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Early Devonian Brachiopods Of Oklahoma

Part I.—Articulate Brachiopods of the Frisco Formation (Devonian)

by

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Part II.—Articulate Brachiopods of the Sallisaw Formation (Devonian)

by

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Part III.—Supplement to the Haragan (Devonian) Brachiopods

by

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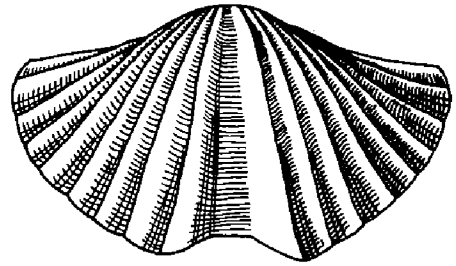

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EARLY DEVONIAN BRACHIOPODS OF OKLAHOMA

ABSTRACT

Part I. The Frisco is a Lower Devonian formation which crops out in the Arbuckle Mountains region of south-central Oklahoma and in a small area of Sequoyah County in northeastern Oklahoma. It is largely a bioclastic calcarenite with a substantial megafauna, predominantly brachiopods and snails, but with some bryozoans, corals, trilobites and pelecypods; locally the strata grade into a pelmatozoan limestone although complete calyces are few. The shells and other skeletal elements were subjected to considerable movement by wave and/or current action, either before or during deposition, resulting in fragmentation and extensive disarticulation of the shells. The brachiopods are represented largely by disarticulated valves, and for most species there are far more pedicle valves than brachial valves; this disparity between the numbers of opposing valves is interpreted as the result of more extensive fragmentation of the thinner, weaker valves during deposition. Thirty-two articulate brachiopod species (one new) assigned to 29 genera are described in the present report. This fauna is assigned a Deerparkian age and shows a marked similarity to the brachiopod fauna of the Oriskany Formation of the eastern United States, the Grande Grève Formation of Quebec, the Little Saline Formation of southeastern Missouri and southwestern Illinois, and the Harriman Formation of western Tennessee.

Part II. The Sallisaw is a late Early Devonian formation which crops out in a small area of Sequoyah County in northeastern Oklahoma. It is predominantly arenaceous limestone and dolomitic limestone with an insoluble content, mostly fine quartz sand, which averages about 9.5 percent; nodules and lenses of chert are common and locally the entire formation grades into bedded chert. The megafauna consists almost entirely of brachiopods, most of which occur as disarticulated and somewhat fragmentary free pedicle and brachial valves; some of the chert beds carry well-preserved specimens in the form of external and internal molds. Eleven articulate brachiopod species (one new) are described in this report. This fauna is believed to represent a late Esopusian age, with similarities to the brachiopod fauna from the Woodbury Creek Member of the Esopus Formation in New York. The Sallisaw fauna has a marked resemblance to the brachiopod faunas from the Clear Creek Formation of southwestern Illinois and the Camden Formation of western Tennessee. It is also similar to the fauna of the Littleton Formation of New Hampshire.

Part III. The Haragan is a Lower Devonian (Helderbergian) formation which crops out in the Arbuckle Mountains region of south-central Oklahoma. The articulate brachiopod fauna from this formation has been described in an earlier publication (Amsden, 1958a), which also includes a discussion of its age and correlatives. The present report adds four additional species (one new) to this Haragan fauna. Two of these species, *Anopliopsis pygmaea* Amsden and *Spinoplasia gaspensis*? Boucot, are of particular interest because they expand the known stratigraphic and geographic range of the Paeckelmanniinae and Ambocoeliininae.

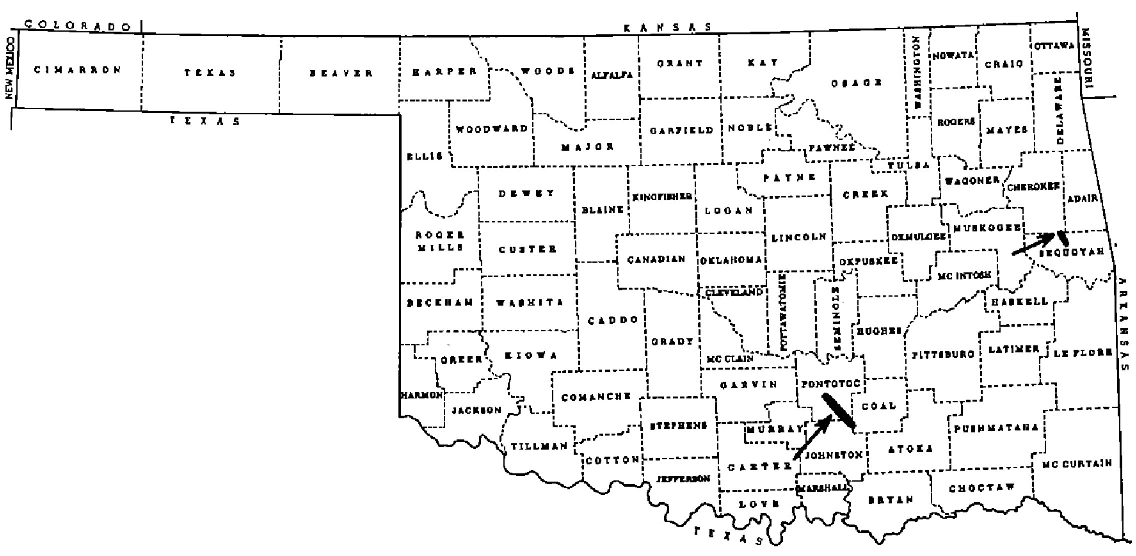
PART I. — ARTICULATE BRACHIOPODS OF THE FRISCO FORMATION (DEVONIAN)

THOMAS W. AMSDEN AND WILLIAM P. S. VENTRESS

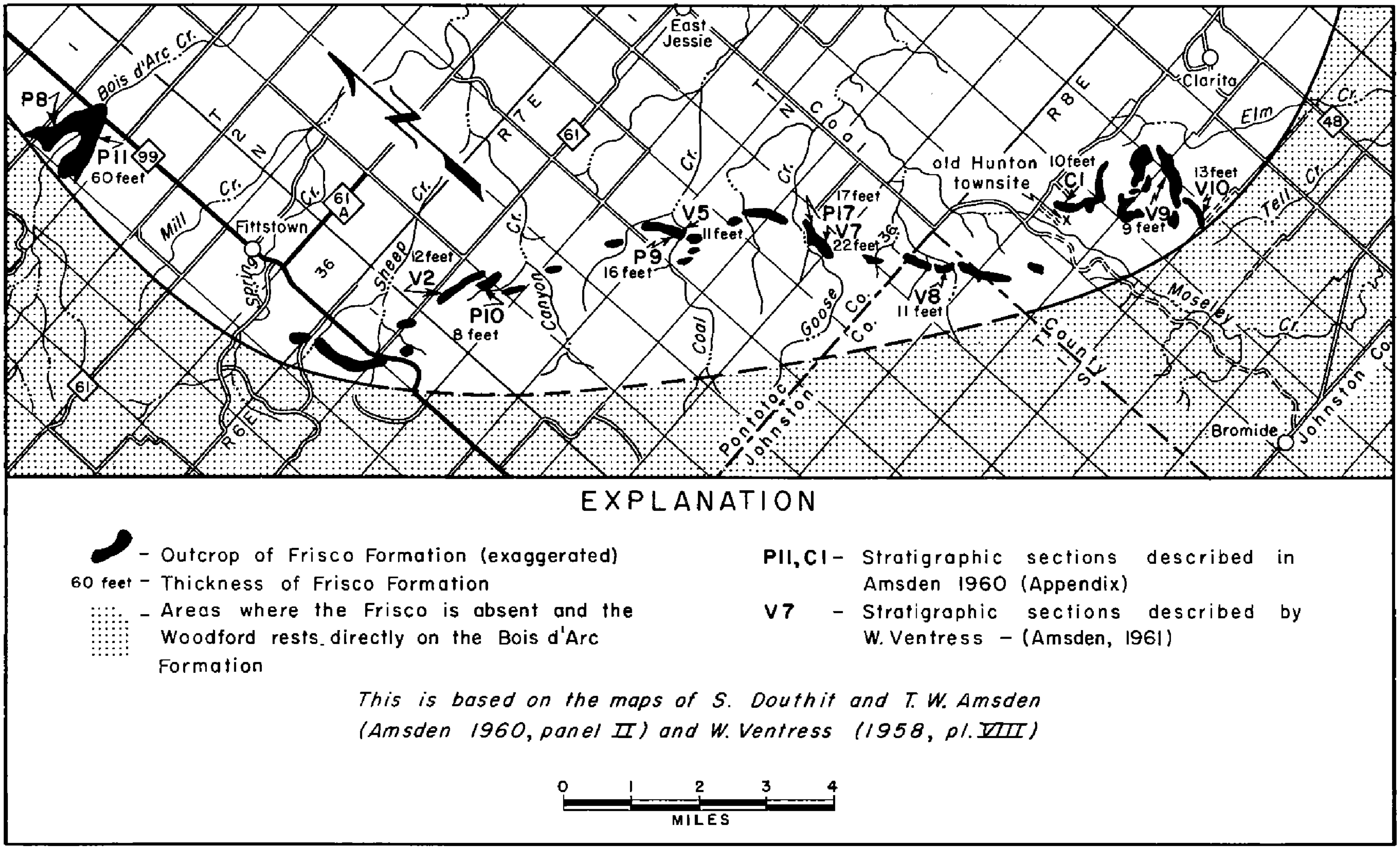
INTRODUCTION

The Frisco Formation crops out in two small areas in Oklahoma (text-fig. 1): (1) the Arbuckle Mountains region of south-central Oklahoma, where it forms a series of narrow, linear outcrops extending from the type section on Bois d'Arc Creek in a southeasterly direction for a distance of about 15 miles (text-fig. 2), and (2) Sequoyah County in northeastern Oklahoma, where it crops out in an area of about six square miles just north of Marble City (text-fig. 3). In the Arbuckle region the Frisco is treated as the uppermost formation in the Hunton Group*; in this area it rests upon the Bois d'Arc Formation of Helderbergian age and is overlain by the Woodford Formation. The stratigraphic relations are somewhat different

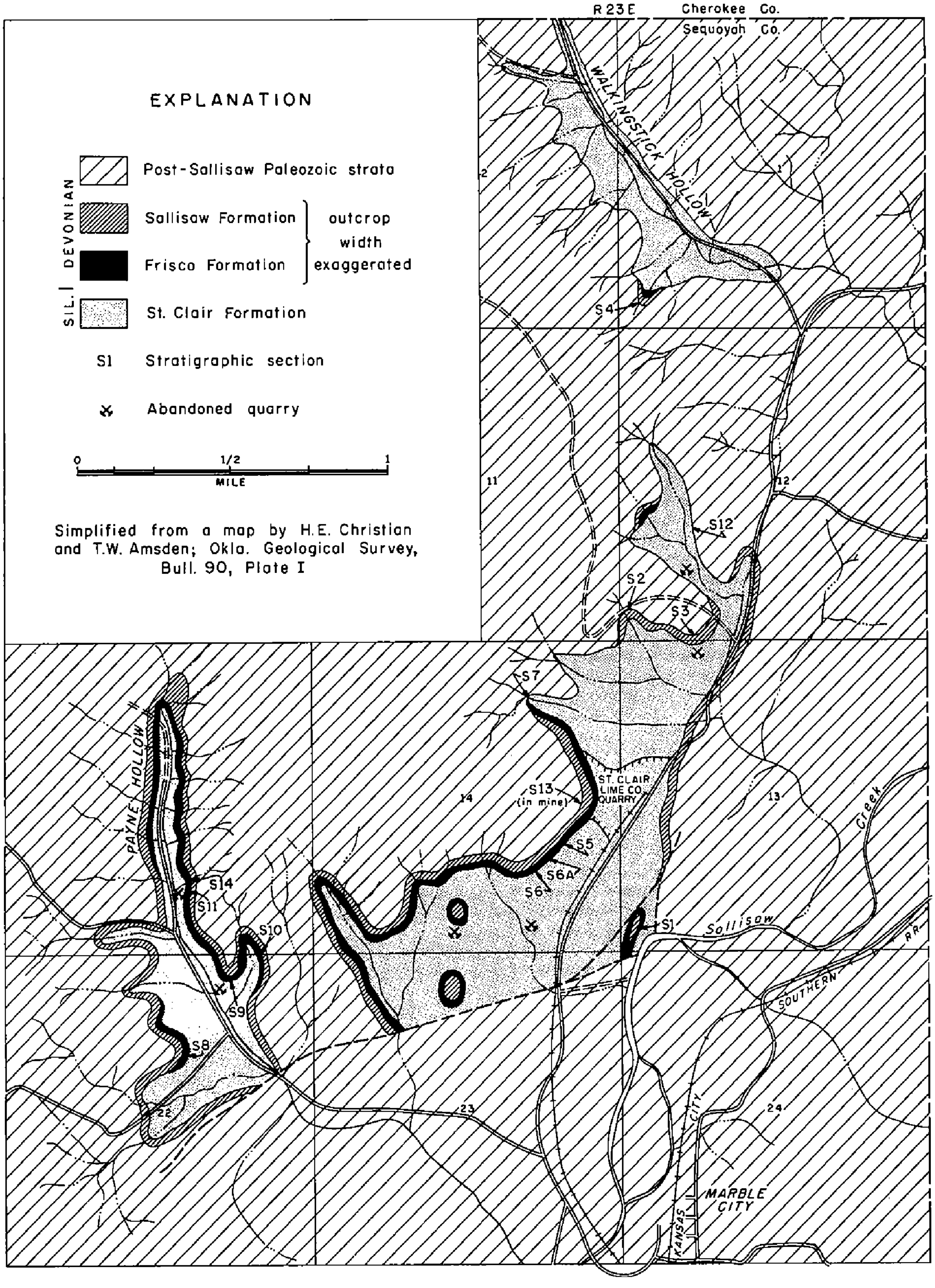
* At its type locality near old Hunton townsite (text-fig. 2) the Hunton Group includes all of the strata between the base of the Ideal Quarry Member (Early Silurian) and the top of the Frisco Formation (Amsden, 1960, p. 178-188). This name has not been used in the Marble City area and there does not appear to be any need to employ a group name for the Silurian-Devonian strata in Sequoyah County (Amsden, 1961, footnote, p. 24).



Text-figure 1. Map showing the outcrop areas of the Frisco and Sallisaw Formations. The Frisco crops out in south-central and northeastern Oklahoma, whereas the Sallisaw is present only in the northeastern area.



Text-figure 2. Outcrop map of the Frisco Formation in the Arbuckle Mountains region showing the location and thickness of the described stratigraphic sections. The descriptions of these sections are given in the appendix of Amsden, 1960 and 1961. The stippled areas indicate those places where the Frisco was removed by pre-Woodford post-Hunton erosion, allowing the Woodford to be deposited upon the Bois d'Arc Formation (Helderbergian). The Frisco type section is at P11 on Bois d'Arc Creek.

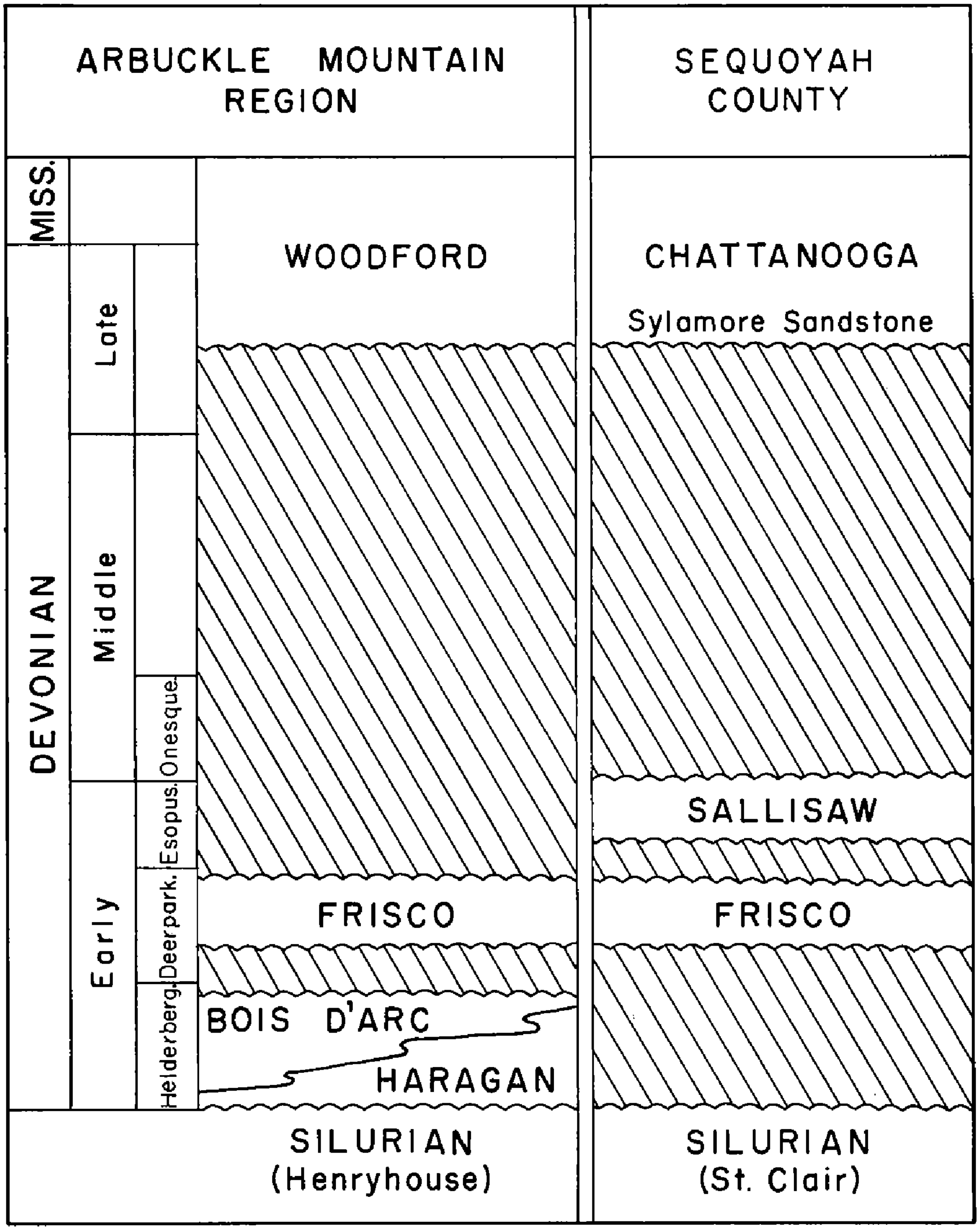


Text-figure 3. Simplified geologic map showing the distribution of the Sallisaw, Frisco, and St. Clair Formations in the area just north of Marble City, Sequoyah County, Oklahoma. The descriptions of the stratigraphic sections shown in this map may be found in Amsden, 1961.

in Sequoyah County as the Frisco is here underlain by Silurian strata (St. Clair Formation) and overlain by the Sallisaw Formation of Esopusian age, or where that formation has been removed by pre-Chattanooga erosion, by the Sylamore Sandstone Member of the Chattanooga (text-fig. 4). Throughout both outcrop areas the Frisco is a bioclastic limestone, which appears to represent a fairly high-energy deposit; the $MgCO_3$ content and acid insolubles are uniformly low. The Frisco attains its greatest thickness at the type section, where it is about 60 feet thick, but elsewhere in the Arbuckle region it is generally less than 20 feet thick (text-fig. 2); in Sequoyah County it is everywhere less than 10 feet thick. The Frisco Formation is Early Devonian* in age and carries a fairly large fauna similar to that of the Oriskany Sandstone of the eastern United States.

Previous investigations. — For many years it has been known that the fossils from the Frisco Formation in the Arbuckle Mountains region show marked affinities with those from the Oriskany Sandstone, although the published information has been almost entirely confined to faunal lists. As early as 1904 Taff (p. 31) stated that "The uppermost member of the Hunton formation (now Hunton Group) is probably lower Oriskany in age . . ." Reeds (1911, p. 264-265), in his early work on the Hunton, included all of the upper limestones in his Bois d'Arc Formation (which he assigned a Helderbergian age), although he did note that "It may yet be determined that the uppermost 40 feet of the Bois d'Arc are Oriskany in age." Some years later Reeds (1926, p. 10, 13) removed the upper, thick-bedded limestone, which carries a Deerparkian fauna from the Bois d'Arc Formation, and placed it in the Frisco Formation. The following species were recorded from this formation: *Leptostrophia magnifica, L. oriskania, Rensselaeria marylandica, Strophodonta becki, Orthonychia* cf. *O. plicatum.* In 1936 Maxwell completed a Ph. D. dissertation at Northwestern University on the Hunton Group. This author assigned the Frisco an early Oriskany age (p. 102) and listed 58 species, of which 32

* In a recent article Fuller (1961, footnote, p. 1361) stated, "The dating of upper Hunton-Interlake in Oklahoma as Lower Devonian (cf. Reeds, 1926, p. 12; Amsden, 1957), however, seems to be untenable on regional stratigraphical grounds, for the great pre-Devonian unconformity was erased, the surface having been further eroded before Mississippian deposition; . . ." This author gave no further elaboration or explanation of what is meant by "regional stratigraphic grounds," or "great pre-Devonian unconformity," but he clearly implied that there is no Devonian in the Hunton of Oklahoma. We do not subscribe to this conclusion as we believe the Frisco is Early Devonian (Deerparkian) in age, our evidence for this being given in Part I of the present report. Moreover, we believe the underlying Haragan and Bois d'Arc Formations are also Early Devonian (Helderbergian in age), the evidence for this being given in part III and in earlier publications. (See footnote, p. 198 of part III.)



Text-figure 4. Chart showing the Devonian formations present in Sequoyah County of northeastern Oklahoma, and in the Arbuckle Mountains region of south-central Oklahoma. (There may be some Onesquethawan or Esopusian strata exposed along Turkey Creek in Marshall County; see Amsden, 1960, p. 151-159). The relative ages of the Frisco and Sallisaw Formations are discussed in the text, part I and part II of this report; the age of the Bois d'Arc and Haragan Formations is discussed in Amsden, 1958a and 1958b. The age of the Woodford and Chattanooga Formations is that given by Hass (1956) and has not been investigated by us. The formations underlying the Devonian are shown, but his chart does not attempt to give the relative ages or correlatives of these Silurian strata.
(After Amsden, 1961.)

are brachiopods (p. 104-105). In 1958 Ventress completed a Master of Science thesis at The University of Oklahoma on the stratigraphy and megafauna of the Frisco Formation in the Arbuckle Mountains region. This report described and illustrated 32 species of which 22 are brachiopods; the results of this study are incorporated in the present study. In 1960 (p. 134-135) and 1961 (p. 25-45) the senior author described the lithostratigraphy of the Frisco Formation and briefly discussed its age, but did not list any fossils.

Strata of Oriskany age were first recognized in the Marble City area of Sequoyah County by Schuchert (1922, p. 666-670) who referred to those beds as the "upper Oriskany white limestone." He listed the following species: *Favosites shriveri, F.* sp. (large ramose form), large crinoid stems, *Fenestella* (two species), Trepostomata bryozoans, *Rhipidomella musculosa* (Hall), *Leptaena rhomboidalis ventricosa* (Hall), *Leptostrophia oriskania* Clarke, *Strophodonta vascularia* Hall, *Strophonella* sp., *Eatonia peculiaris* (Conrad), *Plethorhyncha praespeciosum* Schuchert, *Delthyris raricostus* (Conrad)?, *Spirifer arenosus* (Conrad), *S. murchisoni* (Castelnau), *S.* n. sp. in line to *S. divaricatus, Meristella lata* Hall, *Rensselaeria marylandica* Hall, *Orthonychia tortuosa* (Hall), *Dalmanites (Odontocephalus).* Schuchert also commented on the similarity between this fauna and that present in the "white limestones of Sainte Genevieve County, Missouri" (later named the Little Saline Limestone). In 1930 Cram (p. 550) applied Reeds' name Frisco to the Sequoyah County strata, but he did not discuss the fauna. Some years later Christian (1953) presented a Master of Science thesis to The University of Oklahoma on the geology of the Marble City area. Much information on the lithostratigraphy of the Frisco Formation is in this thesis, including a geologic map showing the distribution of this formation. Christian listed 39 species from the Frisco of this area, of which 24 are brachiopods. We have examined Christian's collections, which are at The University of Oklahoma, and some of his specimens are illustrated in the present report. Huffman (1958, p. 33-35) briefly discussed the stratigraphy and distribution of the Frisco Formation in Sequoyah County and listed the fossils collected and identified by Christian. Amsden (1961) described the lithostratigraphy of the Sequoyah County Frisco in considerable detail and briefly discussed its age, but did not list any fossils.

Amsden and Huffman (1958, p. 73-75) illustrated a Frisco brachiopod, "*Rensselaeria elongata,*" from a core obtained at a depth of 4,930 feet in Pottawatomie County, Oklahoma (SW¼ NE¼ NW¼ sec. 36, T. 8 N., R. 2 E.). This fossil is described and re-illustrated in the present report as *Rensselaeria* sp. (p. 133 and pl. VII, fig. 20). In so far as we are aware, this is the only Frisco fossil to be identified from the subsurface of Oklahoma.

Present report. — The present report is based on a lithostratigraphic and biostratigraphic study of the Frisco Formation in the Arbuckle Mountains region made by both of us during the years 1955 to 1958, and a similar study of the Frisco Formation in Sequoyah County by the senior author during the years 1959 to 1961. In the course of this investigation approximately 1,400 brachiopod specimens were collected from the Arbuckle region and about 450 from Sequoyah County. All of these specimens were collected in situ (broken out of the limestone) from strata the geographic and stratigraphic positions of which were carefully determined in the field. The stratigraphic data pertaining to these collections are recorded in the appendices of the senior author's 1960 and 1961 reports (see p. 60 of the present report). In this connection it should be noted that the Frisco Formation has been mapped in considerable detail throughout its entire outcrop area in the Arbuckle Mountains area and in Sequoyah County; geologic maps showing the distribution of the Frisco Formation may be found in Ventress (1958, pl. 8); Amsden (1960, panel 2, pls. A-B); and Amsden (1961, pl. 1). See also text-figures 2 and 3 of the present report.

Our understanding of Frisco brachiopods has been increased by a study of related Early Devonian faunas from other areas in the central and eastern United States. The senior author has examined the large collections of brachiopods from the Oriskany, Glenerie, and Harriman Formations at the U. S. National Museum and at the Peabody Museum, Yale University. He has also collected and studied a substantial number of fossils from the Little Saline Limestone at its type locality in Ste. Genevieve County, Missouri. Our faunal analysis has been further supplemented by an examination of several type specimens borrowed from other institutions: Hall's type specimens of *Rhynchonella barrandi, Rhynchonella speciosa, Atrypa pleiopleura, Strophodonta lincklaeni, Spirifer pyxidatus,* and *Meristella lata* from the Oriskany Sandstone were borrowed from the American Museum of Natural History; Clarke's type specimens of *Meristella? vascularia, Orthotetes becraftensis,* and *Strophodonta lincklaeni* from the Oriskany Sandstone were borrowed from the New York State Museum; Stewart's type specimens of *Meristella carinata, Uncinulus salinensis, Uncinulus parvus,* and *Uncinulus* *welleri* from the Little Saline Limestone were borrowed from the Walker Museum at the University of Chicago. Thus the conclusions reached in this report with respect to the identification of Frisco brachiopods and their relations to other described North American brachiopods is based upon a study of published reports supplemented by a direct comparison with specimens from other formations.

Acknowledgments. — In collecting fossils from the Frisco Formation we were aided at various times by C. C. Branson, W. E. Ham, Tom Rowland, and F. H. Manley. We also wish to acknowledge our use of the Frisco brachiopod collection made by H. E. Christian. The senior author would like to thank G. Arthur Cooper of the U. S. National Museum, and Karl M. Waage of the Peabody Museum, Yale University, for extending every courtesy to him during his study of the collections at these institutions. We are also indebted to M. H. Nitecki of the Walker Museum, the University of Chicago, C. F. Kilfoyle of the New York State Museum, and Donald F. Squires of the American Museum of Natural History for the loan of type specimens.

FRISCO STRATIGRAPHY

We have already described the lithostratigraphy of the Frisco Formation in some detail and therefore only a short summary is included in the present report (Ventress, 1958, p. 8-17, pl. 8; Amsden, 1960, p. 125-130, pl. 15, figs. 1-4, text-figs. 41-43; Amsden, 1961, p. 24-45, pls. 1, 2, 4, 9, 10, text-figs. 8-14). The lithologic characters of this formation are similar in both the Arbuckle Mountains region and in Sequoyah County, but for convenience these areas will be treated separately.

Arbuckle Mountains region. — The Frisco Formation is predominantly a biocalcarenite, locally grading into a biocalcirudite, or, less commonly, into a biocalcilutite. The bedding is generally irregular and ranges up to two or three feet thick. Nodules and small lenses of chert are locally present, being fairly abundant in a few places. Generally the Frisco is composed of fossil debris set in a matrix of clear, sparry calcite. The organic debris is predominantly brachiopod and snail shells, along with some bryozoans, corals, and other groups. Many of the fossils are broken and most of the bivalved shells are disarticulated. The grain size is controlled by the character of this fossil debris, the calcilutite facies being confined to those beds composed of smaller fragments which were washed out of the broken shell debris. The insoluble-residue content is low, ranging from 0.7 to 1.7 percent in the majority of specimens tested; the residues are dominantly silt-sized, subangular quartz grains, with some glauconite, pyrite, and, in some beds, fragments of silicified fossils. The magnesium content is low. Of eight specimens tested, all had less than one percent $MgCO_3$.

The Frisco Formation is exposed in a fairly continuous series of outcrops extending in a southeasterly direction from Bois d'Arc Creek in the southern part of Pontotoc County to near Bromide in southeastern Coal County (text-fig. 2). At the northern end of this belt the formation is about 60 feet thick, but elsewhere its thickness is generally between 10 and 20 feet. Throughout this area the Frisco rests upon the Fittstown Member of the Bois d'Arc Formation (text-fig. 4). The Bois d'Arc and Haragan Formations, which represent lithofacies and biofacies of one another, are Helderbergian in age, bearing a fauna much like that of the New Scotland Formation of the eastern United States. The lithostratigraphic and biostratigraphic relationships of the Haragan-Bois d'Arc Formations have already been described in detail (Amsden, 1958a, p. 18-24; 1958b, p. 7-25, text-figs. 2-5; 1960, p. 84-125, text-figs. 28-41); however, a brief review is given here as the relationship of these stratigraphic units to themselves and to the overlying Frisco offers an opportunity to compare the effect that environmental changes have on a particular biologic group (brachiopods) with the phylogenetic changes produced by the passage of time.

The Bois d'Arc Formation is divided into two members: (1) an upper Fittstown Member which is composed of fairly thin-bedded, bioclastic calcarenites with a low acid-insoluble content (about 4.5 percent), and (2) a lower Cravatt Member consisting of cherty marlstones having a reduced fossil content and increased insoluble residues, largely in the form of terrigenous clay and silt (average 11.5 percent). In their typical expression these units are distinct, but they grade laterally and vertically into one another so that the boundary between them is indistinct. These strata are generally underlain by the Haragan, which is a marlstone averaging about 16 percent insolubles, mostly in the form of silt-size, subangular quartz detritus. There is substantial biostratigraphic and lithostratigraphic evidence to show that a complete lateral as well as vertical gradation exists from the high insoluble-low fossil-bearing beds of the Haragan through the cherty marlstones of the Cravatt to the high fossil-low insoluble beds of the Fittstown. Accompanying this is a change in the character of the matrix, the Fittstown having a sparry calcite cement in contrast to the Haragan which has a micrite matrix (text-fig. 5A). The Fittstown appears to have been laid down in a considerably higher energy environment than was the Haragan. In the latter formation the fossils are well preserved and complete specimens are common, whereas in the Fittstown the fossils show much breakage. This factor is clearly reflected in the degree of disarticulation of the brachiopod shells (text-fig. 5B); only 21 percent of the Haragan brachiopods are disarticulated* as compared with 50 percent for the Cravatt and 96 percent for the Fittstown. (See discussion under Brachiopod Faunas, *Pedicle-brachial ratio.*) This disarticulation factor was determined by counting the total number of specimens in the collections from each stratigraphic unit (pedicle valves, plus brachial valves, plus articulated shells) and calculating the percentage of the total that occur as free valves. (The Haragan specimens in our collections total about 4,000 specimens; the Cravatt about 600; the Fittstown about 800; the Frisco from the Arbuckle region about 1,400 specimens.) The Haragan has a large and varied fauna, predominantly brachiopods, but with many trilobites, corals, bryozoans, snails, and other fossils. On the other hand the Fittstown fauna is largely brachiopods with some trilobites and few other fossils. There are also changes in the composition of the brachiopod faunas; the generic suite of the Fittstown is similar to that of the Cravatt and Haragan (text-figs. 5C, 10) and a large number of species are common to all facies, but there are marked differences in the relative abundance of many of the species.† This is discussed at length in Amsden 1958b (p. 17-20; see especially text-fig. 4).

It is interesting to compare the Frisco Formation with the Haragan-Bois d'Arc Formations in the light of the relationships discussed above. The Frisco is a distinctive lithostratigraphic unit which is easily distinguished from the underlying strata by its thicker beds and lack of marly partings (Amsden, 1960, p. 133). Throughout the outcrop area in Pontotoc, Johnston, and Coal Counties the Frisco-Bois d'Arc contact is sharply defined and there is no lithostratigraphic

* The Haragan fossils, unlike the Frisco, Fittstown, and (to some extent) Cravatt fossils, were largely collected loose on the surface. To some extent this would probably bias the collection in favor of articulated shells because the free valves are more fragile and tend to be more easily broken. This is partly offset by the extra effort made by the serious collector to obtain free valves because these show many of the more diagnostic features. Moreover, the large number of articulated shells in the Haragan collections would seem to indicate that these collections do reflect fairly accurately the condition which exists in the strata (text-fig. 5B).

† In any discussion concerning the relationship between biofacies and lithofacies, it simplifies the problem to assume that the organisms lived in the same environment as that in which they were deposited and buried. This, of course, is extremely difficult to prove, especially where the fossils have been subjected to some breakage and disarticulation before burial; see discussion under *Environment of deposition.*

or biostratigraphic evidence of any gradation between these two formations. The Frisco is a mappable unit and has been mapped throughout its outcrop area (Amsden, 1960, panel 2, pls. A, B; Ventress, 1958, pl. 8). The Frisco has, however, some lithologic features in common with the Fittstown. It is a bioclastic calcarenite with sparry calcite cement and low percentage of acid insolubles (average 1.7 percent). The fossil debris which makes up a large part of the rock has undergone extensive breakage and 97 percent of the brachiopod shells are disarticulated (text-fig. 5B). The Frisco therefore would appear to represent a high-energy deposit, similar in many respects to that of the Fittstown and quite unlike the quiet-water deposition of the Haragan.

The Frisco megafauna, like that of the underlying strata, is strongly dominated by the brachiopods, but there is a marked change in the composition of the brachiopod fauna at the specific, generic, and even superfamily levels. It is worth pointing out here that no brachiopod species is common to the Frisco and the underlying Helderbergian strata, and there are marked differences between the generic suites.

Less than half of the Frisco genera is present in the underlying Fittstown (text-fig. 5B), whereas the generic suite of the Fittstown is almost identical to that of the Haragan (text-figs. 10, 12; Amsden 1958b, fig. 4). This abrupt change in the brachiopod faunas at the Frisco-Fittstown boundary would seem to be most reasonably interpreted as the result of phylogenetic changes introduced during the lapse of time between the deposition of the Fittstown and the deposition of the Frisco.

Sequoyah County. — The Frisco Formation in Sequoyah County is a light- to medium-gray limestone in beds up to two feet thick. Chert is rare, but small nodules up to 2 inches or so in length are locally present. Typically the formation is composed of a heterogeneous mixture of fossil material, mostly brachiopod shells with some snail shells, bryozoans, corals, and remains of other groups; this is mostly in the form of a poorly sorted calcarenite or, less commonly, a calcirudite. Locally this coquinalike material grades into a finer textured rock, a fine calcarenite or calcilutite, composed of broken organic debris which appears to represent the fines that were flushed out of the coarser material. Pelmatozoan plates are present in most parts of the Frisco, and locally they are abundant enough to form a crinoidal limestone. The matrix which binds these allochems is variable, some parts having a sparry calcite cement and other parts a micrite cement. These different rock types are intimately associated and grade into one another.

The organic material which makes up a large part of the Frisco Formation was extensively fragmented, either before or during deposition (text-fig. 6A; pl. IX, fig. 18). At this time much of the skeletal material was broken and the bivalved shells largely disarticulated. Our brachiopod shells from Sequoyah County include approximately 450 specimens of which 97 percent are disarticulated; this compares with 96 percent disarticulation for our Frisco brachiopod collections from the Arbuckle Mountains region (text-fig. 5B). All of this indicates deposition in an environment of rather active currents and/or waves.

The acid-insoluble content of the Frisco Formation is low; 25 rock specimens collected in Sequoyah County had an average of only 1.1 percent. Much of this insoluble material is in the form of small quartz grains. These are commonly angular and many show well-developed crystal faces; doubly terminated crystals are common (few exceed 0.3 mm in length). In addition to the quartz grains, most residues include some glauconite. Limonite may also be present and locally there is a considerable amount of dark, carbonaceous material.

The $MgCO_3$ content is uniformly low. Of 25 rock specimens tested, only two exceed one percent (1.9 and 2.1%), the average being 0.8 percent.

The Frisco Formation is confined to a small area just north and west of Marble City, Sequoyah County (text-fig. 3). It is well exposed at a number of places in natural outcrops and in the various prospect pits, in quarries, and in the underground limestone mine of the St. Clair Lime Company. In the Marble City area the Frisco is underlain by the St. Clair Formation (Silurian) and overlain by

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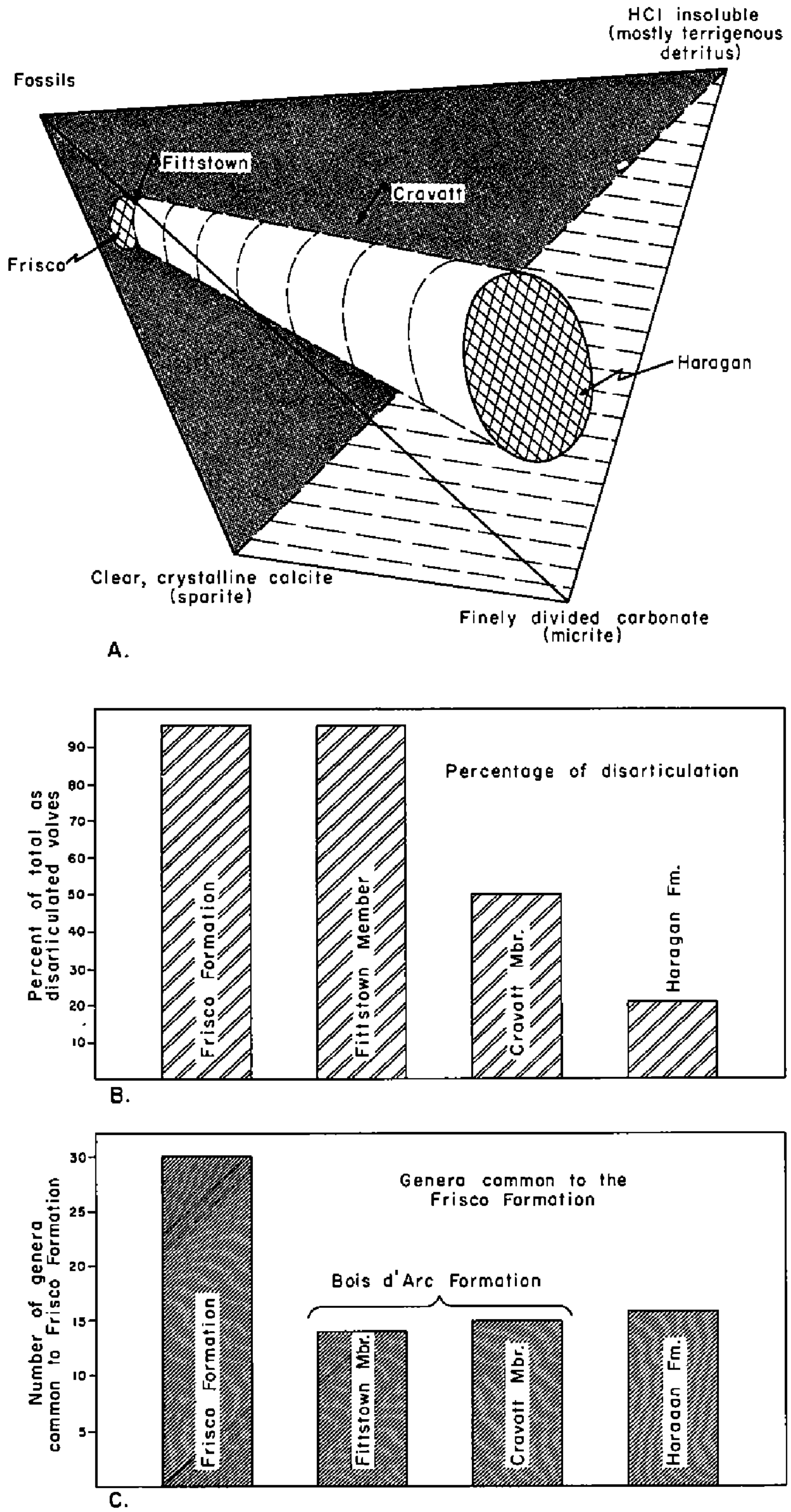
Text-figure 5. Lithologic and faunal characteristics of Haragan, Cravatt, Fittstown, and Frisco strata.

A. Quaternary diagram showing the range in composition and texture of the Haragan, Cravatt, Fittstown (Helderbergian), and Frisco (Deerparkian) strata. The Frisco in the Arbuckle region is primarily a biosparite, although locally it has some micrite cement (Amsden, 1961, pl. 10, fig. 1). (Modified from Amsden, 1960)

B. Graph comparing the percentage of disarticulation in the Haragan Formaion, Cravatt and Fittstown Members of the Bois d'Arc Formation, and the Frisco Formation (Arbuckle region; in Sequoyah County the Frisco shows about the same degree of disarticulation). The height of the bar indicates the percentage of free valves (pedicles plus brachials) in the total number of specimens (free valves plus articulated shells).

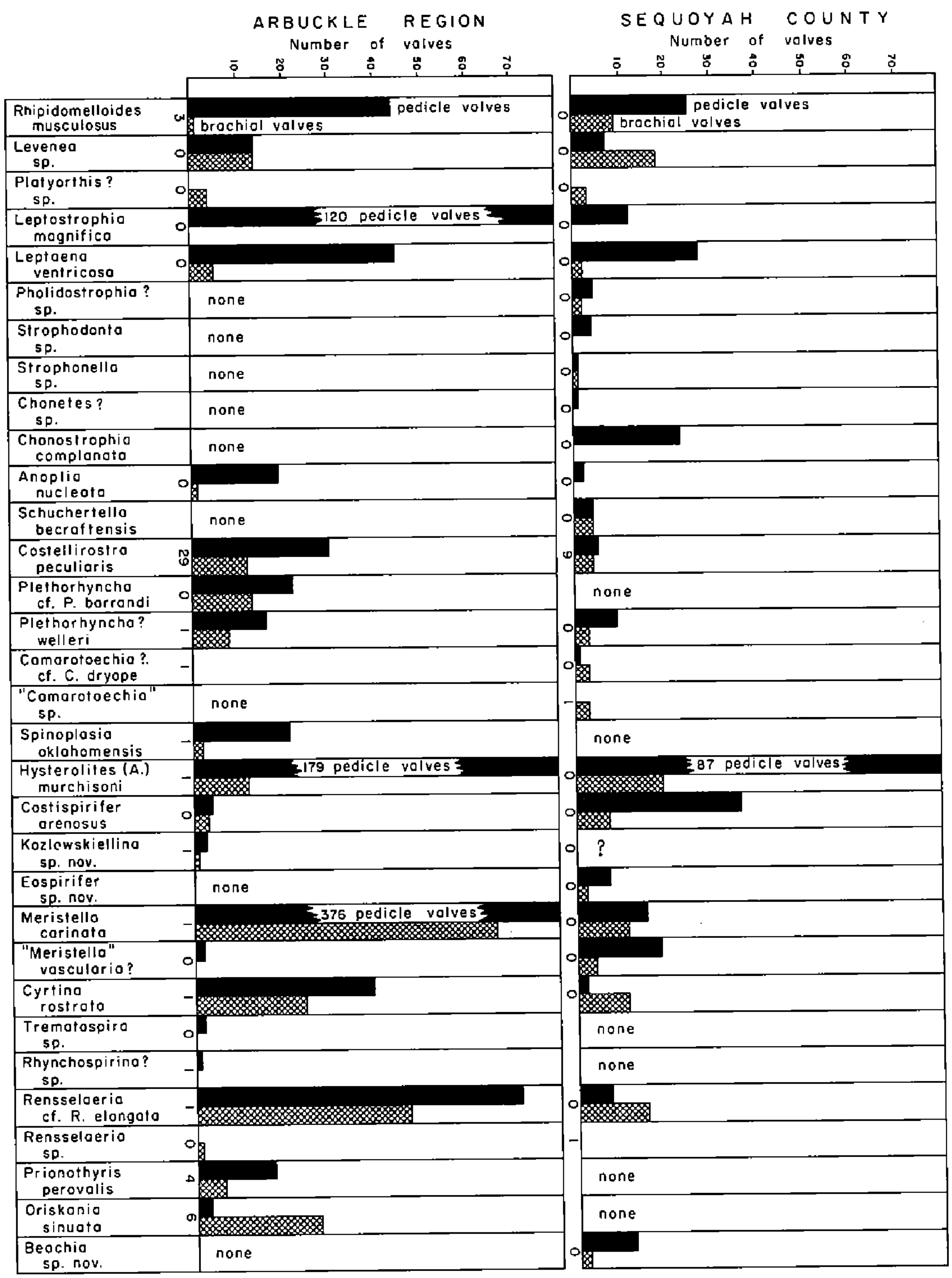
C. Graph showing the number of Frisco genera (total of 30 genera) present in the Fittstown and Cravatt Members of the Bois d'Arc Formation (Helderbergian) and Haragan Formation (Helderbergian). See also text-figures 10, 12.


HCl insoluble (mostly terrigenous detritus)
Fossils
Fittstown
Cravatt
Frisco
Haragan
Clear, crystalline calcite (sparite)
Finely divided carbonate (micrite)
A.
Percent of total as disarticulated valves
Percentage of disarticulation
Frisco Formation
Fittstown Member
Cravatt Mbr.
Haragan Fm.
B.
Number of genera common to Frisco Formation
Genera common to the Frisco Formation
Bois d'Arc Formation
Frisco Formation
Fittstown Mbr.
Cravatt Mbr.
Haragan Fm.
C.

the Sallisaw Formation (Esopusian). In places the Frisco has been removed by post-Frisco and pre-Sallisaw erosion, thus bringing the Sallisaw into contact with the St. Clair. In other places both the Frisco and the Sallisaw have been removed by post-Sallisaw and pre-Chattanooga erosion, allowing the Sylamore Sandstone Member of the Chattanooga to rest directly upon the St. Clair. Throughout this area the Frisco is thin, at no place exceeding 10 feet in thickness.

Subsurface data. — Shannon (1962, p. 18) recently published a subsurface study on the Silurian and Devonian strata in Oklahoma in which he stated that the Frisco bears a facies relationship to the Bois d'Arc (as defined by Shannon, the "Bois d'Arc Formation" is equivalent to the Fittstown Member of the present report). Our study does not reveal any such facies relationship for the Frisco and Bois d'Arc Formations, and we believe that Shannon has confused these two formations. Shannon's description of the Frisco Formation is not in accord with the lithologic characteristics of this formation as they appear at the surface. He described the Frisco as a ". . . white to buff, fine-crystalline limestone with a high content of

Text-figure 6A. Rock specimen showing the typical texture of the Frisco shell coquina facies. Note that the brachiopod shell in the center of the picture was broken before being deposited. Enlarged about 2½ times. Stratigraphic section S1-B; see also plate IX, figure 18.



Text-figure 6B. Graph showing the number of free pedicle (solid black) and brachial (crosshatched) valves for each species in our Frisco collections. The left graph is for the Arbuckle Mountains region collections, and the right for the Sequoyah County collections. The figure to the left of each set of bars shows the number of articulated shells of that species. Data compiled from table 1.

milk-white to pale-blue chert," and went on to note that, "It is difficult to discern from well samples whether the chert is evenly distributed throughout the unit, or if it occurs as interbeds with less cherty limestone." In contrast the Frisco in both areas of outcrop is a bioclastic calcarenite or calcilutite with only scattered nodules of chert. Possibly his Frisco represents the lower chert beds which are locally present in the basal part of the Woodford (Ventress, 1958, p. 17-20; Amsden, 1960, p. 139-140). In some places Shannon's "Bois d'Arc" probably consists of the combined Frisco and Fittstown, and in some areas it is composed entirely of the Frisco. The latter case is certainly true in Sequoyah County where he showed only "Bois d'Arc" with no Frisco (Shannon, 1962, fig. 10), whereas the surface exposures in this county reveal only Frisco with no Bois d'Arc. The Frisco and Fittstown are easily separated at the surface on the basis of such features as bedding characteristics, nature of weathering, and faunal content, but it would be difficult to distinguish between them on the basis of electric logs supplemented by well cuttings and impossible to do so on the basis of electric logs alone.

A Frisco brachiopod was definitely identified from a core in Pottawatomie County by Amsden and Huffman (1958, p. 73-75, text-figs. 1, 2), but to our knowledge this is the only Frisco fossil which has been recorded from the subsurface.

FRISCO MEGAFAUNA

The Frisco Formation carries a substantial megafauna which belongs largely to the sessile and vagrant benthos. Brachiopods are the dominant element and probably equal or outnumber all of the other species combined. A number of snails are also present and some of these are large. Both solitary and colonial corals are common, but there is no evidence of reef development. Pelmatozoan plates are represented in almost all parts of the Frisco and, in some beds, make up most of the rock. Ostracodes and sponge spicules are locally abundant. No calcareous algae have been observed.

Reeds (1926, p. 10) reported only a few species, mostly brachiopods, from the Frisco Formation in the Arbuckle region, but Maxwell (1936), working in the same area, listed 58 species, including 32 brachiopods, 10 snails, 5 corals, 8 bryozoans, 2 trilobites, and 1 pelecypod. Ventress (1958) described a total of 33 species from the Arbuckle region. These were distributed as follows: 22 brachiopods, 6 snails, 4 corals, and 1 pelecypod (no bryozoans were described, but our collections from this area include a number of specimens). In the present report we describe 23 brachiopod species from this region. Our Frisco collections from Sequoyah County are somewhat smaller than those from the Arbuckles, but still include a rather varied fauna. The megafauna from this area, like that of the Arbuckles, is strongly dominated by the brachiopods. We describe a total of 26 brachiopod species in this report; in addition our collections include a number of snails, corals (both solitary and colonial), bryozoans, and trilobites. Only the brachiopods have been studied in detail, but a preliminary survey shows that the entire fauna is similar to that of the Frisco in the Arbuckle region.

Environment of deposition. — Either before or during deposition the Frisco organisms were subjected to movement by current and/or wave action, producing some breakage and extensive valve disarticulation. This indicates that the fauna is, to some degree, a thanatocoenose; however, we are inclined to doubt that the organisms were moved any great distance after death, and probably the fossils which are found together in the same bed were fairly closely associated in life, i. e. a biocoenose (see Boucot, 1953, p. 25-40 for a discussion on life and death assemblages). The fact that similar conditions of deposition prevailed over a large geographic area,* and that the composition of the fauna is much the same in all outcrop areas, suggests that the organisms were essentially indigenous to the area in which they are found as fossils and that the habitat in which they lived was similar to the environment in which they were buried. These inferences are, of course, difficult to prove, especially in view of the fact that few, if any, of the fossils collected appear to be in the position occupied in life.

The exact nature of the depositional environment is difficult to determine, but it undoubtedly involved considerable energy. In 1960 the senior author suggested that the Frisco was deposited in an offshore, outer neritic environment, but we are now inclined to believe it represents somewhat more turbulent water. The small quantity of terrigenous material is probably not significant in determining the proximity to shore; if little detritus were available, then the deposit would have little regardless of where it was laid down. Quite possibly the Frisco was deposited close to shore, in the inner neritic

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* The Frisco seas certainly covered a large part of central and northeastern Oklahoma, and similar conditions of deposition probably extended as far east as southeastern Missouri and southwestern Illinois; see discussion under *Correlation and age.*

zone. It could even be a deposit of the littoral zone, although the extensive geographic area covered would seem to militate against interpreting it as a beach deposit.

BRACHIOPOD FAUNA

Our Frisco brachiopod collections include a total of 32 species assigned to 29 genera. Twenty-three of these species are represented in our collections from the Arbuckle Mountains region, and 25 from our Sequoyah County collections. The preservation of fossils in both areas of outcrop leaves something to be desired. As noted before, the brachiopod shells have undergone extensive disarticulation and fragmentation during deposition so that many of the species are represented by disarticulated valves only, and for a few species we have no brachial valves. Additional breakage takes place during the process of collecting, with the result that many of our specimens are incomplete. In identifying this fauna we have tried to follow a conservative policy and to make definite species assignments only where the material seemed to justify such a procedure fully. Under the systematic description for each species we include a discussion on preservation and number of specimens; these descriptions are supplemented by numerous illustrations (none retouched), which further help to show the preservation. Thirteen of the species described in this report are not assigned definite specific names and undoubtedly several of these represent new taxa, but we have established only one new species because the preservation of the others does not warrant assigning them new names. The description of each species is, however, accompanied by a discussion giving our ideas concerning its relationship to other described species. Table 1 lists all of the Frisco brachiopod species and shows the number of specimens representing each species.

Disarticulation and the ratio of pedicle valves to brachial valves. —At the time of deposition the Frisco brachiopods were extensively disarticulated; 96 percent of the specimens in our Arbuckle Mountains region collections are disarticulated (text-fig. 5B) and 97 percent are disarticulated in the Sequoyah County collections.* The percentage of disarticulation is roughly comparable for all spe-

* All of our specimens were collected by breaking the fossils out of the rock and, therefore, none of this disarticulation is the result of recent weathering. Considerable breakage takes place in the process of collecting, but in most cases this can be easily distinguished from the fragmentation which occurred during deposition.

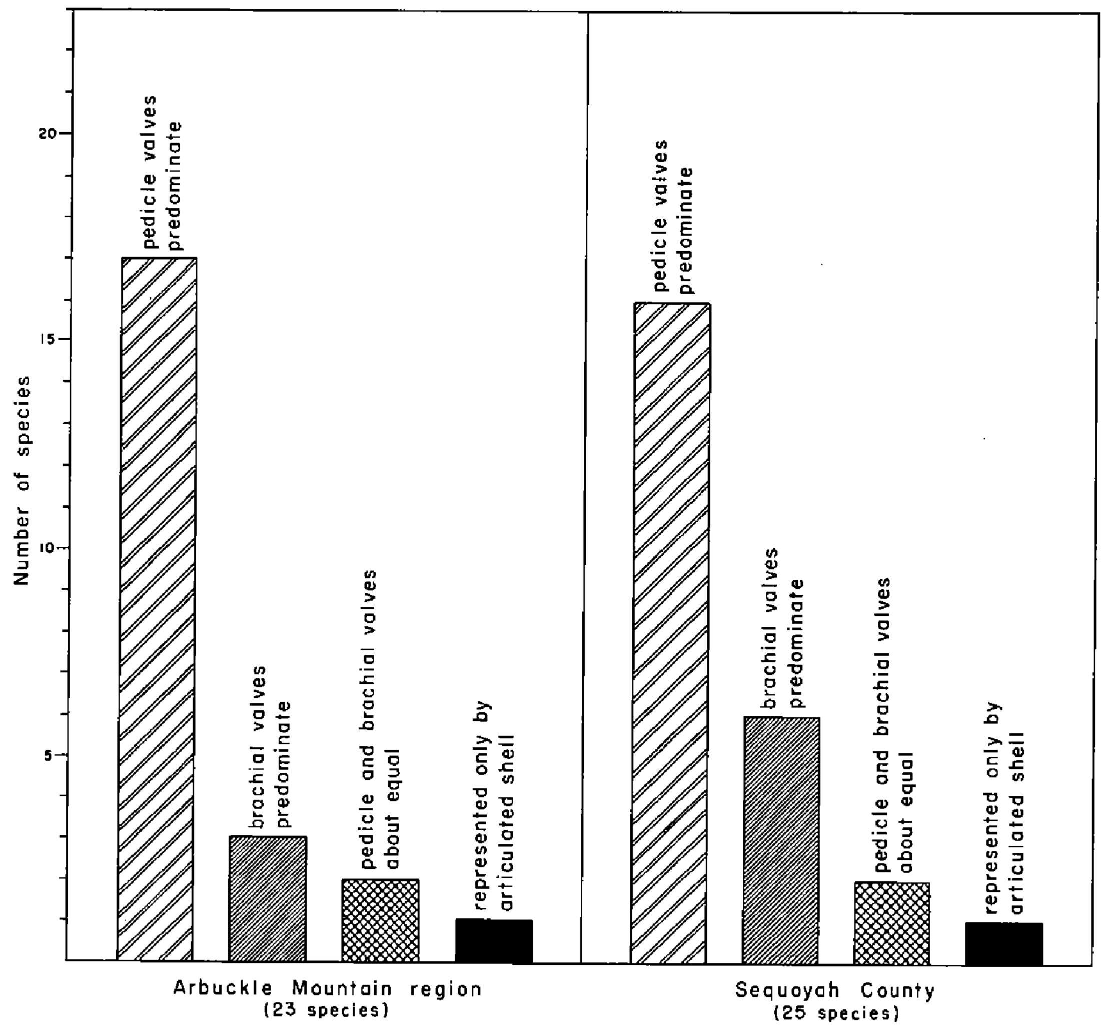
TABLE 1.—FRISCO BRACHIOPODS
(Numbers of specimens)

	Arbuckle Region				Sequoyah County			
	Articulated shells	Pedicle valves	Brachial valves	Pedicle/Brachial ratio	Articulated shells	Pedicle valves	Brachial valves	Pedicle/Brachial ratio
Rhipidomelloides musculosus	3	44	1	44.0	0	25	9	2.8
Levenea sp.	0	14	14	1.0	0	7	18	0.4
Platyorthis? sp.	0	0	4		0	0	3	
Leptostrophia magnifica	0	120	0		0	12	0	
Leptaena ventricosa	0	45	5	9.0	0	27	2	13.2
Pholidostrophia? sp.	0	0	0		0	4	2	2.0
Strophodonta sp.	0	0	0		0	4	0	
Strophonella sp.	0	0	0		0	1	1	1.0
Chonetes? sp.	0	0	0		0	1	0	
Chonostrophia complanata	0	0	0		0	23	0	
Anoplia nucleata	0	19	1	19.0	0	2	0	
Schuchertella becraftensis	0	0	0		0	4	4	1.0
Costellirostra peculiaris	29	30	12	2.5	9	5	4	1.2
Plethorhyncha cf. P. barrandi	0	22	13	1.7	0	0	0	
Plethorhyncha? welleri	1	16	8	2.0	0	9	3	3.0
Camarotoechia? cf. C. dryope	1	0	0		0	1	3	0.3
"Camarotoechia" sp.	0	0	0		1	0	3	
Spinoplasia oklahomensis	1	21	2	10.5	0	0	0	
Hysterolites (A.) murchisoni	1	179	12	15.0	0	87	19	4.5
Costispirifer arenosus	0	4	3	1.3	0	36	7	5.1
Kozlowskiellina new species	1	3	1	3.0	0	0	(?)5	
Eospirifer new species	0	0	0		0	7	2	3.5
Meristella carinata	1	376	66	5.6	0	15	11	1.4
"Meristella" vascularia?	0	2	0		0	18	4	4.5
Cyrtina rostrata	1	39	24	1.6	0	2	11	0.2
Trematospira sp.	0	2	0		0	0	0	
Rhynchospirina? sp.	1	1	0		0	0	0	
Rensselaeria cf. R. elongata	1	71	47	1.5	0	7	15	0.5
Rensselaeria sp.	0	1	0		1	0	0	
Prionothyris perovalis	4	17	6	2.8	0	0	0	
Oriskania sinuata	6	3	27	0.1	0	0	0	
Beachia new species	0	0	0		0	12	2	6.0

cies with a single notable exception, *Costellirostra peculiaris.* In this rhynchonellid species about half of our specimens are articulated shells* (48 percent in the Arbuckle collections and 50 percent in the Sequoyah collection), a rather striking proportion in view of the fact that disarticulation approaches 100 percent in most of the other Frisco species. The explanation for this fact undoubtedly lies in the efficient articulating mechanism of *C. peculiaris;* the stout teeth and sockets were aided by notches or crenulations in the valve margins (Amsden, 1958b, p. 72-73, text-fig. 13). The only other species in our collections represented by more than a single articulated shell are *Rhipidomelloides musculosus, Prionothyris perovalis,* and *Oriskania sinuata,* and in none of these does the proportion of articulated shells exceed 15 percent (text-fig. 6B, table 1).

