably belonging to this genus. Clay partings of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. 4997.
- FIGURES 33-40. *Protocanites louisianensis* (Rowley) (p. 108). Specimens shown in figures 33-38 are from the clay partings of the Louisiana limestone at locality 599. Univ. Mo. 5518.
 33. Specimen that is questionably identified, showing first lateral lobe.
 34. Specimen that shows the constrictions.
 35. View of another specimen that shows the first lateral lobe.
 36. Another view of above specimen.
 37. Very small individual.
 38. Side view of an average specimen.
 39. Diagrammatic representation of about half of a restored and composite external suture. The ventral lobe and about half of the first lateral saddle are from the specimen shown in figure 36, and the rest of the first lateral saddle and the first lateral lobe and the second lateral saddle are from the questionably identified specimen shown in figure 33. This specimen is much crushed and distorted.
 40. Diagrammatic representation of half of external suture as shown on specimen shown in figure 38.
- FIGURES 41-44. *Grammysia hannibalensis* (Shumard) (p. 92).
 41. Left valve of a specimen with posterior of shell well preserved. Limestone beds of the Louisiana at Louisiana, Mo. Univ. Mo. 3645.
 42. Anterior view of a specimen belonging to R. R. Rowley. Limestone beds of the Louisiana at Louisiana, Mo.
 43. Anterior view of a small specimen from the limestone beds of the Louisiana at locality 634. Univ. Mo. 3644.
 44. Lateral view of specimen shown in figure 43.

FIGURES 45-50. *Proetus missouriensis* Shumard (p. 112).

45. An average pygidium, with part of shell preserved. Limestone beds of the Louisiana at locality 552. Univ. Mo. 3774.
 46. The type glabella. Louisiana limestone at Louisiana, Mo. Washington Univ. collection.
 47. A small pygidium. Limestone beds of the Louisiana at locality 1009. Univ. Mo. 3775.
 48. A part of specimen shown in figure 45, enlarged to show ornamentation.
 49. An average glabella. Limestone beds of the Louisiana at locality 798. Univ. Mo. 3770.
 50. A small glabella with parts of the free cheeks. Same locality and horizon as specimen shown in figure 49. Univ. Mo. 3771.

FIGURES 51-54. *Aganides compressus* Moore (p. 108). Louisiana limestone at Hamburg, Ill. Walker Mus. 32117.

- 51-53. Three views of the holotype. In figure 52 part of a piece of rock that adheres to and possibly includes part of the conch is not shown. This rock is shown in figure 53 as it appears on the specimen.
 54. Diagrammatic representation of half of external suture as shown on the holotype.

FIGURE 55. "*Orthoceras*" n. sp. A. (p. 106). A natural longitudinal section of the only specimen. Limestone beds of the Louisiana at locality 798, about 2½ miles west of Frankford, Mo. Univ. Mo. 5516.FIGURES 56-59. *Platyceras pulcherrimum* Rowley (p. 104). Yellow-brown mudstone of the Louisiana at or near Louisiana, Mo.

- 56, 57. Two views of a specimen from R. R. Rowley collection.
 58, 59. Two views of another specimen, which was labeled the type. R. R. Rowley collection.

FIGURE 60. *Sanguinolites?* sp. (p. 100). An incomplete specimen that probably belongs to this genus. Yellow-brown mudstone of the Louisiana at locality 634, Ralls County, Mo. Univ. Mo. 3664.FIGURES 61-63. *Aviculopecten marbuti* (Rowley) (p. 99).

- 61, 62. Posterior and lateral views of the holotype. Limestone beds of the Louisiana at Louisiana, Mo. R. R. Rowley collection.
 63. Part of the surface of the holotype showing ornamentation.

FIGURE 64. *Ptyctodus calceolus* Newberry and Worthen (p. 114). Specimen from the yellow-brown mudstone of the Louisiana at locality 593, Louisiana, Mo. Univ. Mo. Vertebrate Paleontology collection 759.FIGURES 65, 66. *Proetides? straton-porteri* (Rowley) p. 110). Two of Rowley's type specimens. The figure of the pygidium does not clearly show three rows of nodes on either side of the median row on the axis, but they can be made out on the specimen. Limestone beds of the Louisiana, Louisiana, Mo. R. R. Rowley collection.FIGURE 67. *Proetus tenuituberculus* Williams (p. 113). The holotype showing markings ascribed to an original color pattern. Limestone beds of the Louisiana at locality 728, Marion County, Mo. Univ. Mo. 3778.FIGURE 68. *Brachymetopus? spinosiformis* Williams, n. sp. (p. 111). A wax cast of the holotype, which is a natural mold of the exterior of pygidium. Limestone beds of the Louisiana at locality 599, 1 mile south of Louisiana, Mo. Univ. Mo. 3780.FIGURES 69, 70. *Dinichthys* sp. (p. 114). Two fragments, probably a posterior end and an anterior margin of an infero-gnathal. Clay parting of the Louisiana limestone at locality 593, Louisiana, Mo. Univ. Mo. Vertebrate Paleontology collection 560.

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