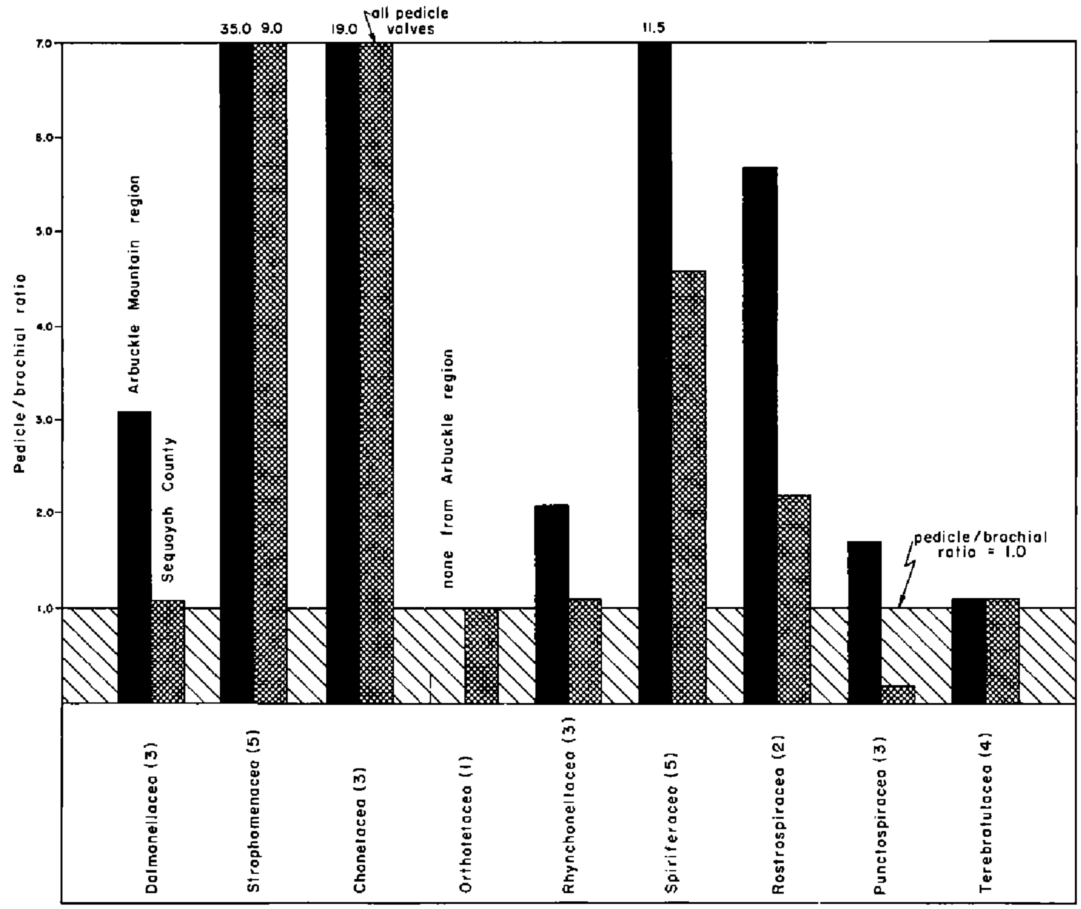
It is interesting to compare the ratio of pedicle to brachial valves in the disarticulated part of the Frisco brachiopod fauna. For most

* This is also the condition of the specimens of *C. peculiaris* collected by the senior author from the Little Saline Limestone of southeastern Missouri; 53 percent of these shells are articulated (text-fig. 9).



Text-figure 7. Graph comparing the pedicle and brachial valve relationship of the different species in the Frisco Formation of the Arbuckle Mountains region with that of Sequoyah County. The bar on the left side shows the number of species in our collections which are represented by more pedicle than brachial valves; the next bar shows the number of species of which there are more brachial than pedicle valves; the third bar shows the number of species in which the numbers of pedicle and brachial valves are about equal; the right bar the number of species represented by only a single, articulated shell. See also text-figures 6B, 8.

species there is a marked disparity between the numbers of the pedicle and brachial valves, the pedicles generally being more numerous than the brachials (table 1, text-fig. 6B). Our entire Frisco brachiopod collection has an average pedicle/brachial ratio of 3.3. In the Arbuckle Mountains region 17 species (out of a total of 23) are represented by more pedicle valves than brachials, whereas the brachials are more numerous than the pedicles in only three species (text-fig. 7). Sixteen of the species found in Sequoyah County (out of a total of 25) are represented by more pedicles than brachials, with only six species having more brachials than pedicles (text-fig. 7). In only two of the species from both areas are the two valves



Text-figure 8. Graph showing the pedicle/brachial valve ratio for the different superfamilies represented in our Frisco collections. The bar on the left side shows the ratio for specimens collected from the Arbuckle Mountains region, and the one on the right for specimens collected from Sequoyah County. The figure following the superfamilial name gives the number of Frisco genera assigned to that group.

approximately equal in number. For certain of the common species such as *Rhipidomelloides musculosus, Leptaena ventricosa,* and *Hysterolites (A.) murchisoni,* the preponderance of pedicle valves is enormous, and in *Leptostrophia magnifica,* a species which is well represented in our collections, no brachial valves have been found (text-fig. 6B). The pedicle/brachial ratio is graphically illustrated by superfamilies in text-figure 8; in only the Dalmanellacea (Sequoyah County), Orthotetacea (Sequoyah County), Rhynchonellacea (Sequoyah County), and Terebratulacea (Arbuckle region and Sequoyah County) do the ratios approach 1.0.

The degree of disarticulation is about the same in our Frisco collections from Sequoyah County as it is in the Arbuckle Mountains region, but the disparity between the numbers of pedicle and brachial valves is not as marked in the Sequoyah County specimens. In the latter the pedicle/brachial ratio averages 2.4, whereas in the Arbuckle collections it averages 4.2. This is shown in text-figure

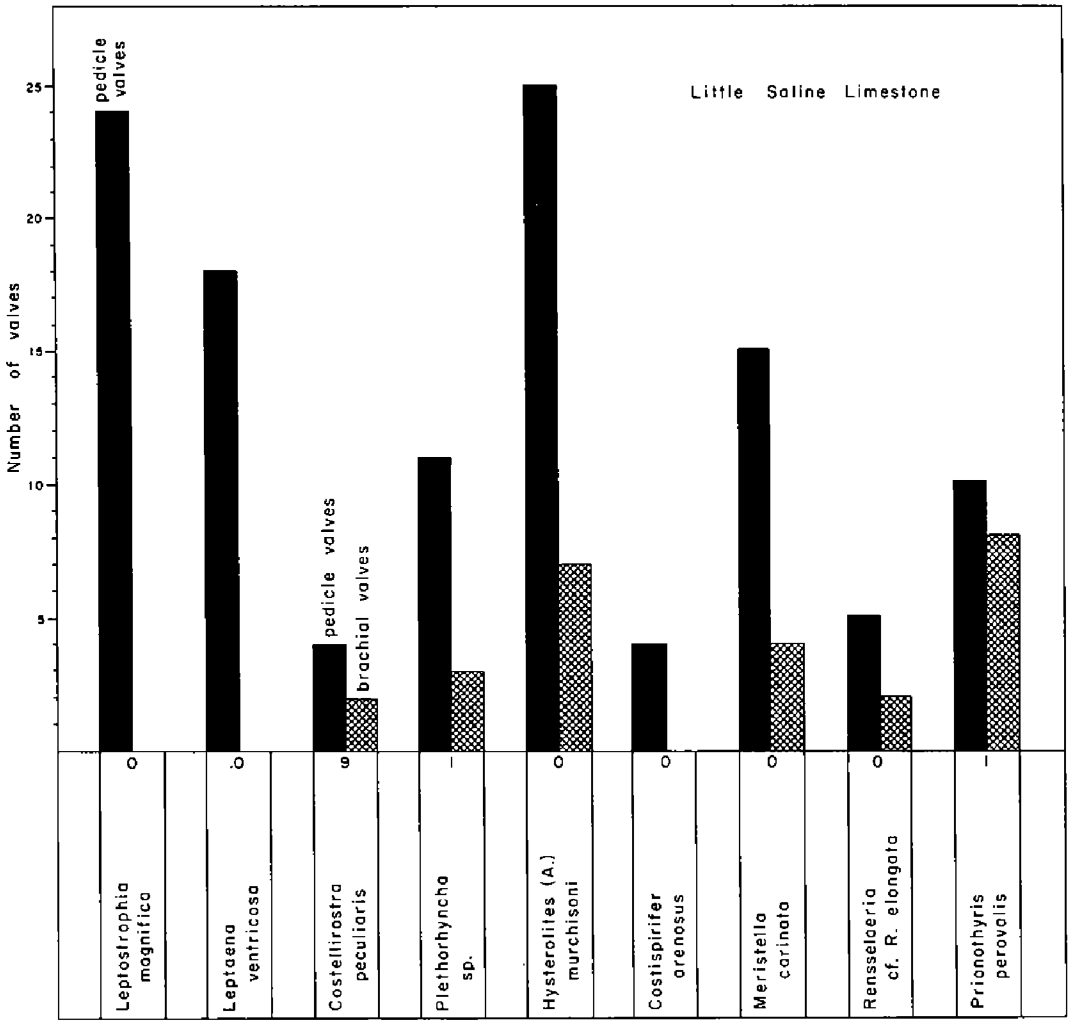
6B where the pedicle-brachial relationship is compared by species, and in text-figure 8 where it is treated by superfamilies. We suspect that our collections probably approximate the pedicle-brachial ratio which actually exists in the strata, although it should be noted that our Sequoyah County collections are considerably smaller than are those from the Arbuckles.

In the spring of 1961 the senior author and F. H. Manley made a collection of fossils from the Little Saline Limestone at its type locality in Ste. Genevieve County, Missouri. This formation carries an abundant brachiopod fauna which is much like that of the Frisco, and the two formations are believed to be closely related in age. About 93 percent of the Little Saline specimens are disarticulated and the separated valves, like those of the Frisco, show a marked disparity in the pedicle/brachial ratio. The average pedicle/brachial ratio is 4.4, and in only one species, *Prionothyris perovalis,* does the ratio approach 1.0. In *Leptostrophia magnifica, Leptaena ventricosa,* and *Costispirifer arenosus* we do not have brachial valves (text-fig. 9; compare with text-fig. 6B). It is also interesting to note that the Little Saline representatives of *Costellirostra peculiaris* are similar to those from the Frisco Formation in having a high percentage of articulated shells.

The valve relationship represented by our collections is certainly not the one which existed when the brachiopod fauna was living in the Frisco sea. At a later time some process acted to disrupt the natural valve balance. Three possible explanations of this relationship occur to us.

(1). The discrepancy between the numbers of pedicle and brachial valves is artificial and was introduced in the process of collecting. This is based on the assumption that there is some factor which would favor the collecting of one valve at the expense of the opposing one. We do not think this is a reasonable explanation. Actually, brachial valves are much sought after by brachiopod fanciers as they show many of the more diagnostic features; and if there is any predilection in collecting, it would be in the direction of producing an assemblage weighted in favor of the brachial valves.

(2). The discrepancy between numbers of opposing valves was produced by the sorting action of waves and/or currents. Certain valves, because of their size, shape, or weight, are more easily transported than others, and these would be flushed out from among the heavier ones and deposited elsewhere. Other investigators, such as Martin-Kaye (1951, p. 432-434) and Boucot (1953, p. 32-33; 1958b, p. 331-332), who have worked on similar problems else-



Text-figure 9. Graph showing the number of free pedicle and brachial valves in a collection of brachiopods from the Little Saline Formation of Missouri. The left bar shows the number of free pedicle valves and the right bar the number of free brachial valves; the figure following each specific name gives the number of articulated shells. This is based on a collection made by the senior author from the Little Saline Formation at the type locality, about 2 miles south of Ozora, Ste. Genevieve County, Missouri; only the better represented species in this collection are shown. Compare with text-figure 6B.

where, have generally favored an explanation of this kind; and there are certain features in our Frisco brachiopod collections which seem to fit in with this interpretation. Almost all of the common species* in which pedicles predominate have a thick pedicle valve with deep muscle scars, and a relatively thin, light brachial valve. This is the condition in species such as *Rhipidomelloides musculosus*, *Leptaena ventricosa*, *Leptostrophia magnifica*, and *Hysterolites (A.) murchisoni*. In other species, such as *Oriskania sinuata*, *Rensselaeria*

* Several of the Frisco species are not represented by enough specimens to furnish a reliable guide to the valve relationship. For the most part, however, the disparity between the numbers of opposing valves is present in all species, even those represented by only a few specimens; see text-figure 6B.

cf. *R. elongata,* or *Cyrtina rostrata,* where the brachial valves either predominate or are relatively abundant, the brachial hinge-plate is rather thick, generally with a cardinal process (text-figs. 40B, 42; pl. VII, figs. 5, 6), and the pedicle valve is thinner. This suggests that the lighter valves have been flushed out and deposited elsewhere. There are, however, serious objections to such an explanation. Most of the well-represented specimens (e. g., *Rhipidomelloides musculosus, Leptaena ventricosa, Leptostrophia magnifica,* and *Hysterolites (A.) murchisoni*) show the same preponderance of pedicle valves at all localities in both Sequoyah County and in the Arbuckle region. Moreover, the same species show the same valve relationship in the Little Saline Limestone of Missouri (text-fig. 9). It is unusual, to say the least, that we have never found the deposits bearing the corresponding valves; for example, intensive collecting has failed to yield a single brachial valve of *Leptostrophia magnifica,* let alone enough to match the pedicle valves. It should also be kept in mind that there is a fine-grained facies of the Frisco which appears to represent the smaller and lighter fragments that were flushed out of the coarse shell coquina (see under Frisco Stratigraphy, and Amsden, 1961, p. 31, pl. 9, figs. 2-4), thus making it appear less likely that some part of the Frisco has been lost by being washed away and deposited elsewhere. Some sorting was produced by wave and/or current action, but this does not appear to have been sufficient to account for the marked disparity in the numbers of valves.

(3). The disparity between the numbers of opposing valves is the result of breakage which took place before or during deposition. There is clear evidence that the skeletal elements in the Frisco fauna were extensively disarticulated and broken by being shifted about on the sea floor by wave and/or current action. According to this third explanation the lighter, thinner-walled valves would be more easily moved and more easily broken. It would not be necessary for a valve to be ground to flour or even to tiny pieces; merely breaking it several times would make it less likely to be recognized and collected. We favor this explanation as it seems to fit best all the known facts. It accords with the extensive fragmentation which has been observed in all Frisco fossils. It fits in with the fact that it is the thicker, heavier valves which are most commonly found (this also supports explanation 2), and, most important of all, it accounts for the presence of valve discrepancy in all areas of outcrop. As noted before, the Sequoyah County collections have a somewhat greater proportion of brachial valves than do those from the Arbuckle region, which might indicate that the water in this area was slightly less turbulent (or that sorting was not so marked), but even in this area the disparity, especially among the common species, is marked. It should be emphasized that this explanation is offered only for the Frisco Formation (in which there is marked evidence of breakage), and we are not suggesting that it will account for all deposits in which there is a disparity in the numbers of valves.

Composition and distribution of the Frisco brachiopod fauna.— The present study is concerned only with the articulate brachiopods; inarticulates have been reported (Maxwell, 1936, p. 104), but they constitute only a small part of the brachiopod fauna. The total articulate brachiopods are assigned to 32 species representing 29 genera and 9 superfamilies. A complete list follows (the more common and widespread species are marked with an asterisk).

Superfamily DALMANELLACEA

Family Rhipidomellidae
- **Rhipidomelloides musculosus* (Hall)

Family Dalmanellidae
- *Levenea* sp.
- *Platyorthis?* sp.

Superfamily STROPHOMENACEA

Family Strophodontidae
- **Leptostrophia magnifica* (Hall)
- *Pholidostrophia?* sp.
- *Strophodonta* sp.
- *Strophonella* sp.

Family Strophomenidae
- **Leptaena ventricosa* (Hall)

Superfamily CHONETACEA

Family Chonetidae
- *Chonetes?* sp.
- *Chonostrophia complanata* (Hall)
- *Anoplia nucleata* (Hall)

Superfamily ORTHOTETACEA

Family Schuchertellidae
- *Schuchertella becraftensis* (Clarke)

Superfamily RHYNCHONELLACEA

Family Camarotoechiidae
- **Costellirostra peculiaris* (Conrad)
- *Plethorhyncha* cf. *P. barrandi* (Hall)
- *Plethorhyncha? welleri* (Stewart)
- *Camarotoechia?* cf. *C. dryope* (Billings)
- "*Camarotoechia*" sp. (may not be congeneric with *C.?* cf. *C. dryope*)

Superfamily SPIRIFERACEA

Family Spiriferidae

Spinoplasia oklahomensis Amsden and Ventress, new species
**Hysterolites (Acrospirifer) murchisoni* (Castelnau)
Costispirifer arenosus (Conrad)
Kozlowskiellina (Megakozlowskiellina), new species
Eospirifer, new species

Superfamily ROSTROSPIRACEA

Family Meristellidae

**Meristella carinata* Stewart
"Meristella" vascularia? Clarke

Superfamily PUNCTOSPIRACEA

Family Cyrtinidae

**Cyrtina rostrata* (Hall)

Family Rhynchospirinidae

Trematospira sp.
Rhynchospirina? sp.

Superfamily TEREBRATULACEA

Family Centronellidae

**Rensselaeria* cf. *R. elongata* (Conrad)
Rensselaeria sp.
Prionothyris perovalis Cloud
Oriskania sinuata Clarke
Beachia, new species

The impunctate spire bearers (Spiriferacea, Rostrospiracea) are the most common element in the brachiopod faunas, representing 23 percent of the genera (text-fig. 10). Next in abundance are the Strophomenacea with five genera, or 16 percent. The Rhynchonellacea and Terebratulacea each constitute 13 percent, the latter being of special interest because the Frisco is the oldest Devonian formation in Oklahoma to carry a substantial number of terebratulids. Only a single terebratulid genus, *Rensselaerina*, is present in the underlying Haragan-Bois d'Arc Formations (Helderbergian), and none has been found in the Silurian strata of Oklahoma (text-fig. 10).

Our Frisco brachiopods were collected from two areas, one in the Arbuckle Mountains region and the other in Sequoyah County. In both places the areal distribution of fossils, or at least of those beds from which satisfactory specimens can be collected, is somewhat spotty, although we have been able to obtain fossils throughout much of the outcrop area (text-figs. 1-3).

The best collecting in the Arbuckle Mountains region is in the vicinity of the type locality on Bois d'Arc Creek (stratigraphic sections P8 and P11; see text-fig. 2, and Amsden, 1960, p. 277-279, 283-285, panel 2, pl. A). In this area the basal 10 feet is the most richly fossiliferous, but at stratigraphic section P11 other fossiliferous zones are present 40 and 60 feet above the base. The brachiopod fauna collected from the upper 60 feet is somewhat less abundant than that found in the lower part, but otherwise the two are nearly identical; the only exception is the terebratulid, *Oriskania siñuata,* which has been found only in this upper part of the Frisco. We also have substantial collections at stratigraphic sections P9 on Coal Creek, P10 west of Canyon Creek, and V7 on Goose Creek, in the southwestern corner of Pontotoc County (text-fig. 2). The southernmost exposures of the Frisco Formation in the Arbuckles yield fewer fossils, and we have only a few species from sections V9 and V10 (descriptions of these stratigraphic sections may be found in the appendices of Amsden, 1960 and 1961). Most of the fossils from the outcrops south of Bois d'Arc Creek came from the lower 10 feet of the formation, but it should be noted that, excluding stratigraphic section P11, the formation at few places exceeds 15 feet in thickness (text-fig. 2). A complete list of the Frisco brachiopods from the Arbuckle Mountains region is given in table 1A (those marked with a single asterisk are represented by more than 20 specimens; those by two asterisks by more than 50 specimens).

TABLE 1A.—FRISCO BRACHIOPODS, ARBUCKLE MOUNTAINS REGION

	Stratigraphic Section					
	P8, P11	P10	P9	V7	V9	V10
**Rhipidomelloides musculosus	X	X		X		
*Levenea sp.	X		X			
Platyorthis? sp.	X					
**Leptostrophia magnifica	X	X	X	X		
**Leptaena ventricosa	X	X	X	X		
*Anoplia nucleata	X		X	X		
**Costellirostra peculiaris	X		X	X		
*Plethorhyncha cf. P. barrandi	X	X	X			
*Plethorhyncha? welleri	X		X			
Camarotoechia? cf. C. dryope		X				
*Spinoplasia oklahomensis new species	X	X	X			
**Hysterolites (A.) murchisoni	X	X	X	X	X	X
Costispirifer arenosus	X					
Kozlowskiellina new species	X					
**Meristella carinata	X	X	X	X	X	X
"Meristella" vascularia	X					
**Cyrtina rostrata	X	X				
Trematospira sp.	X					
Rhynchospirina sp.			X			
**Rensselaeria cf. R. elongata	X	X	X	X		
Rensselaeria sp.	X					
*Prionothyris perovalis	X		X			
*Oriskania sinuata	X					

The foregoing list comprises 23 species of which 15 are reasonably well represented. The more abundant and widespread species are: *Rhipidomelloides musculosus, Leptostrophia magnifica, Lep-*

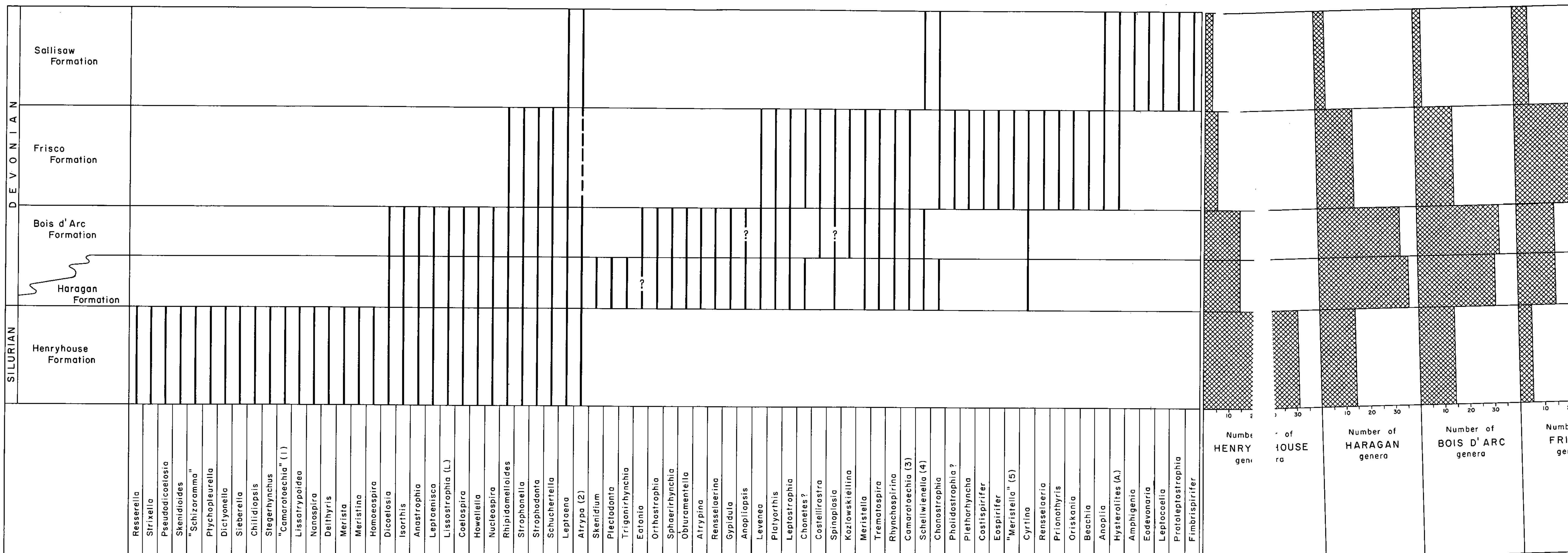
taena ventricosa, Costellirostra peculiaris, Hysterolites (A.) murchisoni, Meristella carinata, Cyrtina rostrata, and *Rensselaeria* cf. *R. elongata.*

The Frisco outcrops in northeastern Oklahoma are confined to a small area just north of Marble City (text-fig. 3). The best collecting is on Sallisaw Creek at stratigraphic section S1 and a short distance south of the St. Clair Lime Company quarry at sections S5 and S6, but we also have substantial collections from the outcrop belt along Payne Hollow (section S8 is especially good and has yielded most of the Frisco brachiopod species). The fauna ranges throughout the formation although this observation has little significance as the Frisco does not exceed a thickness of 10 feet. A complete list of brachiopods collected from the Frisco of Sequoyah County is given in table 1B; those species marked with a single asterisk (*) are represented by more than 20 specimens and those marked with a double asterisk (**) are represented by more than 50 specimens. (A complete description and precise location of each of these stratigraphic sections is given in the appendix of Amsden, 1961.)

TABLE 1B.—FRISCO BRACHIOPODS, SEQUOYAH COUNTY

	Stratigraphic Section							
	S1	S4	S5	S6	S6(A)	S7	S8	S10
*Rhipidomelloides musculosus	X		X	X	X		X	X
*Levenea sp.			X	X	X	X		
Platyorthis? sp.			X		X			
Leptostrophia magnifica			X	X		X	X	
*Leptaena ventricosa	X		X	X	X		X	
Pholidostrophia? sp.				X				
Strophodonta sp.			X				X	X
Strophonella sp.			X				X	
Chonetes? sp.				X				
*Chonostrophia complanata		X	X		X			
Anoplia nucleata				X				
Schuchertella becraftensis							X	
*Costellirostra peculiaris	X		X	X			X	
Plethorhyncha? welleri	X		X	X			X	X
Camarotoechia? cf. C. dryope			X	X	X			
"Camarotoechia" sp.	X	X		X			X	
**Hysterolites (A.) murchisoni	X		X	X	X		X	X
*Costispirifer arenosus	X		X	X			X	
Kozlowskiellina new species			X	X				
Eospirifer new species			X	X	X			
*Meristella carinata	X		X	X		X	X	X
*"Meristella" vascularia?	X			X			X	X
*Cyrtina rostrata		X	X	X	X	X		
*Rensselaeria cf. R. elongata	X		X	X			X	X
Rensselaeria sp.			(one specimen near S13)					
Beachia new species			X	X				

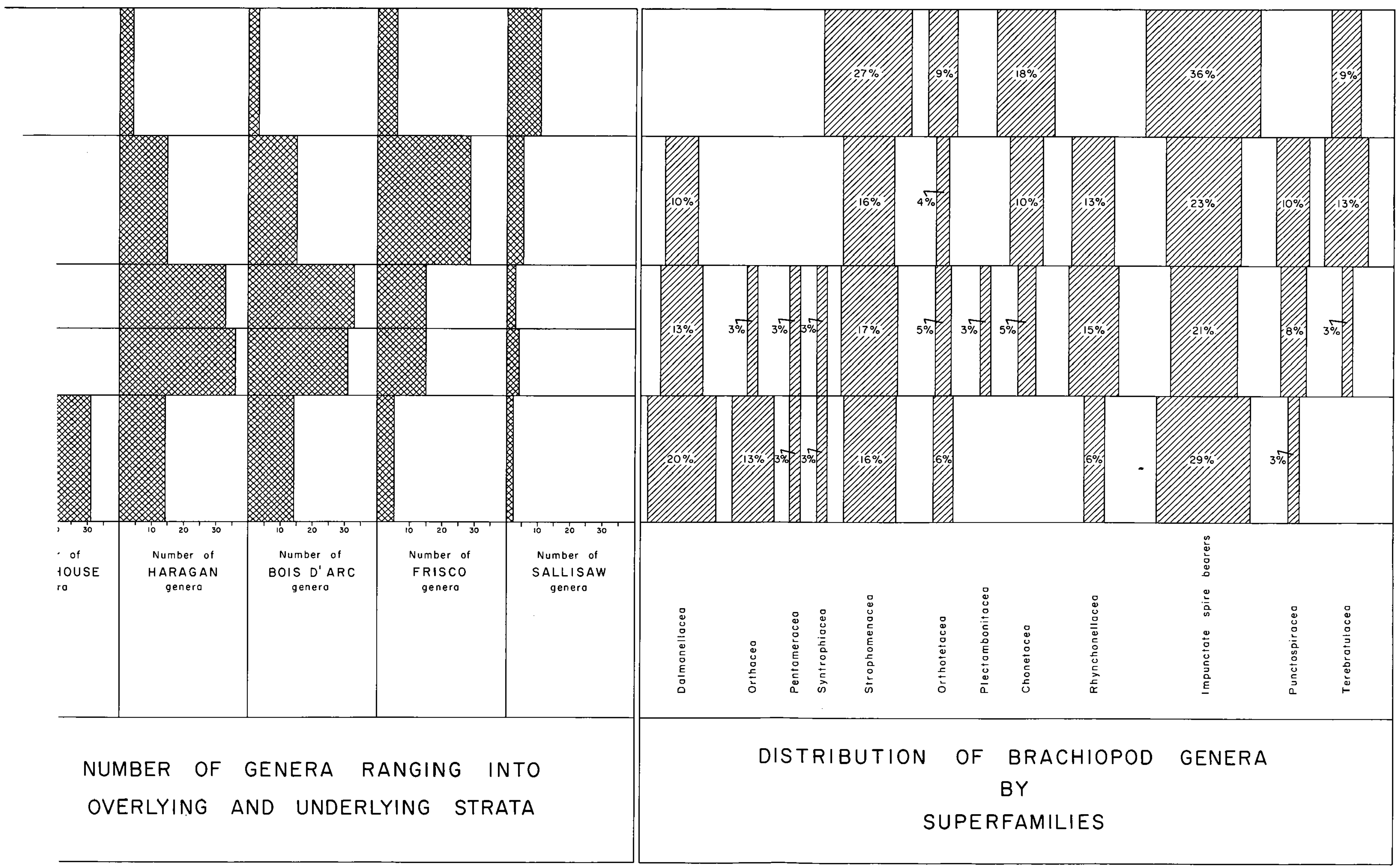
Twenty-six species are listed in the foregoing table. Of these, 11 are relatively common and widespread: *Rhipidomelloides musculosus, Levenea* sp., *Leptaena ventricosa, Chonostrophia complanata, Costellirostra peculiaris, Hysterolites (A.) murchisoni, Costispirifer*



(1) The Henryhouse "Camarotoechia" are not congeneric with those from the Devonian.
(2) No specimens of Atrypa have been found in the Frisco.
(3) The Haragan and Frisco species referred to Camarotoechia probably represent more than one genus.
(4) Schellwienella s.l. is applied to those orthotetacid brachiopods having dental plates.
(5) The Frisco species "Meristella" vascularia probably represents an undescribed genus.

RANGE OF BRACHIOPOD GENERA

NUMBER OF GENERA RANGIN
OVERLYING AND UNDERLYING



Number of HARAGAN genera
Number of BOIS D'ARC genera
Number of FRISCO genera
Number of SALLISAW genera
10 20 30
NUMBER OF GENERA RANGING INTO OVERLYING AND UNDERLYING STRATA
Dalmanellacea
Orthacea
Pentameracea
Syntrophiacea
Strophomenacea
Orthotetacea
Plectambonitacea
Chonetacea
Rhynchonellacea
Impunctate spire bearers
Punctospiracea
Terebratulacea
27%
9%
18%
36%
9%
10%
16%
4%
10%
13%
23%
10%
13%
13%
3%
3%
3%
17%
5%
3%
5%
15%
21%
8%
3%
20%
13%
3%
3%
16%
6%
6%
29%
3%
DISTRIBUTION OF BRACHIOPOD GENERA BY SUPERFAMILIES

arenosus, Meristella carinata, "Meristella" vascularia?, Cyrtina rostrata, Rensselaeria cf. *R. elongata.* By far the most abundant of all is *Hysterolites (A.) murchisoni,* which is represented in our collections by more than 100 specimens.

Our combined Frisco collections from both areas comprise 32 species, of which the following 17 are common to both areas:

Rhipidomelloides musculosus
Levenea sp.
Platyorthis? sp.
Leptostrophia magnifica
Leptaena ventricosa
Anoplia nucleata
Costellirostra peculiaris
Plethorhyncha? welleri
Camarotoechia? cf. *C. dryope*
Hysterolites (A.) murchisoni
Costispirifer arenosus
Kozlowskiellina new species
Meristella carinata
"Meristella" vascularia
Cyrtina rostrata
Rensselaeria cf. *R. elongata*
Rensselaeria sp.

We have found the following six species in the Arbuckle region only:

Plethorhyncha cf. *P. barrandi*
Spinoplasia oklahomensis, new species
Trematospira sp.
Rhynchospirina? sp.
Prionothyris perovalis
Oriskania sinuata

We have found the following nine species only in the Frisco of Sequoyah County:

Pholidostrophia? sp.
Strophodonta sp.

Text-figure 10. Chart showing the distribution of brachiopod genera in the Henryhouse (Ludlovian), Haragan (Helderbergian), Bois d'Arc (Helderbergian), Frisco (Deerparkian), and Sallisaw (Esopusian) Formations. All of these brachiopods are described, either in the systematic descriptions of the present report, or in previous papers of the senior author (Amsden, 1951; 1958a, 1958b; Boucot and Amsden, 1958). The section on the left shows the range of brachiopod genera in each of the five formations (note that the Bois d'Arc and Haragan Formations are facies of one another). The middle section shows the number of genera in each formation which range into the overlying and underlying formations. The section on the right shows the distribution of brachiopods in each of the formations by superfamilies. This last is based on genera; for example, 20 percent of the Henryhouse genera belong in the superfamily Dalmanellacea. Compare to text-figure 51.

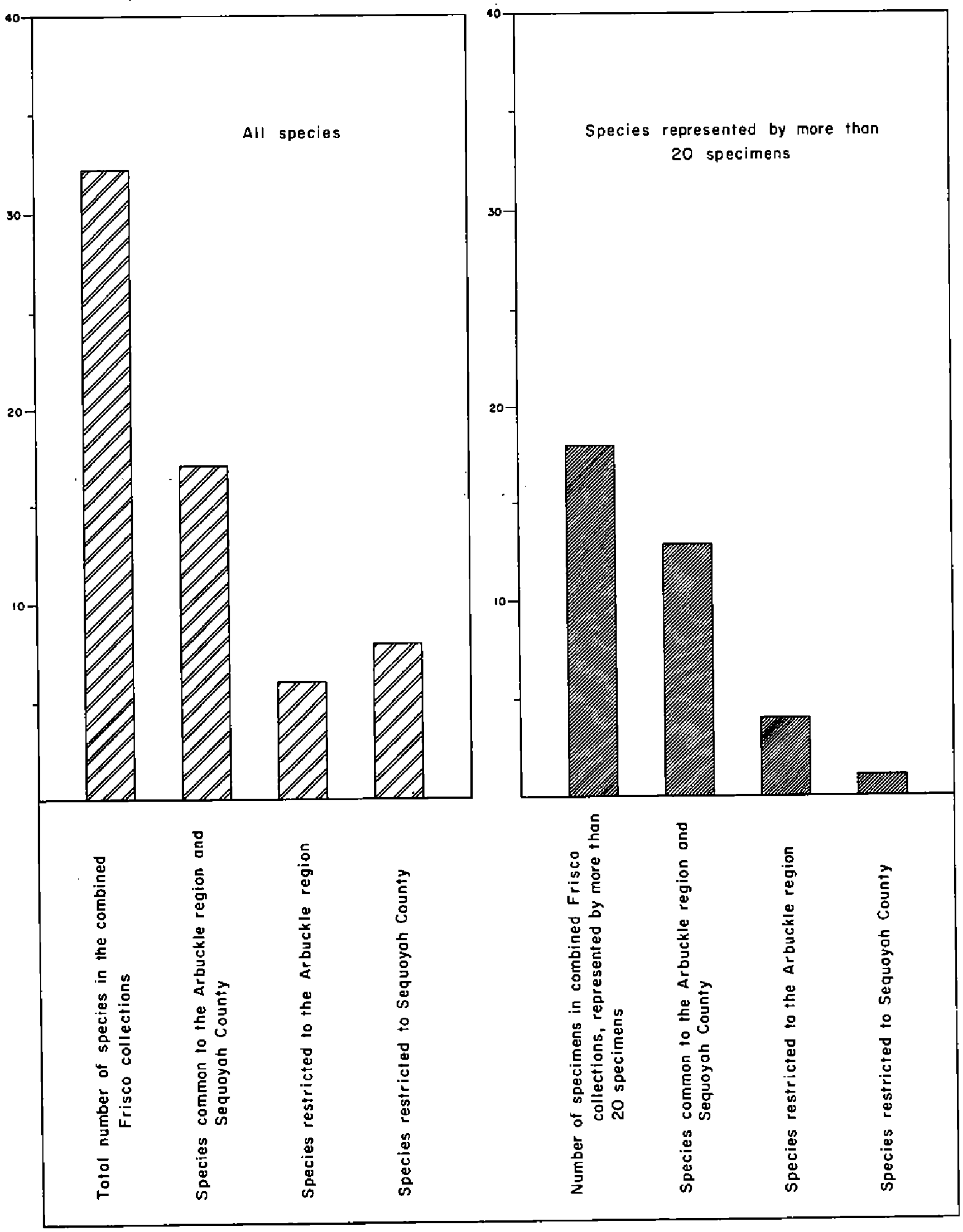
Strophonella sp.
Chonetes? sp.
Chonostrophia complanata
Schuchertella becraftensis
"*Camarotoechia*" sp.
Eospirifer new species
Beachia new species

The foregoing shows that slightly more than half (53%) of the total Frisco brachiopod fauna is present in both areas (text-fig. 11); however, in comparing the two faunas it should be kept in mind that many of the species which are restricted to one area or the other are represented by only a few specimens. If the comparison is based on the more abundant brachiopods, for example on those which are represented by 20 or more specimens in the combined collections, the percentage of species which are common to both areas is increased to 71 percent (text-fig. 11). This is a rather close similarity considering the fragmentary nature of the fossils and the difficulties encountered in making satisfactory collections. Moreover, it should be noted that many of the brachiopods which have been found in only one of the two areas are typical Deerparkian species; for example, *Chonostrophia complanata, Schuchertella becraftensis, Plethorhyncha* cf. *P. barrandi,* and *Oriskania sinuata* are all present in the Oriskany Sandstone where they are associated with *Rhipidomelloides musculosus, Leptostrophia magnifica, Leptaena ventricosa, Anoplia nucleata, Costellirostra peculiaris, Costispirifer arenosus, Hysterolites (A.) murchisoni, Cyrtina rostrata* and many other brachiopods (see under *Correlation and age*).* We are therefore of the opinion that the Arbuckle Frisco and Sequoyah County Frisco are closely related in age and represent, for all practical purposes, synchronous deposits in the same sea.

Comparison with Haragan-Bois d'Arc brachiopods. — Throughout the Arbuckle region the Frisco rests upon the Fittstown Member of the Bois d'Arc Formation (Helderbergian; text-fig. 4). The lithostratigraphic relations of these two formations have been described in previous reports (Amsden, 1960 and 1961) and are summarized in an earlier part of the present paper (Frisco Stratigraphy, *Arbuckle Mountains region*). The Frisco brachiopod fauna is quite unlike that of the Fittstown. None of the Fittstown species ranges into the Frisco and there is a significant change at the generic level; only 45 percent of the Fittstown genera is present

* The only possible exception to this is the Frisco brachiopod *Eospirifer* new species, a genus which has not heretofore been reported from Deerparkian strata (see discussion under *Correlation and age*).

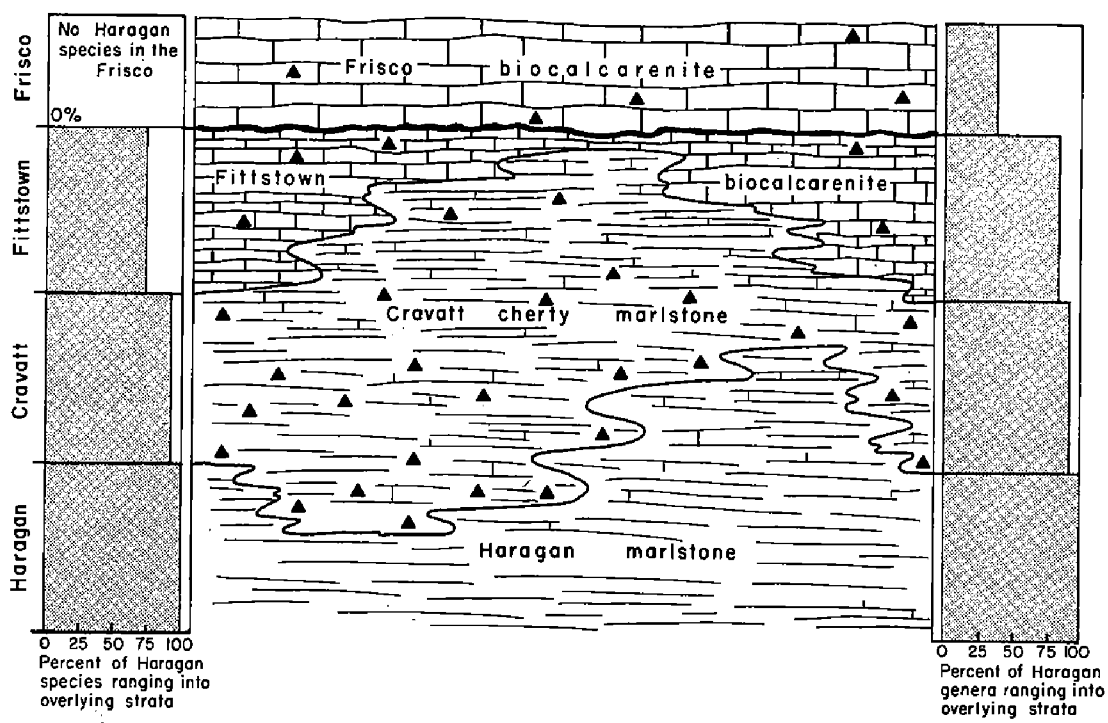
in the Frisco (52 percent of the Frisco genera is present in the Fittstown; see text-fig. 10). Moreover, those genera which do range from one formation into the other are represented by quite different species. This change not only affects the brachiopod genera, but it is also apparent at the superfamily level (text-fig. 10). The Orthacea, Pentameracea, Syntrophiacea, and Plectambonitacea which



Text-figure 11. Frequency diagram comparing the brachiopods from the Frisco of the Arbuckle region with those from the Frisco of Sequoyah County. The diagram on the left is based on the complete brachiopod fauna, whereas the one on the right is based only on those species represented by more than 20 specimens in our combined collections.

are present (although not common) in the Haragan-Bois d'Arc have nowhere been found in the Frisco; whereas the Terebratulacea, which are known only by a single species in the Haragan-Bois d'Arc, are represented by five species in the Frisco. This abrupt and marked change between the faunas of the Fittstown and the Frisco is not correlated with any profound lithologic change; there is a much greater lithologic difference between the Fittstown and the Haragan Formations which have similar brachiopod faunas (Amsden, 1958b), than between the Fittstown and Frisco Formations (text-figs. 5, 12). The Frisco Limestone of Oklahoma and the Oriskany Sandstone of New York, which exhibit extreme lithologic differences and which crop out in widely separated geographic areas, have remarkably similar brachiopod faunas; whereas the Frisco and Fittstown, which are contiguous bioclastic limestones of similar texture and composition, have markedly different faunas.

In Sequoyah County the Frisco Formation is underlain by the "St. Clair" Formation of Silurian age (Amsden, 1961, p. 15, 23).



Text-figure 12. Diagram summarizing the lithostratigraphic and biostratigraphic relations of the Haragan, Bois d'Arc (Cravatt and Fittstown Members), and Frisco Formations. The graph on the left side shows the percentage of Haragan species which are present in the Cravatt and Fittstown; note that none of these species ranges into the Frisco Formation. The graph on the right side shows the percentage of Haragan genera which range into the Cravatt, the Fittstown, and the Frisco. The lithostratigraphic relations are generalized, but this drawing is based on described stratigraphic sections (see Amsden, 1958a, 1958b, 1960, 1961); the brachiopod faunas which furnish the data for the graphs are described and illustrated, either in the present paper or in earlier reports. See also text-figures 5, 10.

The senior author has made large collections from these Silurian strata and this fauna will be described in a future publication. However, enough preliminary work has already been done to show that there is a pronounced difference between the "St. Clair" and Frisco brachiopods, a difference which is comparable in degree to that between the Frisco and Henryhouse brachiopods. For comparison, the distribution of Henryhouse genera is included on the chart shown in text-figure 10; note that all of the brachiopods included on this chart are described, either in the present paper, or in earlier publications of the senior author (Amsden, 1951, 1958a, 1958b).

Comparison with Sallisaw brachiopods. — The Sallisaw brachiopods are described in Part II of this bulletin and a detailed comparison of this fauna with the Frisco is deferred to that part. The distribution of Frisco and Sallisaw genera is shown in the range chart, text-figure 10. In comparing the Sallisaw fauna with earlier faunas, it should be kept in mind that it is much smaller. The Sallisaw fauna comprises only 11 genera compared to 30 in the Frisco, 38 in the Haragan-Bois d'Arc, and 31 in the Henryhouse.

AGE AND CORRELATION

The Frisco carries a brachiopod fauna similar to that found in the middle part of the Early Devonian of New York. The Lower Devonian of New York is represented by a reasonably complete sequence of strata, most of which are fossiliferous. The brachiopods from these strata have been studied for many years and there is now a substantial amount of information on the stratigraphic range of the various species and genera which have been described. Currently the faunas are grouped into three stages, Helderbergian, Deerparkian, and Esopusian, with the Onesquethawan Stage (restricted) generally referred to the Middle Devonian. (Some authors include the Manlius and upper Roundout in the Devonian.) To facilitate comparison with the Devonian faunas of Oklahoma, the ranges for most of the brachiopod genera present in the Early Devonian of New York have been plotted on the chart shown in figure 51 (in part III of this report). This chart brings out the similarity between the phylogenetic development attained by Frisco and Deerparkian brachiopod faunas. Twenty-four of the Frisco genera are present in Deerparkian strata, with four of these *(Rensselaeria, Oriskania, Beachia,* and *Plethorhyncha)* being confined to this stage in New York (note the strong development of terebratuloids and large spiriferoid brachiopods in the Frisco of Oklahoma and Deerparkian of New York). Three Frisco genera *(Costellirostra, Leptostrophia,* and *Rhynchospirina)* appear to terminate in the Deerparkian, being absent in the overlying Esopusian and younger strata; four Frisco genera *(Costispirifer, Acrospirifer, Anoplia,* and *Prionothyris)* make their first appearance in the Deerparkian, being unknown in the underlying Helderbergian and older strata. The close relationship between Frisco and Deerparkian brachiopods is fully substantiated by a comparative study based on species (see discussion below). Note also the general similarity between the sequence of faunas present in the Devonian of Oklahoma (Haragan-Bois d'Arc, Frisco, and Sallisaw) and that of New York, although the latter appears to have a more complete faunal representation.

The Deerparkian Stage* was named for exposures in Deerpark Township, Sullivan County, New York (Cooper and others, 1942, p. 1733), and in New York is composed mostly of the Oriskany Formation. The similarity of Frisco and Oriskany has been noted by many investigators (Reeds, 1926; Schuchert, 1922; Maxwell, 1936; Christian, 1953; Ventress, 1958), and is fully confirmed by the present study. The senior author has compared the Frisco brachiopods directly with specimens in the Oriskany collections at the U. S. National Museum and at Peabody Museum, Yale University. These collections include a large number of brachiopods from the Oriskany and Glenerie Formations of New York, and the Oriskany (Ridgeley Sandstone)† near Cumberland, Maryland. The U. S. National Museum collections include some especially fine specimens from the Glenerie Formation near Glenerie, New York.

Oriskany Formation. — The Oriskany Formation crops out over a large area in New York, New Jersey, Pennsylvania, Maryland, Virginia, and West Virginia (Stow, 1938, p. 544; text-fig. 17 of this report). Throughout much of this area the strata are fossiliferous, with brachiopods being the most common element. Clarke

* The Deerparkian Stage is generally assigned to the early part of the Coblenzian Series of Europe (Cooper and others, 1942, chart 4). In a recent article Boucot (1960, table 1) correlated the Oriskany Sandstone with the Lower and Middle Siegenian beds of Europe.

† The arenaceous limestones exposed near Glenerie, New York, have been named the Glenerie Limestone. The fossils from this formation are nearly identical with those from the Oriskany Sandstone and almost all stratigraphers and paleontologists regard it as a calcareous facies of the Oriskany. In Maryland and adjacent areas the Oriskany Formation (or Group) has been divided into two members (or formations): an upper Ridgeley Sandstone Member and a lower Shriver Chert Member. The Shriver Chert is sparsely fossiliferous and almost all of the fossils which have been described from this area are from the Ridgeley Sandstone (all of the Maryland fossils recorded in table 2 are from the Ridgeley Sandstone). This fauna is similar to that of the Oriskany Sandstone of New York with which it is almost certainly correlative. As used in this report, Oriskany Formation includes the Oriskany Sandstone, Glenerie Limestone, and Ridgeley Sandstone.

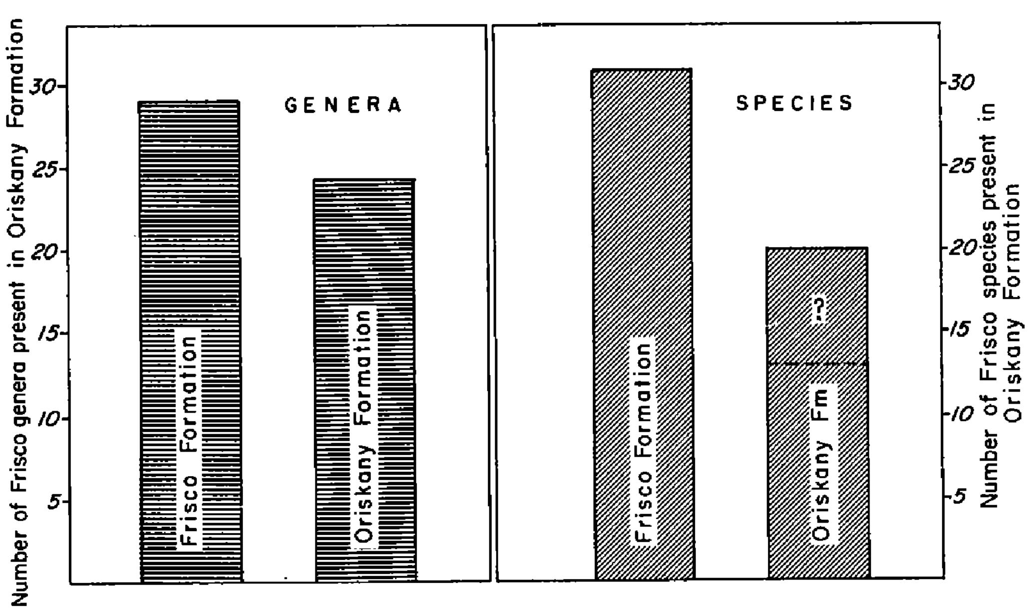
(1900, p. 65-67) listed 113 species from the Oriskany at Becraft Mountain, New York, of which 43 are brachiopods. Schuchert and Maynard (1913, p. 124-132) described 120 species from the Oriskany of Maryland, of which 63 are brachiopods. The Mollusca are also an import element of the Oriskany fauna. Clarke listed 22 species of gastropods and pelecypods, and Schuchert and Maynard recorded 59 species of mollusks. The fossils are most commonly preserved as internal and external molds, but locally, as near Glenerie, New York, and Cumberland, Maryland, the shells are well preserved by silicification (pl. VI, figs. 1, 2, and pl. XII, figs. 8-13). A large number of brachiopods have been described from Oriskany strata. Many of the specimens collected in New York were described by James Hall and John M. Clarke (see especially Hall, 1857 and 1859; and Clarke, 1900). The New Jersey fossils were described by Weller (1903) and the Oriskany fauna of Maryland by Schuchert and Maynard (1913). Cloud (1942) described the Oriskany terebratuloid brachiopods in detail, and recently Boucot (1959a) described some of the Deerparkian Ambocoeliinae. Unfortunately there is no recent systematic treatment of all Oriskany brachiopods and, therefore, it is difficult to obtain a complete record of described species. The list given in table 2 was compiled by us from various sources and is believed to be reasonably complete. We have included only the species the descriptions of which were based on specimens from the Oriskany Formation (most are from New York or Maryland), excluding those based on specimens from other formations (see footnote, p. 42). Many of the species in the latter category may be correctly identified, but further study is needed to verify them. The column on the left side of table 2 shows those Oriskany species which have been identified in the Frisco with certainty (*) and questionably (?). On the right side are four columns showing those species which are present in the Oriskany of: (1) New York, (2) Pennsylvania (compiled from Cleaves, 1939, p. 110-113), (3) Maryland, and (4) New Jersey. This list includes 72 brachiopods, more than twice as many as we describe from the Frisco Formation; however, we suspect that some are only morphologic variants of the same species and should be suppressed as synonyms. For example, there are ten named species of *Hysterolites (Acrospirifer)* of which some, perhaps all, would appear to be merely minor variants of *H. (A.) murchisoni* (see *Discussion* of this species in the section on Brachiopod Descriptions); this may also be true of other species groups, such as the meristellas and leptostrophias. Even if a dozen or so Oriskany species are suppressed, its brachiopod fauna will still be considerably larger than that found in the Frisco,

Frisco	TABLE 2.—ORISKANY BRACHIOPODS	Oriskany-Glenerie, New York	Oriskany, Pennsylvania	Oriskany, Maryland	New Jersey
X	Rhipidomelloides musculosus (Hall)	X	X	X	?
	R. musculosus arctisinuatus (Schuchert)			X	
	R. marylandicus (Schuchert)		X	X	
?	Platyorthis planoconvexa (Hall)	X	X	X	
	Schizophoria oriskania Schuchert			X	
X	Leptostrophia magnifica (Hall)	X	X	X	X
	L. magniventra (Hall)	X		X	
	L. oriskania Clarke	X			
	Strophodonta lincklaeni Hall	X			
	S. vascularia Hall	X			
	S. majus (Clarke)	X			
	S. schuchertana (Clarke)	X			
	Pholidostrophia? lincklaeni (Clarke) [not Hall, 1857]	X			
	Leptaena ventricosa (Hall)	X	X	X	X
?	Chonetes [?] rowei Schuchert		X	X	
	C. [?] hudsonicus (Clarke)	X	X	X	X
X	Chonostrophia complanata (Hall)	X	X	X	X
X	Anoplia nucleata (Hall)	X	X	X	X
X	Schuchertella becraftensis (Clarke)	X	X	X	
	Hipparionyx proximus Vanuxem	X	X	X	X
X	Costellirostra peculiaris (Conrad)	X	X	X	X
	Eatonia sinuata Hall	X	X	X	
	E. hartleyi Schuchert			X	
?	Plethorhyncha barrandi (Hall)	X	X	X	X
	P. speciosa (Hall)	X	X	X	
	P. pleiopleura (Conrad)	X	X	X	
	P. fitchana (Hall)	X		X	
	P. ramsayi (Hall)			X	
	Pegmarhynchia whitfieldi (Hall)				X
	P. zimmi Cooper	X			
	Camarotoechia [?] oriskani Rowe			X	
	"Camarotoechia" breviplicata (Weller)				X
	Metaplasia paucicostata (Schuchert)			X	
	M. pyxidata (Hall)	X	X	X	X
	Plicoplasia cooperi Boucot	X			
	P. plicata (Weller)				X
X	Hysterolites (A.) murchisoni (Castelnau)	X	X	X	X
	H. (A.) arrectus (Hall)			X	
	H. (A.) tribulus (Hall)			X	
	H. (A.) cumberlandiae (Hall)			X	
	H. (A.) intermedius (Hall)			X	
	H. (A.) angularis (Schuchert)			X	
	H. (A.) murchisoni marylandicus (Schuchert)			X	
	H. (A.) hartleyi (Schuchert)			X	
	H. (A.) perdewi (Schuchert)			X	
	H. (A.) tribuarius (Schuchert)			X	
X	Costispirifer arenosus (Conrad)	X	X	X	X
	Meristella lata Hall	X	X	X	X
	M. lentiformis Clarke	X	X	X	
	M. rostellata Schuchert		X	X	
	M. symmetrica Schuchert			X	
	M. [?] fausta (Clarke)	X			
X	"Meristella" vascularia Clarke	X			
	Coelospira dichotoma (Hall)	X	X	X	X
	C. equistriata Schuchert			X	
	Leptocoelia flabellites (Conrad)	X	X	X	X
	L. fimbriata (Hall)	X	X	X	
X	Cyrtina rostrata (Hall)	X	X	X	X
	C. varia Clarke	X			X
?	Trematospira "multistriata" Hall	X	X		
?	Rhynchospirina rectirostris (Hall)	X		X	
?	Rensselaeria elongata (Conrad)	X	X		
	R. marylandica Hall		X	X	
	R. marylandica symmetrica Schuchert			X	
	Beachia suessana (Hall)	X	X	X	X
	B. suessana immatura Schuchert			X	
	Eurythyris lucerna (Schuchert)			X	
	E. dunbari Cloud			X	
X	Prionothyris perovalis Cloud	X			
	P. ovalis (Hall)	X	X	X	
	Oriskania navicella Hall and Clarke	X			

a fact which should be kept in mind when comparing the two faunas.

The generic suite of Frisco brachiopods is much like that of the Oriskany Formation (compare figs. 10 and 51). We recognize 29 genera of Frisco brachiopods of which 24 (83%) are present in the Oriskany (text-fig. 13A). In so far as we are aware none of the following Frisco genera is represented in the Oriskany fauna: *Levenea, Strophonella, Spinoplasia, Kozlowskiellina,* and *Eospirifer. Spinoplasia* was described by Boucot (1959a) and included only the type species, *S. gaspensis* Boucot, from the Helderbergian strata of Gaspé; however, other closely related genera such as *Metaplasia* and *Plicoplasia* are present in the Oriskany Formation. The genus *Eospirifer* has not, to our knowledge, been heretofore recorded from post-Helderbergian strata of North America, but Havlíček (1959, p. 229-230) cited two species from the Middle Devonian of Europe. The other three genera, *Levenea, Strophonella,* and *Kozlowskiellina* are represented by species ranging in age from Silurian to Onesquethawan or later and are therefore not incompatible with a Deerparkian age (Schuchert and Cooper, 1932, p. 123; Williams, 1953, p. 48; Boucot, 1957, p. 318).

Thirty-five Oriskany genera are listed in table 2; of these, 24 (68%) are also present in the Frisco Formation. The following 11 genera have not been found in the Frisco:



Text-figure 13A. Chart showing the number of Frisco genera (left side) and species (right side) present in the Oriskany Formation. The lower part of the bar on the right side shows the number of Frisco species which are definitely present in the Oriskany, and the upper part (marked with a query) the number which are questionably present. This is based on the data given in tables 1, 2. Compare with text-figure 18.

Pegmarhynchia
Schizophoria
Hipparionyx
Eatonia
Metaplasia
Plicoplasia
Coelospira
Leptocoelia
Eurythyris
Globothyris
Nanothyris

Some of these genera are relatively uncommon in the Oriskany; but others, such as *Coelospira* and *Leptocoelia,* have been widely reported from Deerparkian strata of North America. The number of absent genera does not seem unduly large in view of the fact that the Frisco has a smaller brachiopod fauna with six fewer genera than the Oriskany.

The Frisco fauna comprises 32 species, of which 13 are definitely known to be present in the Oriskany Formation (table 2, text-fig. 13A), including some of the most common and distinctive of Deerparkian species: *Rhipidomelloides musculosus, Leptostrophia magnifica, Costellirostra peculiaris, Hysterolites (A.) murchisoni, Cyrtina rostrata, Costispirifer arenosus, Prionothyris perovalis, Oriskania sinuata,* and *Beachia* sp. (this last genus is known only from Oriskany species; Cloud, 1942, p. 61). This is a substantial number of common species, especially considering the fragmentary nature of the Frisco fossils. Only 18 of the Frisco brachiopods are assigned definite species names (72 percent of these are Oriskany species), most of the others being too poorly preserved to be precisely identified. Of those species which are not precisely identified, at least six are tentatively identified with Oriskany species; possibly more and better preserved specimens would show that several others belong in this category.

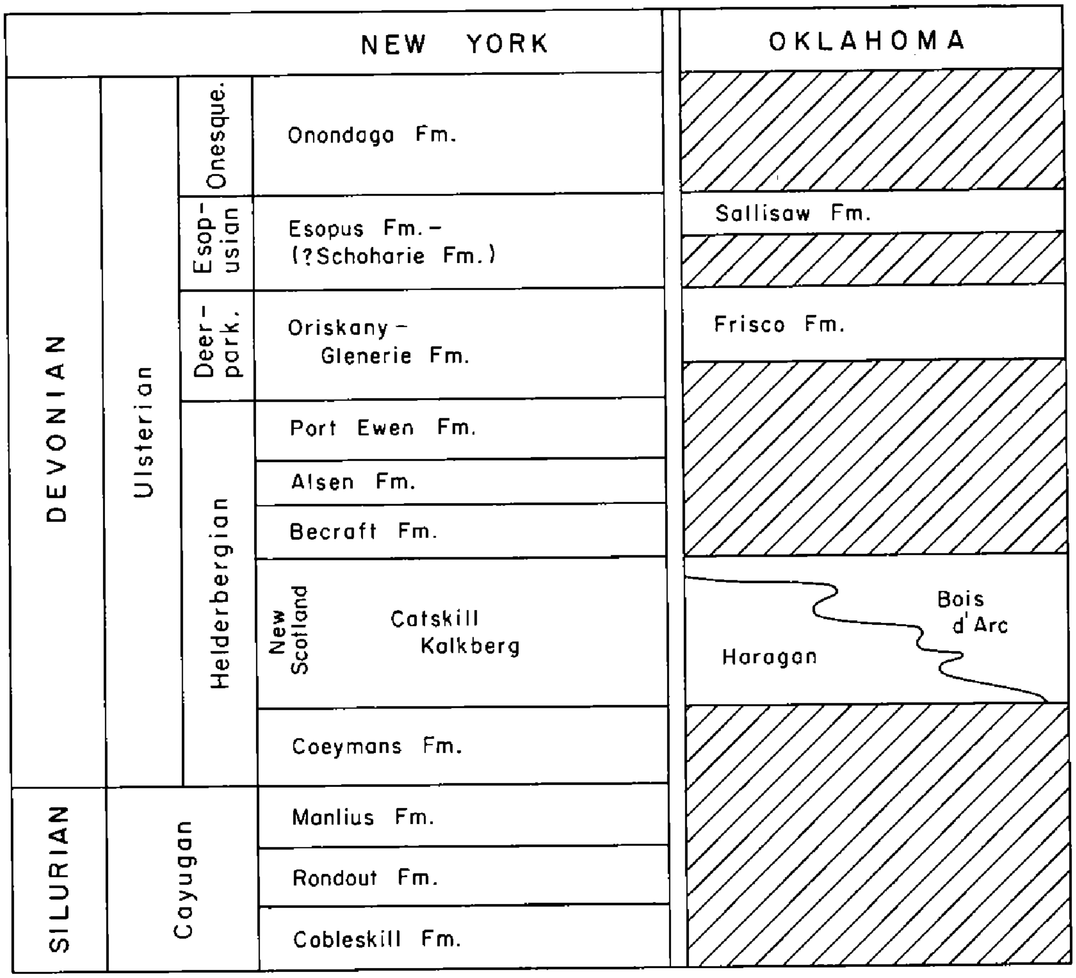
The similarity of Frisco and Oriskany brachiopod faunas is striking in view of the marked lithologic difference between these two formations. Typically the Oriskany is an orthoquartzite with rounded quartz grains, which are generally less than 1.5 mm in diameter, but locally it is conglomeratic. Quartz overgrowths on the detrital grains are common and these may largely fill the interstices (Fettke, 1938, p. 250-253; Martens, 1939, p. 31; Cleaves, 1939, p. 97-101). Accessory minerals are few (Stow, 1938, p. 556-560) and in places the Oriskany is an exceptionally pure orthoquartzite which has been worked as a source of glass sand. Some calcium carbonate is generally present, and locally this increases to such an extent that the rock grades into an arenaceous limestone (e. g., the Glenerie Limestone). In parts of Maryland and West Virginia the quantity of calcium carbonate increases downward (Martens, 1939, p. 31; Amsden, 1954, p. 84), and the formation appears to grade into the underlying Helderbergian strata. Fossils are present in much of the Oriskany although they are in few places, if anywhere, the dominant constituent of the rock. In contrast, the Frisco is a bioclastic limestone made up largely of fossil debris set in a sparite or micrite matrix. Most of the rock is 98 percent to more than 99 percent calcium carbonate, whereas parts of the Oriskany are more than 99 percent silica (Pettijohn, 1957, p. 298). Despite their lithologic differences, the close similarity of the faunas of these two formations* suggests that they may represent fairly similar environments. The Oriskany Formation has generally been interpreted as a shallow-water or beach deposit. Those Oriskany fossils which we have examined do not show nearly so much breakage as do the Frisco fossils, suggesting that the water in the eastern sea was somewhat less turbulent. Whether this condition prevailed throughout the entire area of Oriskany deposition is not certain; possibly a more intensive sampling of Oriskany fossils throughout the outcrop area would show areas of more turbulent deposition, but we are inclined to believe that, in general, the Frisco represents a somewhat higher energy deposit. It is interesting to note that the Frisco and the Fittstown, which are contiguous deposits of similar lithology and presumably similar environments of deposition, have such different faunas; whereas the Frisco and Oriskany, with almost diametrically opposed lithologies, are so similar in faunal composition (text-figs. 5, 12).

The Frisco fauna is clearly of middle Early Devonian age. Its brachiopod fauna agrees with the phylogenetic stage of development represented by the Deerparkian faunas of New York (text-fig. 51), but whether Frisco deposition was precisely contemporaneous with some part, or with all, of the Oriskany Formation is difficult to ascertain. Although the two faunas are much alike as regards both generic as well as specific composition, differences exist, and it is these differences which are difficult to evaluate in terms of exact age relationships. In few instances are two faunal assemblages

* Only the brachiopods are considered in this report, but it should be noted that the other Frisco faunal elements are also like those found in the Oriskany. The total Frisco fauna is somewhat smaller, but, like the Oriskany, it is a "shelly fauna," being dominantly a brachiopod-snail assemblage with considerable numbers of bryozoans and some corals, trilobites, and other groups. Many of the genera and species representing these groups are reported to be identical with those from the Oriskany (Maxwell, 1936, table 8; Christian, 1953, p. 31-32; Ventress, 1958, p. 33-37).

exactly alike, even when they come from nearby outcrops whose contemporaneity can be demonstrated by tracing from one to the other. In such local areas conclusions with respect to the age relationships can in many cases be supported by evidence that is independent of the faunas. The problem, however, becomes more complicated when it involves the correlation of strata that are separated by a considerable geographic distance, such as the Frisco Formation of Oklahoma and the Oriskany Sandstone of New York. For all practical purposes the correlation then depends entirely upon the faunal evidence, and it becomes difficult to distinguish between those faunal differences produced by such factors as differences in ecologic conditions, in deposition, and in geographic isolation and those faunal differences produced by phylogenetic changes introduced with the passage of time. The contrasting lithostratigraphy of the Frisco and Oriskany suggests that there were at least some differences between the original environments of these two formations, and certainly we cannot rule out the possibility of some differences in the time of deposition. The faunal differences are such as could be produced in part, or entirely, by geographic separation combined with differences in habitat. On the other hand, these differences could be entirely the result of phylogenetic changes, one or the other assemblage being slightly older. Even if the latter explanation is favored, the difference is undoubtedly slight, and the two must be closely related in age, a conclusion which is supported by a careful appraisal of the Frisco brachiopods in terms of the known phylogeny represented in the New York section and elsewhere.

The faunal succession in the Lower Devonian of Oklahoma is also similar to that found in other parts of the eastern United States. The Frisco is underlain by strata carrying a Helderbergian fauna (Haragan-Bois d'Arc) and overlain by the Sallisaw Formation which bears an Esopusian fauna (see part II of this bulletin), a sequence which is similar to that found in New York, western Tennessee, southeastern Missouri, and other areas. It should be noted that, although the faunal sequence in these different areas is similar, the lithostratigraphic sequence is not the same. For example, the faunal sequence present in the Haragan-Bois d'Arc-Frisco-Sallisaw of Oklahoma is like that of the Bailey-Little Saline-Clear Creek of Illinois, the Ross-Harriman-Camden of western Tennessee, and the Helderberg-Oriskany-Esopus of New York, although the lithostratigraphic sequences in these areas are quite different. In making this comparison it should be kept in mind that the New York section represents a more complete faunal succession than do the sections in these other areas (text-fig. 13B; text-fig. 51).



Text-figure 13B. Correlation chart showing the inferred relation between Early Devonian strata of Oklahoma and New York. The Sallisaw Formation is present only in northeastern Oklahoma and the Haragan-Bois d'Arc Formations only in the Arbuckle Mountains region and Criner Hills. The New York geological survey places the Silurian-Devonian boundary somewhat lower in the section, between the upper and lower Rondout. This chart is not to scale, either in terms of stratigraphic thickness or of time.

Little Saline Formation.—The Little Saline Limestone crops out in Ste. Genevieve County, southeastern Missouri.* According to Weller and St. Clair (1928, p. 136-141), the type locality is at the quarries of the Ozora Marble Company on the east bank of the Little Saline Creek, about two miles southwest of Ozora. In April of 1961 the senior author and F. H. Manley examined the strata at the type locality and collected a number of fossils. The Little Saline is a light-gray to pinkish-gray, richly fossiliferous limestone in beds up to a foot or two thick (Weller

* The Backbone Limestone of southwestern Illinois is generally considered to be an exact correlative of the Little Saline Limestone (Weller, 1944, p. 208; Cooper, 1944b, p. 219). In April of 1961 the senior author and F. H. Manley examined exposures of the Backbone Limestone along Hutchins Creek in northern Union County, Illinois. The lithologic character of these strata is similar to that of the Frisco; two thin sections show the rock o be a biosparite with little quartz or other insoluble material. No fossils were collected.

and St. Clair gave a total thickness of 100 feet). The fossils show some breakage and the bivalved shells have been extensively disarticulated; 93 percent of the brachiopods in our collection are separate valves. Two thin sections show this rock to be a biosparite with a texture much like that of the Frisco. The fossil debris includes many pelmatozoan plates along with brachiopod and snail shells, bryozoans, and other organisms. There is little quartz or other insoluble debris, and the Little Saline appears to be a rather high-calcium stone. No dolomitic strata were observed by us.

In 1922 Stewart described and illustrated the Little Saline fauna. This fauna totals 102 species and is, like the Frisco and Oriskany faunas, strongly dominated by the brachiopods and mollusks. Stewart described 43 species of brachiopods (only one is an inarticulate brachiopod), 21 gastropods, 11 bryozoans, 17 trilobites,

TABLE 3.—BRACHIOPODS FROM THE LITTLE SALINE LIMESTONE OF MISSOURI
(from Stewart, 1922)

Frisco	Little Saline Limestone	Oriskany
?	Levenea oriskania (Stewart)	
	L. lenticularis (Vanuxem)	
X	Rhipidomelloides musculosus (Hall)	X
	R. emarginatus (Hall)	
X	Leptaena ventricosa (Hall)	X
	Strophodonta missouriensis Stewart	
	S. cf. S. demissa (Conrad)	
	S. cf. S. inaequiradiata Hall	
?	S. aff. S. majus (Clarke)	X
	S. sp.	
X	Leptostrophia magnifica (Hall)	X
	L. magniventra Hall	X
	Schuchertella sp.	
X	Anoplia nucleata (Hall)	X
X	Chonostrophia complanata (Hall)	X
X	Costellirostra peculiaris (Conrad)	X
	Eatonia plicata Stewart	
	Plethorhyncha [?] parvum (Stewart)	
	P. [?] salinense (Stewart)	
X	P. [?] welleri (Stewart)	
?	P. barrandi (Hall)	X
	P. principale (Hall)	X
	Centronella glansfagea (Hall)	
?	Rensselaeria elongata (Conrad)	X
	Pleurothyris cf. P. stewarti (Clarke)	
	Beachia suessana (Hall)	X
X	Prionothyris perovalis Cloud	X
	Atrypa reticularis (Linné)	
X	Costispirifer arenosus (Conrad)	X
X	Hysterolites (A.) murchisoni (Castelnau)	X
	"Spirifer" varicosus Hall	
	Metaplasia cf. M. pyxidata Hall	X
X	Cyrtina rostrata Hall	X
?	Rhynchospirina attenuata (Stewart)	
?	Trematospira multistriata (Hall)	
	Nucleospira cf. N. ventricosa (Hall)	
X	Meristella carinata Stewart	
	M. ampla Stewart	
	M. elliptica Stewart	
	M. ovalis Stewart	
	Leptocoelia flabellites (Conrad)	X
	Coelospira dichotoma (Hall)	X

4 corals, 3 pelecypods, 2 "pteropods," and 1 crinoid. The articulate brachiopods are listed on table 3.

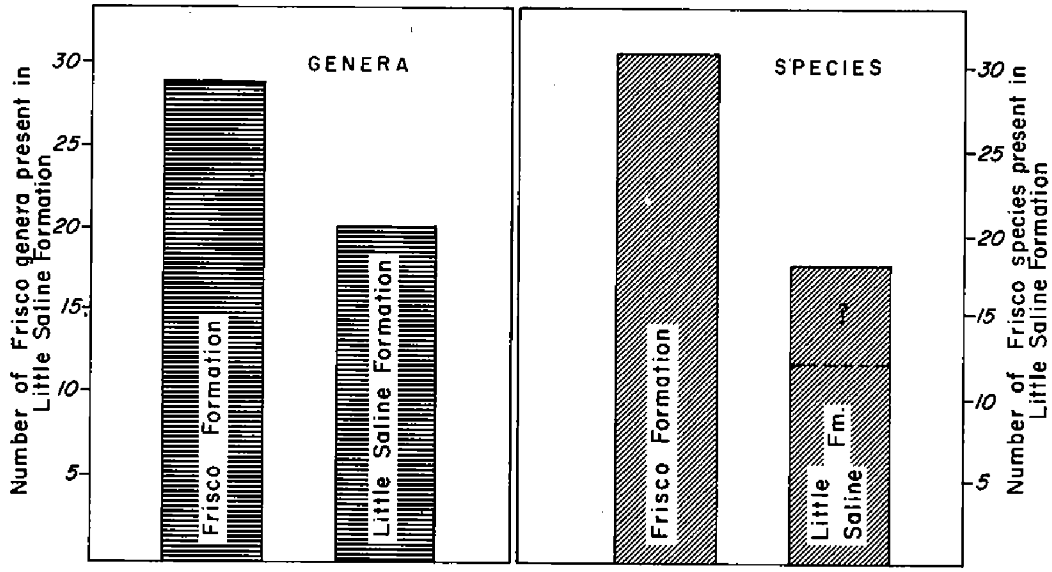
The Little Saline fossils collected by the senior author and F. H. Manley include the following brachiopods:

Rhipidomelloides musculosus
Leptaena ventricosa
Leptostrophia magnifica
Strophodonta missouriensis?
Costellirostra peculiaris
Plethorhyncha? welleri
P. cf. *P. barrandi*
Chonetes? sp.
Hipparionyx? sp.
Costispirifer arenosus
Hysterolites (*A.*) *murchisoni*
Meristella carinata
Atrypa sp.
Prionothyris perovalis
Rensselaeria cf. *R. elongata*

Two of the genera cited above were not recorded by Stewart; however, the specimens which we have referred to these species are not well preserved and these identifications are provisional.

The articulate brachiopod fauna described by Stewart comprises 28 genera and 42 species, 11 being new species proposed by Stewart.* This is a somewhat larger fauna than that of the Frisco; however, some of the species of *Plethorhyncha?* and *Meristella* may be only minor morphologic variations of the same species (see discussion under *Plethorhyncha? welleri*). This fauna has unmistakable affinities with those of the Oriskany and Frisco Formations. Twenty of the 29 Frisco genera (69%) and 18 of the 32 species (56%) are present in the Little Saline Limestone (six of the species identifications are provisional; see text-fig. 14). It is somewhat surprising to find that the Frisco shows a closer faunal correlation with the Oriskany than with the Little Saline, in spite of the fact that the Little Saline is much closer geographically and is lithostratigraphically nearly identical with the Frisco; 83 percent of the Frisco genera and 63 percent of the species (including provisional identifications) are present in the Oriskany (compare text-figs. 13A and 14). However, in making this comparison it should be kept in mind that the Oriskany fauna (including the fossils

* We borrowed Stewart's type specimens of *Meristella carinata, Plethorhyncha? salinense, P. ? parvum,* and *P. ? welleri* from Walker Museum, University of Chicago; the types of *M. carinata, P. ? welleri* and *P. ? salinense* are illustrated on plate X, figures 4-12, and plate XII, figures 4-7.



Text-figure 14. Chart showing the number of Frisco genera (left side) and species (right side) present in the Little Saline Formation of Missouri. The lower part of the bar on the right side shows the number of Frisco species which are definitely present in the Little Saline, and the upper part (marked with a query) the number which are questionably present. This is based on the data given in tables 1, 3. Compare with text-figure 18.

from the Ridgeley Sandstone of Maryland and Glenerie Limestone of New York) is much larger than those of either the Frisco or Little Saline.

The faunal sequence in southeastern Missouri is like that found in Oklahoma. The Little Saline and Backbone Limestones* are underlain by the Bailey Formation, which has a Helderbergian fauna like that of the Haragan-Bois d'Arc Formations of Oklahoma (Amsden, 1958a, p. 24) and are overlain by the Clear Creek Chert with an Esopusian fauna like that of the Sallisaw Formation (see part II of this report).

Harriman Formation. — The name Harriman Novaculite was applied by Dunbar (1919, p. 71) to a sequence of light-colored, thin-bedded cherts exposed in Decatur County of western Tennessee. In the same publication Dunbar proposed the name Quall for the light-gray, cherty and glauconitic limestones exposed on the farm of Jim Quall in Hardin County, western Tennessee. These were treated as distinct lithostratigraphic units, although the faunas recorded from them were nearly identical and both were correlated with the upper Oriskany Sandstone. More recently C. W. Wilson,

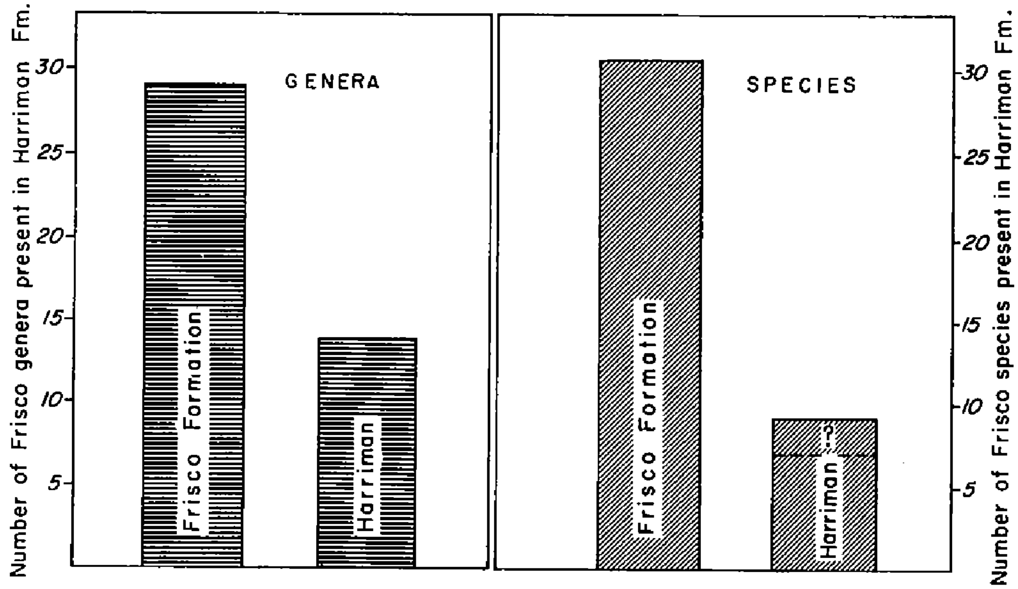
* In Ste. Genevieve County, Missouri, the Little Saline Limestone is overlain by the Grand Tower Limestone, the lower part of which is upper Onondagan in age (Cooper and others, 1942, chart 4; Cooper, 1944b, p. 219); however, a short distance to the south, in southwestern Illinois, the Backbone Limestone is overlain by the Clear Creek Chert, which is herein correlated with the Sallisaw Formation of Oklahoma.

Jr., (1949, p. 306-307) restudied the Devonian of western Tennessee, and obtained evidence from some fresh exposures that the Quall Limestone is a facies of the Harriman Chert. Therefore he proposed to combine the two into a single stratigraphic unit, the Harriman Formation, a procedure which is followed in the present report. The senior author has studied Dunbar's collections from the Harriman Formation, which are in Peabody Museum, Yale University. These collections include a number of well-preserved brachiopods from the Harriman Chert, most of these being in the form of external molds and steinkerns.

TABLE 4.—BRACHIOPODS FROM THE HARRIMAN FORMATION, TENNESSEE (from Dunbar, 1919)

Frisco	Harriman Formation	Oriskany
X	Leptostrophia magnifica (Hall)	X
	L. oriskania (Clarke)	X
	L. magniventra (Hall)	X
	Leptaena ingens Dunbar	
X	Anoplia nucleata (Hall)	X
	Chonetes? hudsonicus camdenensis Dunbar	
X	Chonostrophia complanata Hall	X
X	Costellirostra peculiaris (Conrad)	X
?	Plethorhyncha cf. P. barrandi (Hall)	?
X	Costispirifer arenosus (Conrad)	X
X	Hysterolites (A.) murchisoni (Castelnau)	X
	H. (A.) perdewi (Schuchert)	X
	"Spirifer" paucicostatus Schuchert	X
	"Spirifer" nearpassi Weller	
	Metaplasia pyxidata (Hall)	X
	Meristella lata (Hall)	X
	M. rostellata Schuchert	X
	Coelospira dichotoma (Hall)	X
	Leptocoelia flabellites (Conrad)	X
X	Cyrtina rostrata (Hall)	X
	Beachia suessana (Hall)	X
?	Rensselaeria elongata (Conrad)	X
	Prionothyris saffordi (Dunbar)	

Dunbar (1919, p. 70, 75-76) reported a total of 34 species from the Harriman Formation (Quall Limestone and Harriman Novaculite combined), distributed as follows: 23 brachiopods, 5 corals, 3 mollusks, and 1 crinoid. The brachiopods are listed on table 4. As noted by Dunbar, the Harriman fauna has marked affinities with that of the Oriskany. Fifteen of the 18 genera (83%) and 19 of the 23 species (83%) in the Harriman are present in the Oriskany. The correlation between the Frisco and Harriman faunas is not so conspicuous, but there are still a number of genera and species common to the two formations (text-fig. 15); 14 of the 29 Frisco genera (49%) and 9 of the 32 species (28%) are present in the Harriman. There is thus a considerably closer relationship between the Frisco and Oriskany brachiopods than between the Frisco and the Harriman brachiopods. This may be related, at least in part, to the fact that the Oriskany has a much



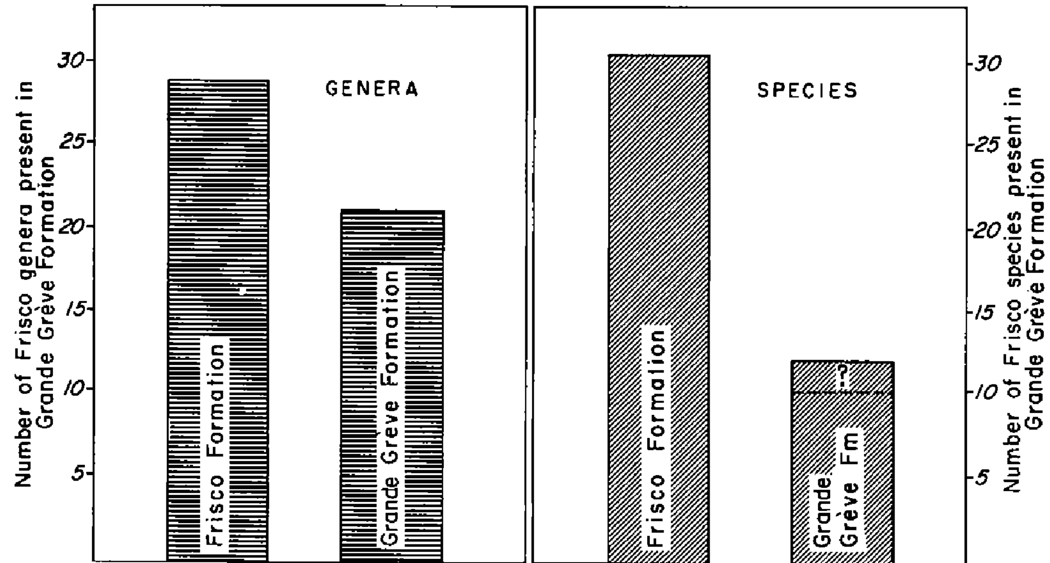
Text-figure 15. Chart showing the number of Frisco genera (left side) and species (right side) present in the Harriman Formation of western Tennessee. The lower part of the bar on the right side shows the number of Frisco species which are definitely present in the Harriman, and the upper part (marked with a query) the number which are questionably present. This is based on the data given in tables 1, 4. Compare with text-figure 18.

larger fauna than has the Harriman. It may also be that the Harriman Chert facies (from which most of the Harriman fossils come) represents an environment somewhat farther removed from the Frisco than does that of the Oriskany. This last point is open to question. Wilson (1949, p. 308) suggested that the cherts of the Harriman are post-depositional, resulting from the concentration of silica by ground waters, in which case they would have no significance in terms of the original environment of the rock. We have not had an opportunity to study the lithostratigraphic relationships of this formation and therefore cannot comment on this rather crucial point.

Grande Grève Formation. — The Grande Grève Limestone crops out on Gaspé Peninsula, Quebec (Clarke, 1908, map, opp. p. 102; Parks, 1931, fig. 1). According to Clarke (1908, p. 39-41) this formation consists of about 550 feet of fossiliferous limestones, cherty limestone, and argillaceous limestones. We have not had an opportunity to study Grande Grève fossils; but, according to Clarke, the fauna consists of 157 species distributed as follows: 5 annelids, 16 trilobites, 3 ostracodes, 4 cephalopods, 5 pteropods, 21 gastropods, 16 pelecypods, 73 brachiopods, 3 bryozoans, 7 corals, 2 graptolites, and 2 sponges. The articulate brachiopod fauna is a large one, comprising the 60 species listed in table 5, although it might be noted that, for certain genera such as *Leptostrophia* and *Strophodonta,* Clarke recognized a suspiciously large number of species. It is somewhat difficult for us to appraise this fauna and its relationships as our knowledge is based entirely on published descriptions; however, it would appear to have marked Oriskany affinities. Of the total fauna, 52 species are either conspecific with,

TABLE 5.—BRACHIOPODS FROM THE GRANDE GRÈVE FORMATION OF QUEBEC
(from Clarke, 1908)

Frisco	Grande Grève Formation	Oriskany
X	Rhipidomelloides musculosus (Hall)	X
	R. [?] logani (Clarke)	
	Loganella lehuquetiana (Clarke)	
	Schizophoria? amii Clarke	
	Platyorthis lucia (Billings)	
	Chonetes [?] canadensis Billings	
	C. [?] billingsi Clarke	
	C. [?] antiopa (Billings)	
	Eodevonaria melonica (Billings)	
X	Chonostrophia complanata Hall	X
X	Anoplia nucleata (Hall)	X
X	Leptostrophia magnifica (Hall)	X
	L. magnifica tullia (Billings)	
	L. irene (Billings)	
	L. oriskania Clarke	X
	L. tardifi Clarke	
	L. magniventra	X
X	Pholidostrophia [?] lincklaeni (Clarke) [not Hall, 1857]	X
	Strophodonta hunti Clarke	
	S. pattersoni precedens Clarke	
	S. crebristriata simplex Clarke	
	S. parva avita Clarke	
	S. galatea (Billings)	
	S. majus (Clarke)	
	Leptaena rhomboidalis (Wilckens)	
	Strophonella continens Clarke	
	S. ampla (Hall)	
	Gaspesia aurelia (Billings)	
X	Schuchertella becraftensis (Clarke)	X
	S. woolworthana gaspensis Clarke	
	Hipparionyx proximus Vanuxem	X
X	Costellirostra peculiaris (Conrad)	X
?	Plethorhyncha barrandi (Hall)	X
	P. pliopleura (Conrad)	X
	Uncinulus [?] mutabilis (Hall)	
?	Camarotoechia [?] dryope (Billings)	
	C. [?] excellens (Billings)	
	C. [?] cf. C. ramsayi (Hall)	X
	Leptocoelia flabellites (Conrad)	X
	Coelospira concava (Hall)	
	Nucleospira cf. N. ventricosa (Hall)	
	Meristella lata Hall	X
	M. champlaini Clarke	
	M. [?] fausta (Clarke)	X
X	Hysterolites (A.) murchisoni (Castelnau)	X
	Howellella cycloptera (Hall)	
X	Costispirifer arenosus (Conrad)	X
	C. arenosus unicus (Hall)	
	Elytha fimbriata (Conrad)	
	Metaplasia plicata Weller	X
	"Spirifer" raricosta (Conrad)	
	"S." modestus nitidulus Clarke	
X	Cyrtina rostrata (Hall)	X
	Rhynchospirina [?] sp.	
	Centronella glansfagea (Hall)	
	Cranaenella [?] ellsi (Clarke)	
	Etymothyris gaspensis (Clarke)	
	Rensselaeria? sp.	
	Beachia amplexa Clarke	
	B. thunei (Clarke)	



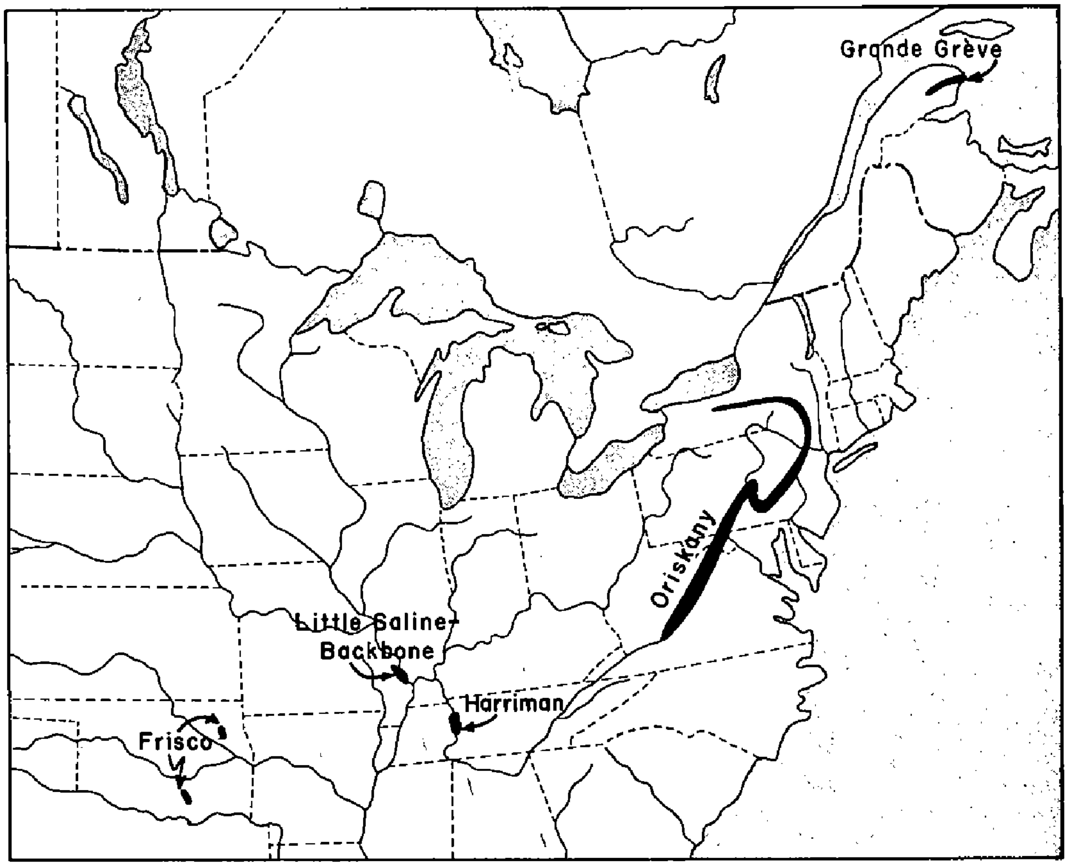
Text-figure 16. Chart showing the number of Frisco genera (left side) and species (right side) present in the Grande Grève Formation of Gaspé. The lower part of the bar on the right side shows the number of Frisco species which are definitely present in the Grand Grève and the upper part (marked with a query) the number which are questionably present. This is based on the data given in tables 1, 5. Compare with text-figure 18.

or closely related to, Oriskany species (Clarke, 1908, p. 250); 20 of the articulate brachiopods are present in the Oriskany. The Grande Grève fauna also shows affinities with that of the Frisco; 21 of the 29 Frisco genera (73%) and 12 of the 32 species (38%) are believed to be present in the Grande Grève (text-fig. 16).

New England Formations.—The Moose River Sandstone of Maine and the Littleton Formation of New Hampshire have generally been assigned to the Deerparkian Stage, but recently Boucot and Arndt (1960) showed that these strata have a post-Oriskany fauna similar to that of the Camden Formation of western Tennessee (see part II of this report).

Summary.—The Frisco Formation carries a Deerparkian fauna which is believed to be closely related in age to those of the Little Saline and Backbone Formations of southeastern Missouri and southwestern Illinois, the Harriman Formation of western Tennessee, the Oriskany Formation of the Appalachian region, and the Grande Grève Formation of Gaspé (text-fig. 17).* These strata carry a large and varied megafauna which is dominated by the brachiopods. Approximately 105 brachiopod species have been described, although we suspect some of these are merely minor morphologic

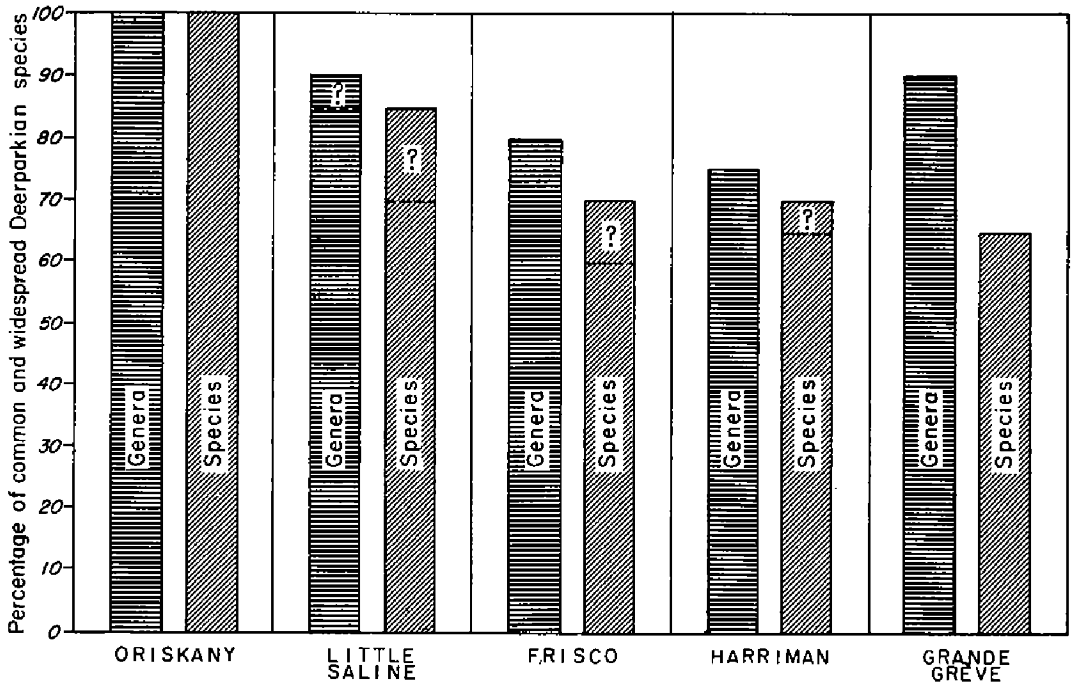
* Deerparkian strata have been reported from various parts of the western United States (Cooper and others, 1942, chart 1). These faunas are largely undescribed, and, as neither of us has had an opportunity to examine fossils from these areas, faunal comparisons are not attempted here.



Text-figure 17. Map of the eastern United States and Canada showing the areas where Deerparkian strata crop out. The areas and locations of the outcrops are generalized.

variants and should be suppressed as synonyms. Even so, the brachiopods from these strata comprise a large and diverse group. There are about 20 species out of the total fauna which are especially abundant and widespread; these are listed in table 6, and a comparison of their distribution in the Oriskany, Frisco, Little Saline, Harriman, and Grande Grève Formations is shown in text-figure 18 (the range of these genera is shown in text-fig 51). These data illustrate quite well the Deerparkian affinities of the Frisco brachiopods. Only four of the 20 genera on this list are not present in the Frisco: *Hipparionyx, Metaplasia, Coelospira,* and *Leptocoelia.* Two additional species, *Meristella lata* and *Beachia suessana,* have not been found in the Frisco; however, these genera are represented by related species. The only Frisco genera which do not appear on this list (and have not been reported from other Deerparkian strata) are *Spinoplasia, Kozlowskiellina,* and *Eospirifer. Spinoplasia* is closely related to *Metaplasia,* and the other two genera are believed to range from the Silurian into Onesquethawan, or later, strata.

The close similarity of the Frisco, Little Saline, Oriskany, Harri-



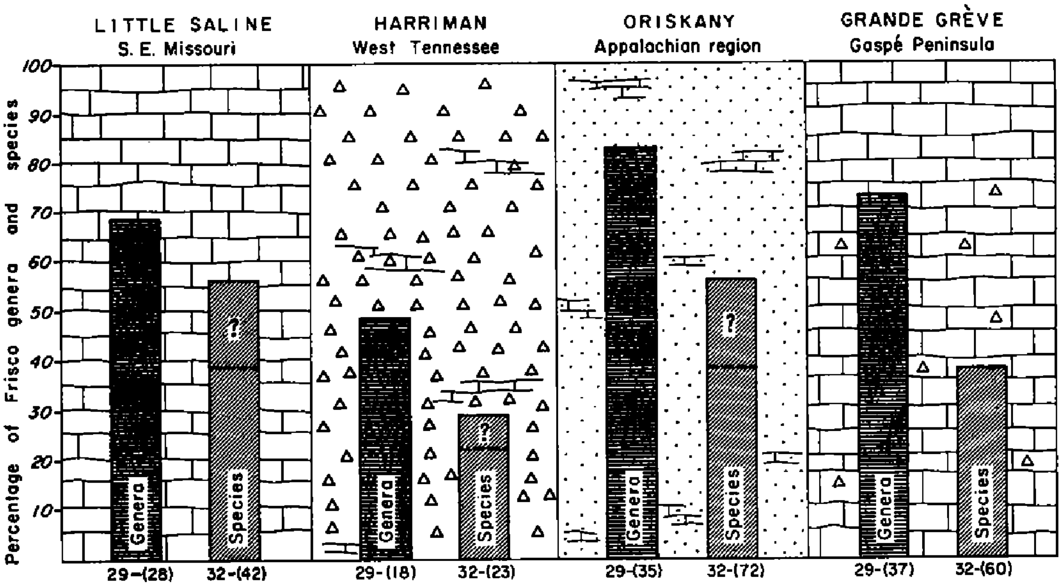
Text-figure 18. Chart comparing the percentage of common and widespread Deerparkian brachiopods in the Oriskany, Little Saline, Frisco, Harriman, and Grande Grève Formations. This is based on the species listed in table 6. Queries indicate the percentage of genera and species which are questionably represented. Compare with text-figures 13A, 14-16, 19.

man, and Grande Grève brachiopod faunas is especially remarkable in view of the diverse lithologies represented. The Little Saline is a bioclastic limestone* which is nearly identical with the Frisco, whereas the Oriskany is an orthoquartzite with varying amounts of carbonate cement, and the Harriman is largely a bedded chert (excluding the Quall facies). One would expect the Frisco fauna to be most like that of the Little Saline, as this is closest in area of outcrop and in lithostratigraphic character; however, as shown in text-figure 19, the Frisco brachiopods show a slightly closer resemblance to the Oriskany, followed by the Little Saline, and least like the Harriman. In this connection it should be noted that the Oriskany and Grande Grève have the larger brachiopod faunas, followed by the Little Saline, the Harriman having the smallest. Even if these represent precisely contemporaneous faunas, it is still somewhat surprising to find so close a faunal correlation in the face of such contrasting lithologies. This suggests that these represent different lithofacies which were deposited in essentially similar environments, probably in clear, shallow water with a fairly firm bottom. The general similarity of the other invertebrate faunal

* We have not examined lithologic specimens from the Grande Grève, but the available descriptions suggest that it is, at least in part, a bioclastic limestone similar to that of the Frisco and Little Saline Limestones.

elements in these formations lends additional support to this conclusion.

All four formations, Frisco, Little Saline, Harriman, and Oriskany, are underlain by strata bearing Helderbergian fossils and overlain by strata bearing Esopusian fossils.



Text-figure 19. Chart showing the percentage of Frisco genera and species in the Little Saline Limestone, Harriman Chert, Oriskany Sandstone, and Grande Grève Limestone. The figure in parentheses at the bottom of each bar represents the total number of genera or species which have been described from that particular formation; this is preceded by the number of Frisco genera (29) and species (32). The approximate outcrop area of each of these stratigraphic units is shown in text-figure 17. See also text-figures 14-16, 18.

TABLE 6.—COMMON AND WIDESPREAD DEERPARKIAN BRACHIOPODS

Frisco		Oriskany	Little Saline	Harriman	Grande Grève
X	Rhipidomelloides musculosus (Hall)	X	X		X
X	Leptostrophia magnifica (Hall)	X	X	X	X
X	Leptaena ventricosa (Hall)	X	X		
X	Chonostrophia complanata (Hall)	X	X	X	X
X	Anoplia nucleata (Hall)	X	X	X	X
X	Schuchertella becraftensis (Clarke)	X			X
	Hipparionyx proximus Vanuxem	X	?		X
X	Costellirostra peculiaris (Conrad)	X	X	X	X
?	Plethorhyncha barrandi (Hall)	X	?	?	X
	Metaplasia pyxidata (Hall)	X	?	X	
X	Hysterolites (A.) murchisoni (Castelnau)	X	X	X	X
X	Costispirifer arenosus (Conrad)	X	X	X	X
	Meristella lata Hall	X		X	X
	Coelospira dichotoma (Hall)	X	X	X	
	Leptocoelia flabellites (Conrad)	X	X	X	X
X	Cyrtina rostrata (Hall)	X	X	X	X
?	Rensselaeria elongata (Conrad)	X	X	X	
	Beachia suessana (Hall)	X	X	X	
X	Prionothyris perovalis Cloud	X	X		
X	Oriskania sinuata Clarke	X			

BRACHIOPOD DESCRIPTIONS

Thirty-two Frisco brachiopod species, representing 29 genera and 9 superfamilies,* are described in the following pages. A complete list of these species, with numbers of specimens and geographic distribution, is given in tables 1, 1A, 1B, and they are illustrated on plates I to XIII. Almost all of the brachiopods described in this report were collected by Amsden and Ventress from the Arbuckle Mountains region (Pontotoc and Coal Counties), and by Amsden from Sequoyah County in northeastern Oklahoma (a few of the latter were collected by H. E. Christian). The stratigraphic and geographic distribution of each species is given in the section on *Distribution* which concludes each description. This information has been abbreviated as follows: the stratigraphic section or collecting locality from which specimens of a particular species were obtained is designated by a number with a letter prefix (e. g. P9 for stratigraphic section 9 in Pontotoc County, or S5 for stratigraphic section 5 in Sequoyah County); the stratigraphic position is indicated by a letter (e. g. P9-R; S5-B). A detailed description and locality of each stratigraphic section has been published in earlier reports (Amsden, 1960 and 1961, appendices), and therefore only a brief geographic location is given below. The location is also shown in the maps of text-figures 2 and 3.

ARBUCKLE MOUNTAINS REGION, SOUTH-CENTRAL OKLAHOMA (locations shown on text-fig. 2)

P8 — North side of Bois d'Arc Creek, Pontotoc County; SW¼ NW¼ sec. 11, T. 2 N., R. 6 E. (Amsden, 1960, p. 277-279, panel II, pl. A).

P9 — North side of Coal Creek, Pontotoc County; NW¼ NW¼ sec. 22, T. 1 N., R. 7 E (Amsden, 1960, p. 279-282; Amsden, 1961, map, text-fig. 25).

P10 — About 3 miles southeast of Fittstown, Pontotoc County; NE¼ SE¼ sec. 7, T. 1 N., R. 7 E. (Amsden, 1960, p. 282-283).

* At the present time there is no satisfactory ordinal classification of the articulate brachiopods, and the highest taxonomic rank employed herein is the superfamily.

P11 — Bed of Bois d'Arc Creek, about ½ mile west of P8, Pontotoc County; NE¼ sec. 11, T. 2 N., R. 6 E. (Amsden, 1960, p. 283-284, panel II, pl. A).

V7 — East side of Goose Creek, Pontotoc County; center SE¼ sec. 26, T. 1 N., R. 7 E. (Amsden, 1961, p. 110).

V9 — About a mile southeast of old Hunton Townsite, Coal County; NE¼ NE¼ sec. 16, T. 1 S., R. 8 E. (Amsden, 1961, p. 111).

V10 — About a mile and a half southeast of old Hunton Townsite, Coal County; SE¼ SE¼ sec. 16, T. 1 S., R. 8 E. (Amsden, 1961, p. 111).

SEQUOYAH COUNTY, NORTHEASTERN OKLAHOMA
(locations shown on text-fig. 3)

S1 — Big bend of Sallisaw Creek, Sequoyah County; SW¼ SW¼ SW¼ sec. 13, T. 13 N., R. 23 E. (Amsden, 1961, p. 90-92, pl. I).

S4 — Walkingstick Hollow, Sequoyah County; SW¼ SW¼ SW¼ sec. 1, T. 13 N., R. 23 E. (Amsden, 1961, p. 94-96, pl. I).

S5 — South of St. Clair Lime Company quarry, Sequoyah County; SW¼ NE¼ SE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 96-98, pl. I).

S6 — Southwest of St. Clair Lime Company quarry, Sequoyah County; SE¼ NW¼ SE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 99, pl. I).

S6(A) — Southwest of St. Clair Lime Company quarry, Sequoyah County; SW¼ NE¼ SE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 99, pl. I).

S7 — Northwest of St. Clair Lime Company quarry; SE¼ NW¼ NE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 99-100, pl. I).

S8 — Payne Hollow, Sequoyah County; NW¼ SW¼ NE¼ sec. 22, T. 13 N., R. 23 E. (Amsden, 1961, p. 101-102, pl. I).

S10 — Payne Hollow, Sequoyah County; SW¼ SE¼ SE¼ sec. 15, T. 13 N., R. 23 E. (Amsden, 1961, p. 104-106, pl. I).

Superfamily DALMANELLACEA

GENUS *Rhipidomelloides* BOUCOT AND AMSDEN, 1958

Rhipidomelloides musculosus (Hall), 1857

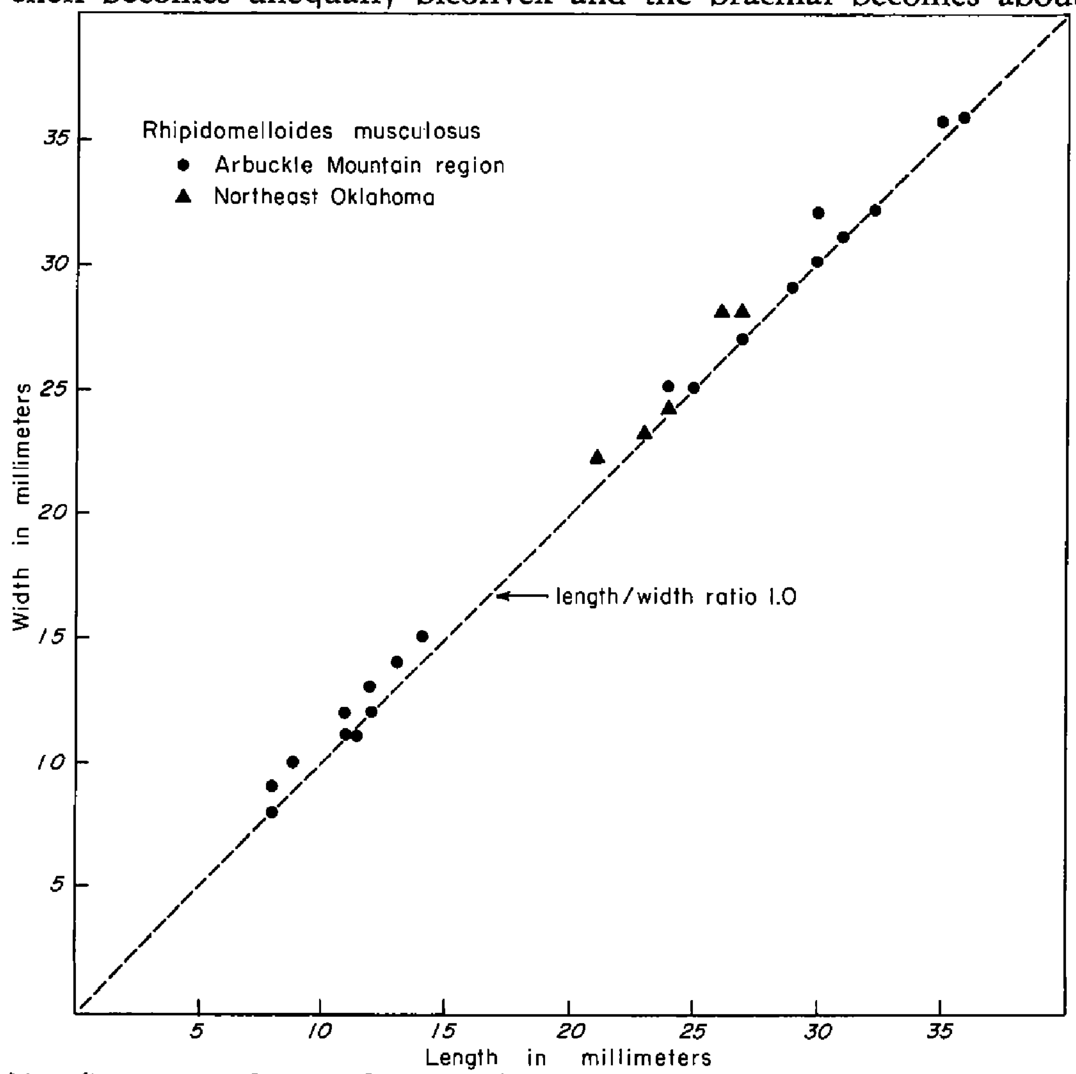
Plate I, figures 18-24; text-figures 20, 21

Orthis musculosa Hall, 1857, p. 46; Hall, 1859, p. 409, pl. 91, figs. 1-3, pl. 95, figs. 1-7.

Rhipidomella musculosa (Hall). Hall and Clarke, 1892, p. 190, 210, 225, pl. 6a, fig. 5; Schuchert and Maynard, 1913, p. 305, pl. 55, fig. 20, pl. 56, figs. 1-4; Schuchert and Cooper, 1932, p. 133, 134, pl. 20, fig. 24.

Rhipidomelloides musculosa (Hall). Boucot and Amsden, 1958, p. 167.

Description.—The immature specimens of *Rhipidomelloides musculosus* are subequally biconvex, but with increased size the shell becomes unequally biconvex and the brachial becomes about



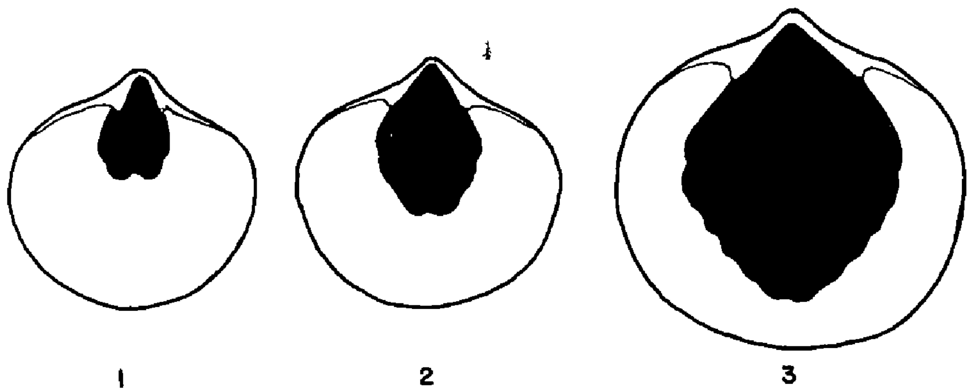
Text-figure 20. Scatter diagram showing the length-width relationship of *Rhipidomelloides musculosus* (Hall) from the Frisco Formation. Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties) are indicated by circles, those from northeastern Oklahoma (Sequoyah County) by triangles.

twice as deep as the pedicle; on large specimens the brachial valve is rather uniformly convex, whereas the pedicle is only weakly convex around the umbonal region, becoming flat toward the anterior and lateral margins. Some small pedicle valves show a flattening along the midline, and a few develop a distinct sulcus. The outline is almost circular with the length about equal to the width; length/width ratio ranges from 0.9 to 1.0 (text-fig. 20). Our collections include specimens which range in length from 8 to 36 mm; the dimensions of a number of specimens are given below. The surface is multicostellate, 15 to 19 costellae occupying a space of 5 mm.

The pedicle interior has a large, deeply impressed, flabellate muscle field which occupies more than three-fourths of the shell. On large specimens the pedicle valve has an extremely thick shell, a fact which helps to account for the great preponderance of pedicle valves over brachial valves. We have not observed the brachial interior; in fact our collections include only three or four mature brachial valves.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Our Frisco collections from the type area consist of about 48 specimens of which three are complete with both valves, 44 are isolated pedicle valves, and one is a brachial valve; pedicle/brachial ratio 44.0. The dimensions of 20 pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
8	9	0.9	15
8	8	1.0	17
9	10	0.9	15
11	11	1.0	----
11	12	0.9	----
11	11	1.0	----
12	13	0.9	----
12	12	1.0	----
13	14	0.9	----
14	15	0.9	17
24	25	0.9	----
25	25	1.0	----
27	27	1.0	----
29	29	1.0	----
30	30	1.0	----
30	32	0.9	19
31	31	1.0	----
32	32	1.0	15
35	36	1.0	----
36	36	1.0	----



Text-figure 21. Pedicle interiors, x3, of three different species of *Rhipidomelloides* showing the differences in the sizes of the pedicle muscle areas.
1. *R. henryhousensis* (Amsden), Henryhouse Formation (Silurian); drawing of a specimen illustrated by Amsden (1958a, pl. 12, fig. 9).
2. *R. oblatus* (Hall), Frisco Formation (Deerparkian); drawing of a specimen illustrated by Amsden (1958a, pl. 2, fig. 3).
3. *R. musculosus* (Hall), Frisco Formation (Deerparkian); drawing of the specimen herein illustrated on plate I, figure 19.

Specimens from northeastern Oklahoma (Sequoyah County).—Our Frisco collections from this area include about 34 isolated valves, of which 25 are pedicles and nine are brachials; the pedicle/brachial ratio is 2.7. There are no complete specimens with both valves and the free valves are poorly preserved. In so far as can be determined from this fragmentary material these are typical representatives of *R. musculosus,* similar in all respects to the shells from the Arbuckles. The costellae spacing is approximately 15 to 16 per 5 mm. In outline the shells are nearly circular with a length/width ratio ranging from 0.9 to 1.0. The larger pedicle valves are slightly convex around the umbo, becoming flattened toward the anterior and lateral margins; the brachial valves are uniformly convex and about twice as deep as the pedicles. The pedicle valve has a thick shell with deeply impressed, flabellate muscle scars which occupy a large part of the valve floor. Measurements of 5 pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
21	22	0.9	.....
23	23	1.0	.....
24	24	1.0	.....
26	28	0.9	15
27	28	1.0	.....

Discussion.—The genus *Rhipidomelloides* was proposed by Boucot and Amsden (1958, p. 164-166; type species *R. henryhousensis*) for those rhipidomellids with rectangular marginal crenulations. Several of our specimens show that the Frisco representatives of this genus have crenulations which are typical for this genus, being strongly flattened on the crests and separated by narrow interspaces.

Hall based his original description of *R. musculosus* upon specimens from the Oriskany Sandstone of New York and Maryland. It is difficult to make a precise comparison on the basis of our rather fragmentary material, but in so far as can be determined the Frisco specimens are similar in all respects to those from the Oriskany. The New York and Maryland specimens have a subcircular shell with a length/width ratio like those from Oklahoma. Specimens from both areas have an equally biconvex shell, with the brachial convexity greatly exceeding that of the pedicle. The costellae spacing appears to be similar and the pedicle musculature nearly identical. The eastern representatives appear to be slightly larger with a few shells exceeding 40 mm, but this difference is not great and we have shells which reach a length of 36 mm. Some of the smaller pedicle valves in our collections (i.e., those less than 15 mm in length) have a marked flattening along the midline, and two or three of these develop a distinct sulcus (pl. I, fig. 22). These shells resemble the subspecies *R. musculosus arctisinuatus,* which Schuchert and Maynard (1913, p. 306, pl. 55, figs. 21, 22) described from the Oriskany Sandstone of Maryland. The Frisco sulcate specimens appear to grade into the typical non-sulcate representatives of *R. musculosus*, and an examination of the collections at the U. S. National Museum suggests that this is also true for the Oriskany shells; in fact, Schuchert and Maynard stated that "the Oriskany material [*R. musculosus arctisinuatus*] grades into *R. musculosus.*"

Three species of *Rhipidomelloides* are represented in the Hunton Group, and it is interesting to note the progressive change in the character of the pedicle muscle scars within this group; *R. henryhousensis* from the Henryhouse Formation (Upper Silurian) has a pedicle muscle field which is shallow and occupies less than half the shell; *R. oblatus* from the Haragan Formation (Helderbergian) has a deeper pedicle scar which occupies more than half the shell; *R. musculosus* from the Frisco has a pedicle muscle scar which occupies more than three-fourths of the shell and is deeply imbedded in the much thickened valve (text-fig. 21). Externally *R. musculosus* is much like *R. oblatus,* the two species being similar in size, shape, and costellation. The Deerparkian species, however, has a deeper brachial valve than has *R. oblatus*, and the length/width ratio is slightly, but consistently, different. In *R. oblatus* the width is almost always greater than the length, this being especially marked in mature individuals; whereas in *R. musculosus* the length and width are about equal at all stages of growth (compare text-fig. 20 of this report with fig. 8, Amsden, 1958a).

Figured specimens. — Localities P8-H and P11, Pontotoc County; numbers OU 3258-3262.

Distribution. — *Rhipidomelloides musculosus* has been widely reported from the Oriskany Formation in the eastern United States, and Clarke described specimens from the Grande Grève Limestone of Gaspé. It is also present, although uncommon, in the Little Saline Limestone of Missouri (Stewart, 1922, p. 231, pl. 61, figs. 6-8). Our collections from the Frisco Formation comprise about 80 specimens, mostly isolated pedicle valves, from the following localities: Pontotoc County, P8-H, P11 (at this section it ranges through 60 feet of strata), P9-R, P10-V, V3, V7; Sequoyah County, S1-B, S5-B, S6, S6(A), S7-B, S8-C, S10-B,C.

GENUS *Levenea* SCHUCHERT AND COOPER, 1931

Levenea sp.
Plate I, figures 5-9

Description. — *Levenea* sp. has an unequally biconvex shell, the pedicle valve having fairly strong convexity and the brachial moderate convexity. Its outline is subcircular; length/width ratio ranges from 1.0 to 0.9. The pedicle valve is weakly carinate around the umbonal region, but toward the anterior and lateral margins it develops a uniform curvature. The convexity of the brachial valve is variable, some shells having a moderate, some a weak curvature. The strength of the brachial sulcus is also variable, and on some valves it is fairly shallow at the front end (pl. I, fig. 5) and on others moderately deep (pl. I, fig. 9; this specimen is from Sequoyah County; see below). This surface is multicostellate, 15 to 22 costellae occupying a space of 5 mm; shell punctate.

The pedicle valve has short, but deeply impressed, muscle scars, with the adductors on an elevated track (pl. I, fig 7). None of our brachial interiors is well preserved, but some spcimens do show a prominent cardinal process with a short shaft and relatively large brachiophores which do not seem to extend forward very far.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Twenty-eight specimens are in our collections from this area, although many of these are quite fragmentary. All are free valves, the pedicle/brachial ratio being 1.0. The dimensions of eight reasonably complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
17	18	0.9	----
20	21	0.9	18
21	23	0.9	19
22	23	0.9	18
22	22	1.0	----
22	----	----	21
23	25	0.9	----
23	25	0.9	18

The dimensions of 6 brachial valves are given below:

19	22	0.9	----
20	22	0.9	19
21	24	0.9	----
23	----	----	18
25	28	0.9	17
25	27	0.9	17

Specimens from northeastern Oklahoma (Sequoyah County).— Our collections from Sequoyah County include a number of fragmentary, punctate orthids which we refer to *Levenea* sp. Some are well enough preserved to leave little doubt that they are conspecific with those from the Arbuckles. However, among the more fragmentary shells are some of questionable identity and these may include shells representing other genera.

We have 25 shells from this area, of which seven are pedicles and 18 are brachials; pedicle/brachial ratio 0.4. Most of these are incomplete; the brachial valve illustrated on plate I, figure 9 measures 20 mm long by 23 mm wide.

Some of the larger brachial valves from the Marble City area have a fairly strong convexity and a rather prominent sulcus. In fact, the brachial sulcus of the Sequoyah County specimens is generally better developed than on those from the Arbuckle region (compare the valve illustrated on pl. I, fig. 5 with the one shown in pl. I, fig. 9). Other than this the specimens from the two areas are similar, including the internal structure of the pedicle valve (none of the Sequoyah County specimens shows the character of the brachial valve).

Discussion.—The better preserved Frisco specimens, most of which come from the Arbuckle Mountains region, appear to have the internal and external characters of the genus *Levenea.* The pedicle muscle scars are somewhat larger and deeper than are those in the genotype *L. subcarinata,* but this is not unusual in view of the relatively large size of the Frisco shells. The Sequoyah County specimens are not so well preserved as are those from the Arbuckles, and among the more fragmentary individuals from this area may be representatives of *Isorthis* and/or *Platyorthis.*

Levenea sp. appears to have an external resemblance to *Dalmanella oriskania* Stewart (1922, p. 229, pl. 61, figs. 12-14) from the Little Saline Limestone of Missouri. Stewart did not describe the internal characters of the Missouri species, but it has the external appearance of a *Levenea,* and in the original description it was compared to *Levenea subcarinata* from the Helderberg (Schuchert and Cooper, 1932, p. 123, did not list *Dalmanella oriskania* under *Levenea*). We are reluctant to assign the Frisco specimens to *oriskania* without more diagnostic data, although it seems quite possible that the Oklahoma and Missouri shells are conspecific.

Figured specimens. — Localities P11, Pontotoc County, and S5-B, Sequoyah County; numbers OU 3246-3250.

Distribution. — We have 26 specimens, all free valves, from the Frisco Formation in the Arbuckle Mountains region; all of these came from the lower five feet of the formation at stratigraphic section P11. There are 26 free valves in our Sequoyah County collections; these came from S5-B, S6, S6(A), S7-B.

GENUS *Platyorthis* SCHUCHERT AND COOPER, 1931

Platyorthis? sp.

Plate I, figures 16, 17

Description. — Our collections include seven brachial valves which are provisionally referred to *Platyorthis.* These are almost circular in outline with the length slightly greater than the width; pedicle/brachial ratio 0.8 and 0.9. The brachial valve is almost flat with weak curvature in the umbonal region; there is a slight, poorly defined sulcus on the anterior half of the valve. Surface multicostellate, 11 to 12 costellae in a distance of 5 mm. Shell punctate.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Four brachial valves from Pontotoc County. The specimen figured on plate I, figure 16 measures 15 mm long and 16.5 mm wide.

Specimens from northeastern Oklahoma (Sequoyah County). — Three brachial valves from Sequoyah County. The figured specimen (pl. I, fig. 17) measures 14 mm long by 17 mm wide.

Discussion. — The reference of this species to *Platyorthis* is provisional as it is based entirely on the external features of the brachial valve; we have not seen any brachial interiors or any pedicle valves. The brachial valve has the circular outline and flattish surface which is characteristic of this genus.

The Frisco material is inadequate for specific identification. Our shells appear to be somewhat smaller and more finely ribbed than *P. planoconvexa* (Hall) from the Oriskany Sandstone (Amsden, 1958b, p. 52) and *P. lucia* (Billings, 1874; Clarke, 1908, p. 204, pl. 44, figs. 8-20) from the Grande Grève Limestone of Gaspé. The size is similar to that of *P. angusta* Amsden (Amsden, 1958b, p. 51-53, pl. 1, figs. 11-21) from the Bois d'Arc Formation, but the Frisco shells appear to have somewhat coarser costellation.

We might digress here to add some remarks on the genotype, *P. planoconvexa,* a species which Hall (1859, p. 169) and most subsequent authors (Cooper, 1944a, p. 355) have considered to range from the Helderberg into the Oriskany. In 1958 the senior author (Amsden, 1958b, p. 51-53, pl. 1, figs. 11-21) established a new species, *P. angusta,* from the Bois d'Arc Formation (Helderberg). It was noted that, among other things, this species differed from the Oriskany representatives of *Platyorthis planoconvexa* (Schuchert and Cooper, 1932, pl. 19, fig. 23) in having a relatively narrow pedicle muscle scar. Recently the senior author had an opportunity to examine the U. S. National Museum collections of *Platyorthis* from the New Scotland (Helderberg) strata at Licking Creek, Washington County, Maryland, and from the Oriskany Sandstone. Externally, the Helderberg and Oriskany shells are much alike, the most conspicuous difference being size; some Oriskany shells reach a length of 22 mm and a width of 27 mm, whereas the largest New Scotland specimen observed was 17 mm long. There is, however, a difference in the pedicle interiors, those from the Oriskany having a large, fan-shaped pedicle muscle scar, whereas the Helderberg shells have a relatively narrow muscle field like that of *P. angustus.* We have not examined Hall's type specimens, but they should be restudied and a lectotype selected to represent the species.

Figured specimens. — Localities P11, Pontotoc County, and S5-B, Sequoyah County; numbers OU 3256, 3257.

Distribution. — Seven brachial valves from localities P11, Pontotoc County, and S5-B and S6(A), Sequoyah County.

Superfamily STROPHOMENACEA

GENUS *Leptostrophia* HALL AND CLARKE, 1892 (emended Williams, 1953)

Leptostrophia magnifica (Hall), 1857

Plate II, figures 1-5

Strophomena (Strophodonta) magnifica Hall, 1857, p. 54-55.

Strophodonta magnifica Hall, 1859, p. 414-415, pl. 93, fig. 4, pl. 94, figs. 2a-d, pl. 95, fig. 8.

Stropheodonta (Leptostrophia) magnifica Hall, Hall and Clarke, 1892, p. 288, pl. 13, figs. 27, 28; Schuchert and Maynard, 1913, p. 313-319, pl. 58, figs. 2-5.

Leptostrophia magnifica (Hall). Williams, 1953, p. 40.

Description. — Specimens of *Leptostrophia magnifica* are common in parts of the Frisco Formation, especially in the Arbuckle region, but our collections consist entirely of isolated pedicle valves, most of which are exfoliated and incomplete. The pedicle valve has a long, straight hinge line, and on most specimens the cardinal extremities are broadly rounded (pl. II, fig. 3). On one specimen the shell is slightly alate and the hinge line marks the point of greatest width; this extended hinge may be in part the result of breakage, but we suspect that, at least in part, it reflects a morphologic variation of the species. The anterolateral margins are rounded. The width is greater than the length at all growth stages, although the length/width ratio ranges widely from 0.6 to 0.9. The pedicle valve is gently and evenly convex, a specimen 36 mm long having a depth of about 3 mm. No brachial valves are in our collections.

The surface is multicostellate, the costellae spacing ranging from 11 to 25 in a distance of 5 mm. As the shell grew larger, new costellae were added by implantation and bifurcation so that the spacing remains more or less constant from beak to front. However, the costellae tend to broaden slightly with increased shell size, as shown in the measurements given below.

Some of the shells of this species attain a large size. One specimen in our collection has a width of 95 mm, and shells 60 to 70 mm wide are moderately common.

None of our specimens shows the detailed structure of the pedicle interior, but several are sufficiently exfoliated to reveal the large, fan-shaped muscle field which is so characteristic of this species. No brachial interiors were seen.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — *L. magnifica* is one of the more common species in the Frisco Formation of the Arbuckle region. Our collections include about 120 pedicle valves although many of these are only fragments. We have no brachial valves. The dimensions of 13 pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm (at anterior end)
6	7	0.8	18
12	14	0.8	25
36	45	0.8	20
37	44	0.8	21
42	49	0.9	19
44	55	0.8	20
48	54	0.9	15
57	73	0.8	15
58	73	0.8	14
59	73	0.8	18
63	70	0.9	14
67	89	0.8	12
77	95	0.8	11

Specimens from northeastern Oklahoma (Sequoyah County). — *L. magnifica* is not nearly so common in northeastern Oklahoma as it is in the Arbuckle region. Our collections include only 12 specimens, all of these being isolated pedicle valves. Most of these are small, but we have one specimen with an estimated length of 55 mm and an estimated width of 68 mm. The dimensions of five specimens are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
13	16	0.8	---
15	17	0.9	19
20	24	0.8	17
23	37	0.6	---
55	68	0.8	11

Discussion. — The genus *Leptostrophia* was proposed by Hall and Clarke, the genotype being *L. magnifica* (Hall) from the Oriskany Sandstone; in 1953 Williams emended the original generic diagnosis.

Hall's original description of *L. magnifica* was based upon specimens from the Oriskany Sandstone of Albany and Schoharie Counties, New York. In 1857 Hall also recorded this species from Cumberland, Maryland, and in 1913 Schuchert and Maynard described and illustrated Maryland specimens. Our Frisco specimens appear to be like those from New York and Maryland in all respects. The length/width ratio is like that given by Hall (1859, p. 414) and the size of our largest specimens approaches that of the eastern representatives. This comparison is, of course, based entirely upon the pedicle valves as we do not have any brachials in our Frisco collections.

This species has some resemblance to the non-wrinkled variety of *L. becki tennesseensis* Dunbar from the Bois d'Arc Formation (Amsden, 1958a, p. 78-80, pl. 3, figs. 15-20, pl. 6, fig. 1, pl. 11, figs. 27, 28; Amsden, 1958b, p. 58-59, pl. 2, figs. 7-9). The Bois d'Arc species, however, has a much smaller shell with coarser costellation.

Figured specimens. — Localities P8-H, P11, Pontotoc County, and S5-B, Sequoyah County; numbers OU 3263-3267.

Distribution. — *Leptostrophia magnifica* has been rather widely reported from the Oriskany Sandstone in the eastern United States. Clarke (1908, p. 190, pl. 38, figs. 1, 2) described specimens from the Grande Grève Limestone of Gaspé; Dunbar (1919, p. 70-75) recorded it from the Harriman Formation of western Tennessee; and Stewart (1922, p. 233-234, pl. 62, figs. 1-3) reported that it is abundant in the Little Saline Limestone of Missouri.

This is one of the more common species in the Frisco Formation in the Arbuckle region; we have about 120 specimens from the following localities: P9-R, P10-V, P11-V, P10, V7, V9; on P11 it was collected through the lower 40 feet of the Frisco and elsewhere in the lower 5 feet. Twelve specimens in our collections are from Sequoyah County: S5-B, S6, S7-B, S8-C.

GENUS *Pholidostrophia* HALL AND CLARKE, 1892 (emended Williams, 1953)

Pholidostrophia? sp.

Plate XI, figures 21, 23

? *Stropheodonta lincklaeni* Clark, 1900, p. 53, pl. 6, fig. 37 [not Hall 1859, p. 415, pl. 93, figs. 2, 3a, 3b].

Discussion. — We have six fragmentary specimens of a large, concavo-convex strophodontid with moderate convexity. The interiors of these shells have weak, radiating ridges, but the exteriors are smooth except for concentric growth-lines. None of our specimens shows the character of the pedicle interior, and the only brachial interior is that of the valve fragment illustrated on plate

XI, figure 23. These resemble the specimen which Clarke identified as *Stropheodonta lincklaeni* Hall (from the Oriskany Sandstone, Becraft Mountain, N. Y.) and in order to make a more precise comparison we borrowed Hall's type specimens of *S. lincklaeni* from the American Museum of Natural History (also from the Oriskany Sandstone of New York) and Clarke's figured specimen from the New York State Museum (pl. XI, fig. 22). Hall's specimens, which consist of a pedicle exterior and two brachial steinkerns, represent a finely ribbed concavo-convex strophodontid with shallow curvature.* Clarke's figured specimen is a brachial interior with part of the shell broken away to reveal a mold of the exterior (pl. XI, fig. 22). Although Clarke (1900, p. 53) stated that fine striae are present, his figured specimen does not reveal any trace of costellae and is, therefore, quite unlike Hall's specimens of *S. lincklaeni.* Clarke's specimen is, however, similar to the Frisco shells and we suspect that these represent a common species, but better material is needed to verify this. Clarke (1908, p. 184-185, pl. 34, figs. 15-18) described and figured a specimen from the Grande Grève Limestone which may also be conspecific with the Oriskany and Frisco specimens.

The generic position of these shells is uncertain. They have the outline, profile, and smooth exterior of *Pholidostrophia* sensu lato (Williams, 1953, p. 36), but, in so far as we can tell, they do not have a pseudonacreous shell. They are far larger than any known species of *Lissostrophia,* and have a much shallower convexity than is normal for this genus. Nothing is known about the pedicle interior of either the Frisco or Oriskany specimens, and the structure of the brachial valve is known only from rather fagmentary material.

Figured specimens. — The pedicle valve figured on plate XI, figure 21, is from locality S6; number OU 3940. The brachial interior illustrated in plate XI, figure 23, was borrowed from Peabody Museum, Yale University, and is from the Frisco Limestone "near Marble City, Okla.," YPM 21751; (a plaster cast of this specimen is in The University of Oklahoma repository, OU 3941).

Distribution. — Clarke's figured specimen is from the Oriskany Sandstone, Becraft Mountain, Hudson, New York. All Frisco specimens collected by us came from Sequoyah County, Oklahoma, locality S6.

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* The pedicle valve may be a partly exfoliated specimen of *Leptostrophia magnifica;* the brachial interiors, however, appear to represent the genus *Strophodonta.*

GENUS *Strophodonta* HALL, 1850
(*Stropheodonta* Hall, 1852, of authors)
(emended Williams, 1953)

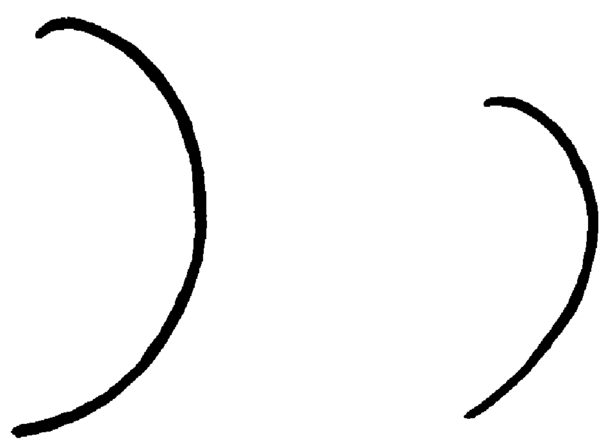
Strophodonta sp.

Plate II, figures 6, 7; text-figure 22

Description. — We have four pedicle valves in our Frisco collections from Sequoyah County which are here referred to *Strophodonta* sensu lato. These are convex, as shown in text-figure 22, but the degree of convexity is sufficiently different among them to suggest they may represent two species. On the other hand, the similarity in outline and ornamentation points to a close relationship. These valves are transversely elliptical in outline, the largest one measuring 20 mm wide and 15 mm long, and the smallest 15 mm wide and 11 mm long. The surface is costellate, 20 to 21 costellae occupying a space of 5 mm; the costellae are subangular and are separated by relatively broad interspaces. Minor costellae in the interspaces are apparently absent.

Pedicle and brachial interiors are unknown.

Discussion. — This genus has generally been cited as *Stropheodonta* Hall, 1852 (Schuchert and LeVene, 1929, p. 118; Williams, 1953, p. 34), but Imbrie (1959, p. 375) has shown that *Strophodonta* Hall, 1850, is the proper orthography and reference. Since Hall proposed this genus, it has been discussed and diagnosed by many authors. The latest and most comprehensive treatment is that of Williams (1953), who proposed two subgenera, *Strophodonta (Strophodonta)* and *Strophodonta (Brachyprion).* We have



Text-figure 22. *Strophodonta* sp. Profile drawings of two pedicle valves, x3, showing the variations in degree of curvature. Frisco Formation, Sequoyah County, Oklahoma.

no information pertaining to the internal character of our species; in fact the brachial valve is completely unknown, and therefore its reference to *Strophodonta* is based entirely upon the external features of the pedicle valve. It is clearly a costellate Strophomenacea with normal curvature and accordingly is assigned to *Strophodonta* sensu lato. Our specimens have an external resemblance to the Little Saline species which Stewart (1922, p. 235, pl. 62, figs. 6, 7) identified as *Brachyprion* cf. *B. majus* Clarke. *B. majus* was first described by Clarke (1900, p. 54-56, pl. 8, figs. 8-13) from specimens out of the Oriskany Sandstone of New York, and later from the Grande Grève Limestone of Gaspé (Clarke, 1908, p. 190, pl. 36, figs. 1-6). Both the Oklahoma and Missouri shells differ in their ornamentation from those described by Clarke, the Oriskany specimens having minor costellae alternating with major ones. The morphology of the Frisco species is not sufficiently well known to justify a more precise identification.

Figured specimens. — Localities S8-C and S10-B, Sequoyah County; numbers OU 3268-3269.

Distribution. — Four specimens from localities S5-B, S8-C, S10-B, Sequoyah County.

GENUS *Strophonella* HALL, 1879
(emended Williams, 1953)

Strophonella sp.
Plate II, figure 8

Discussion. — There are two fragmentary specimens of a resupinate Strophomenacea in our Frisco collections. The curvature would appear to have been fairly uniform except for a small area around the umbo which is nearly flat. Both specimens are exfoliated, but enough of the surface remains to show that they were once costellate with about 6 costellae per 5 mm. The larger of these shells, when complete, had an estimated length of 25 to 28 mm and a width of 35 to 37 mm. Nothing is known of the interiors.

In so far as we are aware no species of *Strophonella* have been described from the Oriskany Formation. Clarke (1908, p. 247-248) recorded several species from the Grande Grève Limestone.

Figured specimens. — Locality S5, Sequoyah County; number OU 3270.

Distribution. — Two incomplete specimens from S8-C and near S5, Sequoyah County.

GENUS *Leptaena* DALMAN, 1828

Leptaena ventricosa (Hall), 1857
Plate II, figures 9-14

Strophomena depressa ventricosa Hall, 1857, p. 55-56.
Strophomena rugosa ventricosa Hall. Hall, 1859, p. 417-418, pl. 94, figs. 2a,f, 3.
Leptaena rhomboidalis ventricosa (Hall). Hall and Clarke, 1892, pl. 15a, fig. 43; Schuchert and Maynard, 1913, p. 309, pl. 56, fig. 18, pl. 57, fig. 1.
Leptaena ventricosa (Hall). Stewart, 1922, p. 231, pl. 61, figs. 15-17.

Description. — *Leptaena ventricosa* is represented in our collections mostly by pedicle valves, many of which are badly broken and incomplete. It is difficult to get a clear picture of the shell morphology on such incomplete material, although it is quite evident that *L. ventricosa* varies considerably in profile and outline. All reasonably complete shells show a well-marked, rugose visceral disc separated from the non-rugose trail by a sharp geniculation; however, the disc exhibits considerable variation, being almost flat on some individuals (pl. II, fig. 10) and strongly concave on others (pl. II, figs. 12, 13). On some specimens (pl. II, fig. 13) the trail is large, equaling or even exceeding the length of the visceral disc. (This structure is broken on many shells, so that it is impossible to determine the original size.) Although the outline varies considerably, most shells are transversely subquadrate, the length/width ratio falling between 0.6 and 0.8, but on a couple of specimens the length and width are nearly equal. Our collections include only a few fragmentary brachial valves.

The visceral disc is crossed by concentric rugae which range widely in width and spacing. Both the disc and the trail are marked by radial costellae; 9 to 17 occupy a space of 5 mm.

The pedicle interior is characterized by deeply impressed, subcircular muscle scars; the muscle area is divided into two parts by a thick ridge or platform which presumably represents the point of attachment of the adductor muscles (pl. II, fig. 14). No brachial interiors observed.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — *L. ventricosa* is common in the Frisco of the type area although we do not have any well-preserved articulated specimens. Our collections include 50 specimens, 45 of which are pedicle valves; pedicle/brachial ratio is 9. The dimensions of three reasonably complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
32	42	0.8	13
32	42	0.8	14
44	56	0.8	9

Specimens from northeastern Oklahoma (Sequoyah County). — *L. ventricosa* is not so common in the Frisco of northeastern Oklahoma as it is in the Arbuckles, but the preservation is slightly better and we have several pedicle valves which are reasonably complete. Our collections from this area comprise 27 pedicle valves and two brachials, giving a pedicle/brachial ratio of 13. The dimensions of seven pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
18	24	0.7	17
24	32	0.7	15
25	40	0.6	14
30	35	0.9	15
32	41	0.8	----
32	34	0.9	14
41	42	1.0	11

Discussion. — Hall based his original description upon specimens from the Oriskany Sandstone of New York and Maryland; later Hall and Clarke, and Schuchert and Maynard published additional illustrations of this species. The senior author has examined a number of well-preserved Oriskany specimens of *L. ventricosa* at the U. S. National Museum. These are similar to the Frisco shells in size, outline, and profile; the pedicle interiors of the Oriskany and Oklahoma species are almost identical. The only difference seems to be in the spacing of the costellae, the Oriskany shells having 8 to 10 costellae in a space of 5 mm, whereas the Oklahoma shells may have as many as 17 in a space of 5 mm.

The Bois d'Arc species *L.* cf. *L. rhomboidalis* (Amsden, 1958a, p. 87, pl. 3, figs. 1-14; Amsden, 1958b, p. 62-66, pl. 2, figs. 12-15) does not have a ventricose pedicle valve, the visceral disc being almost flat; furthermore, these shells are, on the average, considerably smaller and more transverse than are the Frisco specimens.

Dunbar (1920, p. 125-126, pl. 2, fig. 24) described the species *Leptaena ingens* from the Harriman Novaculite of western Tennessee. This species has a large shell with a deeply impressed pedicle muscle scar similar to that of *L. ventricosa*, but the Tennessee species is not geniculate and has subdued corrugations with fine costellae.

Figured specimens. — Localities P9-R and P11, Pontotoc County; S1-B and S6, Sequoyah County; numbers OU 3271-3275.

Distribution. — *Leptaena ventricosa* has been widely reported from the Oriskany Sandstone of the eastern United States. Clarke (1909, p. 87, pl. 21, fig. 17) reported it from Stony Brook, Moose River, Maine, and Stewart (1922, p. 231, pl. 61, figs. 15-17) described and illustrated specimens from the Little Saline Limestone of Missouri.

Our Frisco collections include 50 specimens from the Arbuckle region, Pontotoc County: P8-H, P9-R, P10-V, P11 (collected through 60 feet of strata), and V7. We have 19 specimens from the Frisco in Sequoyah County: S1-B,C, S5-B, S6, S6(A), and S8-C.

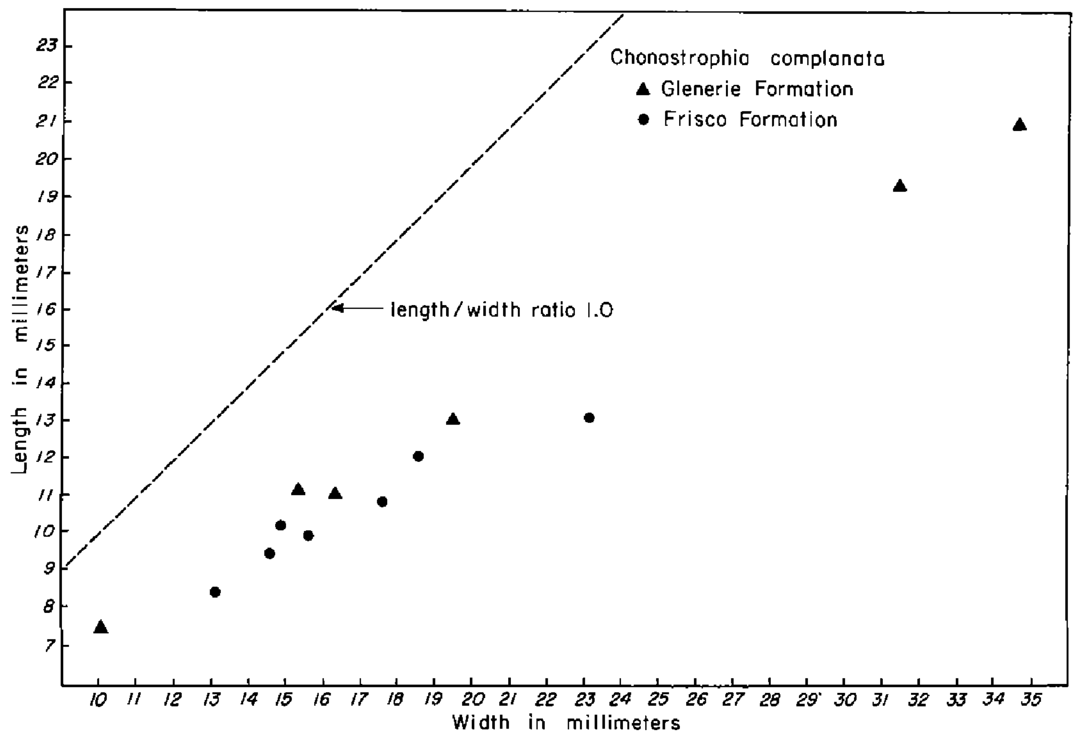
Superfamily CHONETACEA

GENUS *Chonetes* FISCHER DE WALDHEIM, 1837

Chonetes? sp.

Plate I, figure 10

Description. — A single pedicle valve is provisionally referred to *Chonetes*. This is a small shell, measuring 5 mm long by 6.5



Text-figure 23. Scatter diagram showing the length-width relationship of specimens of *Chonostrophia complanata* (Hall) from the Frisco Formation (circles) and the Glenerie Formation of New York (triangles). The Glenerie specimens are in the collections of the U. S. National Museum.

mm wide, with gentle convexity (depth about 1 mm). The surface is costellate, 8 costellae in a space of 1 mm; the costellae are crossed by closely spaced, concentric lirae. The interior was not observed.

Discussion. — The reference of our specimen to *Chonetes** is conjectural as nothing is known about its internal structure, and only a single pedicle exterior has been observed; moreover, this shell does not show well-marked hinge spines, although there are some irregularities on the hinge that resemble spine bases.

Figured specimen. — Locality S6, Sequoyah County; number OU 3251.

Distribution. — A single pedicle valve from the Frisco Formation, Sequoyah County; S6.

GENUS *Chonostrophia* HALL AND CLARKE, 1892

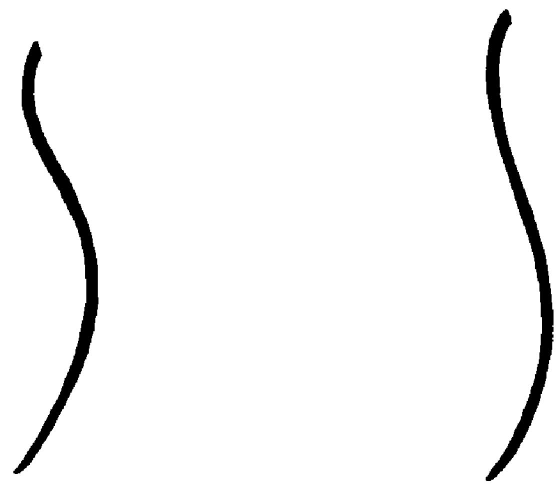
Chonostrophia complanata (Hall), 1857

Plate I, figures 11-15; text-figures 23, 24

Chonetes complanata Hall, 1857, p. 56; Hall, 1859, p. 418, pl. 93, figs. 1a-d.
Chonostrophia complanata (Hall). Hall and Clarke, 1892, p. 311, pl. 16, figs. 13, 29; Clarke, 1900, p. 50, pl. 7, figs. 7-8; Schuchert and Maynard, 1913, p. 341, pl. 62, figs. 1, 2; Cooper, 1944a, p. 347, pl. 135, figs. 9, 10.

Description. — Our Sequoyah County collections include 23 pedicle valves of *Chonostrophia complanata,* several of which are complete. The outline is strongly transverse (text-fig. 23) with a nearly straight hinge line (average length/width ratio 0.64); from the cardinal extremities forward the shell is evenly rounded. The pedicle valve is weakly convex near the beak, but just in front of the umbo the curvature is reversed and the shell becomes moderately concave (text-fig. 24). There were spines along the posterior margin of the pedicle valve although these are broken on all of our specimens, leaving only the point of attachment. The specimen illustrated on plate I, figure 11 had three spines on each side, and these were inclined away from the beak. The ornamentation consists of delicate costellae with the spacing ranging from 20 to 23 per 5 mm and averaging 21 (four specimens). On our better preserved specimens, such as the one illustrated on plate I, figure 12, the costellae appear to be uniform in size and separated from one another by relatively narrow interspaces. On other shells, such as the one illustrated on plate I, figure 14, the costellae appear to be

* There appears to be some question concerning the author of *Chonetes;* see discussion by Imbrie (1959, p. 394).



Text-figure 24. *Chonostrophia complanata* (Hall). Profile drawings of two pedicle valves, x4, from the Frisco Formation.

separated by wide interspaces, but this condition is probably due to exfoliation of the shell. There is no evidence of an alternating type of costellation.

The largest specimen in our collection has a width of 23.2 mm; measurements of seven pedicle valves are given below.

Length mm	Width mm	Length/Width ratio
8.4	13.2	0.64
9.5	14.6	0.65
10.0	15.6	0.64
10.3	14.9	0.69
10.9	17.7	0.62
12.3	18.6	0.66
13.2	23.2	0.57

The pedicle valve has a relatively large, fan-shaped muscle scar (pl. I, fig. 13). We have not found any brachial valves in the Frisco Formation.

Discussion. — Hall's original description of *Chonostrophia complanata* was based upon specimens from the Oriskany Sandstone of New York. The senior author has examined the collection of *C. complanata* at the U. S. National Museum, which includes a number of complete shells from the Glenerie Formation of New York. Our Frisco specimens are similar to those from New York in outline and profile; six specimens from the Glenerie have an average length/width ratio of 0.67 which is comparable to the average (0.64) of the Oklahoma shells (text-fig. 13). Many of the New York specimens are distinctly larger than any in our collections, as shown by the following measurements of six specimens from the Glenerie Formation, Glenerie, New York:

Length mm	Width mm	Length/Width ratio
7.5	10.0	0.75
11.1	15.4	0.72
11.0	16.4	0.67
13.2	19.5	0.68
19.5	31.4	0.63
21.0	34.7	0.60

The ornamentation on the New York specimens is not well preserved, but the better preserved shells appear to have a slightly irregular ribbing, spaced about 18 or 19 per 5 mm. Clarke (1900, p. 50, pl. 7, fig. 12), in his study of the Oriskany brachiopods from Becraft Mountain, found that the ribs were distinctly fasciculate, but this condition is not present on our Frisco specimens, nor was it observed on the shells in the U. S. National Museum (at least not to the extent illustrated by Clarke). However, it should be noted that the ornamentation of this species is delicate and commonly obscured by exfoliation.

Chonostrophia helderbergia Hall from the Haragan Formation (see part III and pl. XXI, figs. 29, 30) has angular ribs which are more closely spaced than are those of *C. complanata.* This species, or a closely related one, is present in the Sallisaw Formation; see part II of this report and plate XIV, figures 22-25; plate XX, figures 18, 19.

Figured specimens. — Localities S6 and S6(A), Sequoyah County; numbers OU 3252-3255.

Distribution. — *Chonostrophia complanata* has been reported from the Oriskany Sandstone at a number of places in the eastern United States. Clarke (1908, p. 210, pl. 46, figs. 6-13) described and illustrated specimens from the Grande Grève Limestone of Gaspé; Dunbar (1919, p. 75) reported it as common in the Harriman Novaculite of western Tennessee; and Stewart (1922, p. 237, pl. 63, figs. 6, 7) illustrated specimens from the Little Saline Limestone of Missouri. We have found 23 specimens in the Frisco Formation of northeastern Oklahoma, at localities S4-E, S5-B, S6, S6(A). None has been found in the Frisco of the Arbuckle Mountains region.

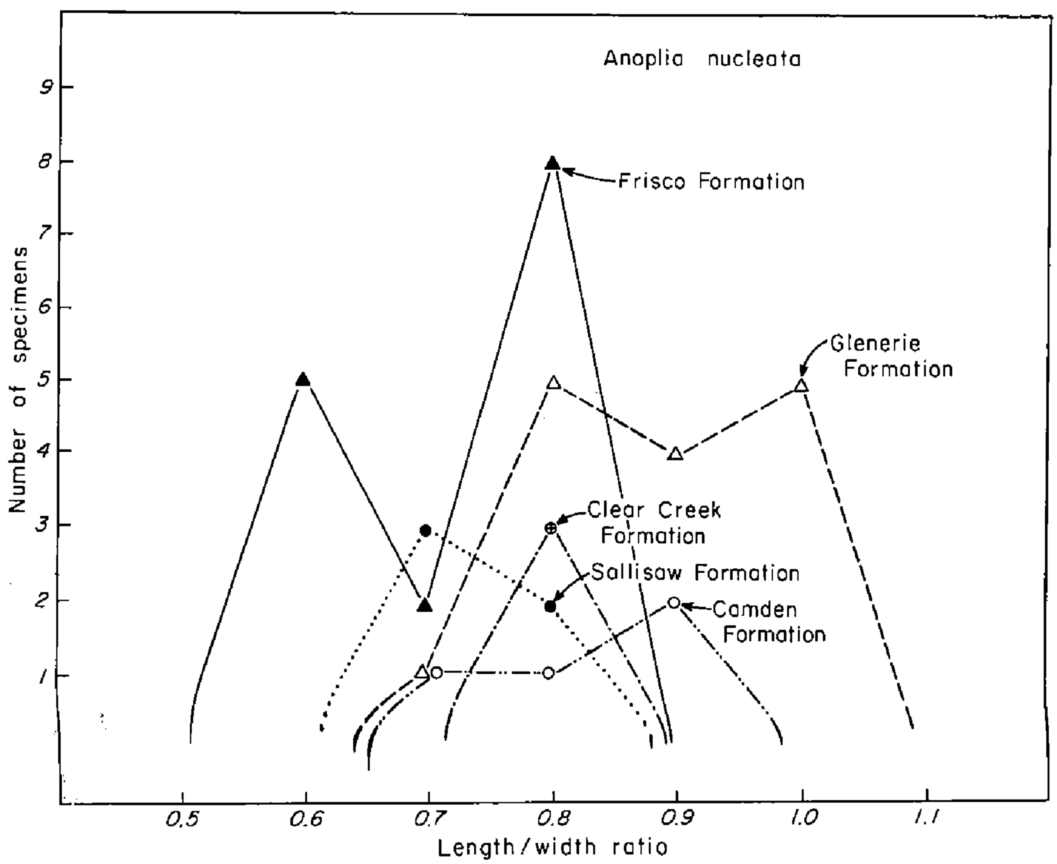
GENUS *Anoplia* HALL AND CLARKE, 1892

Anoplia nucleata (Hall), 1857

Plate I, figures 1-4; plate X, figures 13-16; plate XI
figure 20, text-figures 25, 26, 27

Leptaena nucleata Hall, 1857, p. 47; Hall, 1859, p. 419, pl. 94, figs. 1a-1d.
Anoplia nucleata (Hall). Hall and Clarke, 1892, p. 309, pl. 15a, figs. 17, 18, pl. 20, figs. 14-17; Clarke, 1900, p. 51, pl. 7, fig. 14; Schuchert and Maynard, 1913, p. 340, pl. 61, figs. 22-24; Cooper, 1944a, p. 347, pl. 135, figs. 17-20.

Description. — *Anoplia nucleata* is represented in our collections by 21 pedicle valves. It has a straight hinge line and on complete shells the cardinal extremities are extended slightly; from the hinge line forward the outline is uniformly rounded. All of our specimens have transverse shells, the length/width ratio ranging from 0.6 to 0.8 (text-fig. 25). The pedicle valve is deeply and evenly convex along the midline extending from the beak to the front margin (text-fig. 26); toward the posterolateral margins the curvature is flattened slightly. Surface is smooth except for a few concentric growth-lines. No interiors were observed.



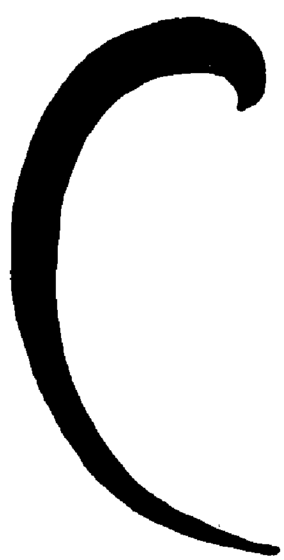
Text-figure 25. *Anoplia nucleata* (Hall). Frequency diagram comparing the length/width ratio of specimens from the Frisco and Sallisaw Formations of Oklahoma, the Glenerie Formation of New York, the Camden Formation of Tennessee, and the Clear Creek Formation of Illinois.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Nineteen pedicle valves from this area are in our collections. The measurements of 15 nearly complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio
2	3	0.6
3	4	0.7
3	4	0.7
3	5	0.6
3	5	0.6
4	5	0.8
4	5	0.8
4	5	0.8
4	5	0.8
4	5	0.8
4	5	0.8
4	5	0.8
4	5	0.8
4	6	0.6
4	6	0.6

Specimens from northeastern Oklahoma (Sequoyah County). — We have only two pedicle valves from this area. In so far as can be determined from this meager representation, these are similar in all respects to those from the Arbuckle region (pl. I, fig. 2).

Discussion. — Hall based his original description of this species on specimens from the Oriskany Sandstone, Albany County, New York. Later Schuchert and Maynard described specimens from the Oriskany of Maryland, and Clarke (1908, p. 211, pl. 41, figs. 15-17) illustrated specimens from the Grande Grève of Gaspé. The



Text-figure 26. *Anoplia nucleata* (Hall). Profile view of a pedicle valve, x15, from the Frisco Formation. Profile taken along the midline of the shell, extending from the beak to the front margin.

senior author has examined a number of well-preserved specimens of this species in the collections of the U. S. National Museum from the Glenerie Limestone, Glenerie, N. Y. (two shells from this collection are illustrated on pl. X, figs. 13-16); presumably this Glenerie material is conspecific with Hall's specimens, although we have not examined the primary types. The New York shells are distinctly larger than those from Oklahoma; few of the latter, if any, are longer than 4 mm, whereas specimens 6 to 7 mm long are common in the Glenerie. Compare the following measurements of Glenerie pedicle valves (Glenerie, N. Y.) with those given above for the Frisco.

Length mm	Width mm	Length/Width ratio
4.9	6.7	0.73
5.1	6.5	0.78
5.4	6.6	0.82
5.4	6.1	0.85
6.1	6.2	0.98
6.1	7.2	0.85
6.2	7.9	0.78
6.3	6.3	1.00
6.4	7.0	0.92
6.5	7.0	0.93
6.7	7.4	0.91
6.8	7.7	0.88
6.9	7.0	0.98
7.2	7.3	0.99
7.2	7.5	0.96

The New York specimens tend to be somewhat more elongate than are those from the Frisco Formation. The length-width ratios of the latter range from 0.6 to 0.8, whereas the ratios of the Glenerie specimens are as high as 1.0 (text-fig. 27). This difference, however, is not believed to be significant because there is such a marked overlap in the ratios of these two groups. Moreover, measurements of a series of well-preserved Glenerie specimens show that the length-width relationship is not a constant shell feature. In such other features of the pedicle valve as shape and profile, the Frisco shells are much like those from the Glenerie and the two groups are considered to be conspecific.

This species is also present in the Sallisaw Formation of northeastern Oklahoma; for a comparison with the Frisco shells see part II, *Anoplia nucleata.*

Figured specimens. — Localities P11 and V7, Pontotoc County, and S6, Sequoyah County; numbers OU 3242-3245.

Distribution. — *A. nucleata* has been widely reported from the

Oriskany Formation in the eastern United States. Clarke described and illustrated specimens from the Grande Grève Limestone of Gaspé, and Stewart (1922, p. 236, pl. 63, fig. 5) found a single pedicle valve in the Little Saline Limestone of Missouri; Dunbar reported it as very rare in the Harriman Formation of western Tennessee. Our Frisco collections contain 21 pedicle valves, all but two of which are from the Arbuckle Mountains region, Pontotoc County: P11, P9, V7; the two Sequoyah County specimens came from locality S6.

This species is present in the Sallisaw Formation, Sequoyah County, Oklahoma; see part II for additional information on distribution.

Superfamily ORTHOTETACEA

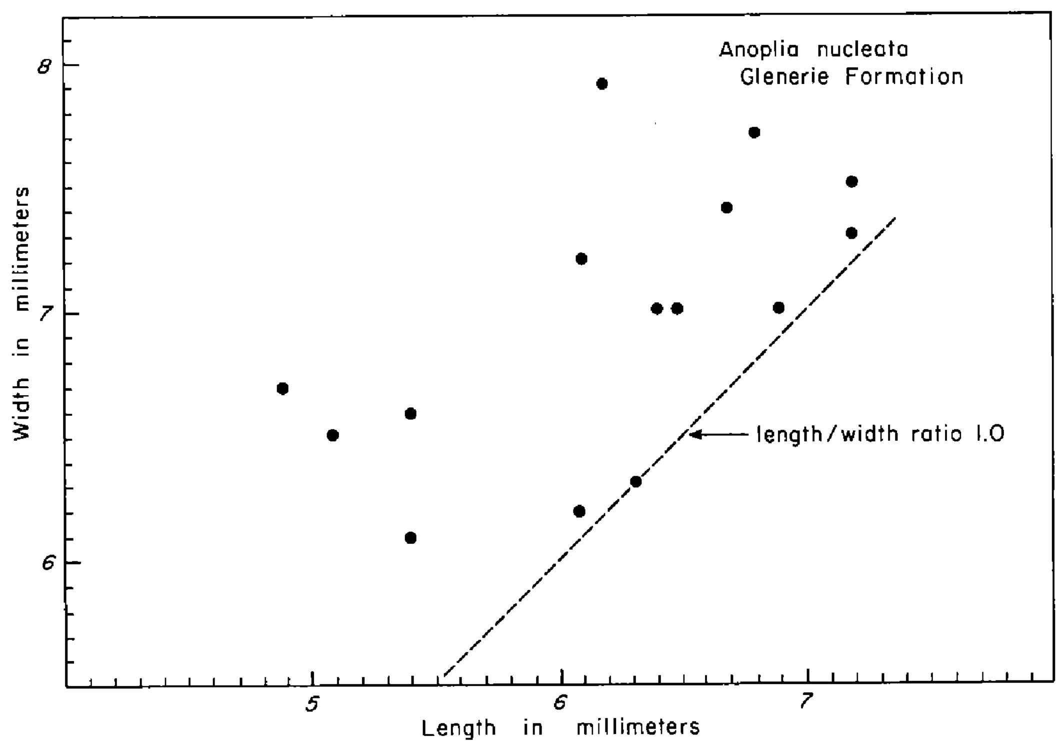
GENUS *Schuchertella* GIRTY, 1904

Schuchertella becraftensis (Clarke), 1900

Plate XI, figures 10-20

Orthothetes becraftensis Clarke, 1900, p. 51, pl. 7, figs. 15-28.
Orthothetes (Schuchertella) becraftensis Clarke, 1908, p. 199, pl. 41, figs. 1-8.

Description. — *Schuchertella becraftensis* has a small, transverse shell; on mature individuals the width is slightly, but consistently,



Text-figure 27. *Anoplia nucleata* (Hall). Scatter diagram showing the length-width relationship of specimens from the Glenerie Formation of New York.

greater than the length. The pedicle valve is fairly deep, tending to be subpyramidal with a well-developed apsacline to almost catacline palintrope; delthyrium closed by an arched pseudodeltidium (pl. XI, figs. 11, 19). The brachial valve is only moderately convex. The ornamentation consists of narrow, subangular costellae separated by broad, U-shaped interspaces; five to seven ribs occupy a space of 2 mm. New costellae are introduced by bifurcation and implantation.

In the pedicle valve the teeth are largely unsupported, with only abbreviated ridges at the posterior end (pl. XI, fig. 12); the muscle scars appear to have been shallow. We have no brachial valves from the Frisco showing the internal structure, but brachial interiors from the Oriskany Sandstone are illustrated on plate XI, figures 16, 18.

Discussion. — Clarke based his original description of this species on specimens from the Oriskany Sandstone of New York. A few years later he illustrated specimens from the Grande Grève Limestone of Gaspé. Through the courtesy of the New York State Museum, we borrowed his Oriskany type specimens, comprising about a dozen shells, most of which are wax casts of external molds and steinkerns (pl. XI, figs. 16-20). In so far as can be determined from our small number of rather fragmented specimens, the Frisco shells are like those from the Oriskany in size, outline, profile, and ornamentation. The only pedicle interior among Clarke's types shows no trace of dental plates, whereas the Frisco specimens have abbreviated ridges; however, the Oriskany shell is silicified and may be worn or exfoliated. The Grande Grève pedicle valve illustrated by Clarke (1908, pl. 41, fig. 4) appears to have short ridges similar to those in the Frisco valves. We have no brachial interiors from the Frisco Formation.

There is some question as to the precise internal structure of *Schuchertella,* but at the present time it is common practice to assign those Devonian orthotetacid brachiopods without dental plates (or with poorly developed plates) to this genus (see Amsden, 1958a, p. 89, 152; 1959, p. 74-77).

Figured specimens. — The Frisco specimens are from locality S8-C, Sequoyah County; numbers OU 3936-3939. The Oriskany specimens are from Becraft Mountain, Hudson, N. Y., New York State Museum numbers 1659, 1661, 1663, 1665, 1669.

Distribution. — Clarke collected specimens of this species from the Grande Grève Limestone of Gaspé and from the Oriskany Sandstone of New York. Schuchert and Maynard (1913, p. 329) also reported it from the Oriskany Sandstone of Maryland. Our collection consists of eight free valves (four pedicles and four brachials), all from locality S8-C, Sequoyah County, Oklahoma. None is from the Arbuckle Mountains region.

Superfamily RHYNCHONELLACEA

GENUS *Costellirostra* COOPER, 1942

Costellirostra peculiaris (Conrad), 1841

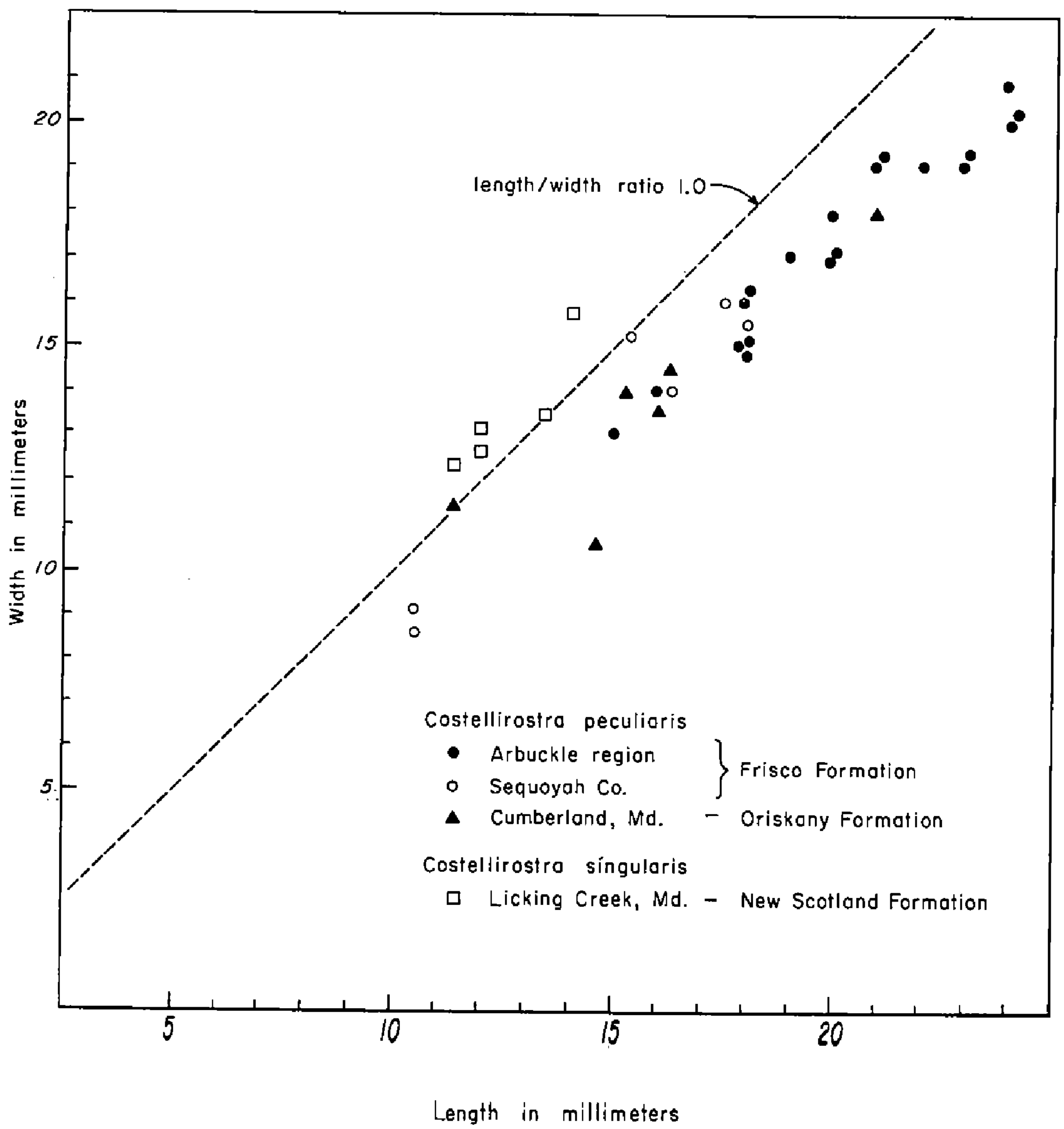
Plate III, figures 1-15; text-figures 28, 29

Atrypa peculiaris Conrad, 1841, p. 56.
Eatonia peculiaris (Conrad). Hall, 1859, p. 244, pl. 38, figs. 21-26, pl. 101, figs. 2a-g, pl. 101A, fig. 1; Clarke, 1900, p. 40; Schuchert and Maynard, 1913, p. 372-373, pl. 65, figs. 23-28.
Costellirostra peculiaris (Conrad). Cooper, 1942, p. 231.

Description. — There are a number of well-preserved, articulated specimens of *Costellirostra peculiaris* in our collections, it being the best represented of all the Frisco brachiopod species. The shell is elongate oval in outline, with a length/width ratio ranging from 1.0 to 1.2 and averaging 1.1 (text-fig. 28). Around the umbonal region the pedicle valve is weakly convex and the posterolateral margins are abruptly deflected toward the brachial valve. The beak is short and slightly inclined toward the brachial. The pedicle valve retains its slight convexity for a distance of 7 to 10 mm and then develops a broad, U-shaped sulcus which becomes prominent at the anterior end. The brachial valve is deeply convex, even on small shells (pl. III, figs. 13, 14), becoming swollen at the anterior end. At a distance of 10 to 15 mm, a brachial fold appears and becomes fairly prominent near the front margin of large shells; however, this fold is in no case abruptly marked off from the lateral margins. The anterior commissure is deeply uniplicate, the sulcate portion of the pedicle valve extending into a long tongue. The anterolateral margin is crenulate although the crenulations do not appear to be constant either in number or position. Serrations or cenulations are present in nearly all specimens on each side of the fold and sulcus; on some specimens crenulations are present near the end of the pedicle tongue (crest of brachial fold), but on other shells this part of the commissure is smooth (text-fig. 29; pl. III, figs. 13, 14, 15). This variation may be at least in part related to size, the larger individuals developing an interlocking mechanism at the conjunction of the valves. The surface ornamentation consists of fine costellae, 19 to 28 occupying a space of 5 mm; commonly the center costella in the pedicle sulcus is more prominent than the others (pl. III, fig. 9).

By calcining the shell, we have obtained two reasonably well-preserved internal cores showing the structure of the pedicle valve. These appear to be typical in all respects for this species; the diductors are large and deeply impressed and the adductors small, central in position, and located on an elevated platform. We have two brachial interiors showing the characteristic, stout, bifid cardinal process.

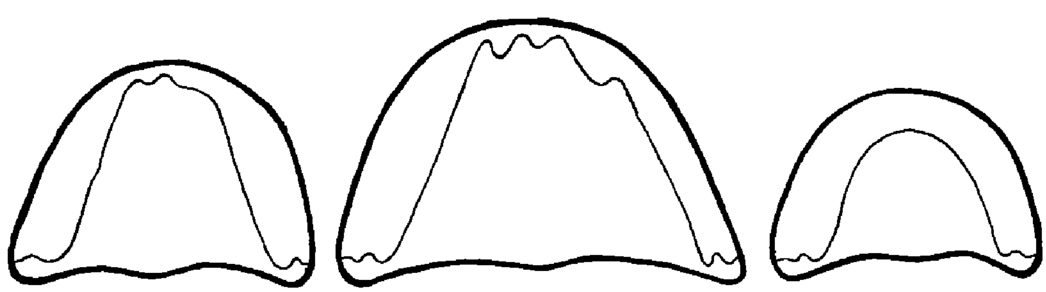
Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — *Costellirostra peculiaris* is well represented in the



Text-figure 28. Scatter diagram comparing the length-width relationship of specimens of *Costellirostra peculiaris* (Conrad) from the Frisco Formation of Oklahoma and the Oriskany Formation of Cumberland, Maryland, with specimens of *C. singularis* (Vanuxem) from the New Scotland Formation (Helderbergian) of Licking Creek, Washington County, Maryland. The measurements of Oriskany and New Scotland specimens are of specimens in the collections of type area; our collections include a total of 71 specimens, of which 29 are articulated shells, 30 are pedicle valves, and 12 are brachial valves (pedicle/brachial ratio 2.5). These specimens seem to be typical for the species, although a few are unusually large, one shell attaining a length of 24 mm. The measurements of 19 specimens are given below:

Length mm	Width mm	Length/Width ratio	Thickness mm	Costellae per 5 mm
14	13	1.1	9	----
15	13	1.2	11	26
16	14	1.1	12	----
18	15	1.2	14	23
18	16	1.1	----	26
18	15	1.2	----	24
18	16	1.1	----	27
18	15	1.2	12	24
19	17	1.1	----	27
20	17	1.2	16	27
20	18	1.1	15	24
20	17	1.2	15	26
21	19	1.1	18	24
22	19	1.2	17	20
23	19	1.2	18	25
23	19	1.2	18	20
24	20	1.2	27	19
24	21	1.1	16	25
24	20	1.2	16	19

Specimens from northeastern Oklahoma (Sequoyah County).— *C. peculiaris* is not so well represented in the eastern outcrop areas as in the type region; our collections include a total of 18 specimens of which nine are articulated shells, five are pedicle valves, and four are brachial valves (pedicle/brachial ratio 1.2). These specimens are like those from the Arbuckles except for their somewhat



Text-figure 29. Anterior views of three specimens of *Costellirostra peculiaris* (Conrad) showing the crenulations affecting the commissure, x2. These specimens are from the Frisco Formation along Bois d'Arc Creek, Pontotoc County, Oklahoma (P11 and P8).

smaller size (text-fig. 28). The measurements of seven complete shells are given below:

Length mm	Width mm	Length/Width ratio	Thickness mm	Costellae per 5 mm
10.5	8.5	1.2	5.5	27
10.5	9.1	1.1	5.7	22
15.7	15.1	1.0	12.1	22
16.5	14.1	1.2	9.7	24
16.6	17.3	1.0	9.0	22
17.5	16.2	1.1	10.8	24
18.0	15.7	1.2	12.2	20

Discussion. — In 1942 Cooper (p. 231) described the genus *Costellirostra* and assigned three species to it: the genotype, *Atrypa peculiaris* Conrad, *Atrypa singularis* Vanuxem, and *Eatonia tennesseensis* Dunbar. Vanuxem's description of *C. singularis* (1842, p. 120, 121, fig. 3) was based on specimens from the Helderberg of New York, and Conrad's description of *C. peculiaris* was based on specimens from the Oriskany Sandstone of New York. Subsequent investigators have, however, questioned the validity of these two species. In 1859 Hall (p. 244) stated:

> This species [*C. peculiaris*] was regarded by Mr. Conrad as restricted to the Oriskany sandstone; but in the course of many years' collections, a considerable number of specimens have been found in the limestone of the Lower Helderberg group. In its surface characters, it scarcely differs from the preceding species [*C. singularis*]; the form, however, is always more or less distinctly ovate, the mesial sinus less deeply and less distinctly pronounced; while the mesial fold of the opposite valve is less abrupt, and does not extend so nearly to the beak of the valve; . . .

Clarke (1908, p. 173) reviewed the ideas of earlier authors on these two species, and then went on to state that in his opinion *C. singularis* and *C. peculiaris* represented an artificial separation (thus clearly implying that *C. singularis* should be suppressed as a synonym of *C. peculiaris*). In 1944 Cooper (p. 311) reported *C. peculiaris* from both the Helderberg and the Oriskany.

During the course of his investigations on the Lower Devonian strata of Oklahoma, the senior author has had occasion to study the Helderberg and Oriskany collections at the U. S. National Museum and at Peabody Museum, Yale University. In all of the collections examined at these institutions there is a well-marked morphologic difference between the Helderberg and the Oriskany specimens of *Costellirostra*. The Oriskany specimens of *C. peculiaris* have, as noted by Hall, an elongate shell, the length being almost always greater than the width; on rare specimens the length is about equal to the width (text-fig. 28). In contrast the Helderberg specimens of *C. singularis* are in almost every specimen wider than long; only a few shells have the width and length about equal (text-fig. 28). This is shown in the following measurements of Oriskany and New Scotland specimens from the U. S. National Museum:

Length mm	Width mm	Length/Width ratio
	Oriskany Sandstone — Cumberland, Md.	
11.6	11.4	1.01
14.7	11.5	1.28
15.3	14.1	1.09
16.1	13.7	1.18
16.5	14.5	1.13
21.1	18.1	1.18
	New Scotland — Licking Creek, Washington County, Md.	
11.5	12.3	0.94
12.2	13.1	0.93
12.2	12.5	0.98
13.7	13.1	1.06
14.2	15.9	0.89

There is an even more marked difference between these two species in the character of the fold and sulcus. In *C. singularis* the fold and sulcus begin near the middle of the shell, becoming well defined at the anterior end, whereas in *C. peculiaris* the fold and sulcus are restricted to the anterior end of the shell and are not sharply marked off from the lateral margins. These differences are clearly defined in the Oklahoma representatives of *C. singularis* from the Bois d'Arc Formation (Amsden, 1958b, p. 72-74, pl. III, figs. 25-32) and *C. peculiaris* from the Frisco Formation. For a comparison with *C. tennesseensis* (Dunbar) from the Birdsong Shale of western Tennessee, see Amsden 1958b (p. 74).

Our Frisco specimens are similar in all respects to those from the Oriskany Sandstone of Maryland and New York; they also appear to be like those from the Little Saline Limestone of Missouri.

This is an unusual Frisco brachiopod in that it is well represented by articulated shells; 43 percent of our specimens are complete with both valves. *C. peculiaris* must have a stout hinge mechanism as it is common in those beds where the other brachiopods are largely, or entirely, disarticulated.

Figured specimens. — Localities P11, Pontotoc County, and S5-B, S6, Sequoyah County; numbers OU 3283-3291.

Distribution. — Conrad's specimens came from the Oriskany Sandstone of New York; this species has been widely reported from this formation in many parts of the eastern United States. Clarke (1908, p. 172-174, pl. 29, figs. 1-13) described and illustrated specimens from the Grande Grève Limestone of Gaspé and Stewart (1922, p. 237-238, pl. 62, figs. 12-16) illustrated specimens from the Little Saline Limestone of Missouri; Dunbar (1919, p. 75) reported *C. peculiaris* from the Harriman and Camden Formations of western Tennessee (this species is not known to be present in the Sallisaw of Sequoyah County, a formation which is closely related in age to the Camden; see part II of this report).

Our Frisco collections include a total of 89 specimens from the following localities: Arbuckle Mountains region, Pontotoc County, P11 (0 to 25 feet above the Frisco), P8-H, P9, V7; Sequoyah County, S1-B, S5-B, S6, S8-C. Most of the articulated Sequoyah County specimens came from locality S6.

GENUS *Plethorhyncha* HALL AND CLARKE, 1894

Plethorhyncha cf. *P. barrandi* (Hall), 1857

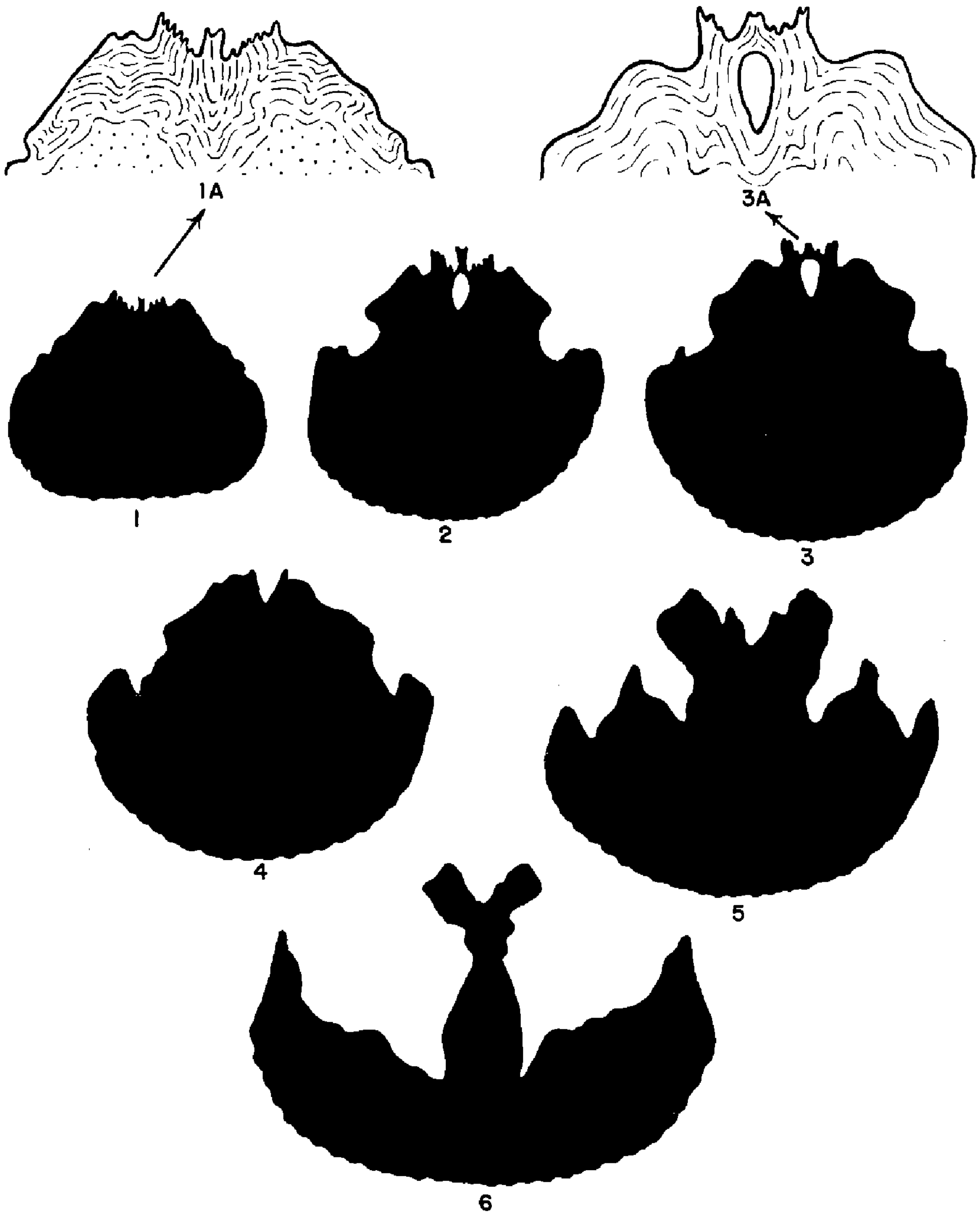
Plate IV, figures 5-10; text-figure 30

Rhynchonella barrandi Hall, 1857, p. 82-83, figs. 1-3; Hall 1859, p. 442, pl. 103, figs. 3-8.

Plethorhyncha barrandi (Hall). Hall and Clarke, 1894, p. 191.

Description. — This species is represented by a number of specimens; but, as most of these are fragmentary and none has the valves articulated, it is difficult to get a precise concept of the morphologic features. The shell is large and elongate with a length/width ratio ranging from 1.1 to 1.5; the hinge line is short and the palintrope obscure. The pedicle valve is weakly convex to almost flat in the umbonal region, and the posterolateral margins are abruptly deflected at nearly right angles to the ventral surface (pl. IV, fig. 5). This valve shows little or no tendency toward the development of a sulcus and on several specimens there is a faint elevation along the midline. None of our specimens is complete at the anterior end and so it is not known if the pedicle valve is extended into a tongue. The brachial valve is much deeper than the pedicle and its lateral margins less sharply deflected; large brachial valves show a slight swelling toward the front, but none of our specimens has a clearly marked fold. The surface is costate with the individual costa expanding toward the front where four to ten occupy a space of 10 mm; costae are subangular with narrow interspaces, and crossed by concentric filae (pl. IV, fig. 7).

Two pedicle valves were calcined to produce fairly good steinkerns showing the internal characters. The posterolateral walls are thick and the teeth stout and attached directly to the laeral walls (no trace of dental plates present on mature shells). The delthyrial



Text-figure 30. Transverse serial sections of *Plethorhyncha* cf. *P. barrandi* (Hall). Distance from the posterior tip of the brachial valve: 1 — 1.9 mm; 2 — 3.3 mm; 3 — 4.0 mm; 4 — 5.4 mm; 5 — 7.2 mm; 6 — 7.5 mm; all x2. Numbers 1A and 3A are enlarged details (x5) showing the growth lines (stippled areas are organic calcite showing no growth lines). This specimen from the lower 5 feet of the Frisco Formation near P11, Pontotoc County (OU 3304).

cavity is narrow and deep; in front of this cavity are the muscle scars, deeply impressed at the posterior end, shallow toward the anterior. These scars are large, a specimen approximately 40 mm long having scars about 20 mm in length. Our specimens do not permit a distinction between diductor and adductor scars; possibly one set of muscles was attached in the delthyrial cavity.

The structures forming the brachial cardinalia are ponderous (text-fig. 30). At the posterior end the upper surface of this structure is serrated, the central part being elevated into a cardinal process; undoubtedly the muscles were attached to this surface. Two or 3 mm in front of the beak a cleft appears and this extends into a ponderous cruralium which is supported on a stout median septum; the crura are subcircular in cross section and very stout.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — There are about 35 specimens of this species in our collections, all being isolated valves and most being fragmentary; the ratio of pedicle valves to brachial valves is 1.7. The larger shells are easily recognized, but the smaller, more incomplete individuals are difficult to distinguish from *Plethorhyncha? welleri,* and it is possible that we have included some of the latter in *P.* cf. *P. barrandi.* The dimensions of 7 valves are given below (* indicates a pedicle valve, ** a brachial valve).

Length mm	Width mm	Length/Width ratio	Costae per 10 mm
**69	45	1.5	5
*63	51	1.2	4
**57	41	1.4	5
**57	47	1.2	4
*47	40	1.2	8
**56	46	1.2	4
*48	33	1.4	5

Specimens from northeastern Oklahoma (Sequoyah County). — We have not identified any specimens of this species from northeastern Oklahoma, although it is possible that some of the more fragmentary shells referred to *Plethorhyncha welleri?* may belong here.

Discussion. — The genus *Plethorhyncha* was proposed by Hall and Clarke (1894, p. 191), the genotype (subsequent designation by Schuchert, 1897, p. 313) being *Rhynchonella speciosa* Hall (1857, p. 81; 1859, p. 444, pl. 103A, figs. 1-6) from the Oriskany Sandstone of Maryland. Hall's type specimens of *P. speciosum,* which are in the American Museum of Natural History (AMNH 2734), include five silicified shells. Two of these are pedicle valves having relatively small, shallow, elliptical muscle scars and no trace of dental plates (pl. XII, fig. 8). There is one nearly complete brachial valve with a stout cardinalia supported on a high median septum; the crura are short and a large, bifid cardinal process occupies the posterior end of the cruralium (pl. XII, figs 9, 10). In their discussion of *Plethorhyncha,* Hall and Clarke stated that young specimens of *P. speciosum* lack a cardinal process, and Hall's types do include one fragment of a brachial valve which has an open cruralium without any trace of a cardinal process (this was not figured by Hall). This specimen is similar in other respects to the more complete brachial valve which has a process and it may well represent an immature stage of this species, or it may represent a different species; *P. speciosum* and related Oriskany species need to be more fully investigated before this problem can be solved. The type specimens include one nearly complete shell with the valves articulated; this is strongly costate and has almost no trace of a fold or sulcus.

Hall and Clarke included two other species in their genus *Plethorhyncha: Rhynchonella pleiopleura* Hall (1857, p. 86, figs. 1-4; 1859, p. 440, pl. 102, figs. 3, 4) and *Rhynchonella barrandi* Hall (1857, p. 82-83, figs. 1-4; 1859, p. 442, pl. 103, figs. 3-8). Hall's illustrations of *P. barrandi* are poor and his type specimens, which are from the Oriskany Sandstone, Knox, Albany County, New York (AMNH 2675), consist of only three fragmentary steinkerns. The pedicle steinkern illustrated by Hall (pl. 103, fig. 4) has a deep, narrow delthyrial cavity, a moderately well-defined muscle scar, and no trace of dental plates. His most complete specimen is a steinkern of an articulated shell, which suggests the presence of a shallow fold and sulcus (this is probably the specimen illustrated by Hall on pl. 103, figs. 5-7); one significant feature of this specimen is that it preserves a fairly good mold of the brachial apparatus. Hall and Clarke thought *P. barrandi* lacked a cardinal process, but a rubber cast of this steinkern clearly reveals the presence of a large, bifid cardinal process (pl. XII, fig. 7).

Hall's type specimens of *P. pleiopleura* include the steinkerns of two articulated shells from the Oriskany Sandstone, Schoharie, New York (AMNH 2697). As illustrated by Hall, these are relatively broad shells of moderate convexity and with well-developed fold and sulcus. The pedicle muscle scars are fairly deep, and dental plates are absent; the brachial apparatus is supported on a stout median septum and appears to have a bifid cardinal process.

The external and internal characters of the Frisco shells would clearly seem to ally them with the genus *Plethorhyncha,* although their species relationship is uncertain. In their large-sized, thick pedicle shell with deep muscle scars and stout brachial apparatus, they would seem to be most closely related to *P. barrandi;* however, Hall's species appears to be a more strongly biconvex shell with a better developed fold and sulcus. The Frisco shells may represent an undescribed species, but in the absence of better material no more exact species identification is justified.

Figured specimens. — Localities P8-H, P10, P11, Pontotoc County, Oklahoma; numbers OU 3305-3308. Some of the type specimens of *P. speciosum* (Hall) and *P. barrandi* (Hall) are illustrated on plate XII.

Distribution. — *P. barrandi* has been reported from the Oriskany Sandstone of New York and Maryland, the Grande Grève Limestone of Gaspé, and the Little Saline Limestone of Missouri. Apparently most of the specimens referred to this species are fragmentary.

There are approximately 35 free valves in our collections, all from Pontotoc County in the Arbuckle Mountains. We have specimens from the following localities: P8-H, P11, P10, P9; all from the lower 10 feet of the Frisco Formation.

Plethorhyncha? welleri (Stewart), 1922

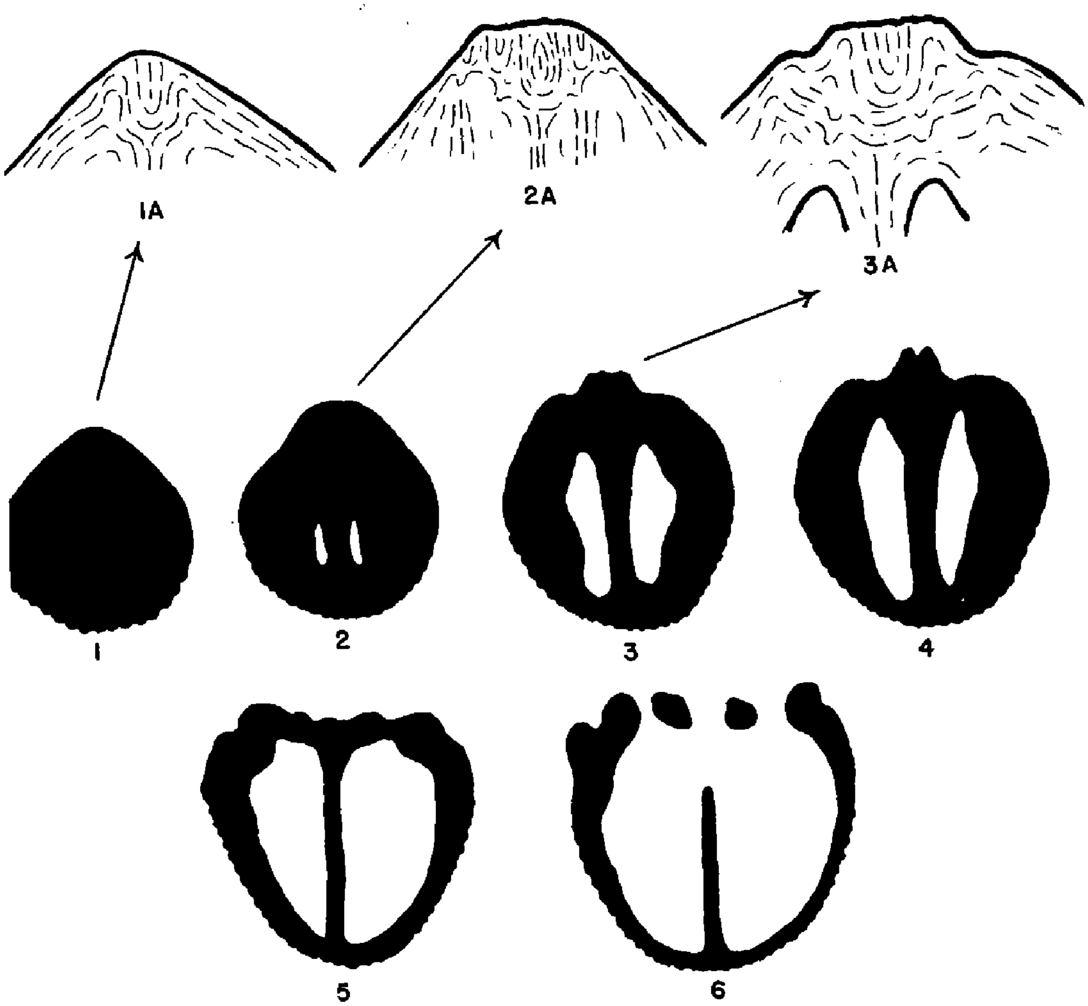
Plate III, figures 19-26; plate IV, figures 16, 17; plate XII, figures 1-3; text-figure 31

Uncinulus welleri Stewart, 1922, p. 240, pl. 63, figs. 13-14.

Description. — *Plethorhyncha? welleri* is represented by a number of fragmentary, disarticulated valves; we have found only one specimen with both valves articulated and this is badly crushed. The pedicle valve is oval in outline with a rather blunt beak and broadly rounded anterior margin; it is commonly slightly longer than wide with a length/width ratio of about 1.0 to 1.1. In the umbonal region this valve is gently convex with the posterolateral margins deflected toward the brachial valve. At 20 to 25 mm in front of the beak a broad, shallow sulcus appears, and this is extended into a long tongue at the anterior margin. The brachial valve is deep, and near the front margin it develops a moderate fold; 6 to 8 costae occupy the crest of this fold. The anterior commissure is uniplicate with the brachial valve having a deep indentation to receive the linguiform extension of the pedicle valve. Surface is costate; costae are subangular and separated by narrow interspaces. The ribs increase in width toward the front where five to eight occupy a space of 10 mm.

We have calcined several pedicle valves in order to produce steinkerns showing the internal characters. The pedicle interior is similar to that of *Plethorhyncha* cf. *P. barrandi;* the delthyrial cavity is narrow and deep and the teeth attach directly to the lateral walls (dental plates appear to be absent in mature shells). In front of the delthyrial cavity are the rather deep, elongate muscle scars with the adductors appearing to occupy a slightly raised elongate track in the center.

The structures forming the brachial cruralium are ponderous (text-fig. 31). At the posterior end the cruralium appears to have been completely filled with shell material, the upper surface of which is roughened, probably to give a better attachment surface for the



Text-figure 31. ***Plethorhyncha*? *welleri* (Stewart).** Transverse serial sections of the brachial valve. Distance from the posterior tip of brachial valve: 1 — 3.0 mm; 2 — 3.4 mm; 3 — 4.6 mm; 4 — 5.6 mm; 5 — 6.9 mm; 6 — 7.6 mm; all x3. Numbers 1A, 2A, 3A are enlarged views showing the growth lines. This specimen is illustrated on plate III, figures 23, 25.

muscles. The serially sectioned specimen does not show any well-defined cardinal process although it is possible that this was originally present and later broken. The supporting median septum is thick and extends forward for some distance. The crura are large, rodlike bodies, more or less circular in cross section.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — There are about 23 specimens of *Plethorhyncha? welleri* in our collection. Most are fragmentary and some are so incomplete that it is difficult to distinguish them from *Plethorhyncha* cf. *P. barrandi.* Only one specimen includes both valves, the rest being about equally distributed between the pedicle and brachial valves; pedicle/brachial ratio 1.2. The measurements of seven isolated valves are given below (* indicates pedicle valve, ** indicates brachial valve):

Length mm	Width mm	Length/Width ratio	Costae per 10 mm
*34	31	1.1	6
*33	32	1.0	6
*38	36	1.1	5
**36	33	1.1	8
**36	32	1.1	7
*35	31	1.1	5
**33	33	1.0	6

Specimens from northeastern Oklahoma (Sequoyah County). — Our collections from Sequoyah County include 12 isolated valves (pedicle/brachial ratio 3.0). All of these are fragmentary, and among the more incomplete specimens may be representatives of *P.* cf. *P. barrandi.* The spacing of the costae ranges from 6 to 8 in a distance of 10 mm. The length/width ratio appears to be about 1.0 or slightly higher, although most specimens are not complete enough to permit precise measurements. In so far as can be determined the Sequoyah County specimens are similar in all respects to those from Pontotoc County.

Discussion. — In 1922 Stewart referred three species from the Little Saline Limestone of Missouri to the genus *Uncinulus: U. welleri* Stewart, *U. salinensis* Stewart (p. 239, pl. 63, figs. 8-10), and *U. parvus* Stewart (p. 239, pl. 63, figs. 11-12; herein referred with question to *Plethorhyncha).* According to this author *P. ? salinense* differed from *P. ? welleri* in having a slightly more transverse shell and a somewhat stronger fold and sulcus. The description of *P. ? parvum* was based on one small shell (plus a questionable pedicle valve) which, according to Stewart, might be an immature individual. Through the courtesy of Matthew H. Nitecki, we were able to borrow Stewart's type specimens from the Walker Museum, University of Chicago. These include the following specimens: *P. ? welleri*, one nearly complete articulated shell (pl. XII, figs. 1-3) and one brachial valve; *P. ? salinense*, one articulated shell (pl. XII, figs. 4-6) and one pedicle steinkern; *P. ? parvum*, one articulated shell and a fragment of a pedicle valve. As noted by Stewart, the type specimens of *P. ? salinense* differ from those of *P. ? welleri* in having a more transverse shell* and a slightly better defined fold and sulcus; however, it should be kept in mind that this comparison is based on only four specimens and it is quite possible that a larger collection would show a gradation from one type to the other (our Frisco specimens vary some in their length/width ratio; see above). The type of *P. ? parvum* is only 17 mm long, 17 mm wide, and 10 mm thick, and it may not be a mature shell, although its well-defined fold and sulcus suggest that it is not a young form of the other shells (also indicated by its finer costellation). The holotype of *P. ? welleri* (pl. XII, fig. 1) has a part of the pedicle beak broken away to show that the muscle scars are rather deep and the dental plates are absent. The paratype of *P. ? salinense*, illustrated by Stewart (pl. 63, fig. 10), shows a muscle scar which is deep at the posterior end and is separated into two parts by a ridge; it has no dental plates. Nothing is known about the brachial interior of the Little Saline shells (the pedicle interior of *P. ? parvum* is unknown).

In so far as can be determined from the material at hand, the Frisco shells are like *P. ? welleri* in size, shape, costation, and development of the fold and sulcus. The ratio of length to width varies on the Frisco shells (1.0 to 1.1), but none appears to be nearly so transverse as the holotype of *P. ? salinense* (0.9). The pedicle interior of the Oklahoma shells appears to be identical to those of *P. ? welleri* and *P. ? salinense*.

P. ? welleri is easily distinguished from *P.* cf. *P. barrandi* by its less elongate shell and its well-developed fold and sulcus.

We are uncertain regarding the generic affinities of this species. Stewart referred all three of her species to *Uncinulus* and this may be the correct assignment. According to Muir-Wood (1925, p. 92-94) and Oehlert (1884, p. 422-430, pl. 21), *Uncinulus subwilsoni* (genotype) has a cardinal process and a large, deep, pedicle muscle scar. Externally, however, this species is characterized by a small, costellate shell and a subcuboidal outline, which is quite unlike the

* The holotype of *P. ? salinense* has a length/width ratio of 0.9 (brachial valve) and the holotype of *P. ? welleri* has a length/width ratio of 1.0 (brachial valve).

Frisco-Little Saline shells. In its large size, coarse costation, and general internal characters (compare text-figs. 30, 31) *P. ? welleri* would seem to be related to *Plethorhyncha,* although its well-marked fold and sulcus are quite unlike the genotype, *P. speciosum* (see *Discussion* under *P.* cf. *P. barrandi* and pl. XII, fig. 12). For the present we refer *P. ? welleri* with question to *Plethorhyncha,* although it is quite possible that further studies on Lower Devonian rhynchonellids will show the need for a different generic assignment.

Figured specimens. — Localities P11, Pontotoc County, and S1 and S8-C, Sequoyah County, Oklahoma; numbers OU 3295-3301. Stewart's type specimens of *U. welleri* and *U. salinensis* are illustrated on plate XII.

Distribution. — Stewart's specimens came from the Little Saline Limestone, Little Saline, Missouri. Our Frisco collections include about 23 specimens from the Arbuckle Mountains region and 12 specimens from northeastern Oklahoma; only one specimen has the valves articulated, the rest being isolated valves, many quite fragmentary. These came from the following localities: P11, P9-R, P10, Pontotoc County, (all from the lower 10 feet of the Frisco except for a single specimen which was collected 60 feet above the base at P11) and S1-B, S5, S6, S8-C, S10-B,C, Sequoyah County.

GENUS *Camarotoechia* HALL AND CLARKE, 1894

Camarotoechia? cf. *C. dryope* (Billings), 1874
Plate IV, figures 1-3

Rhynchonella dryope Billings, 1874, p. 37, pl. 3a, figs. 1a-c.
Camarotoechia dryope (Billings). Clarke, 1900, p. 41, pl. 5, figs. 20, 21; Clarke, 1908, p. 170, pl. 28, fig. 2.

Description. — This species is represented in our collections by one reasonably complete shell with the valves articulated and four fragmentary valves. It has a biconvex shell, the brachial being deeper than the pedicle; the outline is subtriangular with a length/width ratio of 0.8 (figured specimen). The pedicle valve develops a sulcus at midlength which becomes deep toward the anterior margin; four costae occupy the fold. The brachial valve has a corresponding fold which is fairly deep at the front; five costae occupy the fold. The costae are angular; five occupy a space of 10 mm. The figured specimen measures 19 mm long, 24 mm wide, and 17 mm thick.

Specimen from the Arbuckle Mountains region (Pontotoc and Coal Counties). — The only specimen from this area is the one illustrated on plate IV.

Specimens from northeastern Oklahoma (Sequoyah County). — We have four fragmentary valves from this area which are provisionally referred to this species.

Discussion. — The reference of our specimens to the genus *Camarotoechia* is conjectural as we have no information concerning the internal structure.

Rhynchonella dryope was named by Billings who based his description on specimens from the Gaspé Limestone. Later Clarke described and illustrated specimens from the Oriskany Sandstone of New York and the Grande Grève Limestone of Gaspé; he referred *dryope* to *Camarotoechia* although neither he nor Billings mentioned the internal characters. The specimen illustrated on plate IV has some external resemblance to those described and illustrated by Clarke and by Billings, although the Frisco material is not well enough known to be precisely identified.

Figured specimen. — Locality P10-V, Pontotoc County; number OU 3302.

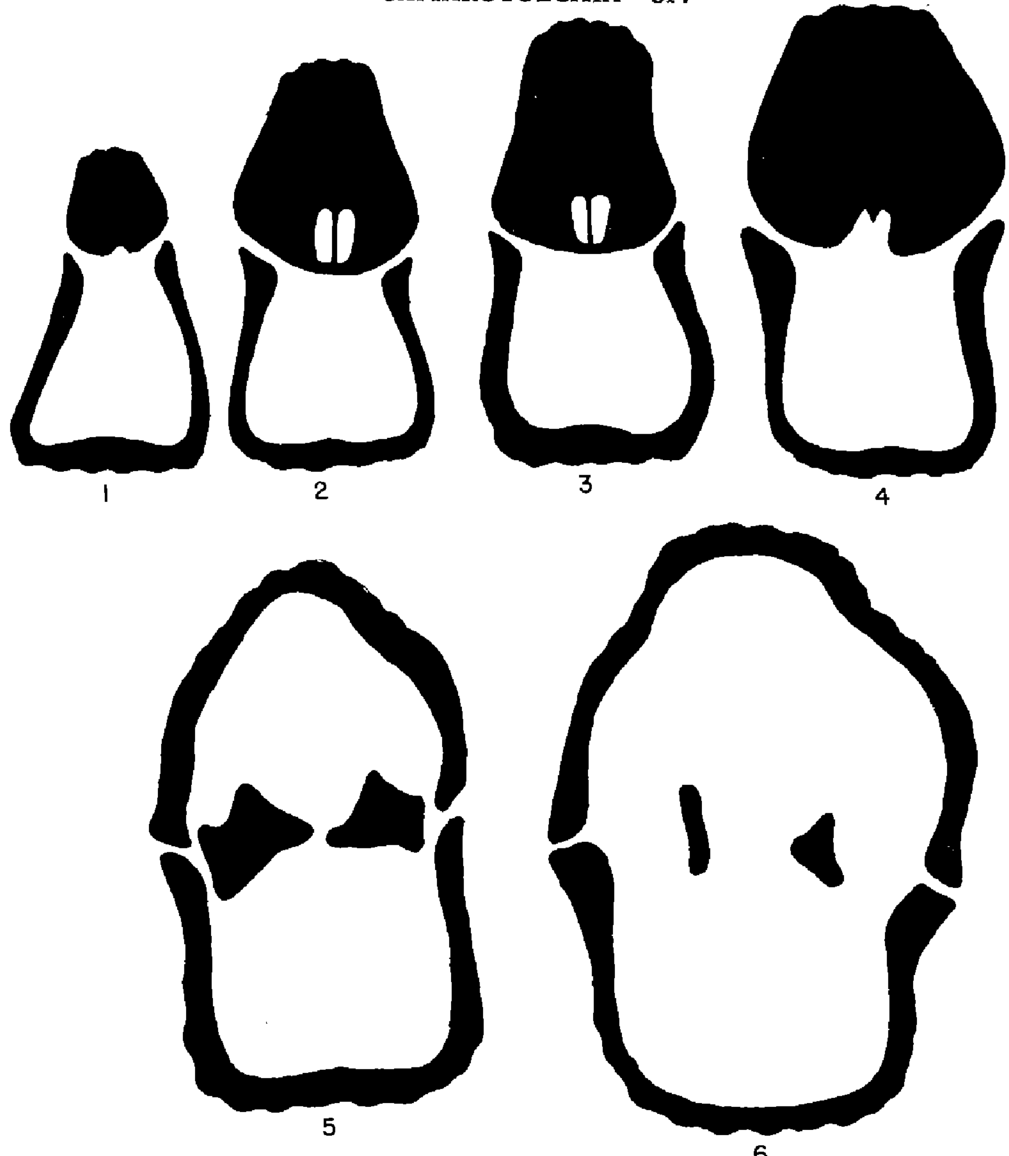
Distribution. — We have one reasonably complete specimen from P10-V, Pontotoc County, and four fragmentary valves from S5-B, S6, and S6(A), Sequoyah County.

"*Camarotoechia*" sp.

Plate III, figures 16-18; text-figure 32

Description. — "*Camarotoechia*" sp. is known from only a few fragmentary specimens collected in Sequoyah County. It has a biconvex, subtriangular shell which is somewhat pinched at the posterior end to give a rather distinctive outline (pl. III, fig. 18). The brachial valve has a fold that begins near the posterior end, becoming quite prominent at the front; four to five ribs occupy the fold. We have only a single, incomplete pedicle valve and this has a deep sulcus. The costae are subangular and coarse, spaced about five per 5 mm; costae are crossed by widely spaced lirae. The costae become obsolescent on the posterolateral margins. The small brachial valve illustrated on plate III, figure 17, measures 15 mm long, 17 mm wide; the large brachial valve figured on plate III, figure 18, measures 26 mm long, 28 mm wide.

Serial sections showing some of the internal features are illustrated in text-figure 32. The pedicle valve is relatively deep and appears to have no trace of dental lamellae. At the posterior end of the brachial valve there is a thin, vertical plate (cardinal process?) which extends forward for about 1.5 mm; aside from this there



Text-figure 32. Transverse serial sections of *"Camarotoechia"* sp. Distance from posterior tip of pedicle beak: 1 — 0.7 mm; 2 — 1.0 mm; 3 — 1.3 mm; 4 — 1.7 mm; 5 — 3.0 mm; 6 — 3.1 mm; all x6. Frisco Formation, Sequoyah County (S4-3), Oklahoma.

appears to be no trace of a median septum supporting the hinge plate.

Discussion. — The reference of this species to *Camarotoechia* is a matter of convenience as its internal characters would seem to be quite unlike that of the genotype, *C. congregata* (Cooper, 1944a, p. 311). In all probability this represents an undescribed generic stock, but neither the internal nor external characters are well enough known to permit a precise diagnosis. Externally it does not look much like any of the described Lower Devonian rhynchonellids known to us.

Figured specimens. — Localities S1-B, S6, and S8-C, Sequoyah County; numbers OU 3292-3294.

Distribution. — We have six specimens from S1-B, S4-E, S6, and S8-C, Sequoyah County. One of these specimens is a fragment with the two valves joined, and the rest are brachial valves.

Superfamily SPIRIFERACEA

GENUS *Spinoplasia* BOUCOT, 1959

Spinoplasia oklahomensis Amsden and Ventress, new species
Plate XI, figures 1-9

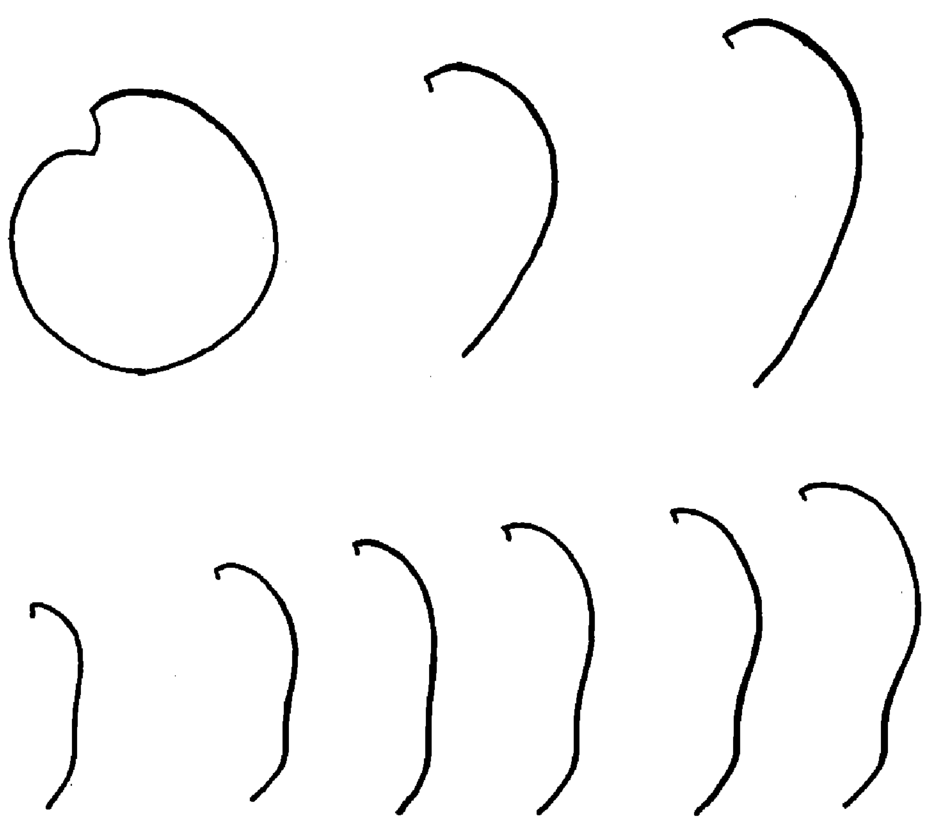
Description. — We have about two dozen specimens representing *Spinoplasia oklahomensis,* new species, all from the Frisco of Pontotoc County. They have an unequally biconvex shell, the brachial having gentle, fairly uniform convexity, the pedicle with much stronger convexity, becoming subpyramidal toward the posterior end. The hinge line is straight and the cardinal extremities are rounded; maximum width is at, or near, the hinge line. The pedicle beak is prominent, pointed, and slightly hooked at the posterior end; palintrope curved, apsacline. All our specimens have a well-defined pedicle sulcus, beginning near the beak and extending to the front margin; this is bordered on each side by a strong plication (pl. XI, figs. 2, 5). On most specimens the lateral slopes of the pedicle valve are nearly smooth, but on the larger shells there may be one or two weak lateral plications in addition to the ones bordering the sulcus (pl. XI, fig. 1). The brachial valve has a low fold bordered on each side by one or two broad, low plications. Most specimens have the surface obscured by exfoliation, but we do have one shell (pl. XI, figs. 1, 3) which clearly shows the ornamentation; this consists of concentric growth lamellae bearing rows of spines. Partly exfoliated shells commonly show a peculiar, pitted structure (pl. XI, fig. 2), possibly representing that part of the shell where the spine base was attached.

We have pedicle steinkerns showing that the muscle scars are relatively shallow and that dental plates are absent. No brachial interiors were observed.

We have 24 specimens of this species in our Frisco collections from Pontotoc County; one of these is complete with the two valves articulated, 21 are pedicle valves, and two are brachial valves (pedicle/brachial ratio 10.5). The dimensions of four nearly complete pedicle valves and of two nearly complete brachial valves are given below:

Length mm	Width mm	Length/Width ratio
	pedicle valves	
3	5	0.6
6	8	0.7
7	11	0.6
10	12	0.8
	brachial valves	
8	14	0.6
8	14	0.6

Discussion.—The genus *Spinoplasia* was proposed by Boucot for ambocoeliinids having a brachial fold with flanking plications and a spinose exterior; the genotype is *S. gaspensis* Boucot (1959a, p. 18, pl. 2, figs. 14-16) from the Helderberg of southwestern Gaspé, Quebec. The reference of our species to this genus is based largely on its external resemblance to the genotype as we have no information on the internal character of the brachial valve. *S. oklahomensis* is, however, externally quite similar to *S. gaspensis;* both species have a brachial fold with low, flanking plications, and both are ornamented with concentric rows of spines. The pedicle interior of the Frisco species is, as far as we can determine, similar to that of



Text-figure 33. Profile drawings of *Hysterolites (Acrospirifer) murchisoni* (Castelnau), x1. All are free pedicle valves except for the articulated shell in the upper left corner. The upper row is from the Frisco Formation in the Arbuckle Mountains region; the lower row is from the Frisco Formation in Sequoyah County.

S. gaspensis. Our species differs from *S. gaspensis* in having a considerably larger shell with better developed plications. The specimen which Stewart (1922, p. 247, pl. 65, fig. 14) identified as *Metaplasia* cf. *M. pyxidata* Hall may be a representative of *S. oklahomensis.* See also part III, *Spinoplasia gaspensis?* Boucot (pl. XXI, figs. 13-26).

Holotype. — Locality P9, Pontotoc County; OU 3934.

Figured specimens. — Localities P9 and P11, Pontotoc County; numbers OU 3314-3317, 3934, 3935.

Distribution. — We have 24 specimens, all from the Frisco Formation of the Arbuckle Mountains region, Pontotoc County: localities P9, P10, P11 (lower 20 feet of the Frisco).

GENUS *Hysterolites* SCHLOTHEIM, 1820
SUBGENUS *Hysterolites (Acrospirifer)* HELMBRECHT AND WEDEKIND, 1923

Hysterolites (Acrospirifer) murchisoni (Castelnau), 1843

Plate VI, figures 1-18; text-figures 33, 34

Spirifer murchisoni Castelnau, 1843, p. 41, pl. 12, figs. 1, 2; Schuchert, 1897, p. 398; Clarke, 1900, p. 46-48, pl. 6, figs. 26-30; Schuchert and Maynard, 1913, p. 411-412, pl. 70, figs. 1-5.

Spirifer arrectus Hall, 1859, p. 422-424, pl. 97, figs. 1a-h, 2a-i.

Acrospirifer murchisoni (Castelnau). Cooper, 1944a, p. 325, pl. 123, figs. 15, 16.

Description. — The shells of *Hysterolites (A.) murchisoni* are large and transverse, the width being greater than the length at all growth stages; length/width ratio ranges from 0.4 to 0.6. The hinge line is straight, with cardinal extremities subalate to subrounded; greatest width is at or near hinge line. The pedicle valve has variable convexity, as shown in text-figure 33; pedicle beak is slightly hooked at the posterior end; interarea fairly well developed, apsacline. We have not observed any deltidial plates and the delthyrium is presumed to have been open. The brachial valve is convex, moderately deep as shown in text-figure 3; beak slightly incurved over the hinge area. Well-developed, non-costate brachial fold and pedicle sulcus; sulcus generally deep, rounded at the bottom and becoming broad toward the front end; brachial fold tends to be sharply angular toward the anterior end, especially on larger shells. Surface costate, the costae ranging from subangular to subrounded, a variation probably due in part to exfoliation (costae spacing discussed below). Well-preserved specimens have low, concentric lamellae crossing the costae. Each of these lamellae bears a row of wedge-shaped granules (spines?) which have their pointed ends directed toward the front (pl. VI, figs. 3, 4). On most shells the lamellae and granules have been lost by exfoliation. The largest specimen in our collections is a pedicle valve (pl. VI, fig. 17), which measures approximately 64 mm wide and 37 mm long.

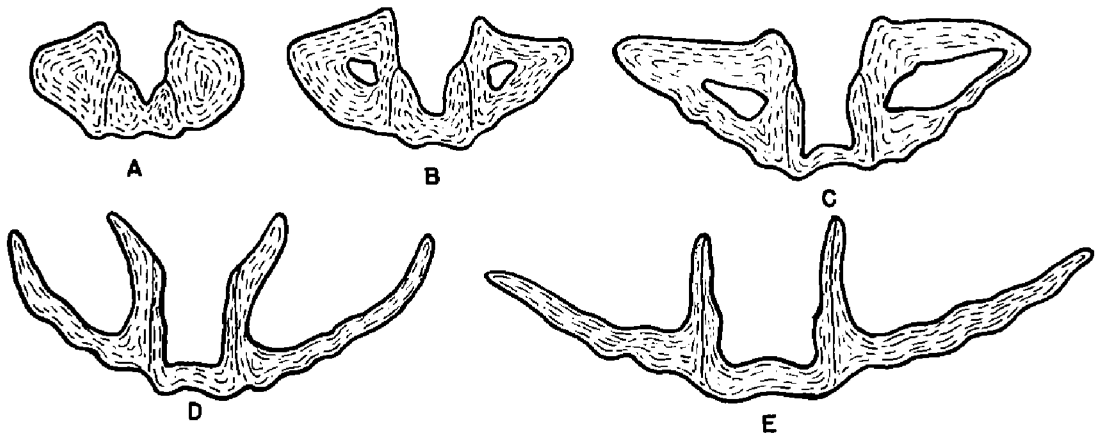
The pedicle valve of immature specimens has only moderately deep muscle scars (pl. VI, fig. 10) and short, but well-defined, dental plates (text-fig. 34). In mature shells the posterior end of the pedicle valve is greatly thickened, the muscle scars are deeply impressed, and the dental plates are short. We have no well-preserved shells showing the character of the brachial hinge-plate or spiralium.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — This is one of the most common species in the Frisco of the type area. Our collections from this region include the largest specimen of *H. (A.) murchisoni* that we have found. The costae spacing is variable, ranging from four to six in a distance of 10 mm, counted 10 mm in front of the beak, and three to five per 10 mm, counted at a distance of 20 mm. The length/width ratio ranges from 0.4 to 0.5, as shown below (all pedicle valves).

Length mm	Width mm	Length/Width ratio
29	58	0.5
19	38	0.5
15	28	0.5
15	32	0.5
18	38	0.5
18	36	0.5
17	34	0.5
22	48	0.5
25	60	0.4
21	44	0.5
23	50	0.5
25	54	0.5
18	44	0.4
25	54	0.5
21	48	0.4
21	40	0.5
35	64	0.5

Approximately 192 fragmentary and complete pedicle and brachial valves are in our collections, the pedicles being much more abundant than the brachials (pedicle/brachial ratio 15.0); we have only a single complete shell with both valves articulated (pl. VI, fig. 16, text-fig. 33).

Specimens from northeastern Oklahoma (Sequoyah County). — *Hysterolites (A.) murchisoni* is common in the Frisco of Sequoyah



Text-figure 34. *Hysterolites (Acrospirifer) murchisoni* (Castelnau). Serial sections of an immature pedicle valve, x2½. Approximate distance from the posterior tip of the pedicle beak: A — 1.1 mm; B — 2.4 mm; C — 2.7 mm; D — 3.4 mm; E — 4.2 mm. Frisco Formation, locality P11 (lower 5 feet).

County. The specimens from this area are similar to those from the type region, although they appear to be slightly smaller, the largest having a width of 43 mm; however, it should be noted that the Sequoyah County collections are smaller, and the specimens somewhat more fragmentary, than are those from the Arbuckles. The length/width ratio is similar in the shells from both areas, most pedicle valves having a ratio of about 0.5. The following measurements were taken from a suite of reasonably complete pedicle valves.

Length mm	Width mm	Length/Width ratio
6	9	0.5
12	20	0.5
14	22	0.6
15	26	0.6
15	28	0.5
17	27	0.5
18	34	0.5
20	32	0.5
20	38	0.5
22	38	0.6
23	34	0.4
25	43	0.6

The spacing of the costae appears to be slightly coarser than on the Arbuckle Mountains specimens; 3 to 5 costae occupying a space of 10 mm, counted 10 mm in front of the beak; 2 to 4 in a space of 10 mm, counted 20 mm in front of the beak.

About 106 pedicle and brachial valves are in our collections although many of these are quite fragmentary. The pedicle valves are much more common than the brachials, the pedicle/brachial ratio being about 4.5 (no articulated shells).

Discussion. — There is a question concerning the generic assignment of this species. The type of *Hysterolites* is *H. hystericus* Schlotheim, and the type species of *Acrospirifer* is *Spirifer primaevus* Steininger, both from the Lower Devonian of Germany. We have not seen representatives of either species and are therefore not familiar with their detailed structure. In 1936 Maillieux (p. 93, 96) treated *Acrospirifer* and *Hysterolites* as subgenera of *Spirifer,* but later (1941, p. 45, 51) he made *Acrospirifer* a subgenus of *Hysterolites.* According to Maillieux, *Hysterolites (Hysterolites)* is characterized by dental plates and *Hysterolites (Acrospirifer)* by its lack of dental plates. Maillieux did not discuss the fine ornamentation, but according to Havlíček (1959, p. 237, pl. 1, fig. 1) both *Hysterolites (H.)* and *Hysterolites (A.)* are characterized by concentric rows of fine spines. In this report we follow these authors and treat *Acrospirifer* as a subgenus of *Hysterolites,* but it should be noted that we are not familiar with the detailed internal and external features of the type species of either *Hysterolites* or *Acrospirifer.*

Spirifer murchisoni was named by Castelnau, who based his description on specimens from the Oriskany Sandstone of New York. Some years later Hall (1859, p. 422), apparently unaware of Castelnau's work, proposed the species *S. arrectus* for specimens from the Oriskany Sandstone of New York and Maryland. In 1897 Schuchert suppressed Hall's species as a synonym of *S. murchisoni,* and this interpretation was accepted by Clarke (1900, p. 46) and by almost all later workers. We have not examined Castelnau's type specimens, but his description and illustrations, although rather generalized, are sufficiently detailed to leave little doubt that he and Hall were describing the same species.

Hall proposed four other species at the same time that he described *S. arrectus: S. submucronatus, S. tribulis, S. cumberlandiae,* and *S. intermedius* (all from the Oriskany Sandstone at Cumberland, Maryland). Clarke (1900) in his study of the Oriskany fauna at Becraft Mountain, New York, did not discuss any of Hall's species except *S. arrectus,* which he regarded as a synonym of *S. murchisoni.* He noted, however, much variability in *S. murchisoni,* and went on to state that "it seems probable to the writer that a knowledge of these lower Devonic shells . . . will prove them to belong for the most part of Sp. *murchisoni.*" In 1913 Schuchert and Maynard published the results of a study on the Oriskany brachiopods of Maryland. These authors recognized *S. murchisoni* and also commented on its morphologic variation. In spite of their conclusion concerning the variability of Castelnau's species, they went on to name five new species and subspecies: *S. angularis, S. murchisoni marylandicus, S. hartleyi, S. perdewi,* and *S. tribuarius.* Schuchert and Maynard noted that *S. intermedius* Hall was not readily distinguishable from *S. murchisoni,* and even questioned whether two of their own creations, *S. angularis* and *S. murchisoni marylandicus,* were anything more than local expressions of one variable species, *S. murchisoni* (1913, p. 412). The senior author's examination of the type specimens of *S. tribuarius, S. perdewi,* and *S. intermedius** at the U. S. National Museum leaves considerable doubt as to the validity of these species. As a matter of fact, he would question all these species of *Hysterolites (Acrospirifer)* described by Hall, and by Schuchert and Maynard; however, a complete restudy of the Oriskany spirifers is needed before any final conclusions can be reached.

The senior author has examined a large number of specimens of *H. (A.) murchisoni* from the Oriskany Sandstone and Glenerie Limestone at the U. S. National Museum which are presumed to be representative of Castelnau's species (pl. VI, figs. 1, 2). These are similar to the typical Frisco shells in size, outline, and convexity; the costation also appears to be alike in all respects, including spacing. Some of the better preserved Oriskany specimens show concentric lamellae which are identical to those of the Frisco shells; they also have granules crossing the lamellae athough none of the Oriskany specimens examined was well enough preserved to indicate whether these were wedge-shaped. The pedicle interiors (pl. VI, fig. 1) of the New York and Maryland shells appear to be identical to those of the Frisco shells; the brachial interiors could not be compared as we have no satisfactory brachial valves from the Frisco.

Our Frisco collections of *H. (A.) murchisoni* are large but consist almost entirely of disarticulated valves, many of which are fragmentary and exfoliated. It is difficult on the basis of such material to get a precise picture of the degree of variation present, although such information as we do have indicates a considerable variation in shell characteristics. Such features as shape and size of costae, development of pedicle and brachial fold and sulcus, and curvature of the pedicle valve (text-fig. 33), clearly point to a fairly wide divergence in shell morphology, and we suspect that a better preserved suite of fossils would serve to emphasize rather than minimize this variation. The typical representatives have coarse, subangular costae and a pedicle sulcus which becomes deep toward the front end (pl. VI, figs. 14, 15, 17). However, our collections also include some

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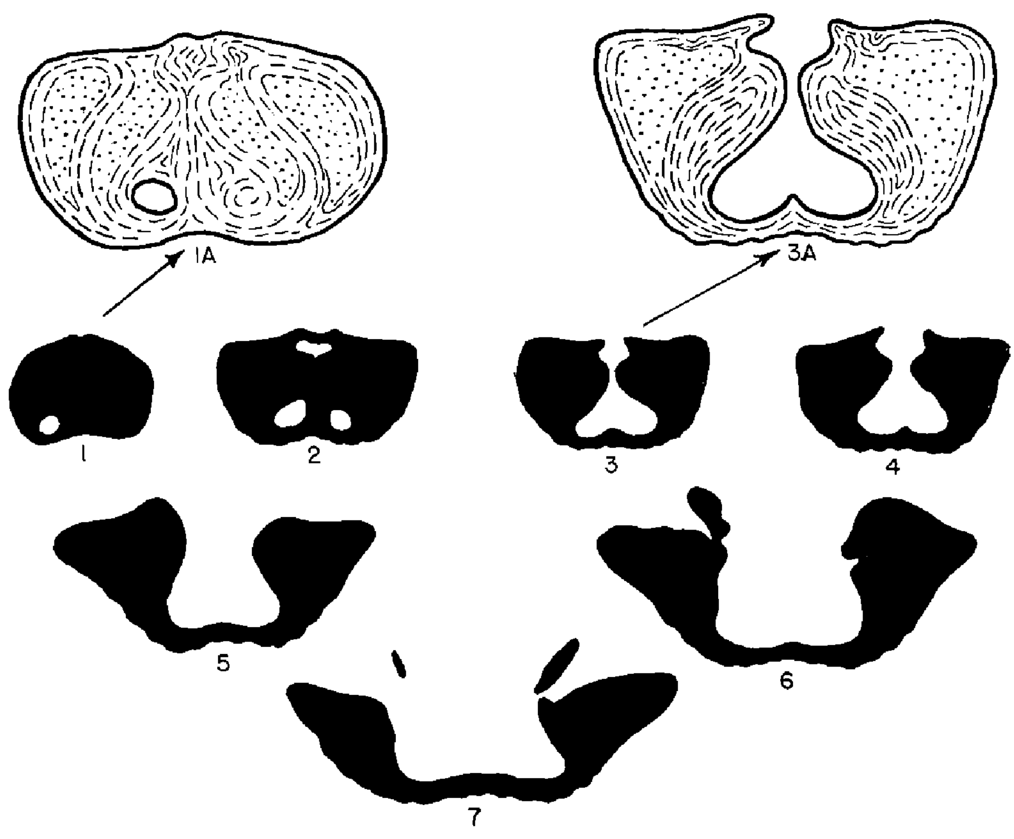
* Hall's type specimens of *S. intermedius* have not been examined; only the specimens figured by Schuchert and Maynard (1913, pl. 69, figs. 17-21) have been studied.

shells with narrower, more rounded costae, and these have some resemblance to the species which Hall (1859, p. 420, pl. 96, figs. 1a-e) named *Spirifer tribulis.** These finer ribbed Frisco specimens appear to be only a variation of the more characteristic, coarse-ribbed shells, and, as noted above, we suspect that the Oriskany specimens which Hall identified as *S. tribulis* are also only a variety of *S. murchisoni.*

Figured specimens. — Localities P8-H, P9-R, P11, Pontotoc County; S1-B, S5-B, S6, S8-C, S10-B, Sequoyah County; numbers OU 3328-3332, 3334-3336, 3338, 3340-3344.

Distribution. — Castelnau's specimens came from the Oriskany Sandstone of New York; this species has been widely reported from

* Hall compared this species to *Howellella cycloptera* (Hall) from the Helderberg, and Christian (1953, p. 31; Huffman, 1958, p. 34) reported *H. cycloptera* from the Frisco Formation of Sequoyah County; however, the Frisco specimens can be distinguished from the Helderberg species by their larger size, stronger fold and sulcus, and more transverse shells (Amsden, 1958a, p. 125-126, pl. 8, figs. 14-26; 1958b, p. 80-82, pl. 4, figs. 20-28). Note that the Haragan-Bois d'Arc species of *H. cycloptera* have double-barreled spines.



Text-figure 35. *Costispirifer arenosus* (Conrad). Serial sections of the pedicle valve; distance from the posterior tip of the pedicle beak: 1 — 4.2 mm; 2 — 5.2 mm; 3 — 5.7 mm; 4 — 6.7 mm; 5 — 9.2 mm; 6 — 12.2 mm; 7 — 14.2 mm; all x1. Numbers 1A and 3A are enlarged views (x2) showing the growth lines (dotted areas represent organic calcite showing no growth lines).

the Oriskany Formation in many parts of eastern United States. Dunbar (1919, p. 70, 75, pl. 3, figs. 1, 5) listed *H. (A.) murchisoni* from the Quall and Harriman Formations of western Tennessee, and Stewart (1922, p. 246, pl. 65, figs. 9-11) described specimens from the Little Saline Limestone of Missouri. Clarke (1908, p. 177, pl. 32, figs. 1-10) described and illustrated specimens from the Grande Grève Limestone of Quebec.

This species is well represented in our collections from both the Arbuckle Mountains region and from northeastern Oklahoma. There are about 300 pedicle and brachial valves (many are only fragments) from the following localities: Pontotoc and Coal Counties, P8-H, P9-R, P11, P10-V, V9, V10; Sequoyah County, S1-B, S5-B, S6, S6(A), S8-C, S10-B,C.

GENUS *Costispirifer* COOPER, 1942

Costispirifer arenosus (Conrad), 1839

Plate V, figures 3-11; text-figure 35

Delthyris arenosa Conrad, 1839, p. 65.

Spirifer arenosus (Conrad). Hall, 1859, p. 425, pl. 98, figs. 1-8; pl. 99, figs. 1-10; pl. 100, figs. 1-8; Schuchert and Maynard, 1913, p. 415, pl. 71, figs. 1-9; pl. 72, fig. 1.

Costispirifer arenosus (Conrad). Cooper, 1942, p. 230; 1944a, p. 323, pl. 122, figs. 27-31.

Description. — *Costispirifer arenosus* is represented in our collections by a number of specimens, mostly free pedicle valves. Most are fragmentary and this fact, coupled with the absence of articulated valves, makes it difficult to present a complete description. The pedicle valve has a straight hinge line, with fairly uniform curvature from the lateral margins to the front. Most specimens have a broad, shallow costate sulcus, but this is variable in its development and on some shells is no more than a midline flattening. The pedicle beak is prominent and only moderately incurved over the hinge area. The brachial valve is represented by only a few specimens, of which three are reasonably complete (pl. V, figs. 6, 9, 10); this valve has a costate fold, although this structure, like the pedicle sulcus, is variable in its development. Some specimens reach a large size; the brachial valve illustrated on plate V, figure 9, has a width of 66 mm. In outline they range from transverse shells with a length/width ratio of 0.7 up to those with a ratio of 1. The surface is completely costate with six to eight costae occupying a space of 10 mm (counted 20 mm in front of the pedicle beak). The costae are broad and separated by narrow interspaces. On all specimens the ribs are low and rounded, and on some there is a distinct flattening along the crest (pl. V, fig. 5). Fine, delicate costellae are superimposed on the costae (pl. V, fig. 11), and these are crossed at intervals by faint growth-lines.

The posterior end of the pedicle valve is much thickened and the muscle scars are deeply impressed (text-fig. 35); dental plates are represented only by an abbreviated ridge on the front edge of the muscle field. The delthyrium is closed, at least toward the posterior end, by a "deltidium" (text-fig. 35), a structure which is also present on the Oriskany specimens. We have not observed the brachial hinge-plate or spiralium of the Frisco specimens.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Our collection from the type region includes only seven specimens; four of these are pedicle and three are brachial valves (pedicle/brachial ratio 1.3). The pedicle valves are too fragmentary to determine their size, but the brachials give the following measurements: length 42 mm (est.), width 66 mm; length 45 mm, width 56 mm; length 40 mm (est.), width 60 mm. These shells are somewhat larger than any from Sequoyah County, but otherwise appear to be similar in so far as can be determined from the rather incomplete representation on hand.

Specimens from northeastern Oklahoma (Sequoyah County). — The collections from Sequoyah County are larger than those from the Arbuckles, but the specimens are mostly fragmentary and consist entirely of free valves. About 40 specimens are in our collections, most of these being pedicle valves; the pedicle/brachial ratio is 5.1. The measurements of five reasonably complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio
17	22	0.8
25	34	0.7
38	40	0.9
40	45	0.9
50	50	1.0

The spacing of the costae ranges from six to eight per 10 mm (counted 20 mm in front of the pedicle beak), with most having a spacing of seven; many specimens show a marked flattening along the crest of the ribs (pl. V, fig. 5). Except for their slightly smaller size, the Sequoyah County specimens resemble those from the Arbuckles.

Discussion. — The genus *Costispirifer* was proposed by Cooper (1942, p. 232), the genotype being *Spirifer arenosus planicostatus* Swartz (1929, p. 56-57, pl. 9, figs. 13-15). This subspecies, which, according to Swartz, came from the cherts in the upper part of the Giles Formation near Saltville, Virginia (? equals Saltville Chert), was distinguished from *Spirifer arenosus* Conrad largely on the basis of its flat costae (Cooper, 1942, recognized *C. planicostatus* as a distinct species). The senior author has examined U. S. National Museum specimens of *C. planicostatus* from the Onondaga (? Saltville Chert), near Saltville, Virginia, and the Huntersville Chert, West Virginia. These shells are characterized by their strongly flattened ribs and extremely narrow interspaces; on some specimens the interspaces are only narrow grooves. He has also examined the U. S. National Museum collections of *C. arenosus* from the Oriskany Sandstone and the Glenerie Limestone and has found that some of these shells, as noted by earlier authors (Clarke, 1900, p. 46; Stewart, 1922, p. 245), also have flattened ribs, but on none of these is the flattening as marked as it is on *C. planicostatus;* furthermore, the interspaces on *C. arenosus* are distinctly wider than on *C. planicostatus.*

Delthyris arenosus was proposed by Conrad, his description being based on specimens from the "Helderberg, in sandstone" (Oriskany Sandstone), New York. We have not seen Conrad's types, but his description would seem adequate to identify the Oriskany shell he was describing. The Frisco specimens appear to be similar to the Oriskany-Glenerie specimens in size, outline, and ornamentation, including the development of flattened ribs. The pedicle interiors of the Oklahoma shells also appear to be identical to those of the New York and Maryland specimens. We do not have satisfactory brachial interiors of the Frisco shells.

Figured specimens. — Localities P8-H and P11, Pontotoc County; S1-B, S5-B, and S8-C, Sequoyah County; numbers OU 3320-3325, 3930, 3931.

Distribution. — *Costispirifer arenosus* has been widely reported from the Oriskany Formation in many parts of the eastern United States. Dunbar (1919, p. 70, pl. 3, fig. 7) found specimens in the Quall Limestone [= Harriman] of western Tennessee, and Stewart (1922, p. 245, pl. 65, figs. 6-8) described and illustrated specimens from the Little Saline Limestone of Missouri. Merriam (1940, pl. 7, fig. 17; pl. 11, fig. 17) illustrated specimens identified as *Spirifer* cf. *S. arenosus* from the Nevada Limestone in the Roberts Mountains, Nevada. Clarke (1908, p. 179, pl. 33, figs. 1-10) described and illustrated specimens from the Grande Grève Limestone.

Our Frisco collections include a total of 50 isolated valves, most being fragmentary. These came from the following localities: Pontotoc County, P11 (specimens from the lower 5 feet of the Frisco, and from 60 feet above the base of the formation); Sequoyah County, S1-B, S8-C, S5-B, S6(A).

GENUS *Kozlowskiellina* BOUCOT, 1958
(= *Kozlowskiella* Boucot, 1957, not Pribyl, 1953)

Kozlowskiellina (Megakozlowskiellina) new species
Plate V, figures 1, 2

Description. — Our description of this species is based on one reasonably complete pedicle valve and a few fragmentary specimens. The shell is biconvex and transverse, with maximum width at, or near, the hinge line. It has a prominent pedicle beak which is slightly hooked toward the brachial; the palintrope appears to be slightly curved and nearly orthocline, although this part of the shell may be somewhat distorted due to crushing. There is a conspicuous, non-costate pedicle sulcus which begins near the beak, becoming broad and deep at the front end. The largest specimen (pl. V, figs. 1, 2) has six costae on each side of the sulcus. The costae are crossed by strongly developed, concentric lamellae; the lamellae have fine, radial costellae (pl. V, fig. 2) which may have extended forward as a fringe of spines. We have only two poorly preserved brachial valves; these show a non-costate fold, but their other features are obscure.

We have no information on the internal structure of this species.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Five specimens are in our Frisco collections from the type area. The illustrated shell is the largest and is the only one which is reasonably complete and well preserved; the brachial valve is preserved on this specimen, athough it is crushed and exfoliated. The other specimens are all small fragments of free valves, three being pedicles and one a brachial; pedicle/brachial ratio 3.0. The figured specimen measures 28 mm long by 52 mm wide; length/width ratio 0.5.

Specimens from northeastern Oklahoma (Sequoyah County). — We have five, small fragmentary brachial valves which may be representatives of *Kozlowskiellina.* They have an external ornamentation like that of the Arbuckle specimens, but appear to have broader and deeper plications. The preservation is not good enough to justify a more precise identification.

Discussion. — The reference of our specimens to *Kozlowskiellina* is based entirely on external features as we have no information concerning its internal structure. In shape and ornamentation our specimens would seem to be sufficiently similar to typical representatives of *Kozlowskiellina* (Boucot, 1957, p. 318-323, pl. 2) to justify this generic assignment. It should be noted, however, that their ornamentation is also similar to that found on *Eleutherokomma* (Crickmay, 1950, p. 220, pls. 36, 37), although there is no evidence that the Frisco shells are even slightly mucronate.

This species has a much larger shell than does *K. (M.) velata* Amsden (1958a, p. 121-126, pl. 8, figs. 1-13; 1958b, p. 78-80, pl. 5, figs. 29-34). Also in the immature stages of the Frisco species the spacing of the costae is slightly closer than it is on the Haragan-Bois d'Arc shells of comparable size.

To our knowledge this is the only report of *Kozlowskiellina* in North American strata of post-Helderbergian age.

Figured specimens. — Locality P11; number OU 3313.

Distribution. — Five specimens in our Frisco collections are from Pontotoc County; all are from locality P11 and were collected from a bed 60 feet above the base of the formation. We also have five fragmentary specimens, which may be representatives of this genus, from the Frisco in Sequoyah County (localities S5-B and S6).

GENUS *Eospirifer* SCHUCHERT, 1913

Eospirifer new species
Plate IV, figures 12-15

Description. — This species is represented in our collections by nine free valves, although all but four of these are extremely fragmentary. The shell is large, subequally biconvex, and has a transverse outline; length/width ratio about 0.6 to 0.7. The hinge line is fairly straight and the cardinal extremities are rounded; from the posterolateral margins forward the outline is broadly rounded. The pedicle beak is pointed and its tip is inclined slightly toward the brachial; the palintrope is apsacline. A pedicle sulcus begins near the posterior end, becoming broad and U-shaped at the front; it is bordered on each side by three lateral plications (pl. IV, fig. 13). The brachial valve has a fold which starts near the posterior end and extends to the front margin, where it is high and broad; the crest is flattened, giving it a subrectangular cross section. Two well-defined plications occupy each lateral slope, and on one specimen (pl. IV, fig. 12) there is a faint third plication near the outer edge. On none of our specimens do the ribs split, nor are new ones implanted between the old ones. The Frisco specimens have lost most of the outer shell by exfoliation, but three still retain patches of the surface and these show fine, radial costellae (pl. IV, fig. 14); approximately seven costellae occupy a space of 2 mm.

No pedicle or brachial interiors were observed.

Specimens from northeastern Oklahoma (Sequoyah County). — This species has been found only in the Frisco Formation of Sequoyah County. Our collections include nine free valves, four of these being moderately complete; pedicle/brachial ratio 3.5. The most complete pedicle valve measures 31 mm long by 42 mm wide; one brachial valve measures 26 mm long by 44 mm wide and another 28 mm long by 40 mm wide.

Discussion. — The genus *Eospirifer* was proposed by Schuchert (1913, p. 411), the genotype being *Spirifer radiatus* Sowerby. In 1959 Havlíček (p. 228-232) reviewed the Eospiriferinae, recognizing three groups. (1) *Eospirifer* sensu stricto characterized by smooth or broadly ribbed shells; in no case do the ribs branch, nor are new ribs implanted between the old ones. The fine ornamentation consists of radial lines (costellae). The basal plates vary in length, but their inner edges always rest on the floor of the brachial valve. Havlíček included 29 species in this genus, most being from rocks of Silurian age; *E. macropleura* (Conrad) was the only specimen reported from the Devonian of North America (seven European Devonian species were included). (2) *Janius* Havlíček, 1957 (genotype *Spirifer nobilis* Barrande), characterized by ribbed shells, the ribs either branching dichotomously or with new ones implanted between the old; fine ornamentation consisting of radial lines (costellae). The basal plates "meet only the thickened posterior margin of the dorsal valve; their inner edges are practically free along the whole length." Nine species were assigned to this genus, most being from strata of Silurian age; none from North America. (3) Group of *Eospirifer sergaensis* Khodalevich characterized by sharply ribbed shells having ribs on the fold and sulcus; fine ornamentation as in the other two groups. Four species listed, none from North America. Havlíček did not give a name to this group as he had no information on the internal structure of the brachial valve.

The external characters of the Frisco shells clearly seem to place them in *Eospirifer* sensu lato (and in *Eospirifer* as diagnosed by Havlíček), but it should be kept in mind that we have no information on the internal character of our specimens, nor are we familiar with the detailed structure of the type species. The Frisco shells are most like *E. macropleura* (Conrad), but a direct comparison with specimens from the Helderberg strata of New York reveals several differences. *Eospirifer* new species has a higher, better defined fold and sulcus than has *E. macropleura;* moreover, the fold on the Frisco shells is flattened along the crest, giving it a subrectangular cross section in contrast to the broadly rounded fold of *E. macropleura.* In addition the plications on the Frisco shells are higher and the interspaces deeper and better defined than are those on the New York shells. The Frisco specimens almost certainly represent a new species, but we are reluctant to name it without more representative material.

In so far as we are aware this is the first report of an *Eospirifer* in North American strata of post-Helderbergian age; however, Havlíček (1959, p. 229-239) listed two species from the Middle Devonian of Russia.

Figured specimens. — Localities S5-B, S6, Sequoyah County; numbers OU 3309-3311.

Distribution. — We have nine specimens from the Frisco Formation in Sequoyah County; localities S5-B, S6, S6(A).

Superfamily ROSTROSPIRACEA

GENUS *Meristella* HALL, 1860

Meristella carinata Stewart, 1922

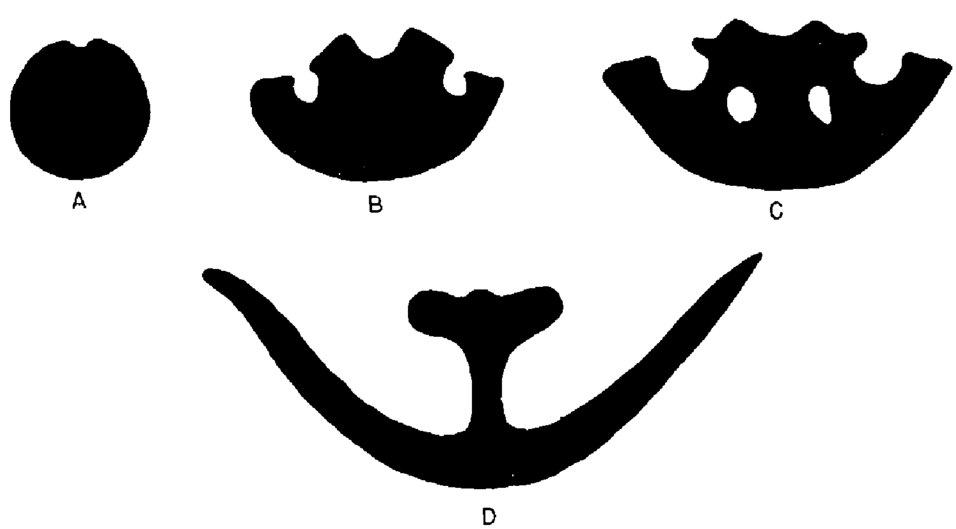
Plate VII, figures 7-18; plate X, figures 4-12; text-figure 36

Meristella carinata Stewart, 1922, p. 250, pl. 66, figs. 12-21.

Description. — *Meristella carinata* is one of the more common brachiopods in the Frisco Formation and is represented in our collections by many free valves. It has a subtriangular outline with the width slightly greater than the length at all growth stages. The pedicle valve is gently and uniformly convex in the umbonal region, and the beak is inclined toward the brachial valve; the posterolateral margins are sharply deflected. Toward the front end this valve is invariably flattened and on some shells the central portion is depressed to produce a shallow sulcus. The development of this sulcus is variable, but it is not conspicuous and on some specimens it is absent. The anterior end of the pedicle valve is extended into a tongue which fits into the brachial fold. Most brachial valves are sharply flexed along the middle of the shell, from the umbo to the front end, and on some specimens this is developed strongly enough to produce a subcarinate shell; from the crest of this structure the valves slope evenly toward the lateral margins. The surface is marked with concentric growth lines, and a few of the Frisco shells have faint, delicate radial ribs; these are quite inconspicuous and seem to be confined to the anterior part of the shell. It is not possible to determine if these ribs are a constant shell feature as most of our specimens are exfoliated to some degree. The shell is impunctate.

The shell is much thickened at the posterior end of the pedicle valve; the delthyrial cavity is narrow and deep, and extends forward into the deeply impressed muscle field (pl. VII, fig. 12; pl. X, fig. 12). Mature shells show no trace of dental plates. The brachial valve is also thickened at the posterior end although not so much as is the pedicle. This valve has a relatively heavy hinge plate, which is supported by a stout median septum; at the posterior end this plate is U-shaped, but anteriorly it develops a low ridge in the middle (text-fig. 36). The median septum is long, extending forward beyond the middle of the valve. The spiralium and jugum were not observed.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — *Meristella carinata* is abundantly represented in our Frisco collections from Pontotoc and Coal Counties. We have approximately 443 specimens, of which one is complete with both



Text-figure 36. Transverse serial sections of the brachial valve of *Meristella carinata* Stewart from the Frisco Formation (OU 3391). Distance from the posterior tip of the brachial beak: A — 1.3 mm; B — 1.6 mm; C — 2.0 mm; D — 2.5 mm; all x5.

valves, 66 are free brachials, and 376 are free pedicles; pedicle/brachial ratio 5.6. The shells from this area are mostly of moderate to small size, few exceeding a length of 20 mm. The dimensions of 12 pedicle valves and five brachial valves are given below:

Length mm	Width mm	Length/Width ratio
	pedicle	
7.8	8.1	1.0
10.6	11.6	0.9
16.0	17.5	0.9
16.2	17.9	0.9
16.4	17.1	1.0
17.3	19.1	0.9
17.3	19.6	0.9
18.5	20.0	0.9
19.0	20.5	0.9
19.1	19.0	1.0
19.7	21.0	0.9
25.0	27.0	0.9
	brachial	
16.5	21.4	0.8
17.0	18.5	0.9
17.3	20.0	0.9
18.5	22.3	0.8
19.5	22.5	0.9

Specimens from northeastern Oklahoma (Sequoyah County). — *Meristella carinata* is not nearly so well represented in the Frisco of Sequoyah County as it is in the Arbuckle region, nor is the preservation as good. We have a total of 26 specimens from this area, 15 being free pedicles and 11 free brachials; pedicle/brachial ratio 1.4. These shells may be, on the average, slightly larger than those from Pontotoc County, but otherwise appear to be typical representatives of *M. carinata,* at least in so far as can be determined from the somewhat fragmentary material on hand. The dimensions of four pedicle valves and four brachial valves are given below:

Length mm	Width mm	Length/Width ratio
	pedicle	
12.0	12.6	1.0
15.5	16.5	0.9
17	21	0.8
26	29	0.9
	brachial	
15.5	16.5	0.9
16.8	18.7	0.9
17.3	20.0	0.8
23.5	26.5	0.9

Discussion. — There is some question concerning the genotype of *Meristella,* but in this report we follow the generally accepted designation of *Atrypa laevis* Vanuxem (Amsden, 1958a, p. 129-130). On the basis of this generic diagnosis, the Frisco specimens of *M. carinata* have the internal and external characters commonly associated with *Meristella,* although it should be noted that we have no information on the spiralium and jugum.

Stewart's description of this species was based on specimens from the Little Saline Limestone of Missouri. Through the courtesy of M. H. Nitecki, we were able to borrow the type specimens from Walker Museum, University of Chicago, and these are reillustrated on plate X, figures 4-12. Our Frisco specimens are not so well preserved as are those from the Little Saline Limestone, but in so far as can be determined the Oklahoma shells are identical to those from Missouri in profile, outline, and development of the fold and sulcus. We have no information on the brachial interior of the Little Saline shells, but the pedicle interiors of the Oklahoma and Missouri specimens are similar. A few of the Frisco shells have faint, delicate, radial ribbing in addition to the concentric growth lines, whereas Stewart's type specimens show only the concentric banding. The latter are, however, partly exfoliated and the apparent absence of radial striae may be due to poor preservation (only a few Oklahoma shells show this).

Maxwell (1936, p. 104) recorded the Oriskany species *Meristella lata* Hall (1859, p. 431, pl. 101, figs. 3a-3m) from the Frisco Formation, and Stewart compared *M. carinata* with Hall's species. Through the courtesy of Donald F. Squires, we were able to borrow Hall's type specimens from the American Museum of Natural History, and these are reillustrated on plate X, figures 17 to 23. *M. lata* has a larger shell than has *M. carinata,* and the brachial valve is not sharply convex as in the Missouri-Oklahoma shells. The Oriskany shells have faint, delicate radial ribs on the front part of the shell (pl. X, fig. 21).

The shells of *M. carinata* are similar in size to those of *M. atoka* Girty from the Haragan and Bois d'Arc Formations (Amsden, 1958a, p. 128-132, pl. 10, figs. 1-15; 1958b, p. 84-85, pl. 4, figs. 1-14). The Frisco specimens can, however, be easily distinguished from *M. atoka* by their more weakly developed folds and sulci and their slightly more transverse shells.

Figured specimens. — The Frisco specimens of *M. carinata* are illustrated on plate VII; localities P8-H, P11, V7 in Pontotoc County, and localities S1-B and S10-C in Sequoyah County; numbers OU

3348-3357. Stewart's type specimens from the Little Saline Limestone of Missouri are illustrated on plate X; these are located at Walker Museum, University of Chicago; numbers WM 27491, 27491B, 27491A (holotype).

Distribution. — The original description of *M. carinata* was based on specimens from the Little Saline Limestone of Missouri. It is abundantly represented in the Frisco Formation of the Arbuckle Mountains region, there being about 443 specimens in our collections from the following localities: Pontotoc County, P8-H; P9-R(V4), P10-V(V3), P11(V1),V7; Coal County, V9, V10. We have only 28 specimens from the Frisco Formation in Sequoyah County: S1-B, S5-B, S6, S7-B, S8-C, S10-B,C.

"Meristella" vascularia? Clarke, 1900

Plate IX, figures 13-17; plate X, figures 1-3; text-figures 37, 38

Meristella? vascularia Clarke, 1900, p. 45-46, pl. 6, figs. 12-14.

Description. — This species is characterized by its large, subequally biconvex shell. The pedicle valve is elongate oval in outline, the length being consistently greater than the width (length/width ratio of three specimens ranges from 1.1 to 1.2); pedicle beak elongate, inclined slightly toward the brachial. A pedicle sulcus begins about 20 mm in front of the beak and becomes broad, but not deep, toward the front end (pl. IX, figs. 14, 17). The brachial valve has a uniform curvature except for a low fold near the anterior end. On most shells the external surface has been lost by exfoliation, but we have a few shells that retain a part of the outside shell and these show an ornamentation consisting of delicate, radial costellae which are crossed by closely spaced, concentric filae; the intersection of these two sets of ridges produces a faint, cancellated texture (pl. IX, fig. 15).

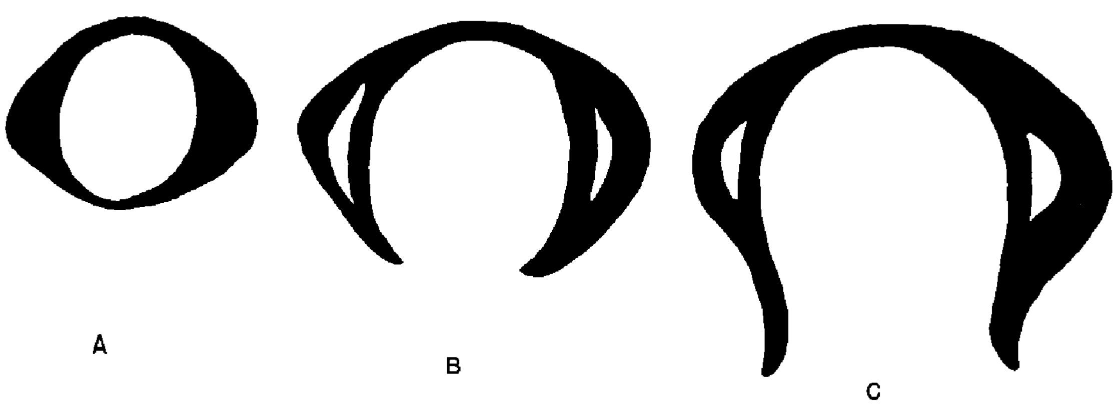
The pedicle interior is characterized by stout dental plates and a weakly impressed muscle area (text-fig. 37). The shell wall is relatively thin, even near the posterior end. One partly exfoliated steinkern shows weak vascular impressions radiating out from the beak. In the brachial interior the socket plates unite to make a shallow cruralium which is supported on a median septum (text-fig. 38). This median septum extends forward a considerable distance. One brachial valve with a total length of 35 mm has a septum almost 15 mm long.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — Two somewhat fragmentary pedicle valves from this area are questionably referred to this species. These have relatively small shells, the larger being approximately 22 mm long by 20 mm wide (length/width ratio 1.1).

Specimens from northeastern Oklahoma (Sequoyah County). — Our collections from this area include 22 specimens, mostly fragmentary, of which 18 are pedicle valves and four are brachial valves; pedicle/brachial ratio 4.5. The dimensions of three reasonably complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio
24	22	1.1
39	32	1.2
54	49	1.1

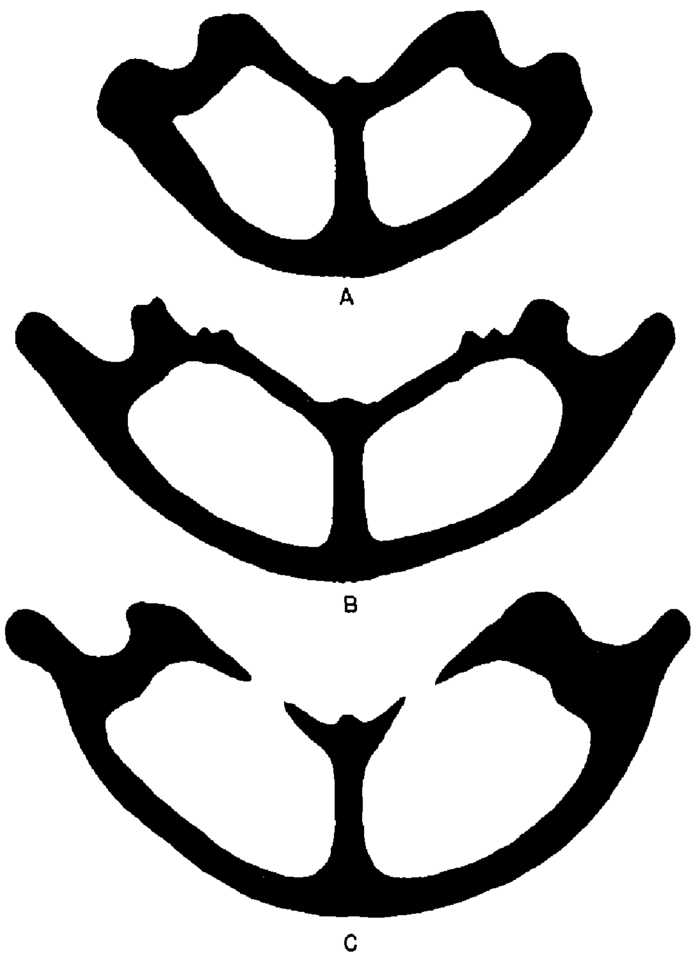
Discussion. — Clarke based his description of this species upon species from the Oriskany Sandstone, Becraft Mountain, New York; and, through the courtesy of Clinton F. Kilfoyle, we were able to borrow his types from the New York State Museum. These comprise three pedicle steinkerns, two of which retain some traces of external shell. We have reillustrated these specimens on plate X, figures 1-3. All three shells have stout dental plates and relatively shallow muscle areas. According to Clarke the "Very prominent lamellae are developed by convergence and union into a strong spoon-shaped process [elsewhere termed a spondylium], which fills the umbonal region and rests on the bottom of the valve, its anterior edge being free." The type specimens have clearly defined dental plates, but do not show any structure which we would call a spondylium. (The delthyrial cavity is marked off from the anterior part of the shell by a low callosity.) Two of the valves show well-defined pallial markings (pl. X, figs. 1, 2), and the third retains some of the external shell, showing faint radial costellae (pl. X, fig. 3). The Frisco shells resemble Clarke's specimens in size, outline, pro-



Text-figure 37. Transverse serial sections of the pedicle valve of *"Meristella" vascularia?* Clarke from the Frisco Formation, Sequoyah County, Oklahoma. Approximate distance from the posterior tip of the pedicle beak: A — 3 mm; B — 4 mm; C — 5 mm; all x4.

file, and ornamentation; however, two of the Oriskany specimens have a narrow portion of the lateral margins deflected dorsally, a shell feature which we have not observed on the Oklahoma specimens. The pedicle interiors of the New York and Oklahoma specimens are also similar except for the pallial markings which appear to be somewhat stronger on the Oriskany shells. It is difficult to make a precise comparison on the basis of this rather fragmentary material, especially as we have not seen any brachial valves from the Oriskany Formation. (Clarke's description indicates that he had no brachial valves.) The Frisco specimens are, however, certainly similar to, and probably conspecific with, those from the Oriskany.

This species does not belong in *Meristella,* at least not as that genus is conventionally diagnosed (see dicussion under *Meristella carinata,* and Amsden, 1958a, p. 129-130). *Meristella* is generally considered to be characterized by deeply impressed pedicle muscle



Text-figure 38. Transverse serial sections of the brachial valve of "*Meristella*" *vascularia?* Clarke from the Frisco Formation, Sequoyah County, Oklahoma. Approximate distance from the posterior tip of the brachial valve: A — 1.5 mm; B — 2.8 mm; C — 3.2 mm; all x8.

scars with the dental plates becoming obscure in mature shells by the deposition of secondary shell material. In contrast the Oriskany and Frisco specimens of *"Meristella" vascularia?*, which are certainly mature shells, have clearly defined dental plates and a shallow muscle field. In all probability *"M." vascularia?* represents an undescribed meristelloid brachiopod characterized by its large size, weak radial costellae, and well-defined dental plates. The cruralium of the Frisco specimens appears to be fairly typical for a meristelloid brachiopod. Unfortunately, we have no information on the structure of the spiralium and jugum, and the preservation of Frisco brachiopods is such that it seems unlikely such information will ever be obtained.

"Meristella" vascularia? has a larger shell and a better defined pedicle sulcus than has either *Meristella carinata* Stewart (pl. VII, figs. 7-18; pl. X, figs. 4-12) or *Meristella lata* Hall (pl. X, figs. 17-23). Both of these species lack dental plates.

Figured specimens. — The Frisco specimens of this species are illustrated on plate IX; localities S1-B, S8-C, S10-B; numbers OU 3388-3390. Clarke's type specimens from the Oriskany Sandstone of New York are illustrated on plate X; these specimens are at the New York State Museum; numbers NYSM 1569, 1570, 1571.

Distribution. — Clarke's specimens came from the Oriskany Sandstone of New York. Our specimens of *"Meristella" vascularia?* came from the Frisco Formation; we have two specimens from the Arbuckle Mountains region at locality P11, and about 22 from Sequoyah County, localities S1-B, S6, S8-C, and S10-B,C.

Superfamily PUNCTOSPIRACEA

GENUS *Cyrtina* DAVIDSON, 1858

Cyrtina rostrata (Hall), 1857

Plate VIII, figures 15-23; text-figure 39.

Cyrtia rostrata Hall, 1857, p. 64; Hall, 1859, p. 429, pl. 96, figs. 1-6; pl. 98, figs. 8a, b.

Cyrtina rostrata (Hall). Hall and Clarke, 1894, pl. 25, figs. 1-8; pl. 28, fig. 6; Schuchert and Maynard, 1913, p. 423-424, pl. 71, figs. 10-16.

Description. — *Cyrtina rostrata* has an unequally biconvex shell, the brachial valve having a gentle and uniform convexity, and the pedicle valve having a deep convexity which becomes subpyramidal in the umbonal region. The pedicle beak is pointed, erect, and not hooked at the posterior tip; pedicle palintrope large, apsacline;

delthyrium partly closed by an arched, hood-like structure (pl. VIII, figs. 21, 22). The pedicle valve has a noncostate sulcus which begins at the posterior tip, becoming broad and deep toward the front margin. There is a corresponding fold on the brachial valve which is commonly flattened along its crest, and which on a few specimens has a faint groove along its midline (pl. VIII, fig. 15). The surface is costate; 5 mm in front of the beak there are six to seven costae in a space of 5 mm. The costae are crossed by closely spaced, concentric lamellae. The shell is coarsely punctate.

The pedicle valve has well-developed dental plates which unite to form a spondylium before reaching the floor of the valve. This spondylium is supported by a median septum that extends into the spondylial cavity as a ridge (pl. VIII, fig. 23); within the cavity this part of the septum is hollow and is divided into halves by a vertical plate (text-fig. 39; pl. VIII, fig. 21). The anterior end of this hollow septum is open, the posterior end is probably closed. We are not entirely certain regarding the function of this ridge; possibly it served as the point of attachment for the muscles (Amsden, 1958a, p. 135). The median septum extends forward beyond the spondylium. A short, but stout, cardinal process is present in the brachial valve. The spiralium was not observed.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — We have 65 specimens from this area; almost all are free valves, and a number are fragmentary. One of our specimens has the two valves articulated; 39 of the free valves are pedicles and 24 are brachials; pedicle/brachial ratio 1.6. Two nearly complete pedicle valves measure 17 mm long by 33 mm wide, and 19 mm long by 40 mm wide. Three brachial valves measure 8 mm long by 19 mm wide, 13 mm long by 25 mm wide, and 14 mm long by 31 mm wide.

Specimens from northeastern Oklahoma (Sequoyah County). — We have 13 free valves from the Frisco Formation of Sequoyah

Text-figure 39. Transverse serial sections of *Cyrtina rostrata* (Hall) from the Frisco Formation. Distance from the posterior tip of the pedicle beak: A — 3 mm; B — 3.7 mm; all x3. A photograph of another peel from this specimen is shown on plate VIII, figure 21.

County; two of these are pedicle valves and 11 are brachial valves; pedicle/brachial ratio 0.18.

Discussion. — The type species of *Cyrtina* is *C. heteroclyta* (DeFrance), a Middle Devonian species the internal structure of which, so far as we know, has never been adequately described (Amsden, 1958a, p. 135). The Frisco specimens here referred to *C. rostrata* have the internal and external characters generally ascribed to *Cyrtina* and accordingly are retained within this genus.

Hall's original description of *C. rostrata* was based upon specimens from the Oriskany Sandstone of Maryland. A couple of years later Hall furnished additional details, including illustrations, on specimens from Maryland and New York. A direct comparison of our shells with those from the Oriskany Sandstone and Glenerie Limestone shows a marked similarity in profile, outline, and costation. According to Hall, *C. rostrata* has fine radiating striae in addition to the costae, but we have not observed this on either the Oriskany-Glenerie or Frisco specimens. The absence of striae may be due to exfoliation, as this delicate type of ornamentation is easily lost. The Frisco specimens appear to be somewhat larger, on the average, than the eastern representatives, although this difference is not marked and the U. S. National Museum collections include some shells from the Oriskany Sandstone almost as large as any from Oklahoma. In so far as can be determined, the internal characters of the Frisco specimens are the same as those of the Oriskany specimens; Hall's illustrations show an open delthyrium, but the New York-Maryland shells which we examined invariably appear to have this structure closed by an arched deltidium.

Two other species, *C. affinis* Billings and *C. varia* Clarke, have been described from Deerparkian strata, but Clarke (1908, p. 183) later suppressed them as synonyms of *C. rostrata.*

The Frisco specimens of *C. rostrata* have a pedicle internal structure similar to that of *C. dalmani nana* Amsden (1958a, p. 133-136, pl. 7, figs. 19-28, text-figs. 34, 35) from the Haragan-Bois d'Arc Formations. The principal difference is that in the Frisco shells the hollow part of the median septum is completely divided into two parts by an internal plate, whereas in the Haragan species this part is only partly cleft by internal plates extending part way down from the top and up from the bottom.

Figured specimens. — Localities P8-H and P11, Pontotoc County; numbers OU 3367-3375.

Distribution. — *Cyrtina rostrata* has been found in the Oriskany Sandstone throughout most of its outcrop area. Clarke (1908, p.

183, pl. 31, figs. 25-28) described specimens from the Grande Grève Limestone of Gaspé, and Stewart (1922, p. 247, pl. 65, fig. 13) found a single brachial valve in the Little Saline Limestone of Missouri. Dunbar (1919, p. 76) reported it from both the Camden and Harriman Formations of western Tennessee.

This species is moderately common in the Frisco Formation of Oklahoma; our collections include a total of 78 specimens although many of these are fragmentary. These came from the following localities in Pontotoc County: P8-H, P10, P11 (at this locality some specimens were found in a bed 40 feet above the base of the Frisco); in Sequoyah County: S4-E, S5-B, S6, S6(A).

GENUS *Trematospira* HALL, 1859

Trematospira sp.
Plate IV, figure 11

Description. — This species is represented in the Frisco collections by only two, incomplete pedicle valves, both coming from the Lawrence uplift in Pontotoc County. These have a transverse shell with moderate and even convexity. The pedicle beak is small and incurved over the brachial; the interarea is obscure. A poorly defined pedicle sulcus begins in front of the beak and becomes broad (but not deep) at the front. The surface is marked with narrow, subangular costellae, four to five occupying a space of 5 mm at the front margin; these increase by bifurcation so that the spacing remains more or less constant from back to front. The costae show some irregularity in height, suggesting fasciculation; but, as our shells are not well preserved, this may be the result of exfoliation. The shell is punctate. No interiors were observed.

Discussion. — It is difficult to make a satisfactory species comparison on the basis of our meager collection, but the Frisco shells do show some similarity to the Oriskany specimens which Clarke (1900, p. 43, pl. 6, figs. 1-4) identified as *T. multistriata,* a species originally described by Hall (1857, p. 59) from the Helderberg of New York. Clarke's illustrations indicate that the Oriskany shells are considerably smaller and more coarsely costate than are those from the Helderberg, and a restudy of specimens from both formations is needed to establish that they are conspecific. The Frisco specimens have a marked resemblance to the Little Saline specimens which Stewart (1922, p. 248, pl. 65, figs. 4, 5) identified as *T. multistriata* (Hall).

Figured specimens. — Locality P11, Pontotoc County; number OU 3312.

Distribution. — This is a rare species and has been found only in the Arbuckle Mountains region. Two pedicle valves from P11 (V1), Pontotoc County.

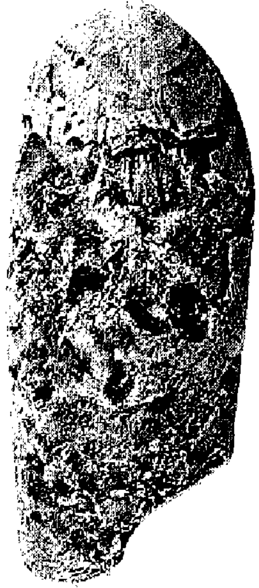
GENUS *Rhynchospirina* SCHUCHERT AND LEVENE, 1929

Rhynchospirina? sp.

Plate IV, figure 4

Description. — Two specimens in our Frisco collections from the Arbuckle Mountains region are tentatively referred to *Rhynchospirina.* One is a small, nearly complete shell with valves articulated; this measures only 5.1 mm long by 4.2 mm wide by 2.5 mm thick and presumably represents an immature individual. The other is an incomplete pedicle valve with a fragment of the brachial adhering to it; the pedicle is about 11.9 mm long by 9.0 mm wide. Our smaller shell is subequally biconvex with an erect pedicle beak and no trace of a fold or sulcus, and the costae are relatively coarse (10 costae on the pedicle valve). The larger specimen has the pedicle beak hooked toward, but probably not in conjunction with, the brachial valve; its costae are relatively large, rounded, and separated by U-shaped interspaces; near the front margin about 14 costae occupy a space of 5 mm. Both specimens are finely punctate. No interiors were observed.

Discussion. — The reference of this species to *Rhynchospirina* is provisional as it is based entirely upon external characters (which



Text-figure 40A. *Rensselaeria* cf. *R. elongata* (Conrad). Brachial valve, x1. Frisco Formation, Arbuckle Mountains region; locality P8-H (OU 4600).

are imperfectly known) and its punctate shell. Our specimens have some resemblance in outline and costation to *R. rectirostra* (Hall, 1857, p. 49; 1859, p. 217, pl. 95A, fig. 1) from the Oriskany Sandstone, and to *R. attenuata* (Stewart, 1922, p. 248, pl. 65, fig. 3) from the Little Saline Limestone of Missouri. However, the Frisco specimens cannot be precisely identified until we have a more representative collection.

Figured specimen. — Locality P9, Pontotoc County; number OU 3303.

Distribution. — Two specimens from the Frisco Formation in the Arbuckle Mountains region; locality P9. None has been found in northeastern Oklahoma.

Superfamily TEREBRATULACEA

GENUS *Rensselaeria* HALL, 1859

Rensselaeria cf. *R. elongata* (Conrad), 1839

Plate IX, figures 1-12; text-figures 40A, 40B

Terebratula ovoides Eaton, 1832, p. 45 [not Sowerby, 1812].

Atrypa elongata Conrad, 1839, p. 65.

Rensselaeria ovoides (Eaton) [not Sowerby]. Hall, 1859, p. 456, pl. 104, figs. 1-4; pl. 105, figs. 1-6; Hall and Clarke, 1894, p. 255-257, pl. 75, figs. 6, 8; pl. 76, figs. 16, 18.

Rensselaeria elongata (Conrad). Cloud, 1942, p. 54, 57-58, pl. 4, figs. 21-24.

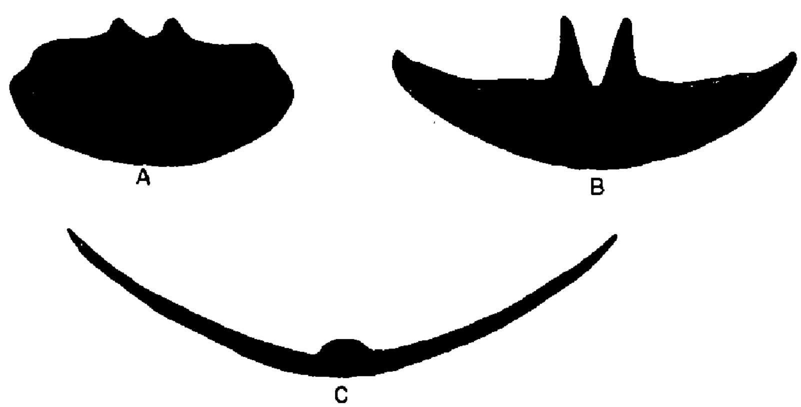
Description. — *Rensselaeria* cf. *R. elongata* is represented in our collections by a large number of isolated pedicle and brachial valves. The posterior end of each valve is much thickened and is generally well preserved, but toward the front the shells are thin and this part is commonly broken and lost, thus making it difficult to obtain satisfactory data on the outline and on the length/width ratio. We have a few valves which are complete enough to show that mature shells are long and narrow; the pedicle valve illustrated on plate IX, figures 7, 8, has a length/width ratio of about 1.5, and the brachial valve shown in text-figure 40A has a length/width ratio of 2.5. The shell is unequally biconvex, the pedicle being considerably deeper than the brachial. The pedicle beak is small, pointed, and hooked against the brachial (pl. IX, fig. 6); the convexity is strong and on some individuals the curvature is subcarinate in the umbonal region. The brachial valve is gently convex in the umbonal region and only the posterolateral margins are sharply deflected.

Most specimens are so deeply exfoliated that they have lost all trace of external ornamentation, but we have a few shells with the entire surface covered by fine costellae; in the umbonal region there are 13 to 14 costellae in a space of 5 mm, but toward the front these broaden and at a distance of 30 mm only eight or nine costellae occupy a space of 5 mm (pl. IX, fig. 12). The shell is punctate.

The pedicle valve is much thickened at the posterior end, the umbonal cavity is narrow, and the muscle scars are deeply impressed. The teeth are attached directly to the lateral walls and the dental plates are obsolescent (pl. IX, figs. 1, 11). The brachial valve is also much thickened at the posterior end (text-fig. 40B). The cardinal plate is stout and is buttressed by two crural plates (pl. IX, fig. 2). On some shells the cardinalia are much thickened by the deposition of secondary shell material (pl. IX, fig. 4). A low median septum extends forward for some distance (text-fig. 40B).

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — We have 119 specimens, of which one has the two valves articulated, 71 are isolated pedicle valves, and 47 are isolated brachial valves, pedicle/brachial ratio 1.5. The posterior margin is lost on most specimens; one reasonably complete pedicle valve measures 42 mm long by 28 mm wide; length/width ratio 1.5.

Specimens from northeastern Oklahoma (Sequoyah County). — Twenty-two specimens are in our Frisco collections from this area, of which seven are free pedicle valves and 15 are free brachial valves; pedicle/brachial ratio 0.5. The Sequoyah County collections are much smaller than those from the Arbuckle region, and the



Text-figure 40B. Transverse serial sections of the brachial valve of *Rensselaeria* cf. *R. elongata* (Conrad) showing the shell thickness near the posterior end. Distance from the posterior tip of the brachial beak: A — 5.5 mm; B — 6.5 mm; C — 12.9 mm. Frisco Formation, P8-H, Pontotoc County, Oklahoma.

preservation is not so good; however, in so far as can be determined the specimens from northeastern Oklahoma are identical to those from the Arbuckles. One nearly complete pedicle valve measures 36 mm long by 25 mm wide; length/width ratio 1.4.

Discussion. — The genus *Rensselaeria* was described by Hall in 1859; the genotype is *Atrypa elongata* Conrad (= *Terebratula ovoides* Eaton, 1832, not *Terebratula ovoides* Sowerby, 1812) from the Oriskany Sandstone. In 1942 Cloud (p. 54, 57-58, pl. 4, figs. 21-24, pl. 5, figs. 1-9) redescribed and reillustrated the external and internal features of the genotype.

Conrad based his description of *R. elongata* on specimens from the Oriskany Sandstone of New York; later Hall (1859), and Hall and Clarke (1894) furnished additional information on this species (as *R. ovoides* [Eaton]; see Cloud, 1942, p. 54). In 1859 Hall (p. 461-463, pl. 108, figs. 3a-3m) described another species, *R. marylandica,* based on specimens from the Oriskany Sandstone at Cumberland, Maryland; he noted that this species closely resembled *R. ovoides* [= *R. elongata*] and might be "only a variety of that species." When Schuchert and Maynard (1913, p. 383) made their study of the Devonian brachiopods of Maryland they stated:

> *R. marylandica* is undoubtedly the southern expression of the well-known upper Oriskany fossil *R. ovoides* (Eaton) [= *R. elongata*]. In fact, some of the Maryland specimens, if found in New York, would without hesitation be referred to *R. ovoides* [= *R. elongata*]. However, the majority of individuals have an expression of their own, and it is advisable to preserve this local variation under the name *R. marylandica.*

Cloud (1942, p. 58-59, pl. 5, figs. 1-9) treated *R. marylandica* as a distinct species although he did not describe its external characters nor compare it with *R. elongata.* In 1960 the senior author examined the U. S. National Museum collections which include a number of well-preserved specimens of *R. elongata* from the Oriskany Sandstone of New York, and *R. marylandica* from the Oriskany Sandstone of Cumberland, Maryland. This study confirmed Schuchert and Maynard's observation that the New York and Maryland specimens differ only in minor details. The Maryland shells are, on the whole, smaller and narrower than are those from New York, but these differences are slight and certainly do not apply to all specimens. In all probability a detailed re-study of Oriskany brachiopods will show that *R. marylandica* should be suppressed as a synonym of *R. elongata.* The dimensions of a few U. S. National Museum specimens from both areas are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
	R. marylandica — Cumberland, Maryland		
40	29	1.4	9
40	24	1.7	--
53	30	1.8	--
54	24	2.2	--
64	30	2.1	7
	R. elongata — New York		
58	35	1.6	7
61	35	1.7	5
63	41	1.5	7
74	44	1.7	6
76	35	2.1	6

Our specimens would appear to be closely related to the Oriskany representatives of *R. elongata* (defined to include *R. marylandica*); they are similar in lateral profile, convexity of the valves, ornamentation, and internal characters. The outline is also similar although the Frisco specimens would appear to have a somewhat narrower and more elongate shell. The Oklahoma shells may be slightly smaller than the New York and Maryland specimens, although the fragmentary nature of our material makes it difficult to get reliable size measurements, especially of the length.

The Frisco specimens appear to be conspecific with shells from the Little Saline Formation which Stewart (1922, p. 242, pl. 64, figs. 8-12) identified as *R. ovoides* (Eaton).

Our collections consist mainly of isolated pedicle and brachial valves. This is the common condition for Frisco brachiopods, but in *R.* cf. *R. elongata* the pedicle/brachial ratio is low, being only 1.5 for specimens from the Arbuckle region and 0.5 for those from Sequoyah County (combined average, 1.2). In this connection it is interesting to note that the posterior end of the brachial valve is much thickened (see *Discussion* on the pedicle-brachial valve ratio under Brachiopod Fauna).

Figured specimens. — Localities V7, P10-V, P11, Pontotoc County; locality S1-B, Sequoyah County; numbers OU 3377-3386, 4600.

Distribution. — This is a common species in the Frisco of the Arbuckle region and our collections include 119 specimens, mostly fragmentary, from the following localities: Pontotoc County: P8-H, P9, P10, P11, V7. We have 22 specimens from the Frisco Formation in Sequoyah County: S1-B, S5-B, S6, S8-C, S10-B, C.

Rensselaeria sp.
Plate VII, figures 19-21

"*Rensselaeria elongata*" (Conrad). Amsden and Huffman, 1958, p. 73-75, fig. 1.

Description. — We have three specimens of *Rensselaeria* sp. Two are reasonably complete shells with the valves articulated, but the third specimen is only a fragment of a brachial valve. One of the articulated shells and the brachial fragment were collected from surface outcrops in Sequoyah and Pontotoc Counties, and their stratigraphic position is accurately known. The other articulated shell came from a core in Pottawatomie County (Amsden and Huffman, 1958, p. 73), and little is known about its stratigraphic position. This specimen is, however, enough like the others to indicate with reasonable certainty that all three are conspecific. These shells are large and strongly biconvex. The pedicle valve is considerably deeper than the brachial and its beak is hooked tightly against the opposite valve (pl. VII, fig. 21). On both valves the posterolateral margins are sharply deflected, producing steep, flat sides. The principal difference between the two articulated specimens is in the length-width relationship; the shell from Sequoyah County is relatively narrow with a length/width ratio of about 2, whereas the specimen from the Pottawatomie core has a length/width ratio of 1.7. Measurements are: for the Sequoyah County specimen (pl. VII, figs. 19, 21), length 82 mm (est.), width 40 mm (est.), thickness 54 mm; for the specimen from the Pottawatomie County core (pl. VII, fig. 20) length 65 mm (est.), width 38 mm (est.), thickness 46 mm. The surface is costellate; near the posterior end about ten costellae occupy a space of 10 mm, but the costellae are broader toward the front and about 50 millimeters in front of the beak there are only seven or eight in a space of 10 mm.

We have prepared serial sections of the free, brachial valve; this shows a heavy cardinal plate, solid except for a small opening near the posterior end, and supported on stout cardinal plates. This structure is similar to that found on *Rensselaeria* cf. *R. elongata* (pl. IX, figs. 2, 4), and appears to be typical for this genus. We have little information on the pedicle interior; on both of the articulated shells the pedicle beak and umbonal region are broken enough to show that this part of the shell wall is thick and that the muscle area is deep.

Discussion. — Two species of *Rensselaeria* are recognized in our Frisco brachiopod collections. One of these, *R.* sp., is represented by only two large articulated shells and a fragment of a brachial valve, whereas the other, *R.* cf. *R. elongata,* is represented by many isolated and largely fragmentary free valves. Because the specimens in the latter group are mostly small, the question arises whether they are merely the immature forms of *R.* sp. This is a possibility which is difficult to eliminate on the basis of our fragmentary material, but we are recognizing two species, primarily because of differences in the brachial valves. The specimens referred to *R.* cf. *R. elongata* have a shallow brachial valve which even on larger individuals shows little tendency toward a strong convexity, whereas the specimens assigned to *R.* sp. have a deeply convex brachial valve. Also the brachial valve of *R.* cf. *R. elongata* appears to be more elongate and narrower than is that of *R.* sp.

These shells resemble mature specimens of *R. elongata* (Conrad) and *R. marylandica* (Hall) from the Oriskany Formation in size, shape, ornamentation, and internal characters. The principal difference is in the lateral profile, the Frisco specimens having a more strongly biconvex shell than have any of the Oriskany shells which we have observed.

Figured specimens. — Numbers OU 3358, 1233; location given below.

Distribution. — Three specimens from the Frisco Formation at the following localities: west rim of the St. Clair Lime Company quarry, SE¼ SE¼ NE¼ sec. 14, T. 13 N., R. 23 E., Sequoyah County; locality P11-C, Pontotoc County; well core from Smith Bros. No. 1 Kytle-Ray at a depth of 4,930 feet, SW¼ NE¼ NW¼ sec. 36, T. 8 N., R. 2 E., Pottawatomie County.

GENUS *Prionothyris* CLOUD, 1942

Prionothyris perovalis Cloud, 1942
Plate VIII, figures 1-5

Prionothyris perovalis Cloud, 1942, p. 67-68, pl. 7, figs. 14-31.

Description. — The Frisco specimens of *Prionothyris perovalis* have a biconvex lateral profile, the convexity of the two valves being about equal. It has a fairly long, pointed pedicle beak which is hooked over, but not in conjunction with, the brachial valve. Both lateral margins are introverted to form long, lateral reentrants (pl. VIII, fig. 2). In outline the shell is elongate oval with the length greater than the width (length/width ratio about 1.2). The hinge line is straight and moderately long and the cardinal extremities are subangular, thus producing well-defined shoulders. The greatest width is at about the middle of the shell. The brachial valve is gently and uniformly convex. The pedicle valve also has moderate convexity, although in the umbonal region the curvature tends to be more sharply defined. The surface appears to be smooth, but the preservation of our specimens is not good and they may have originally had a weak costellation near the front margin. The shell is punctate, and the punctae are closely spaced.

We have one brachial interior showing a ponderous, erect cardinal process bearing two elongate pits on its upper surface. The pedicle interior is without dental plates and the muscle field is large, elongate oval; the adductor scar is small, elongate, and located rather far forward (pl. VIII, fig. 4; compare to the steinkern figured by Cloud, 1942, pl. 7, fig. 28).

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — We have 27 specimens from the Arbuckle region of which four are articulated shells, 17 are free pedicles, and six are free brachials; pedicle/brachial ratio 2.8. Most of these specimens are fragmentary; the one illustrated on plate VIII is the most complete in our collections and measures 32.8 mm long, 27.1 mm wide and 13.1 mm thick. One fairly complete free pedicle valve measures 23 mm long by 21 mm wide.

Specimens from northeastern Oklahoma (Sequoyah County). — We do not have any specimens from this region.

Discussion. — The genus *Prionothyris* was described by Cloud, the genotype being *P. perovalis* Cloud from the Glenerie Limestone and Oriskany Sandstone of New York. Cloud's description and illustrations of this species are excellent. The senior author has also examined the U. S. National Museum Oriskany collections, which include a number of free valves showing the internal characters. The Frisco specimens are remarkably similar to those from the Oriskany and Glenerie in all respects including size. The brachial cardinalia and pedicle muscle area of the Oklahoma shells appear to be identical to those of the New York specimens. The only possible difference is in the ornamentation. Cloud noted that some well-preserved shells had weak costellae on the front part of the shell, a feature which we have not observed on the Frisco specimens; however, in view of the exfoliated character of the Frisco specimens, we cannot be certain that such ornamentation was not originally present.

The Little Saline specimen which Stewart (1922, p. 244, pl. 65, fig. 1) identified as *Beachia ovalis* (Hall) is believed to be a representative of *P. perovalis* Cloud. Stewart's description and illustration indicate an elongate rather than a transverse shell like *P.*

ovalis (Hall) (see description by Cloud, 1942, p. 68). The senior author has collected specimens of *Prionothyris* from the Little Saline Limestone at its type locality, and these appear to be conspecific with *P. perovalis* from the Oriskany and Frisco Formations.

Figured specimens. — Localities P10 and P11, Pontotoc County; numbers OU 3359, 3360.

Distribution. — Cloud's specimens came from the Oriskany Sandstone and Glenerie Limestone of New York. We have 27 specimens, many of which are quite fragmentary, from the Frisco Formation in Pontotoc County, Arbuckle Mountains region: localities P8-H, P9, P10, P11, V7. None from Sequoyah County.

GENUS *Oriskania* HALL AND CLARKE, 1894

Oriskania sinuata Clarke, 1900

Plate VII, figures 1-6

Oriskania sinuata Clarke, 1900, p. 38, pl. 5, figs. 9-12; Cloud, 1942, p. 70, pl. 8, figs. 11, 12, 15-17.

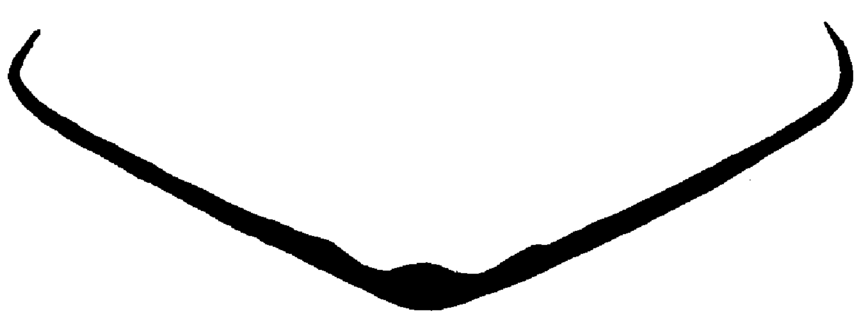
Description. — The Frisco specimens assigned to *Oriskania sinuata* have a relatively small, unequally biconvex shell, the pedicle valve being much deeper than the brachial. The pedicle beak is small, pointed, and hooked over, but not in conjunction with, the brachial. In outline they are elongate oval, with the length greater than the width (length/width ratio of one complete specimen is 1.4). The pedicle valve is sharply flexed, nearly carinate, in the umbonal region, from which point the sides slope steeply to the lateral margins. The brachial valve is almost flat at the posterior end, but at about midlength it is bent toward the pedicle, and this produces a pronounced curve in the lateral commissure (pl. VII, fig. 2); on the front half of this valve is a shallow, poorly outlined sulcus. The surface is smooth except for well-marked growth lines, and the shell is punctate.

We have prepared one pedicle valve which shows some of the internal characters. The teeth are stout, triangular, and attached to the lateral walls; they are supported by short dental plates (pl. VII, fig. 3). Our specimen does not show the muscle area, but presumably it was quite shallow. We have several brachial valves showing the cardinalia; this structure consists of a ponderous, sessile cardinal plate which bears a ridgelike cardinal process on its upper surface (pl. VII, figs. 5, 6).

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — *Oriskania sinuata* has been found at only one locality, P11, where about 36 specimens were collected from a bed 60 feet above the base. All of these were incomplete, the best shell being the one illustrated on plate VII, figures 1, 2, 4; six specimens included at least a part of both valves, three were isolated pedicles, and 27 were isolated brachials; pedicle/brachial ratio 0.1. This high percentage of brachial valves is unusual; and in this connection it is interesting, and probably significant, to note that the pedicle shell is thin, even at the posterior end, whereas the brachial valve is reinforced at the posterior end by the ponderous cardinalia (the part which is most commonly preserved). The only reasonably complete specimen in our collections measures 16.1 mm long, 11.2 mm wide, and 8 mm thick.

Specimens from northeastern Oklahoma (Sequoyah County). — We do not have any specimens from this area.

Discussion. — Cloud included two species in the genus *Oriskania:* the genotype *O. navicella* Hall and Clarke (1894, p. 269, figs. 181-183, pl. 79, figs. 25-27; Cloud, 1942, p. 70-71, pl. 8, figs. 1-10, 13, 14) and *O. sinuata* Clarke, both from the Oriskany Sandstone of New York. The descriptions and illustrations point to considerable similarity between these two species, a similarity which is also brought out by an examination of specimens of these species in the Oriskany collections of the U. S. National Museum. *O. sinuata* has a somewhat smaller shell with a more sinuous lateral commissure than has *O. navicella,* although some of the specimens assigned to the latter exhibit moderate sinuosity (Cloud, 1942, pl. 8, fig. 7); the pedicle and brachial interiors of these species appear to be identical. Our Frisco shells are remarkably similar in size, outline, and lateral profile to typical representatives of *O. sinuata;* the structure of the pedicle and brachial interiors also appears to be identical.



Text-figure 41. Transverse profile of the pedicle valve of *Beachia* new species, x5. This drawing is based on the specimen illustrated on plate VIII, figures 8, 13; profile taken about 7 mm in front of the beak.

Figured specimens. — Frisco Formation, Pontotoc County; numbers OU 3345-3347.

Distribution. — We have about 36 specimens, mostly quite fragmentary, from locality P11 (V1), Pontotoc County; these all came from a bed 60 feet above the base of the Frisco Formation.

GENUS *Beachia* HALL AND CLARKE, 1894

Beachia new species

Plate VIII, figures 6-14; text-figures 41, 42

Description. — *Beachia* new species has an elongate oval shell, with the length greater than the width; length/width ratio ranges from 1.1 to 1.3. The profile is unequally biconvex, the pedicle being much deeper than the brachial. As we have no articulated specimens, it is difficult to determine the contact relationship of the valves, especially with respect to the lateral commissure. Moreover, the free valves are all partly imbedded in matrix, making it difficult to expose the lateral margins. It does, however, appear that the lateral margins in the central part of the shell are introverted; the pedicle valve illustrated on plate VIII, figures 8, 13, and text-figure 41, clearly has its lateral sides deflected, although the precise degree of deflection is uncertain. We have only two free brachial valves, neither of which shows all of the lateral margin. The pedicle beak is small and is inclined toward the brachial, although probably not in conjunction with it; this valve is fairly deep and has a rather sharp curvature along the midline. The brachial valve is gently and uniformly convex. The surface bears low, rounded costellae, seven to eight occupying a space of 5 mm; on all our specimens these are faint and are confined to the anterior portion of the valve, but this condition may be in part the result of exfoliation. The shell has closely spaced punctae.

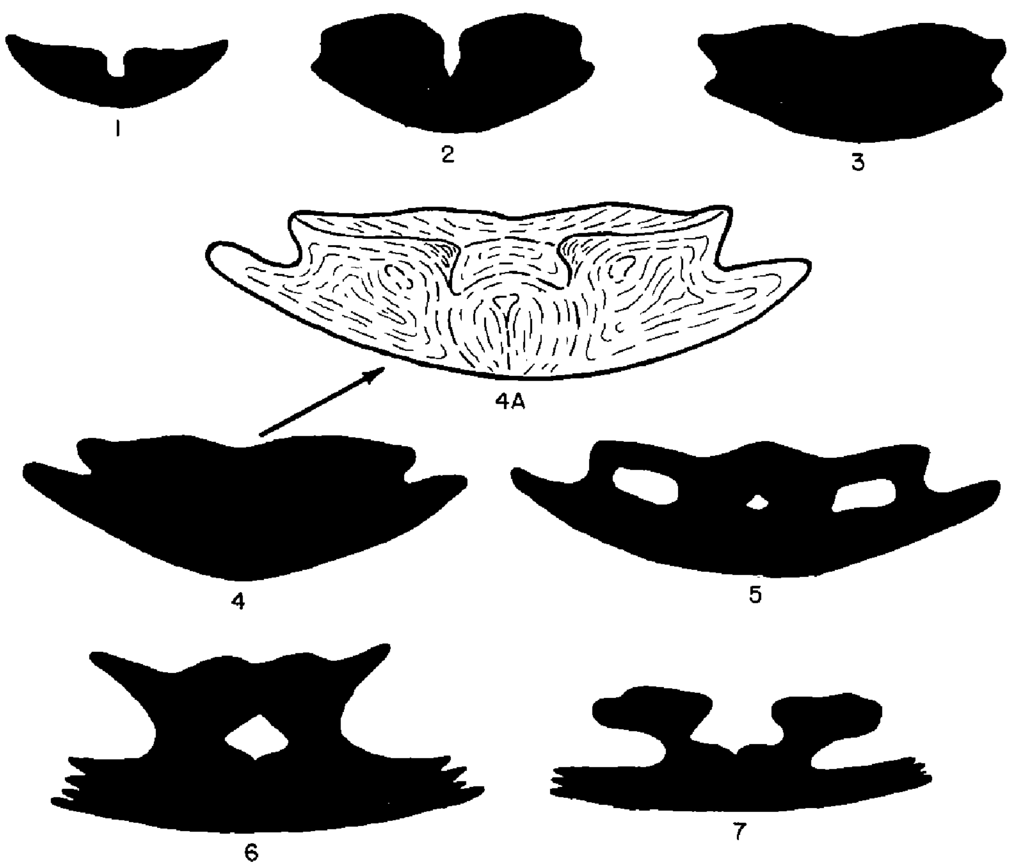
We have calcined one pedicle valve to produce a reasonably sharp pedicle steinkern (pl. VIII, figs. 10, 11). This shows an elongate muscle field that is not deeply impressed; the adductor scars occupy a linear track which is located toward the front end of the field and near the middle of the valve. The teeth are small and are supported by short dental plates. The brachial valve has a flattish cardinal plate, which is sessile at its posterior end but which is supported by short crural plates toward the front (text-fig. 42). We have no information on the loop.

Specimens from the Arbuckle Mountains region (Pontotoc and Coal Counties). — We have no specimens from this area.

Specimens from northeastern Oklahoma (Sequoyah County). — Our collections include about 14 specimens from this area, of which 12 are free pedicle valves and two are free brachial valves; pedicle/brachial ratio 6.0. Many of these are fragmentary, but five pedicle valves are complete enough to give satisfactory length/width measurements:

Length mm	Width mm	Length/Width ratio
14.8	13.7	1.1
18.2	15.7	1.2
20.5	17.5	1.2
20.8	16.4	1.3
21.0	16.0	1.3

Discussion. — The genus *Beachia* was described by Hall and Clarke (1894, p. 260), the type species being *Meganteris suessana* Hall (1857, p. 100; 1859, p. 459, pl. 107, figs. 1-15) from the Oriskany Sandstone at Cumberland, Maryland. In 1942 Cloud (p.



Text-figure 42. Transverse serial sections of the brachial valve of *Beachia* new species. Numbers 1 to 7 enlarged about x5; 4A is an enlarged view (x8) of 4, showing the growth lines. Distance from the posterior tip of the brachial valve: 1 — 0.8 mm; 2 — 1.4 mm; 3 — 1.8 mm; 4 — 2.1 mm; 5 — 2.5 mm; 6 — 3.1 mm; 7 — 3.6 mm. These are sections of the specimen illustrated on plate VIII, figure 7.

60-63, pl. 6, figs. 1-20) gave a detailed redescription of the genus and genotype, including a number of excellent illustrations of *B. suessana.* Our specimens are internally similar to the genotype. The brachial valve has a sessile cardinal plate like that of *B. suessana,* although this plate is not so swollen as in the Oriskany species. In the pedicle valve of the Frisco shells are short dental plates and an elongate, weakly impressed muscle field, which is much like that found in the Oriskany species. Externally our species has the general shape and ornamentation of Hall's species, the only question being whether the Oklahoma shells have strongly introverted lateral margins. This last point is of some importance in making a generic assignment, because, as Cloud points out, "Depressed, subcircular species of *Rensselaeria* . . . could be confused with *Beachia:* but the introverted lateral margins, well-developed planareas, and conjunct deltidial plates of *Beachia* offer a ready external distinction from these." The only one of these three points for which we have any information is the introverted lateral margins, and there is some uncertainty on this point. On well-preserved articulated specimens the distinction between the lateral commissure of *Beachia* and *Rensselaeria* is undoubtedly clear, but some species of the latter do have a mild indentation of this part of the shell (Cloud, 1942, pl. 5, fig. 6; compare to his plate 6, fig. 9) and, on fragmentary material such as we have, the degree of inversion is not clear.

Cloud assigned three species to *Beachia: B. amplexa* Clarke (1908, p. 168, pl. 26, figs. 14-17), *B. suessana* (Hall), and *B. thunii* (Clarke, 1908, p. 168, pl. 26, figs. 8-13). The Frisco shells are most like *B. suessana,* but a direct comparison with Oriskany specimens at the U. S. National Museum shows that the Frisco specimens are more elongate and have less well-developed shoulders. A more definitive collection would in all probability show that the Frisco shells represent a new species.

Figured specimens. — Locality S6; numbers OU 3361-3366, 3376.

Distribution. — We have 14 free valves from the Frisco Formation, Sequoyah County; localities S5-B and S6. None from the Arbuckle Mountains region.

PART II. — ARTICULATE BRACHIOPODS OF THE SALLISAW FORMATION (DEVONIAN)

THOMAS W. AMSDEN

INTRODUCTION

The Sallisaw is a thin formation, mostly arenaceous limestone and dolomitic limestone, of late Early Devonian age. It crops out in a small area of northwestern Sequoyah County, Oklahoma, the best exposures being in the vicinity of Marble City (text-figs. 1, 3). The Sallisaw is overlain by the Sylamore Sandstone Member of the Chattanooga Formation and is underlain by the Frisco, or where that formation has been removed by post-Frisco pre-Sallisaw erosion, by the St. Clair Formation (text-fig. 4). Within its outcrop area the Sallisaw has been removed locally by post-Sallisaw pre-Chattanooga erosion, allowing the Sylamore Sandstone to rest directly upon the Frisco.

Previous investigations. — The Sallisaw Formation was named by Cram (1930, p. 550-551) for exposures on Sallisaw Creek (text-fig. 3). Cram did not discuss the fauna beyond noting that these strata carried a Middle Devonian fauna similar to that of the Camden Chert of western Tennessee. This information was taken from an earlier publication of Schuchert (1922, p. 669) in which *Leptaena rhomboidalis ventricosa, Schuchertella* new species, *Spirifer worthenanus,* and *Amphigenia curta* were recorded from strata referred to as "Middle Devonian Sylamore Sandstone = Camden Chert of western Tennessee." Schuchert lumped the Sallisaw in with the Sylamore, but these are now known to be distinct lithostratigraphic units of different age, the Sylamore being the basal clastic phase of the Chattanooga Shale (text-fig. 4). In 1953 Christian (p. 33-39) made a detailed study of the geology of the Marble City area and recorded 10 species, all brachiopods, from the Sallisaw Formation. His faunal list was later published in Huffman's paper on the *Geology of the [south and west] flanks of the Ozark uplift, northeastern Oklahoma* (1958, p. 37). The lithostratigraphy of the Sallisaw Formation was described in my 1961 paper, which includes information on thickness, distribution, texture, insoluble residues, etc.; this publication does not include any faunal descriptions.

Present investigation. — This report is based upon a lithostratigraphic and biostratigraphic investigation of the Sallisaw Formation in Sequoyah County during the years 1959 to 1961. In the course of this investigation about 500 brachiopods were collected from the Sallisaw in the Marble City area. All of these specimens were collected in situ (broken out of the rock) from strata the geographic and stratigraphic positions of which were carefully determined in the field. The stratigraphic data pertaining to these collections are recorded in the appendix of my 1961 report. It should also be noted that the Sallisaw has been mapped in detail throughout its outcrop area in the Marble City region (Christian, 1953; Amsden, 1961, pl. I; text-fig. 3 of this report).

My investigation of the Sallisaw brachiopods has been helped by a study of related Devonian faunas from Illinois and Tennessee. I have examined the brachiopods from the Clear Creek Formation of Illinois and the Camden Formation of western Tennessee in the collections of the U. S. National Museum and Peabody Museum, Yale University. F. H. Manley and I collected a few fossils from the Clear Creek Formation along the bank of Hutchins Creek in Union County, Illinois (see text-fig. 45). In addition, the following type specimens were borrowed from other institutions: *Chonetes arcuatus* Hall and *Chonetes acutiradiatus* Hall from the American Museum of Natural History; *Spirifer worthenanus* Schuchert (= *Spirifer engelmanni* Meek and Worthen), *Spirifer hemicyclus* Meek and Worthen, and *Stricklandinia elongata curta* Meek and Worthen from the Illinois Geological Survey. Several brachiopods from the Onondaga, Clear Creek, and Camden Formations are illustrated on plates XV, XVII, XIX, and XX.

Acknowledgments. — T. L. Rowland and F. H. Manley helped collect some of the specimens used in this report. I wish to acknowledge the use of H. E. Christian's Sallisaw collections. I also wish to thank G. A. Cooper of the U. S. National Museum; Karl M. Waage of Peabody Museum, Yale University; Donald F. Squires of the American Museum of Natural History; and Lois S. Kent of the Illinois Geological Survey for the loan of specimens.

SALLISAW STRATIGRAPHY

The lithostratigraphy of the Sallisaw Formation has been described in some detail (Amsden, 1961), and therefore only a short summary is included in this report.

The Sallisaw Formation is represented by two lithofacies: (1) an arenaceous carbonate, commonly with nodules and lenses of vitreous chert and (2) an arenaceous chert facies (a discussion of these terms is given in Amsden, 1961, p. 13-14). The arenaceous carbonate is a limestone with varying amounts of $MgCO_3$ and has scattered detrital quartz grains. The quartz detritus, which makes up most of the insoluble part of the rock, is predominantly in the form of angular to subangular grains in the fine-sand-sized range. The quantity of sand is variable, ranging as high as 45 percent, but the average is only 9.5 percent. In addition to quartz, most insoluble residues carry some glauconite, limonite, and other minerals in small amounts. The quantity of $MgCO_3$ is also highly variable with some beds having as much as 25 percent although the average is only 11.5 percent. Nodules and lenses of vitreous chert are fairly common and some of these are fossiliferous. With the possible exception of pelmatozoan debris, the Sallisaw is not a highly fossiliferous rock (Amsden, 1961, p. 48). Most beds carry some scattered brachiopod shells, but, with few exceptions, megafossils do not constitute a significant part of the rock. Of the brachiopods, which are by far the most common megafossils, 98 percent are disarticulated (table 7A*), and some of the shells appear to have been broken either before or during deposition. The Sallisaw appears to have been deposited in a relatively high-energy environment, although the water probably was not so turbulent as it was during Frisco deposition.

The arenaceous chert facies is quite local in its development and consists of angular to subangular detrital quartz grains set in a matrix of finely crystalline quartz. The texture and relationships of this rock indicate that it originated by the silicification of the carbonate, the $CaCO_3$ and, to some extent, the $MgCO_3$ being replaced by finely crystalline quartz. This replacement appears to have occurred fairly early, at least before the deposition of the Sylamore Sandstone Member of the Chattanooga (Amsden, 1961, p. 54-55, 77). This rock also carries scattered brachiopods, almost all being disarticulated.

*The fossils from the vitreous chert are somewhat better preserved than are those from the carbonate, but the degree of disarticulation is about the same as shown in table 7A.

The Sallisaw outcrops are largely confined to a restricted area just north of Marble City (text-fig. 3). Fossiliferous Sallisaw (arenaceous chert facies) is also known to crop out in a small area about three miles west of Tenkiller Dam (Amsden, 1961, p. 45, 54). Throughout much of the Marble City area this formation is overlain by the Sylamore Sandstone Member of the Chattanooga Formation and is underlain by the Frisco Formation (text-fig. 4). In some places, however, the Frisco is absent and the Sallisaw rests directly upon the St. Clair. The Chattanooga truncates both of these Early Devonian formations so that its basal member, the Sylamore Sandstone, may rest upon the Sallisaw, or the Frisco, or the St. Clair (Amsden, 1961, p. 60).

The Sallisaw Formation is thin throughout its outcrop area. It is eight feet thick at the type locality on Sallisaw Creek (stratigraphic section S1) and reaches its maximum of about 20 feet at stratigraphic section S14 in Payne Hollow (text-fig. 3; Amsden, 1961, pl. I, p. 108).

SALLISAW MEGAFAUNA

The Sallisaw megafauna consists almost entirely of brachiopods. I have collected some specimens of *Tentaculites* sp. and one small, solitary tetracoral from stratigraphic section S14 (text-fig. 3), but elsewhere brachiopods are the only fossils obtained.* Schuchert (1922, p. 669) and Christian (1953, p. 38) reported only brachiopods from the Sallisaw. I have not observed conodonts or arenaceous

TABLE 7A.—SALLISAW BRACHIOPODS

	Arenaceous Carbonate Facies				Vitreous Chert Facies			
	Articulated shells	Pedicle valves	Brachial valves	Pedicle/Brachial ratio	Articulated shells	Pedicle valves	Brachial valves	Pedicle/Brachial ratio
Protoleptostrophia blainvillei	0	12	1	12.0	0	2	1	2.0
Leptaena sp.	0	3	0		0	0	0	
Eodevonaria intermedia	0	23	0		0	18	5	3.6
Chonostrophia complanata?	0	0	0		0	3	0	
Anoplia nucleata	0	0	0		0	21	3	7.0
Schellwienella? sp.	1	16	5	3.3	0	1	2	0.5
Leptocoelia flabellites?	1	27	31	0.9	0	0	0	
Atrypa sp.	1	2	4	0.5	0	0	0	
Fimbrispirifer cf. F. divaricatus	0	34	12	2.8	0	0	0	
Hysterolites (A.) worthenanus?	0	80	10	8.0	1	20	8	2.5
Amphigenia curta	0	63	66	0.9	1	1	0	
Total	3	260	129		2	66	19	

* The Sallisaw may include a substantial amount of pelmatozoan debris, but this is difficult to prove because of the state of preservation (Amsden, 1961, p. 48-49).

Foraminifera, although a more intensive check may show them to be present.

Environment of deposition. — Either before or during deposition the Sallisaw shells were subjected to movement by current and/or wave action, which produced some breakage and extensive disarticulation. This fact suggests that the fauna is to a large extent a thanatocoenose (see part I, p. 25); however, I am inclined to doubt that the shells were moved any great distance because the preservation of the specimens in the vitreous chert is good. In all probability the environment in which the organisms lived was essentially the same as that in which they were buried although this is difficult to prove as few, if any, of the fossils collected appear to be in the position occupied during life.

The environment of deposition was probably similar to that of the Frisco, both formations being laid down in fairly shallow, turbulent water. Probably the Frisco sea was somewhat more strongly agitated, as indicated by the more fragmented character of its fossils.

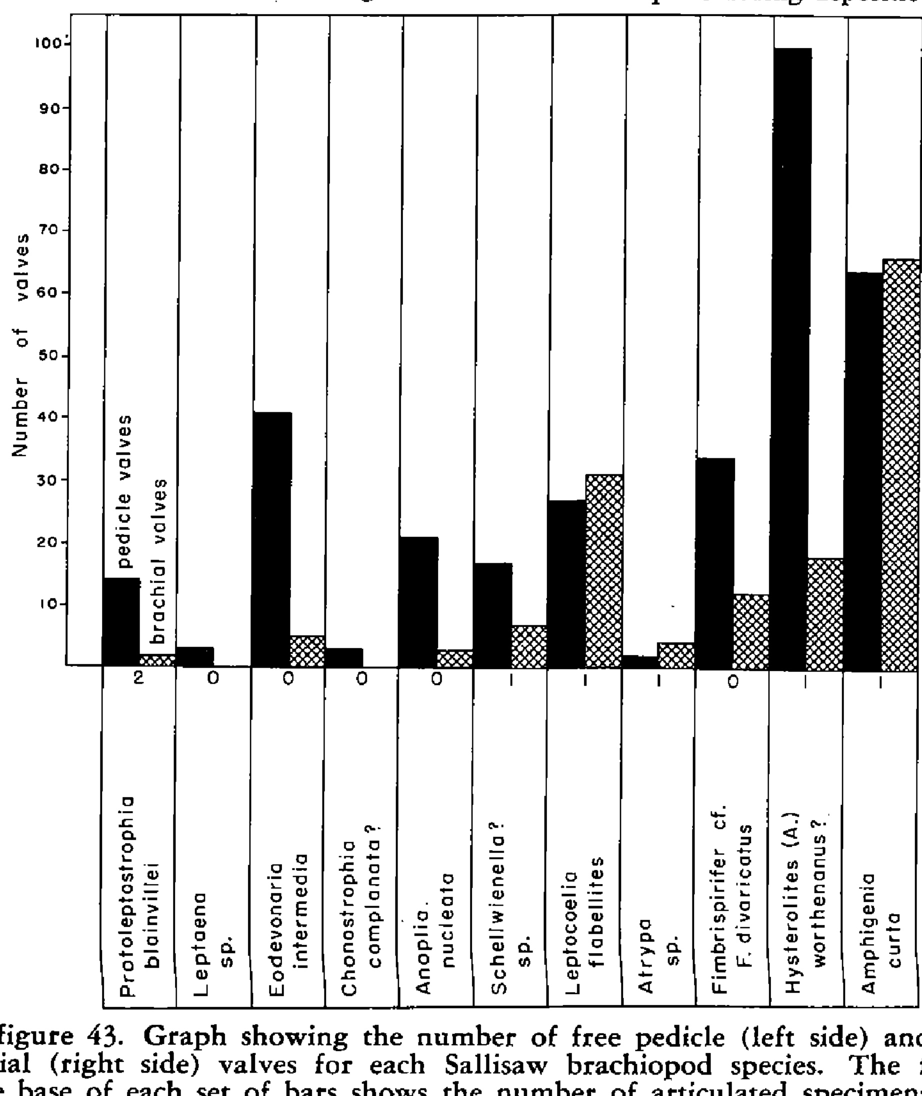
SALLISAW BRACHIOPODS

The Sallisaw has a small articulate brachiopod fauna.* I have collected about 500 specimens which are assigned to 11 species (one new) and 11 genera. The preservation of the specimens from the arenaceous carbonate and arenaceous chert facies is not good. Almost all the specimens are disarticulated and some were broken either before or during deposition. Furthermore, some shells are slightly crushed, probably due to compaction during induration. To this breakage must be added that which occurs during collecting; all specimens were broken out of the rock, making it difficult to obtain really fine specimens. The specimens in the vitreous chert are better preserved, almost all being internal and external molds. Rubber casts of these molds yield fine replicas of the original. A comparison of the brachiopod preservation in the arenaceous carbonate facies with that of the vitreous chert is shown on plate XVI, which illustrates specimens of *Hysterolites (A.) worthenanus*? (Schuchert) from both facies. In describing this fauna, I have tried to follow a conservative policy and make definite species assignments only where the material seems to justify fully such an identification. The systematic description of each species includes information on the number of specimens and the nature of their preservation.

* Both the vitreous chert and arenaceous chert facies of the Sallisaw yield large, orbiculoid brachiopods; no inarticulate brachiopods are described in this report.

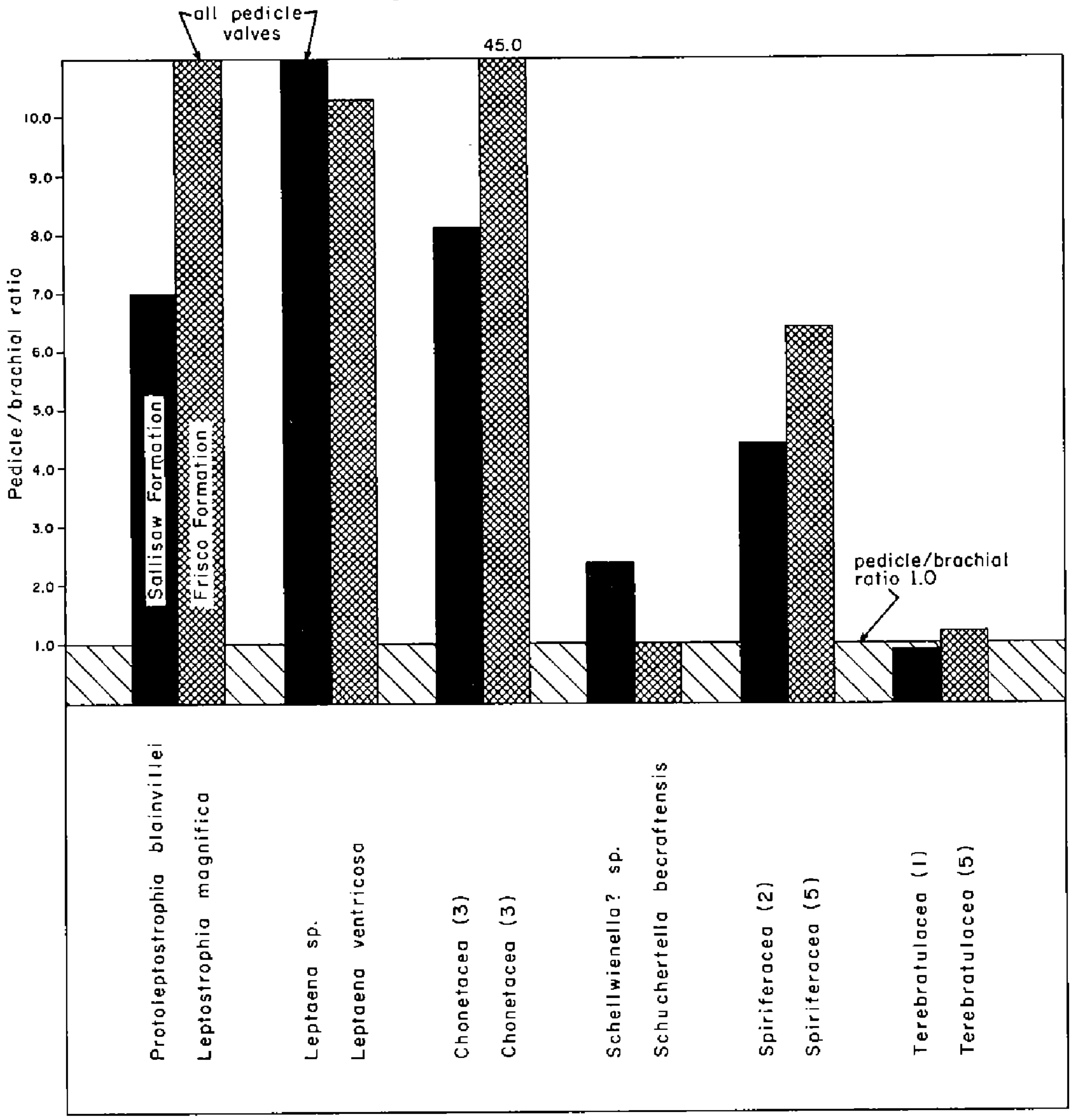
Disarticulation and the ratio of pedicle to brachial valves. — At the time of deposition almost all the Sallisaw brachiopods were disarticulated; 98 percent of the specimens collected are free pedicle and brachial valves (table 7A).* It is interesting to compare the ratio of the number of pedicle valves to the number of brachial valves in the disarticulated part of this fauna. For most species there is a marked disparity between the two, the pedicles generally being much more numerous than the brachials (text-fig. 43). *Leptocoelia flabellites*? and *Amphigenia curta* are the only species in which the two valves are approximately equal in number; in all others the pedicles are much more numerous than the brachials (excluding

* All of my specimens were collected by breaking the fossils out of the rock and therefore none of this disarticulation is the result of recent weathering. Considerable breakage takes place in the process of collecting, but in most cases this can be easily distinguished from the fragmentation which took place during deposition.



Text-figure 43. Graph showing the number of free pedicle (left side) and free brachial (right side) valves for each Sallisaw brachiopod species. The figure at the base of each set of bars shows the number of articulated specimens representing that species. This is compiled from the data given in table 7A; the specimens from the arenaceous carbonate and vitreous chert facies are combined.

Atrypa sp. which is represented by only seven specimens). The relationship is approximately the same in both the arenaceous carbonate and the vitreous chert facies; the average pedicle/brachial ratio in the latter is 3.1 and is 4.1 in the former. (The vitreous chert collection is considerably smaller than that from the carbonate



Text-figure 44. Graph comparing the pedicle/brachial ratio of selected brachiopods from the Sallisaw (left side) and Frisco (right side) Formations. The first two pairs of bars compare the strophomenacid species *Protoleptostrophia blainvillei-Leptostrophia magnifica* and *Leptaena* sp.-*Leptaena ventricosa;* the next compares the three Sallisaw chonetacids, *Eodevonaria intermedia, Chonostrophia complanata,* and *Anoplia nucleata,* with the three Frisco species, *Chonetes?* sp., *Chonostrophia complanata,* and *Anoplia nucleata;* the fourth compares the orthotetacid species *Schellwienella?* sp. and *Schuchertella becraftensis;* the fifth compares the two Sallisaw spiriferacids, *Fimbrispirifer,* cf. *F. divaricatus* and *Hysterolites (A.) worthenanus*? with the five Frisco species, *Hysterolites (A.) murchisoni, Costispirifer arenosus, Spinoplasia oklahomensis, Kozlowskiellina* sp., and *Eospirifer* sp.; the last compares the Sallisaw terebratulacid *Amphigenia curta* with the five Frisco terebratulacids, *Rensselaeria* cf. *R. elongata, R.* sp., *Prionothyris perovalis, Oriskania sinuata,* and *Beachia* sp. The data for this are compiled from tables 1 and 7A. See also text-figures 6B, 7, 8, 43.

strata.) This is quite similar to the pedicle/brachial ratio found in the Frisco (3.3), and a comparison of the related brachiopods from these two formations also shows a fairly well-defined correlation (text-fig. 44). Note the similarity between the Sallisaw terebratulacid, *Amphigenia curta,* and the average ratio of five Frisco terebratulacids. Both *A. curta* and *Leptocoelia flabellites*? are characterized by their stout brachial cardinalia, which in the latter species is further strengthened by a cardinal process. The disparity between the numbers of pedicle and brachial valves in the Frisco has already been discussed in part I, and it was concluded that this resulted largely from the breakage which took place before and during deposition, the more fragile valves being the more easily destroyed. I suspect that this explanation is also true for the Sallisaw, although the evidence is not so conclusive as in the case of the Frisco. For one thing, the Sallisaw brachiopods were collected from a rather restricted geographic area and thus lack the more widespread geographic representation of the Frisco. Also the Sallisaw fossils do not show so much evidence of breakage as do those from the Frisco. However, the fact that taxonomically related (and thus structurally similar) brachiopods from the two formations have similar pedicle/brachial ratios (text-fig. 44) suggests that the same process was responsible in each case.

Distribution and composition of the Sallisaw brachiopod fauna.— Approximately 500 Sallisaw brachiopod specimens were collected, all from the Marble City area. The best collecting area is along Payne Hollow, in the vicinity of stratigraphic sections S8, S10, and S14. I also collected some specimens from the outcrop belts along Walkingstick Hollow and near the St. Clair Lime Company quarries (text-fig. 3). The fossils were collected throughout the formation although this is not especially significant as the Sallisaw is generally less than 10 feet thick; at stratigraphic section S14 the formation is at least 20 feet thick, and representatives of seven species were collected from the upper 2 or 3 feet. The geographic distribution of my collections is given in table 7B.

The Sallisaw articulate brachiopods are referred to 11 species, representing 11 genera, 8 families, and 6 superfamilies. The chonetids and spiriferids are the better represented groups; however, the terebratulacid, *Amphigenia curta,* is the most common and widely distributed species. The following tabulation shows the major taxa in the Sallisaw fauna (* indicates more common species).

Superfamily STROPHOMENACEA

Family Strophomenidae
Protoleptostrophia blainvillei (Billings)

Family Strophodontidae
Leptaena sp.

Superfamily CHONETACEA

Family Chonetidae
**Eodevonaria intermedia* Amsden, new species
Chonostrophia complanata? (Hall)
Anoplia nucleata (Hall)

Superfamily ORTHOTETACEA

Family Orthotetidae
Schellwienella? sp.

Superfamily ATRYPACEA

Family Coelospiridae
Leptocoelia flabellites? (Conrad)

Family Atrypidae
Atrypa sp.

Superfamily SPIRIFERACEA

Family Spiriferidae
Fimbrispirifer cf. *F. divaricatus* (Hall)
**Hysterolites (Acrospirifer) worthenanus*? (Schuchert)

Superfamily TEREBRATULACEA

Family Centronellidae
**Amphigenia curta* (Meek and Worthen)

TABLE 7B.—DISTRIBUTION OF SALLISAW BRACHIOPODS

	Stratigraphic Section									
	S1	S3	S4	S5	S8	S9	S10	S11	S13	S14
Protoleptostrophia blainvillei							X			X
Leptaena sp.							X			
Eodevonaria intermedia					X		X		X	X
Chonostrophia complanata?							X			
Anoplia nucleata					X		X			
Schellwienella? sp.					X	X	X			X
Leptocoelia flabellites?							X			
Atrypa sp.										X
Fimbrispirifer cf. F. divaricatus										X
Hysterolites (A.) worthenanus?					X		X	X		X
Amphigenia curta	X	X	X	X			X	X		X

Comparison with the Frisco brachiopod fauna. — The Sallisaw brachiopod fauna is smaller than that of the Frisco; my Sallisaw collections include 11 species as compared to 32 species in the combined Arbuckle Mountains-Sequoyah County Frisco collections, and 26 species in the Frisco Sequoyah County collections alone. These two faunas have several elements in common. At least four genera, *Leptaena, Chonostrophia, Anoplia,* and *Hysterolites (Acrospirifer),* and two species, *Chonostrophia complanata* and *Anoplia nucleata,* are common to the two formations. In addition, *Leptocoelia flabellites* is well represented in Deerparkian strata of other areas, although it has not been found in the Frisco Formation of Oklahoma (e. g., Oriskany, Little Saline, and Harriman Formations). Some marked differences also exist between the Sallisaw and Frisco brachiopods. The genera *Eodevonaria, Fimbrispirifer,* and *Amphigenia* are not present in the Frisco and, according to Boucot (1959b, p. 733-734, fig. 5) and Cooper (1944a, p. 232, 363), are unknown from strata as old as Deerparkian (text-fig. 51). *Protoleptostrophia* is another genus which has not been found in the Frisco (or older Oklahoma strata). Williams (1953, p. 41) gave the range of this genus as "Earlier than Lower Devonian (Oriskany) to end of Middle Devonian (Erian)," whereas Boucot (1959b, p. 736) stated that it is restricted to strata of post-Helderbergian age. A comparison of the Sallisaw brachiopods with those from the Frisco and older Oklahoma strata is shown in text-figure 10 (note that the Sallisaw fauna is much smaller than any of the others appearing on this chart).

AGE AND CORRELATION

The Sallisaw is unconformably underlain by the Frisco Formation, which carries a large fauna of Deerparkian age and is unconformably overlain by the Chattanooga Formation, the lower part of which is Upper Devonian (Hass, 1956, p. 1, 2, 21, 25; see also Urban, 1960, p. 52, 54). The megafossils from the Sallisaw indicate a late Early Devonian age, although it is rather difficult to make a precise age assignment on the basis of its small fauna. Only 11 species of articulate brachiopods have been collected* and for some of these the preservation is such as to preclude precise specific identification. However, enough diagnostic fossils are present to relate the Sallisaw to the Esopusian or, possibly, the early part of the Onesquethawan (restricted).

* The only other megafossils collected from the Sallisaw consist of a single specimen of a solitary tetracoral, a few specimens of an orbiculoid brachiopod, and *Tentaculites* sp.

Esopus Formation. — The Onesquethawan Stage has generally been considered to include the Esopus, Schoharie, and Onondaga Formations of New York and their faunal equivalents elsewhere (Cooper and others, 1942, p. 1731). Boucot (1959b) made a detailed study of the Esopus Formation and its fauna in the vicinity of Highland Mills, Orange County, New York. He divided this formation into three members: a lower Highland Mills Member, a middle unnamed member, and an upper Woodbury Creek Member. The upper and lower members are fossiliferous, and the brachiopods from these members were described and illustrated in detail. Boucot included a comparison of the genera and species from the Oriskany, Esopus, and Onondaga Formations and concluded that the Esopus fauna should represent a new stage. Thus the Early Devonian would be divided into a Helderbergian Stage, a Deerparkian Stage, and an Esopusian Stage, the last succeeded by the Onesquethawan Stage (restricted) of early Middle Devonian age. The distribution of brachiopod genera through these stages in New York is shown in text-figure 51 (compare with text-fig. 10). The Sallisaw brachiopods are similar in certain respects to those from the Esopus, especially those of the Woodbury Creek Member, and the Sallisaw fauna is tentatively assigned to the Esopusian Stage, although it must be admitted that this faunal comparison is based on relatively few species. An analysis of the Sallisaw fauna in terms of known Deerparkian, Esopusian, and Onesquethawan brachiopods is given below.

The Sallisaw species *Protoleptostrophia blainvillei* (Billings) is represented by only a few specimens; however, the preservation is good, showing both the external and internal characters (pl. XIX, figs. 1-5). Williams (1953, p. 41) gave the range of *Protoleptostrophia* as "Earlier than lower Devonian (Oriskany) to end of Middle Devonian (Erian)," but according to Boucot (1959b, p. 736) this genus is restricted to post-Helderbergian strata. The Sallisaw shells are similar to specimens of *P. blainvillei* from the Gaspé Sandstone; about the only possible difference I can detect is in the character of the pedicle muscle scar which may be slightly more flared in the Gaspé shells. Boucot and Cumming (1953, p. 1397) assigned the lower part of the Gaspé Sandstone to the Lower Devonian and tentatively correlated it with the Siegenian and lower Emsian of Europe; Boucot (1959b, p. 733, 739) correlated the lower marine portion of the Gaspé Sandstone with the Highland Mills Member of the Esopus Formation. The genus *Protoleptostrophia* is not reported from either member of the Esopus Formation, but specimens identified as *Protoleptostrophia* sp. are present in the overlying Kanouse Sandstone (Boucot, 1959b, p. 738, 750-751, pl. 95, figs. 13-16).

Eodevonaria intermedia, new species, is one of the more common species in the Sallisaw Formation (pl. XIII, figs. 1-15). The genus *Eodevonaria* is rather widely represented in Esopusian and Onesquethawan strata in the central and eastern United States and Canada, and Billings and Clarke described the species *E. melonicus* (Billings) from the Grande Grève Limestone of Quebec. The Sallisaw species is similar to the Onondaga species (footnote, p. 168), *E. acutiradiata* (Hall) and *E. arcuata* (Hall), but differs in the character of the ornamentation and in the lateral profile. Boucot (1959b, p. 755-756, pl. 97) illustrated specimens of *Eodevonaria* cf. *E. gaspensis* Clarke from the Highland Mills Member, and specimens of *Eodevonaria* cf. *E. arcuata* (Hall) from the Woodbury Creek Member and Kanouse Sandstone. The Sallisaw specimens have some resemblance to the Woodbury Creek shells.

Chonostrophia complanata? (Hall) has been found only in the vitreous chert facies of the Sallisaw Formation (pl. XIV, figs. 22-25; pl. XVI, fig. 16). The Sallisaw shells have delicate, uniform costellae with no tendency toward the alternating type of rib present on *C. reversa* (Whitfield). Chonostrophias with this type of ribbing are said to be restricted to strata of pre-Onondagan age (Boucot, 1959b, p. 735, 757). *C. complanata* is present in both the Frisco and Sallisaw Formations of Oklahoma. This species (with uniform costellae) is common in the Camden Formation of western Tennessee and is also present in the Clear Creek Formation of Illinois. The Woodbury Creek specimens described by Boucot are not well enough preserved to show whether the costellae were uniform or alternating.

Anoplia nucleata (Hall) is sparsely represented in the vitreous chert facies of the Sallisaw Formation (pl. XIII, figs. 16-24). This genus appears to be restricted to strata of Deerparkian and Esopusian age (in eastern North America); *A. nucleata* has been widely reported from strata of this age throughout the central and eastern parts of the United States and Canada. It is present in the Frisco and Sallisaw Formations of Oklahoma; it is also found in the Clear Creek Formation of Illinois, the Camden Formation of western Tennessee, and the Woodbury Creek Member of the Esopus Formation.

The species herein identified as *Schellwienella*? sp. is moderately common in the Sallisaw Formation. I use the generic name *Schellwienella* in a broad sense to cover the early Devonian orthotetacids having well-developed dental plates. As this group is in need of taxonomic review and revision, the stratigraphic value of the various species recognized is limited. The Sallisaw shells have an internal and external resemblance to the Esopus specimens which Boucot (1959b, p. 752, pl. 96, figs. 3, 4, 6, 7, 9, 11) identified as *Schuchertella* sp. A.

Leptocoelia flabellites? (Conrad) is represented by a number of Sallisaw specimens although the preservation is not good (pl. XIV, figs. 1-10). In so far as can be determined, the Sallisaw shells are conspecific with those from the Oriskany Sandstone of New York; they appear to be specifically different from specimens of *L. acutiplicata* (Conrad) from the Onondaga Formation of New York (see description of *Leptocoelia flabellites*? (Conrad). The Sallisaw shells seem to be conspecific with specimens from the Clear Creek Formation of Illinois and the Camden Formation of western Tennessee. This species is also present in the Highland Mills and Woodbury Creek (lower half) Members of the Esopus Formation (Boucot, 1959b, p. 741, pl. 91, figs. 1-6).

The Sallisaw collections include a number of specimens of *Fimbrispirifer* cf. *F. divaricatus* (Hall) from the arenaceous carbonate facies at stratigraphic section S14 (pl. XVIII, figs. 2-11). Cooper (1944, p. 323) gave the range of the genus *Fimbrispirifer* as Onondaga to Tichenor, and Boucot (1959b, p. 735) stated that it is restricted to strata of post-Oriskany age. The Sallisaw shells are similar to specimens of *Fimbrispirifer divaricatus* (Hall)* from the Onondaga Limestone, but they differ in the nature of the pedicle palintrope. To my knowledge the genus *Fimbrispirifer* has not been reported from the Esopus, Clear Creek, or Camden Formations. The Sallisaw specimens are found in association with the typical Sallisaw brachiopod fauna.

Hysterolites (Acrospirifer) worthenanus? (Schuchert) is well represented in both the arenaceous carbonate and the vitreous chert facies of the Sallisaw (pl. XVI). I follow the diagnosis given by Havlíček and treat *Acrospirifer* as a subgenus of *Hysterolites,* but it should be noted that the internal structure of the type species of *Acrospirifer* and *Hysterolites* is unknown to me (see *H. (A.) murchisoni* in part I and *H. (A.) worthenanus*? in part II, this report). Boucot (1959b, p. 736) treated *Hysterolites* and *Acrospirifer* as

* Cooper (1944a, p. 323) reported this species from the Lower Onondaga; Oliver (1956, p. 1452, 1462) recorded it from the Edgecliff and Moorehouse Members of the Onondaga.

separate genera and gave the range of each as Oriskany to Onondaga. The Sallisaw specimens are certainly closely related to and, in all probability, conspecific with the type specimens from the Clear Creek Formation of Illinois. This species is also believed to be present in the Camden Formation of western Tennessee. Boucot reported a few fragmentary specimens of *Hysterolites* sp. from the Woodbury Creek Member of the Esopus Formation.

The most common Sallisaw brachiopod is *Amphigenia curta* (Meek and Worthen), which is widely distributed in all facies (pl. XIV, figs. 11-21; pl. XX, fig. 8). The genus *Amphigenia* is apparently restricted to strata of Esopusian and Onesquethawan age. Boucot (1959b, p. 737, text-fig. 5) gave an informative discussion on the phylogeny of this genus. He believed that the Onondaga species *A. elongata* (Vanuxem), which has a short spondylium and long median septum, developed out of *Etymothyris,* with long subparallel dental plates, by the convergence of the dental plates. The Woodbury Creek species, *A. preparva* Boucot, is intermediate in structure between the early Esopusian *Etymothyris* and the Onesquethawan species *A. elongata,* having a long spondylium and no median septum. The pedicle interior of *A. curta* appears to be intermediate between *A. elongata* and *A. preparva;* it has a median septum but this is considerably shorter than in *A. elongata* (see *Amphigenia curta* (Meek and Worthen), Brachiopod Descriptions). *A. curta* is common in the Sallisaw, Camden, and Clear Creek Formations.

The Sallisaw also includes a few fragmentary specimens of *Leptaena* sp. and *Atrypa* sp. These species are of little or no value in determining the relative age of this formation.

In summary, the diagnostic elements in the Sallisaw fauna point to a late Esopusian or possibly early Onesquethawan age. The combination of *Protoleptostrophia blainvillei, Chonostrophia complanata*? (evenly ribbed type), and *Leptostrophia flabellites*? suggests the Esopusian Stage*; the species *Eodevonaria intermedia* is compatible with Esopusian or Onesquethawan; the pedicle structure of *Amphigenia curta* would best accord with late Esopusian or, possibly, very early Onesquethawan; *Anoplia nucleata* and *Hysterolites (Acrospirifer) worthenanus* are not incompatible with an Esopusian date, but could be present in Deerparkian or Onesquethawan strata. So far as I know, the genus *Fimbrispirifer* has not been reported from

* It should be kept in mind that the Sallisaw Formation unconformably overlies the Frisco Formation which carries a large and characteristic Deerparkian fauna.

the Esopus, Clear Creek, or Camden Formations, although *F. grieri* (Hall) is present in the Schoharie Formation and *F. divaricatus* has been reported from the Bois Blanc Formation of Michigan; this would suggest a late Esopusian or younger age.

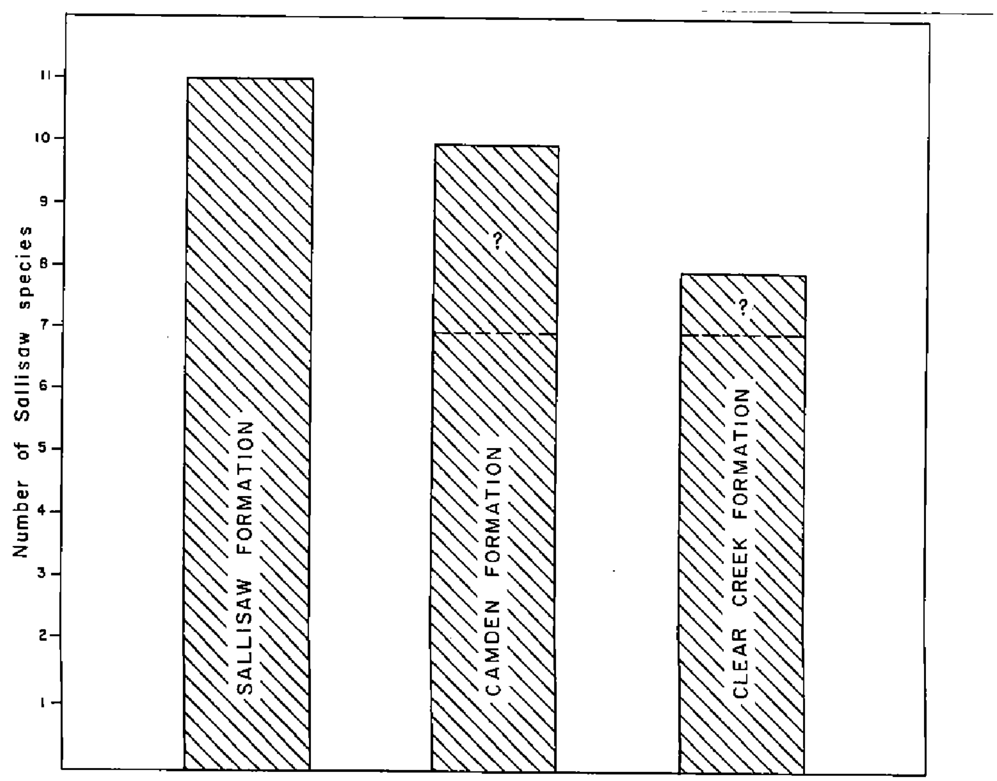
Camden Formation. — The Camden Chert was named by Safford (Safford and Schuchert, 1899, p. 429-430) for exposures at Camden, Benton County, western Tennessee. Schuchert (Safford and Schuchert, 1899, p. 431-432) stated that the fossils are early Oriskany in age and similar to the fauna described by Meek and Worthen (1868, p. 393-404) from the Clear Creek Formation of southern Illinois. Some years later Dunbar (1918, p. 746-754; 1919, p. 79-81) removed the lower part of the Camden to a new formation, the Harriman Chert; on the basis of its fauna the Harriman was considered to be an Oriskany correlative (see part I of this report), whereas the Camden (restricted) was assigned to the early Middle Devonian. In discussing the age of the Camden Formation (restricted) Dunbar (1919, p. 89) stated ". . . the Camden (and Clear Creek) chert may be partially at least the time equivalent of the Esopus and Schoharie grits of New York." In 1949 Wilson (p. 310-312) noted that the Camden was represented by a limestone and a chert facies (see also Dunbar, 1919, p. 80).

Dunbar (1919, p. 86-87) recorded 42 species from the Camden; these were distributed as follows: 1 coral, 1 crinoid, 1 bryozoan, 3 inarticulate brachiopods, 30 articulate brachiopods, 2 trilobites, and 4 mollusks.* The Camden articulate brachiopods cited by Dunbar are given in table 8 of the present report. This is a fairly large brachiopod fauna although it should be noted that many of these species are rare; the following seven species are represented by only one or two specimens: *Rhipidomelloides alsa?, Isorthis* cf. *I. propinqua, Strophodonta* cf. *S. hemisphaerica, Camarotoechia* cf. *C. sappho, Costispirifer unicus, Paraspirifer acuminatus, Metaplasia pyxidata.* I have examined Dunbar's Camden collection at Peabody Museum, Yale University; all of the fossils seen by me came from the chert facies, and are preserved as external molds and steinkerns. I made a careful study of only those species which also are present in the Sallisaw. I did not make an equally careful examination of the other species, especially those which are quite rare, and therefore can verify only those species which are closely related to the Oklahoma shells.

* Bassler (1941, p. 21-27, figs. 1-37) described 27 species of ostracodes from the Camden Formation.

The Camden fauna is considerably larger than that of the Sallisaw, but it is noteworthy that, with the exception of *Fimbrispirifer,* all of the Sallisaw genera are represented in the Camden by identical or closely related species (text-fig. 45). The Sallisaw species, *Protoleptostrophia blainvillei, Schellwienella?* sp., *Anoplia nucleata, Chonostrophia complanata?*, *Amphigenia curta, Hysterolites (A.) worthenanus?*, and *Leptocoelia flabellites* are believed to be conspecific with the Camden representatives; the species *Eodevonaria intermedia, Atrypa* sp., and *Leptaena* sp. are similar to, and may well be conspecific with, Camden species. All of these Camden species are from the chert facies, but in the Sallisaw most are present in both the chert and arenaceous carbonate facies. Only *Fimbrispirifer* has not been recognized in the Camden, nor does it appear to be present in the Clear Creek or Esopus.

Clear Creek Formation.—The Clear Creek was named by Worthen (1866, p. 126-129) for exposures along Clear Creek in Union County, southwestern Illinois. As originally defined, this formation included all of the Devonian strata between the Silurian and the "Oriskany" sandstone (= Dutch Creek Sandstone), and thus included strata now referred to the Bailey, Grassy Knob, Backbone (= Little Saline of Missouri), and Clear Creek Formations.



Text-figure 45. Chart showing the number of Sallisaw species present in the Camden Formation of western Tennessee and the Clear Creek Formation of southern Illinois. That part of the bar marked with a question mark indicates the number of Sallisaw species which are questionably represented.

In subsequent publications by Ulrich, Savage, and others, the Clear Creek was restricted to those strata, mostly bedded cherts, between the Backbone Limestone and the Dutch Creek Sandstone (Savage, 1908, p. 436-437; 1920, p. 170-171, 174-175). In the northern area of outcrop, in Jackson and Union Counties, the Clear Creek rests upon the Backbone Limestone, but farther south, in Alexander County, it rests upon the Grassy Knob Chert (Weller and Ekblaw, 1940, pl. I). Weller (Weller and Ekblaw, 1940, p. 14) described the Clear Creek Formation as consisting

> . . . principally of novaculite chert, although fine-grained very siliceous limestone in variable amounts is present at many outcrops in northern Union County. Much of the chert, particularly in northern Union County, is white, somewhat calcareous, and has the appearance of unglazed porcelain. This type of chert, where unweathered, encloses subordinate amounts of fine-grained siliceous limestone in thin discontinuous beds, nodule-like masses, and slender cyclindrical strands which penetrate the chert in all directions. Where the limestone has been

TABLE 8.—CAMDEN ARTICULATE BRACHIOPODS
(modified slightly from Dunbar, 1919)

	Sallisaw Formation	Clear Creek Formation	Illustrations* Plate	Figure(s)
Rhipidomelloides alsa? (Hall)				
Isorthis cf. I. propinqua (Hall)				
Leptaena "rhomboidalis" (Wilckens)	?	?		
Strophodonta inaequiradiata Hall				
Strophodonta cf. S. hemispherica Hall				
Protoleptostrophia blainvillei (Billings)	X	?	[XIX]	[6]
Schellwienella? sp. [Dunbar identified as Schuchertella pandora (Billings)]	X	X	[XIX]	[10]
?Eodevonaria intermedia Amsden [Dunbar identified as E. arcuata (Hall)]	X	X	4 [XX]	13 [10]
Chonetes [?] hudsonicus camdenensis Dunbar		X	4 II	9 17
Chonetes [?] fornaculus Dunbar			II	25
Anoplia nucleata (Hall)	X	X	4	1-3
Chonostrophia complanata? (Hall) [Dunbar identified as C. reversa (Whitfield)]	X	X	4 [XX]	4, 5 [18, 19]
Costellirostra peculiaris (Conrad)		X		
Camarotoechia cf. C. sappho (Hall)				
Centronella glansfagea (Hall)		X		
Amphigenia curta (Meek and Worthen)	X	X	4 [XX]	14, 15 [1-7]
Prionothyris condoni (McChesney)		X		
Atrypa "reticularis" (Linné)	?	?	4	16
"Spirifer" nearpassi Weller				
"Spirifer" duodenarius (Hall)		?		
Paraspirifer acuminatus (Conrad)				
Costispirifer unicus Hall				
Hysterolites (A.) worthenanus (Schuchert)	X	X	4	12
Brachyspirifer? hemicyclus (Meek and Worthen)		X	4	10, 11
Elytha fimbriata (Conrad)		X		
Metaplasia pyxidata (Hall)		X		
Cyrtina rostrata (Hall)				
Meristella lentiformis Clarke				
Pentagonia unisulcata (Conrad)				
Leptocoelia flabellites? (Conrad)	X	X	4 [XX]	8 [11-14]

*Bracketed references are to illustrations in this report.
Unbracketed references are to illustrations in Dunbar (1919, 1920).

> removed by leaching, the chert has been left as an exceedingly rough, porous, vesicular mass.

This description accords very well with the appearance of the Clear Creek outcrops which I have examined in the northern part of Union County, southern Illinois. One thin section of the Clear Creek chert shows that the rock is predominantly finely crystalline quartz with widely scattered, subangular to angular quartz grains up to a millimeter in diameter.

The Clear Creek fauna was first assigned an Oriskany age (Worthen, 1866, p. 127; Meek and Worthen, 1868, p. 393-406; Savage, 1908, p. 436), but later Savage (1920, p. 174) followed Dunbar (1919, p. 89) and placed this formation in the early part of the Ulsterian. The present study indicates that the Clear Creek, the Camden, and the Sallisaw are of late Esopusian age.

Some of the Clear Creek beds are highly fossiliferous, the fossils being preserved almost entirely as external molds and steinkerns. In 1868 Meek and Worthen described six brachiopods from the Clear Creek Formation: *Anoplia nucleata* (Hall), *Leptocoelia flabellites* (Conrad), *Hysterolites (A.) engelmanni* (Meek and Worthen) [this name preoccupied and later replaced by *H. (A.) worthenanus* (Schuchert)], *Brachyspirifer? hemicyclus* (Meek and Worthen), *Prionothyris condoni* (McChesney), and *Amphigenia curta* (Meek and Worthen). To my knowledge no other descriptive work has been published on this fauna, although Savage gave several faunal lists; the list of Clear Creek articulate brachiopods on table 9 is a slightly modified tabulation of the lists given by Savage (1908, p. 437; 1920, p. 174). I have examined a number of specimens from the Clear Creek Formation. The type specimens of *Amphigenia curta, Hysterolites (A.) worthenanus* and *Brachyspirifer? hemicyclus* were borrowed from the Illinois Geological Survey and are illustrated on plate XVII and text-figure 49 of this report. I have also examined Savage's Clear Creek collections at Peabody Museum, Yale University, and a small collection from this formation at the U. S. National Museum; these include specimens of *Anoplia nucleata, Chonostrophia complanata?*, *Eodevonaria intermedia, Schellwienella?* sp., *Leptocoelia flabellites?*, as well as additional specimens of *Amphigenia curta, Hysterolites (A.) worthenanus,* and *Brachyspirifer? hemicyclus.* The Sallisaw brachiopods have a marked similarity to this fauna with the following species known to be common to both formations: *Anoplia nucleata, Chonostrophia complanata?*, *Eodevonaria intermedia, Schellwienella?* sp., *Leptocoelia flabellites?*, *Hysterolites (A.) worthenanus?*, and

Amphigenia curta (text-fig. 45). The only Sallisaw species not recognized in the Clear Creek are *Atrypa* sp., *Leptaena* sp., *Fimbrispirifer* cf. *F. divaricatus,* and *Protoleptostrophia blainvillei,* and I suspect that the latter may be present. The absence of *Fimbrispirifer* in the Esopus, the Camden, and the Clear Creek has already been discussed. Note the similarity of the Clear Creek brachiopod fauna to that of the Camden; 15 of the 17 species listed on table 9 are also present in the Camden. (According to Bassler (1941, p. 22) the Clear Creek ostracodes are similar to those from the Camden.)

Littleton Formation. — The Littleton Formation comprises a rather thick sequence of slates, sandstones, and volcanics, which crops out in northwestern New Hampshire. Locally the strata are sparsely fossiliferous; and a small fauna, mostly brachiopods, has been collected from three localities. Past investigators have generally assigned these fossils to the Deerparkian Stage (Oriskany) of the Lower Devonian, but recently Boucot and Arndt (1960, p. 41, 42, 50) restudied the Littleton fauna and concluded that it is related to the faunas from the upper part of the Moose River Sandstone of Maine and from the Camden Formation of western Tennessee. The

TABLE 9.—CLEAR CREEK ARTICULATE BRACHIOPODS
(modified from Savage, 1908, 1920)

	Sallisaw Formation	Camden Formation	Illustrations* Plate	Figure(s)
Rhipidomelloides cf. R. musculosus (Hall)				
Anoplia nucleata (Hall)	X	X	XX	9
Chonostrophia complanata? (Hall) [Savage identified as C. reversa (Whitfield)]	X	X		
Eodevonaria intermedia Amsden, new species [Savage identified as E. arcuata (Hall)]	X	?		
?Protoleptostrophia blainvillei (Billings) [Savage identified as Leptostrophia perplana (Conrad); Dunbar (1919, p. 86) stated that a species closely related to P. blainvillei is present in the Clear Creek]	X	X		
Schellwienella? sp. [Savage identified as Schuchertella pandora (Billings)]	X	X	XIX	7-9
Costellirostra peculiaris (Conrad)		X		
Leptocoelia flabellites? (Conrad)	X	X	XX	15-17
Hysterolites (A.) worthenanus (Schuchert)	X	X	XVII	13-21
Hysterolites (A.) macrothyris (Hall)				
Brachyspirifer? hemicyclus (Meek and Worthen)		X	XVII	8-12
"Spirifer" duodenarius (Hall)		X		
Metaplasia pyxidata (Hall)		X		
Elytha fimbriata (Conrad)		X		
Amphigenia curta (Meek and Worthen)	X	X	XVII	1-7
Centronella glansfagea (Hall)		X		
Prionothyris condoni (McChesney)		X		
?Atrypa "reticularis" (Linné)**		X		
Chonetes [?] hudsonicus camdenensis Dunbar**		X		
?Leptaena "rhomboidalis" (Wilckens)**		X		

*References are to illustrations in this report.
**Recorded by Dunbar (1919, p. 86-87) from the Camden Formation.

fossils are distorted by metamorphism so that precise specific identification is, for the most part, not possible. Boucot and Arndt (1960, p. 47-50, pl. 1-3) described the following twelve articulate brachiopods:

Rhipidomelloides musculosus solaris
Costellirostra sp.
Atrypa "reticularis"
Euryspirifer cf. *E. atlanticus*
Brachyspirifer cf. *B. perimele*
Protoleptostrophia cf. *P. blainvillei*
Schuchertella? sp.
Leptaena "rhomboidalis"
"Chonetes" cf. *"C." nectus*
Eodevonaria cf. *E. arcuata*
Amphigenia cf. *A. parva*
Prionothyris? sp.

The poor state of preservation of this fauna makes a detailed comparison difficult, but it would certainly seem to be related to the Camden (table 8). Almost all of the Littleton genera are represented in the Camden by similar or closely related species. These genera are *Protoleptostrophia, Costellirostra, Atrypa, Rhipidomelloides, Leptaena, Eodevonaria, Amphigenia,* and *Prionothyris; "Chonetes" fornaculus* Dunbar is a small, coarse-ribbed chonetid similar to *"C."* cf. *"C." nectus* Clarke; the genus *Brachyspirifer* is probably represented in the Camden by *B.? hemicyclus* (Meek and Worthen). The shell identified by Boucot and Arndt as *Schuchertella*? sp. is not well enough preserved to be compared to *Schellwienella*? sp. The only genus which has not been recognized in the Camden is *Euryspirifer,* and a detailed restudy of the complete Camden fauna might reveal its presence.

This fauna also shows some affinities with the Sallisaw and Clear Creek (tables 7A, 9). Three of the Littleton genera, *Protoleptostrophia, Eodevonaria,* and *Amphigenia,* would seem to be represented in the Sallisaw and Clear Creek faunas by similar species.

Summary. — The Sallisaw Formation is assigned to the latter part of the Esopusian Stage and is thus of late Early Devonian age. Its fauna is closely related to the Clear Creek fauna of southern Illinois and the Camden fauna of western Tennessee, and a recent study of Boucot and Arndt (1960) showed that the Littleton Formation of New Hampshire and the upper Moose River Sandstone of Maine have similar faunas. Several other formations in the central part of the United States have been correlated with the Sallisaw, the Clear Creek, and the Camden, but the faunal evidence supporting these relationships is meager. The lower division of the Arkansas novaculite commonly is correlated with these formations (Miser, 1944, p. 134; Hass, 1951, p. 2526, 2529; Ham, 1961, p. 207), the evidence for this being based on stratigraphic position and lithologic similarity as no diagnostic fossils have been found in this lower part of the formation (Hass, 1951, p. 2534). Such a correlation is, at best, only tentative because as Dunbar noted some years ago (1919, p. 82) this type of rock occurs at several different horizons in the central part of the United States. The Pinetop Formation of southwestern Oklahoma also has been correlated with the Camden, Sallisaw, and lower part of the Arkansas Novaculite. Some of the limestone beds are sparsely fossiliferous, and W. E. Ham and I have collected a few fragmentary fossils from the Pinetop; but to my knowledge no diagnostic fossils have been found, or at least no descriptions or faunal lists have been published. The Penters Chert of north-central Arkansas has generally been considered to be of the same age as the lower division of the Arkansas Novaculite (Miser, 1944), and in 1946 Kinney (p. 613-614) reported a small fauna from a thin limestone at its base; G. A. Cooper of the U. S. National Museum identified the following fossils in this fauna: "*Ambocoelia*" sp., *Leptocoelia flabellites* (similar to the Camden specimens assigned to this species), *Rhipidomella* sp., *Platyceras* sp., *Strophostylus* sp., and *Phacops cristata* (Hall).

The Onondaga Formation of New York was recently studied by Oliver (1954, 1956). He divided the formation into a number of members, each with several faunal zones, and he gave extended faunal lists for the various members and zones. In 1961 Oliver removed his zone B from the lowermost member of the Onondaga (Edgecliff Member), tentatively assigned it a late Early Devonian age, and correlated it with the Bois Blanc Formation of Michigan. The Bois Blanc Formation was named by Landes, Ehlers, and Stanley (1945, p. 80-109) for exposures on Bois Blanc Island, near Mackinac Island, northern Michigan, and it consists of a sequence of limestones, dolomites, and cherts having a thickness of 111 to 150 feet (Stumm, Kellum, and Wright, 1956, p. 4). These authors (Landes and others, 1945, p. 107) listed the Bois Blanc fossils (some are also illustrated), including a number of corals*, some trilobites, and the following brachiopods: *Amphigenia elongata* (Vanuxem),

* Both the Bois Blanc Formation and Oliver's zone B include a substantial number of corals in contrast to the Camden, Clear Creek, and Sallisaw Formations in which corals are uncommon or few.

Centronella glansfagea (Hall), *Chonetes hemisphericus* Hall, *Costispirifer unicus* (Hall), *Cymostrophia patersoni* (Hall), *Protoleptostrophia perplana* (Conrad), *Fimbrispirifer divaricatus* (Hall), *Pentamerella arata* (Conrad), *Strophonella ampla* (Hall), "*Spirifer*" *duodenarius* (Hall), "*S.*" *marcus* Hall, and "*S.*" *varicosus* Hall. A few of these brachiopods have also been reported from the Camden and the Clear Creek, although it should be noted that most of the common Camden-Clear Creek species such as *Anoplia nucleata, Eodevonaria intermedia, Schellwienella*? sp., *Chonostrophia complanata*?, and *Brachyspirifer*? *hemicyclus* are not recorded from the Bois Blanc. The Bois Blanc species of *Amphigenia* does not appear to be conspecific with *A. curta* from the Camden, the Clear Creek, and the Sallisaw (compare pl. XI, figs. 5, 6 of Landes, Ehlers, and Stanley, 1945, with pl. XIV, figs. 11-21, pl. XVII, figs. 1-7, pl. XX, figs. 1-7 of this report). With the exception of the genus *Fimbrispirifer,* the Bois Blanc brachiopods show little in common with those of the Sallisaw; the specimens of *Fimbrispirifer divaricatus* (Hall) illustrated by Landes, Ehlers, and Stanley (1945, pl. XI, figs. 3, 4) have some resemblance to the Sallisaw representatives of *Fimbrispirifer* (compare with pl. XVIII, figs. 2-11 of this report). Some of the brachiopod elements which Oliver records from his zone B, or *Amphigenia* zone, are also suggestive of the Camden, Clear Creek, and Sallisaw faunas, but a detailed study is needed to clarify this relationship.

BRACHIOPOD DESCRIPTIONS

Eleven Sallisaw brachiopod species representing eleven genera and six superfamilies are described herein. A complete list of these species, with numbers of specimens and geographic distribution, is given in tables 7A and 7B and they are illustrated on plates XIII to XX. Almost all of the brachiopods described in this report were collected by me from outcrops in the Marble City area, Sequoyah County (text-fig. 3). A few specimens collected by H. E. Christian were also used. The stratigraphic and geographic distribution of each species is given in the section on distribution which concludes each description and the method of presenting this information is discussed in part I of this report (p. 60). The stratigraphic sections from which the fossils were collected have been described in my 1961 report (appendix) and therefore only a brief geographic location is given below. The locations are also shown on the map, text-figure 3.

S1 — Big bend of Sallisaw Creek; SW¼ SW¼ SW¼ sec. 13, T. 13 N., R. 23 E. (Amsden, 1961, p. 90-92, pl. I).

S3 — Northeast of St. Clair Lime Company quarry; NW¼ NE¼ NW¼ sec. 13, T. 13 N., R. 23 E. (Amsden, 1961, p. 93-94, pl. I).

S4 — Walkingstick Hollow; SW¼ SW¼ SW¼ sec. 1, T. 13 N., R. 23 E. (Amsden, 1961, p. 94-96, pl. I).

S5 — South of St. Clair Lime Company quarry; SW¼ NE¼ SE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 96-98, pl. I).

S8 — Payne Hollow; NW¼ SW¼ NE¼ sec. 22, T. 13 N., R. 23 E. (Amsden, 1961, p. 101-102, pl. I).

S9 — Payne Hollow; NE¼ NW¼ NE¼ sec. 22, T. 13 N., R. 23 E. (Amsden, 1961, p. 102-104, pl. I).

S10 — Payne Hollow; SW¼ SE¼ SE¼ sec. 15, T. 13 N., R. 23 E. (Amsden, 1961, p. 104-106; pl. I).

S11 — Payne Hollow; NW¼ SW¼ SE¼ sec. 15, T. 13 N., R. 23 E. (Amsden, 1961, p. 106-107, pl. I).

S13 — St. Clair Lime Company mine; NE¼ SE¼ sec. 14, T. 13 N., R. 23 E. (Amsden, 1961, p. 108, pl. I).

S14 — Payne Hollow; NW¼ SW¼ SE¼ sec. 15, T. 13 N., R. 23 E. (Amsden, 1961, p. 108-110, pl. I).

Superfamily STROPHOMENACEA

GENUS *Protoleptostrophia* CASTER, 1939 (emended Williams, 1953)

Protoleptostrophia blainvillei (Billings), 1874
Plate XIX, figures 1-6

Strophomena blainvillei Billings, 1874, p. 28-29, pl. 2, figs. 1a, 1b, pl. 3, fig. 1.
Protoleptostrophia blainvilli [sic] (Billings). Williams, 1953, p. 41, pl. 9, figs. 14-15.

Description. — *Protoleptostrophia blainvillei* is present in both the vitreous chert and the arenaceous carbonate facies of the Sallisaw Formation. In the latter facies it is represented by several fairly complete valves. The shell has a subelliptical to subquadrate outline and a width greater than its length (length/width ratio averages 0.82). Its hinge line is straight and fairly long; from the cardinal extremities forward the shell is broadly rounded. It has a plano-convex lateral profile, the pedicle valve having a gentle and uniform convexity. The pedicle beak is small. The ornamentation consists of fine, rounded costellae separated by narrow interspaces, and 17 to 21 costellae occupy a space of 5 mm.

Some of the Sallisaw specimens are fairly large, one fragmentary pedicle valve being almost 50 mm wide. The measurements of five reasonably complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
27	34	0.80	17
30	36	0.83	19
31	38	0.82	----
35	40	0.88	21
38	47	0.81	18
----	----	----	17
----	----	----	18

The pedicle muscle scar is large, fan-shaped, and divided into two parts by a median septum (pl. XIX, figs. 3, 6). In the dorsal valve the two lobes of the cardinal process are disjunct and are directed posteroventrally (pl. XIX, figs. 1, 2). A stout septum extends forward from the base of the cardinal process. The brachial adductor muscle scars are bordered on their outer edges by heavy ridges (pl. XIX, fig. 2). The hinge line is denticulate.

Discussion. — The genus *Protoleptostrophia* was named by Caster; the type species is *Strophomena blainvillei* Billings from the Gaspé Sandstone of Quebec. In 1953 Williams (p. 41, pl. 9, figs. 14, 15) emended Caster's generic diagnosis and reillustrated the internal characters of *P. blainvillei.* I have recently examined the U. S. National Museum collections of this species from the Gaspé Sandstone near Gaspé, Quebec, which include a number of well-preserved specimens showing the external and internal features. The Sallisaw specimens are similar in size, outline, and lateral profile to those from the Gaspé Sandstone. The ornamentation is also similar, the costellae of the Gaspé shells being rounded and separated by narrow interspaces; three of the Gaspé specimens have rib counts of 17, 18, and 20 per 5 mm. The brachial interiors of the Canada shells seem to be identical with those of the Sallisaw. The only possible difference is in the nature of the pedicle scar; in the Gaspé shells the fan-shaped muscle scar may be slightly more flared than it is in the Oklahoma specimens.

I have also examined specimens identified as *P. perplana* (Conrad) in the Middle Devonian (Hamilton) collections of the U. S. National Museum. Internally and externally these shells are much like *P. blainvillei,* but they are are distinguishable on the basis of the costellation. The number of ribs occupying a space of 5 mm is approximately the same on the Hamilton shells as it is on the Gaspé-Sallisaw shells; however, in *P. perplana* the ribs are narrow with sharp, irregular crests and are separated from one another by relatively broad, U-shaped interspaces, whereas in *P. blainvillei* the ribs have rounded crests and are separated by narrow interspaces.

The Camden Chert of western Tennessee has a protoleptostrophid brachiopod which is probably conspecific with *P. blainvillei;* a pedicle interior of a Camden specimen is illustrated on plate XIX, figure 6. According to Dunbar (1919, p. 86) a closely related species is present in the Clear Creek Chert.

Figured specimens. — Frisco Formation, localities S10 and S14-C; numbers OU 4406-4408, 4385. Camden Formtaion, near Camden, Tenn.; YPM 22412.

Distribution. — Billings' specimens came from the Gaspé Sandstone, Quebec. My Sallisaw collections include about 16 free valves, three being from the vitreous chert facies and 13 from the arenaceous carbonate facies (pedicle/brachial ratio 7.0). These are from localities S14-C and S10.

GENUS *Leptaena* DALMAN, 1828

Leptaena sp.

Discussion. — I have four fragmentary free valves from the arenaceous carbonate facies of the Sallisaw which are complete enough to identify generically but not well enough preserved to justify a specific assignment. The largest has a length of about 30 mm and a width of about 50 mm.

The Camden Chert collections at Peabody Museum, Yale University, include a few reasonably well-preserved pedicle valves which are similar to *Leptaena ventricosa* (Hall) from the Oriskany Sandstone and the Frisco Formation. The Sallisaw shells mentioned above are similar in size and outline to these Camden specimens, but their poor preservation prevents a more exact comparison.

Distribution. — Three pedicle valves and one brachial valve from the arenaceous carbonate facies of the Sallisaw Formation at locality S10-D.

Superfamily CHONETACEA

GENUS *Eodevonaria* BREGER, 1906

Eodevonaria intermedia Amsden, new species

Plate XIII, figures 1-15; text-figure 46

Description. — The shells of *Eodevonaria intermedia* have a concavo-convex lateral profile. The pedicle valve is deeply convex (text-fig. 46) and its curvature is rather closely paralleled by the brachial, thus producing a shallow living chamber. The pedicle palintrope is well developed, ranging from anacline to almost orthocline. Spines extend out from the pedicle hinge area as shown in plate XIII, figure 5, although their precise number and arrangement is not known as they are not preserved on most specimens. In outline the shells are transverse with the width consistently greater than the length. The hinge line is straight and the cardinal extremities of unbroken shells are extended into small "ears" (pl. XIII, figs. 4, 7, 14). The pedicle valve is uniformly convex except near the posterolateral margins where the shell is deflected outward, extending into the "ears." Both valves bear low, rounded costellae, which are separated by narrow interspaces (pl. XIII, figs. 4, 11), and 10 to 13 costellae occupy a space of 5 mm. The costellae increase in number by intercalation and bifurcation so that the spacing remains more or less uniform from front to back.

This species has a moderately large shell for a chonetid brachiopod. The measurements of six nearly complete pedicle valves are given below:

Length mm	Width mm	Length/Width ratio	Costellae per 5 mm
16.5	21.8	0.75	13
17.7	21.8	0.81	12
18.1	19.3	0.94	11
18.5	24.9	0.75	13
18.6	25.0	0.75	10
19.9	23.3	0.85	12

In the pedicle interior a low median septum extends from the delthyrial cavity forward for about a third the length of the valve, and elongate, shallow muscle scars are on each side of this septum (pl. XIII, figs. 12, 15). The delthyrium is open on all of the specimens in my collection, and any plate or plates that originally may have been present have been lost. The brachial valve has a bilobed cardinal process which is directed posteriorly. From the base of this process three ridges extend forward, the one in the center making a septum that extends for almost the length of the valve and becomes moderately high near its front end. The outer ridges are much shorter and define an elevated area to which the adductor muscles presumably were attached (pl. XIII, figs. 1, 7). The hinge lines of both valves are crenulate, the denticulations reaching almost to the outer margins.

Text-figure 46. *Eodevonaria intermedia* Amsden, new species. Profile drawings, x1. Sallisaw Formation, Sequoyah County.

Discussion. — The genus *Eodevonaria* was proposed by Breger (1906, p. 534-536) to encompass a group of Lower and Middle Devonian chonetids with denticulate hinge lines. Breger included six American and European species but did not designate a type. In 1929 Schuchert and LeVene (p. 57) selected *Chonetes arcuatus* Hall as the type species. Breger cited three North American species: *Chonetes arcuatus* Hall (1857, p. 116) and *Strophomena acutiradiata* Hall (1843, p. 171, fig. 3) from the Onondaga Limestone of New York (see below), and *Chonetes melonicus* Billings (1874, p. 15, fig. 6; Clarke, 1908, p. 206-207, pl. 46, figs. 1-4) from the

Gaspé Limestone (= Grande Grève Limestone), Gaspé Peninsula. In 1908 Clarke added three other species: *Chonetes antiopa* Billings from the Grande Grève Limestone, *Chonetes hudsonicus* Clarke from the Oriskany Sandstone, and *Chonetes hudsonicus gaspensis* Clarke (1908, p. 240, pl. 45, figs. 6-15) from the Gaspé Sandstone. The first two species seem to be incorrectly placed in *Eodevonaria* as they lack a crenulate hinge line (Clarke, 1908, p. 208, 239), but *E. gaspensis* appears to be a typical representative of *Eodevonaria.* Both *E. gaspensis* and *E. melonica* differ considerably from the Sallisaw shells. The first-mentioned species has a smaller shell with much flatter convexity, whereas *E. melonica* is smaller and appears to have finer ribbing. The Oklahoma specimens are most similar to *E. arcuata* (Hall) and *E. acutiradiata* (Hall); and in order to make a more precise comparison, I borrowed Hall's figured specimens from the American Museum of Natural History (Hall, 1867, pl. 20, figs. 5a-5c, figs. 7a-7f). Both species were described much earlier (1843 and 1857), and it is not certain that the specimens borrowed are the same as those upon which the original description was based. The types of *E. arcuata* came from two different localities; six specimens are from the "Upper Helderberg limestone, Williamsville, N. Y.," and two specimens are from the "Upper Helderberg limestone, Clarence Hollow, N. Y." These include all of the specimens illustrated by Hall (1867) on plate 20, figures 7a-7f, and refigured on plate XV of this report. The types of *E. acutiradiata* are on a single slab, which has several specimens including those figured by Hall (1867) on plate 20, figures 5a-5c, and reillustrated on plate XV of this report. These specimens are from the "Upper Helderberg limestone, East Buffalo, N. Y." One additional specimen from Williamsville, N. Y. (pl. XV, figs. 3, 4) was included with the types, although it was not illustrated by Hall in 1867.* The type specimens of *E. arcuata* are morphologically distinct from *E. acutiradiata,* although a larger collection might show a gradation between them. However, on the basis of Hall's specimens, *E. arcuata* may be distinguished from *E. acutiradiata* by its more deeply convex pedicle valve and more prominently arched umbo; it is also more finely costellate, having 16 to 18 costellae per 5 mm as compared with a spacing of 12 to 13 on *E. acutiradiata.* All of the specimens of *E. arcuata* have at least a slight depression along the midline of the

* All of Hall's figured specimens are presumed to be from the Onondaga Limestone, although it should be noted that Oliver (1956, p. 1469, table 6) does not record any species of *Eodevonaria* from this formation. I saw no specimens of *Eodevonaria* in the Onondaga collections at the U. S. National Museum, nor at Peabody Museum, Yale University. See also Cooper (1944a, p. 347).

pedicle valve, and on some this develops into a distinct sulcus. Only one specimen of *E. acutiradiata* shows a faint pedicle sulcus (pl. XV, fig. 2). The collection from Clarence Hollow includes one pedicle steinkern which shows some of the internal characters of that valve (pl. XV, figs. 8, 9, 16); the type specimens furnish no further information on the pedicle interior of *E. acutiradiata* or on the brachial interiors of either species.

The Sallisaw shells are similar to the Onondaga specimens in size, outline, and, in so far as can be determined, in internal characters. The spacing of the costellae is similar to that of *E. acutiradiata,* but the Oklahoma shells have a much more strongly convex pedicle valve and a more swollen umbo. In their deep convexity the Sallisaw specimens are like *E. arcuata,* but the latter has considerably finer costellation. None of my specimens shows any trace of a pedicle sulcus.

I have examined the collections of *Eodevonaria* from the Clear Creek Formation of southwestern Illinois at the U. S. National Museum and at Peabody Museum, Yale University. These shells are remarkably similar to those from the Sallisaw in internal and external features; the length/width ratio ranges from 0.70 to 0.72 (the average ratio of Sallisaw specimens is 0.80), and the costellae spacing ranges from 11 to 14 in a space of 5 mm (compared to an average of 11 for the Sallisaw specimens). I have also examined a number of specimens from the Camden Chert of western Tennessee. Most are similar to those from the Sallisaw, but there are a few Camden shells with finer costellation (as many as 18 ribs per 5 mm; see pl. XX, fig. 10), and some have a pedicle sulcus. The pedicle interiors of the Tennessee and Oklahoma shells appear to be the same; I have not observed the brachial interiors of the Camden specimens.

Eodevonaria intermedia appears to be similar to the specimens of *Eodevonaria* cf. *E. arcuata* illustrated by Boucot (1959b, p. 756, pl. 97, figs. 11-16) from the Woodbury Creek Member of the Esopus Formation, Orange County, New York.

Figured specimens. — Sallisaw Formation locality S10; numbers OU 4352-4360. Hall's figured specimens of *Eodevonaria acutiradiata* and *E. arcuata* from the Onondaga Limestone of New York are reillustrated on plate XV; American Museum of Natural History, numbers 3046/1, 3049/1, and 3049/2. A specimen from the Camden Formation, Camden, Tennessee, is illustrated on plate XX, figure 10; YPM 22428.

Distribution. — I have about 40 specimens from the arenaceous carbonate facies and the vitreous chert facies; some of the specimens from the chert facies are remarkably well preserved. Localities S8, S10, S13, S14.

This species is present in the Clear Creek Formation of Illinois. It may also be present in the Camden Formation of western Tennessee and in the Woodbury Creek Member of the Esopus Formation, New Jersey.

GENUS *Chonostrophia* HALL AND CLARKE, 1892

Chonostrophia complanata? (Hall), 1857

Plate XIV, figures 22-25; plate XVI, figure 16; plate XX, figures 18, 19

Chonetes complanata Hall, 1857, p. 56; Hall, 1859, p. 418, pl. 93, figs. 1a-1d.

Chonostrophia complanata (Hall). Hall and Clarke, 1892, p. 311, pl. 16, figs. 13, 29.

Description. — I have only a few specimens of this species from the vitreous chert facies of the Sallisaw Formation, but their preservation is quite good. The shells are transverse with a length/width ratio ranging from 0.6 to 0.7. The pedicle valve is weakly convex around the beak, but just in front of the umbo the curvature is reversed and the shell becomes moderately concave. Spines were originally present along the hinge but these are broken on all my specimens, leaving only the basal attachment scar; the specimen illustrated on plate XIV, figure 22 appears to have had three spines on each side, inclined away from the beak. The ornamentation consists of delicate costellae; on our specimens the costellae appear to be partly exfoliated, although enough of the original ornamentation remains to show that the ribs were uniform in size with a spacing of about 20 to 25 per 5 mm (pl. XIV, figs. 22, 23, 25).

The largest specimen has a length of about 7 mm; measurements of three nearly complete shells are given below:

Length mm	Width mm	Length/Width ratio
6	9	0.6
6.5	10	0.6
7	10	0.7

The pedicle interior is illustrated on plate XIV, figure 24; the interior of a pedicle valve from the Camden Formation of Tennessee is illustrated on plate XX, figure 19. No brachial valves were observed.

Discussion. — In so far as can be determined, the Sallisaw shells are similar to representatives of this species from the Oriskany Sandstone and the Frisco Formation (pl. I, figs. 11-15); the Sallisaw-Frisco-Oriskany shells are alike in size, length/width ratio, profile, and ornamentation. I, however, make this identification questionable because of the small number of Sallisaw specimens available and because of their partly exfoliated exteriors, although in all probability they are conspecific with the Oriskany-Frisco specimens. A more extended discussion of *C. complanata* (Hall) is given in part I of this bulletin.

The Sallisaw specimens appear to be conspecific with shells from the Camden Formation of western Tennessee.* Dunbar (1919, p. 86) assigned the Camden specimens to *Chonostrophia reversa* (Whitfield, 1882, p. 213; 1891, p. 549, pl. 11, figs. 8, 9; Hall and Clarke, 1892, p. 311, pl. 15B, figs. 15-19), a species based upon specimens from the "thin-bedded bituminous limestone from above the Bonebed at Smith and Price's quarries, near Columbus, Ohio" [?Columbus Limestone]. I have not had an opportunity to examine any Ohio specimens; but according to Whitfield, Hall and Clarke, and Boucot (1959b, p. 757), this species is characterized by an alternating type of costellation, the larger costellae being separated from one another by several smaller ribs. None of the Camden or Sallisaw specimens observed by me has this type of ribbing.

According to Dunbar (1919, p. 86) the Camden species, which he identified as *C. reversa,* is also present in the Clear Creek Chert. I observed only one Clear Creek specimen of *Chonostrophia* in the Peabody Museum collections at Yale and this has uniform costellation like that of the Camden and Sallisaw shells.

Figured specimens. — Sallisaw Formation, locality S10; numbers OU 4364, 4384, 4385. Camden Formation, ½ mile north of Camden, Tennessee; YPM 22429.

Distribution. — Hall based his description of this species upon specimens from the Oriskany Sandstone of New York. It is also present in the Frisco Formation of Sequoyah County, Oklahoma; additional information on distribution is given in part I under *Chonostrophia complanata.*

Three free pedicle valves are in the Sallisaw collections; all are from the vitreous chert facies at locality S10.

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* The Camden Chert collections at Peabody Museum, Yale University, include a great many specimens of this species; their preservation is excellent, but the collection consists almost entirely of free pedicle valves. Several Camden specimens are illustrated on plate XX, figures 18, 19.

Genus *Anoplia* Hall and Clarke, 1892

Anoplia nucleata (Hall), 1857

Plate XIII, figures 16-24; text-figure 25

Leptaena nucleata Hall, 1857, p. 47; Hall, 1859, p. 419, pl. 94, figs. 1a-1d.
Anoplia nucleata (Hall). Hall and Clarke, 1892, p. 309, pl. 15a, figs. 17, 18, pl. 20, figs. 14-17; Clarke, 1900, p. 51, pl. 7, fig. 14; Schuchert and Maynard, 1913, p. 340, pl. 61, figs. 22-24; Dunbar, 1919, p. 86, pl. 4, figs. 1-3; Cooper, 1944a, p. 347, pl. 135, figs. 17-20; Boucot, 1959b, p. 758, pl. 97, figs. 3-5.
Anoplia nucleata (Hall). Amsden and Ventress, part I, this report, pl. I, figs. 1-4; pl. X, figs. 13-16; pl. XI, fig. 20, text-fig. 25.

Description. — *Anoplia nucleata* is represented by about two dozen free valves from the vitreous chert facies of the Sallisaw Formation (pedicle/brachial ratio 7.0). All of the Sallisaw specimens have small, transverse shells, the length/width ratio ranging from 0.7 to 0.8 (see below and part I, text-fig. 25). The lateral profile is concavo-convex with fairly uniform curvature from back to front; the curvature is similar to that of the Frisco specimens (see part I, text-fig. 26). The hinge line is straight and generally marks the point of greatest width. The surface is smooth except for concentric growth lines.

The largest Sallisaw specimen which I have observed has a length of about 3.5 mm. Measurements of five nearly complete pedicle valves are given below:

Length mm	Width mm	Length/Width Ratio
3	4	0.7
3	3.5	0.8
3.5	4	0.8
3.5	4.5	0.7
3.5	4.5	0.7

The pedicle and brachial interiors appear to be typical for this species; compare the Sallisaw specimens illustrated on plate XIII, figures 16-20, 22, with the Glenerie specimens shown on plate X, figures 14, 16.

Discussion. — *Anoplia nucleata* (Hall) has been widely reported from Deerparkian and Esopusian strata in various parts of the eastern and central United States and in eastern Canada. Hall's original description was based upon specimens from the Oriskany Sandstone, Albany County, New York. Subsequent investigators have found it in the following Deerparkian formations: Glenerie Limestone of New York, Grande Grève Limestone of Quebec, Little Saline Limestone of Missouri, Harriman Formation of Tennessee, and Frisco Limestone of Oklahoma. It has also been reported from the following Esopusian formations: Esopus Formation of New York, Camden Chert of Tennessee, Clear Creek Chert of Illinois, and Sallisaw Formation of Oklahoma. It is always difficult to place precise morphologic limits on small, smooth shells of this type, especially because they are so commonly preserved as internal steinkerns and external molds (all of the Sallisaw specimens are preserved in this way). Nevertheless, a marked resemblance can be demonstrated for most of the representatives of *A. nucleata* from these different formations. I have examnied specimens from the Glenerie Limestone, Camden Chert, Clear Creek Chert, Frisco Formation, and Sallisaw Formation; except for size, they do not show much morphologic variation. The Glenerie shells are distinctly larger, with pedicle valves 6 to 7 mm long not uncommon (part I), whereas few specimens from these other formations exceed 5 mm in length. The Glenerie shells are also slightly more elongate, with a length/width ratio ranging from 0.7 to 1.0, in contrast to a range of 0.5 to 0.8 for the Frisco-Sallisaw shells (part I, text-fig. 25) and 0.7 to 0.9 for the Camden-Clear Creek specimens. The length/width ratios of these shells overlap substantially, and neither the size nor the length/width ratios seem to furnish a satisfactory basis for a morphologic separation. In all other respects, including internal characters, the specimens of *A. nucleata* examined by me are similar and are probably conspecific.

A. nucleata is common in the Camden Formation of western Tennessee, and I have examined the large collections of C. O. Dunbar at Peabody Museum, Yale University. These are like the Sallisaw specimens in all respects, including size; the measurements of four reasonably complete pedicle valves from the Camden are given below:

Length mm	Width mm	Length/Width ratio
3	4	0.7
4	4.5	0.9
4	4.5	0.9
4	5	0.8

I have also examined specimens of *A. nucleata* from the Clear Creek Chert of Illinois at Peabody Museum, Yale University (pl. XX, fig. 9). These specimens, like those from the Camden and Sallisaw Formations, are preserved in chert as internal and external molds. The Clear Creek shells show no significant difference from the Camden or Sallisaw shells; the measurements of three pedicle valves are given below:

Length mm	Width mm	Length/Width ratio
4	5	0.8
4	5	0.8
4.5	5.5	0.8

Additional information on *Anoplia nucleata* is given in part I of this report.

Figured specimens. — Sallisaw Formation, locality S10; numbers OU 4358, 4361-4364, 4385; Clear Creek Formation, Union Co., Illinois; YPM 22421.

Distribution. — Hall's description of this species was based upon specimens from the Oriskany Sandstone of New York. The Sallisaw collections under study include about 24 free valves, all from the vitreous chert facies, localities S8 and S10. This species has also been widely reported from Deerparkian, Esopusian, and Onesquethawan strata in the United States.

A. nucleata is present in the Frisco Formation of the Arbuckle Mountains region and Sequoyah County, Oklahoma; see part I for additional information on distribution.

Superfamily ORTHOTETACEA

GENUS *Schellwienella* THOMAS, 1910

Schellwienella? sp.

Plate XIX, figures 7-16; text-figure 47

Description. — This species has a transverse shell, the length/width ratio ranging from 0.5 to 0.8. It has a straight hinge line with rounded cardinal extremities; the anterior part of the shell is broadly rounded. In lateral profile it ranges from convexo-plane to convexo-concave; on small shells the brachial valve is moderately convex and the pedicle is weakly convex to flat, but with increased size the brachial deepens considerably and the pedicle generally becomes slightly concave (text-fig. 47). The pedicle palintrope is broad, apsacline; a strongly arched pseudodeltidium closes the delthyrium (pl. XIX, fig. 15). Larger brachial valves have a narrow, anacline palintrope. Both valves have narrow, angular costellae which are separated by broad, U-shaped interspaces. Well-preserved specimens have concentric filae crossing the ribs and interspaces. The number of costellae increases by bifurcation and implantation; at a distance of 15 to 20 mm in front of the beak there are 7 to 10 ribs in a space of 5 mm.

Mature specimens of this species are fairly large. One fragmentary pedicle valve from the arenaceous carbonate facies is at least 65 mm wide. The dimensions of 5 smaller valves are given below:

Length mm	Width mm	Costellae per 5 mm
	pedicle valves	
18	24 (est.)	9
24	30 (est.)	7
30 (est.)	35	8
	brachial valves	
25 (est.)	50 (est.)	7
45 (est.)	60	

This species has well-developed dental plates and a broad muscle area; none of the Sallisaw specimens shows the detail of the pedicle muscle area. No satisfactory brachial interiors are in the Sallisaw collections. Pedicle and brachial interiors from the Clear Creek Formation are illustrated on plate XIX, figures 7, 8.

Discussion. — The reference of the Sallisaw specimens to *Schellwienella* is questionable, as I have no detailed information on the internal structures of this species. *Schellwienella* was proposed by Thomas (1910, p. 92) with *Spirifer crenistria* Phillips designated as the genotype. He gave only a brief diagnosis, the principal characters noted being a resupinate profile and dental lamellae. Boucot (1959b, p. 753) stated that *Schellwienella* possessed dental plates, but that these "occur laterally to the hinge-teeth." I have been using the name *Schellwienella* sensu lato (Amsden 1958, p. 90-92; 1959, p. 75-77) to distinguish the Early Devonian orthotetids with dental lamellae from those which lack such plates (the latter referred to *Schuchertella),* and will continue this practice in the present report, although further study of this group will undoubtedly show the need for some taxonomic revision.

The Sallisaw specimens are similar in size, outline, profile, and ornamentation to shells from the Camden and Clear Creek Formations. Measurements of three nearly complete pedicle valves are given below:

Length mm	Width mm	Costellae per 5 mm*
	Camden Formation	
15	18	10
15	19	9
	Clear Creek Formation	
25	40 (est.)	9

*Approximately 5 mm in front of beak

External and internal views of several Camden and Clear Creek specimens are shown on plate XIX, figures 7-10.

Schellwienella? sp. resembles the shells of *Schuchertella* sp. "A" described by Boucot (1959b, p. 752, pl. 96, figs. 3, 4, 6, 7, 9, 11) from the Highland Mills and Woodbury Creek Members of the Esopus Formation, New York. The Esopus shells also have well-developed dental plates.

This species is similar to *Schellwienella marcidula* Amsden (1958a, p. 90-92, pl. 5, figs. 3-9, pl. 13, fig. 25; 1958b, p. 66-67, pl. 2, figs. 16, 17) from the Haragan and Bois d'Arc Formations, although the Sallisaw shells appear to be somewhat more transverse. The spacing of the costellae is about the same on the two species, but the Sallisaw specimens have narrow, angular costellae with relatively broad interspaces, whereas in *S. marcidula* the ribs are thicker and the interspaces are proportionally narrower.

Figured specimens. — Sallisaw Formation near localities S8 and S9; numbers OU 4362, 4409, YPM 22417, YPM 22418. Clear Creek Formation, Union Co., Illinois; numbers YPM 22413-22415. Camden Formation, near Camden, Tennessee; number YPM 22416.

Distribution. — I have about 25 specimens of this species from the arenaceous carbonate, arenaceous chert, and vitreous chert facies of the Sallisaw Formation. These are all free valves except for a single articulated shell; pedicle/brachial ratio is 2.4. The following localities are represented: S8, S9, S10-D, S14-C.

Superfamily ATRYPACEA

GENUS *Leptocoelia* HALL, 1857

Leptocoelia flabellites? (Conrad), 1814

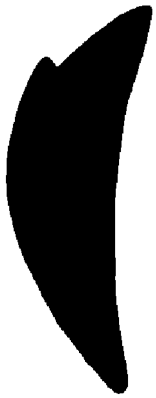
Plate XIV, figures 1-10; plate XX, figures 11-17

Atrypa flabellites Conrad, 1841, p. 55.

Leptocoelia propria Hall, 1857, p. 108-109.

Leptocoelia flabellites (Conrad). Hall, 1859, p. 449-450, pl. 106, figs. 1a-1f, pl. 103, figs. 1a-1f.

Description. — This species has been found only in the arenaceous carbonate facies of the Sallisaw, mostly as partly exfoliated free valves. The shell has a plano-convex lateral profile with the pedicle being moderately curved and the brachial almost flat except for a slight curvature around the umbo. In outline it is transversely elliptical, the width being slightly greater than the length. On the pedicle valve the reversal of curvature takes place along a midline extending from the back to the front of the shell; from this line the valve



Text-figure 47. Profile drawing of *Schellwienella*? sp. from the Sallisaw Formation, x1. Pedicle valve on the right.

slopes rather uniformly to the lateral margins. On the front half of most pedicle valves the middle costa is depressed slightly below the two flanking ribs, thus producing a narrow sulcus. The brachial valve is weakly convex around the umbo, but toward the front it is nearly flat; on larger shells the two middle costae are elevated near the front margin to make a small fold. The shell is costate and plicate; on all of the Sallisaw specimens the costae are low and rounded; however, it should be noted that these shells have undergone some exfoliation. The larger pedicle valves have 5 to 6 ribs on each side of the depressed middle rib.

The largest specimen in my collection has a length of almost 13 mm. The measurements of four free pedicle valves are given below:

Length mm	Width mm	Number of costae on valve
11.1	12.0	11
11.6	13.5	13
11.9	13.7	9
12.7	14.0	13

I have only a single specimen with the two valves articulated and this is small and presumably immature; length 6.1 mm, width 6.7 mm, and thickness 1.9 mm.

The pedicle valve has large teeth, which are cemented directly to the lateral walls (pl. XIV, fig. 2); on the specimens under study the muscle field is poorly outlined but appears to be small and shallow. The brachial hinge plate is large and bears a cardinal process which is directed posteroventrally; none of my specimens is well enough preserved to show the structure of the myophore (my information on the pedicle and brachial interiors is based on steinkerns prepared by calcining the shell). A low median septum extends forward from the cardinal process with the muscle field situated on each side of this ridge (pl. XIV, figs. 8, 10).

Discussion. — The generic name *Leptocoelia* was first used by Hall in 1857 (p. 107-109) without diagnosis, although he did describe three species: *L. concava* Hall (= *Coelospira concava*) from the Helderberg, *L. imbricata* (= *Atrypina imbricata*) from the Helderberg, and *L. propria* Hall from the Oriskany Sandstone; no type species was selected. Two years later Hall (1859, p. 447-448) gave a generic diagnosis of *Leptocoelia* but still did not designate a genotype; in this publication *L. propria* Hall (p. 449) was suppressed as a synonym of the Oriskany species *L. flabellites* (*Atrypa flabellites* Conrad, 1841, p. 55), with a footnote stating that he had overlooked Conrad's earlier description. Some years later Miller (1889, p. 348) designated *L. flabellites* as the type species of *Leptocoelia.* Hall and Clarke (1894, p. 136) also designated *L. flabellites* as the genotype. This presents no nomenclatorial problem if *L. propria* Hall is actually a synonym of *Atrypa flabellites* Conrad; but if these are not conspecific, then Miller's (and later authors') designation of *L. flabellites* as the genotype is invalid because Conrad's species was not included in the original generic indication. The diagnoses given by Hall and Conrad indicate they were describing similar shells, and because both authors were basing their species upon specimens from the Oriskany Sandstone, it is reasonable to suppose the types are conspecific; however, this should be confirmed by a re-study of the type specimens.

Conrad (1841, p. 54, 55) referred the Onondaga shells to a separate species, *L. acutiplicata* (as *Atrypa acutiplicata*), which he characterized as having angular ribs. However, in 1867 Hall (p. 366) questioned whether the Onondaga shells were in fact distinguishable from the Oriskany specimens of *L. flabellites;* and in 1944 Cooper (p. 319) noted that *L. flabellites* ranges from the Oriskany to the Marcellus. On the other hand Clarke (1900, p. 43) stated that *L. acutiplicata* is a distinct species, differing from *L. flabellites* in having more sharply angular plications and a more depressed brachial valve. A comparison of the Oriskany and Onondaga specimens at the U. S. National Museum seems to substantiate Clarke's observations. The Onondaga shells have relatively high, subangular plications, and the two middle costae on the brachial valve are depressed below the general level of the sides. In contrast, the Oriskany shells have slightly lower, more rounded costae, and the two middle brachial ribs are flush with the lateral ribs except at the anterior end where they are elevated to form a small, but distinct fold.

A direct comparison of my somewhat fragmentary specimens with those from the Oriskany Sandstone suggests that they are conspecific. They appear to be similar in outline, profile, character of the pedicle sulcus and brachial fold, and in the rounded costae. The only detectable difference is in size, the Oklahoma shells being somewhat smaller than the typical Oriskany shell. The Sallisaw shells also appear to be similar to, if not identical with, the representatives of *Leptocoelia* from the Clear Creek Formation of Illinois and the Camden Formation of Tennessee. The size of the Tennessee and Illinois shells is closely comparable to those from Oklahoma. For comparison, specimens from the Clear Creek and Camden Formations are illustrated on plate XX. Boucot (1959b, p. 741, pl. 91, figs. 1-6) described specimens of *L. flabellites* from the Highland Mills Member and Woodbury Creek Member of the Esopus Formation, New York.

Figured specimens. — Sallisaw Formation, locality S10-D; numbers OU 4365-4372. Clear Creek Formation, Union Co., Illinois; numbers YPM 22426, 22427. Camden Formation, western Tennessee; numbers YPM 22422-22425.

Distribution. — Conrad's specimens came from the Oriskany Sandstone of New York. This species has been widely reported from North American strata ranging in age from Deerparkian to early Middle Devonian.

About 60 specimens are in the Sallisaw collections; these are almost entirely free valves, most of which are quite fragmentary. All came from locality S10.

GENUS *Atrypa* DALMAN, 1827

Atrypa sp.

Plate XVIII, figure 1

Description. — I have seven fragmentary specimens of *Atrypa* from the arenaceous carbonate facies of the Sallisaw Formation. These are all incomplete, but they do show that the pedicle valve was nearly flat with little or no trace of a sulcus. The brachial valve is strongly convex but appears to have no fold. The length is slightly greater than the width on all of the specimens which are complete enough to measure. The costellation is fine for a shell of this size; 6 or 7 costellae occupy a space of 5 mm near the anterior margin. The largest brachial valve measures 37 mm long by 33 mm wide; the pedicle valve illustrated on plate XVIII has an estimated length of 38 mm and a width of about 35 mm.

Discussion. — This is the only species of *Atrypa* which has been reported from the Lower Devonian beds of northeastern Oklahoma; I found none in the underlying Frisco, nor did Christian (1953, p. 31) list any. *Atrypa oklahomensis* Amsden (1958a p. 116-118, pl. 9, figs. 24-35, pl. 12, figs. 34-37, text-figs. 30, 31; 1958b, p. 77, pl. 5, figs. 41-43) is common in the Haragan and Bois d'Arc Formations (Helderbergian) of the Arbuckle Mountains region, but this species has a smaller shell with a well-developed pedicle sulcus and a brachial fold. The preservation of the Sallisaw specimens is not good enough to justify a more precise specific identification. Dunbar (1919, pl. 4, fig. 16) illustrated a somewhat similar *Atrypa* from the Camden Formation of western Tennessee.

Figured specimen. — Sallisaw Formation, locality S14-C; number OU 4397.

Distribution. — Seven specimens from the Sallisaw Formation at locality S14-C.

Superfamily SPIRIFERACEA

GENUS *Fimbrispirifer* COOPER, 1942

Fimbrispirifer cf. *F. divaricatus* (Hall), 1857

Plate XVIII, figures 2-11; text-figure 48

Spirifer divaricatus Hall, 1857, p. 133; 1867, p. 213-214, pl. 32, figs. 1-9.
Fimbrispirifer divaricatus (Hall). Cooper, 1942, p. 232; 1944a, p. 323, pl. 123, figs. 1, 2.

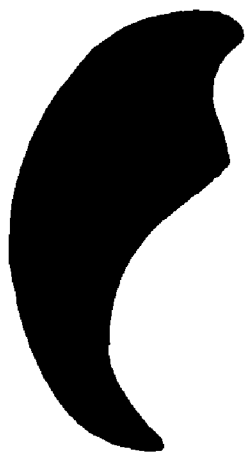
Description. — This species has a large, strongly transverse shell with a length/width ratio ranging from 0.5 to 0.6; the hinge line is straight and marks the point of maximum width. The lateral profile is biconvex; the pedicle valve is deeper than the brachial. The pedicle beak and palintrope are prominent, the latter somewhat curved, apsacline (text-fig. 48); a sulcus begins near the beak and becomes deep at the front margin. A corresponding fold is present on the brachial valve, beginning near the beak and developing into a prowlike ridge at the front. The ornamentation consists of rounded costae which are separated by fairly narrow interspaces; the costae bifurcate toward the front, where 3 or 4 occupy a space of 5 mm (pl. XVIII, fig. 11). Zigzag concentric lamellae cross the ribs and interspaces (pl. XVIII, fig. 4). I have not observed any spines on the lamellae, but all of the Sallisaw specimens are at least partly exfoliated.

The largest specimen in the collections under study is an incomplete pedicle valve with a width of about 70 mm. The measurements of three nearly complete pedicle valves are given below:

Length mm	Width mm	Costae per 5 mm*
32	63 (est.)	4
34	61	3
40 (est.)	67 (est.)	4

*At anterior margin.

The pedicle valve bears a large, deeply impressed muscle scar and dental plates (pl. XVIII, figs. 8, 10). The brachial interior was not observed.



Text-figure 48. *Fimbrispirifer* cf. *F. divaricatus* (Hall). Lateral profile of the large pedicle valve illustrated on plate XVIII, figure 5, x1.

Discussion. — Cooper proposed this genus for a group of Lower* and Middle Devonian spirifers having a costate fold and sulcus, and well-developed dental plates. The ornamentation consists of split costae which are crossed by zigzag concentric lamellae bearing a single row of small spines. Three species were included in the original diagnosis: *Spirifer divaricatus* Hall, *Spirifer grieri* Hall, and the genotype *Spirifer venustus*† from the Hamilton of New York. The Sallisaw specimens closely resemble *F. divaricatus,* a species based upon specimens from the "limestone of the age of the Upper Helderberg group at Williamsville, Erie County [New York]." Cooper (1944a, p. 323) gave the horizon as Lower Onondaga and Oliver (1956, p. 1452, 1462) recorded *F. divaricatus* from the Edgecliff and Moorehouse Members of the Onondaga Formation. I have not seen any New York representatives of this species but judge from Hall's and Cooper's illustrations that the Oklahoma

* According to Boucot (1959b, p. 735) *Fimbrispirifer* is restricted to strata of post-Oriskany age.

† In 1867 Hall (p. 214) suppressed *S. venustus* as a synonym of *S. divaricatus,* but Cooper (1942, 1944a) recognized *S. venustus* as a distinct species.

shells are much like those from the Onondaga, both being large transverse shells with the same kind of ornamentation and similar pedicle interiors. The principal difference would appear to be in the pedicle palintrope, the New York shells having a more strongly apsacline palintrope than have those from Oklahoma. The Sallisaw specimens are quite unlike *S. venustus* and *S. grieri* and may represent a new species; however, the material on hand is not well enough preserved to permit a precise specific diagnosis.

To my knowledge this genus has not been recognized in the Esopus, Camden, or Clear Creek Formations; it is present in the Bois Blanc Formation of Michigan (see Age and Correlation).

Figured specimens. — Sallisaw Formation, locality S14-C; numbers OU 4398-4405.

Distribution. — This species has been found only in the arenaceous carbonate facies of the Sallisaw Formation at locality S14-C; it is common in the upper three feet of the Sallisaw at this locality where it is associated with the typical Sallisaw brachiopod fauna (table 7B). The collections include about 46 free valves, many of which are quite fragmentary. The pedicle/brachial ratio is 2.8.

GENUS *Hysterolites* SCHLOTHEIM, 1820
SUBGENUS *Hysterolites (Acrospirifer)* HELMBRECHT AND WEDEKIND, 1923

Hysterolites (Acrospirifer) worthenanus? (Schuchert), 1890
Plate XVI, figures, 1-16

Spirifer engelmanni Meek and Worthen, 1868, p. 398-399, pl. 8, figs. 5a-5d [not Meek, 1860].

Spirifer wortheni Meek, 1877, p. 42 [not Hall, 1857].

Spirifera worthenana Schuchert, 1890, p. 54; Dunbar, 1919, p. 87.

Description. — *Hysterolites (Acrospirifer) worthenanus*? is well represented in both the arenaceous carbonate and the vitreous chert facies of the Sallisaw Formation. The specimens from the carbonate facies are poorly preserved, but the external and internal molds in the chert facies are excellent and show the external and internal features in considerable detail. The shell is transverse, with the width much greater than the length at all observed stages of growth; length/width ratio ranges from 0.5 to 0.6. In lateral profile the shell is biconvex with the pedicle valve slightly deeper than the brachial. The pedicle beak is pointed and the posterior tip is hooked slightly towards the brachial; palintrope is well developed, slightly curved apsacline. A moderately deep, noncostate sulcus on the pedicle valve begins near the beak, becoming deeper toward the front margin. The brachial valve has a corresponding fold, the crest of which is flattened or even slightly indented near the front. Each valve bears rounded costae separated by U-shaped interspaces; 3 or 4 costae occupy a space of 5 mm (measured next to the pedicle sulcus, about 10 mm in front of the beak). The costae and interspaces are covered with closely spaced, concentric rows of granules, each individual granule being wedge-shaped toward the front; these rows undulate over the costae and interspaces (pl. XVI, figs. 8, 16).

Some shells are moderately large. One incomplete pedicle valve has a length of 23 mm and an estimated width of about 45 mm. The measurements of six pedicle valves are given below:

Length mm	Width mm	Length/Width ratio
9	16	0.5
11	18	0.6
11	19	0.5
13	22	0.5
17	30	0.5
21	42	0.5

The smaller pedicle valves have short dental plates, but with increased size the shell wall thickens and the dental plates become obsolete. The diductor scar is moderately large, subcircular, and divided into two parts by a low ridge (pl. XVI, figs. 2, 7, 15); on the posterior face of the delthyrial cavity is a small pit which probably represents the point of attachment for the adductor muscles (pl. XVI, fig. 15). The delthyrium is open on all of the specimens observed.* The brachial valve has well-developed socket plates; between these is a moderately deep cavity with striated walls for the attachment of the adductor muscles (pl. XVI, figs. 12, 13); the adductor scars are located on the floor in front of this cavity and are separated by a low ridge (pl. XVI, fig. 12). Spiralium and jugum were not observed.

Discussion. — The genotype of *Acrospirifer* is *Spirifer primaevus* Steininger, 1853, from the Lower Devonian of Germany. I am not familiar with the detailed structure of this species and hence base my generic concept upon the diagnosis given by Havlíček (1959, p. 237, pl. 2, figs. 2-4). The internal and external characters of *Hysterolites (Acrospirifer) worthenanus?* seem to agree quite well with the description given by Havlíček. Further discussion of this

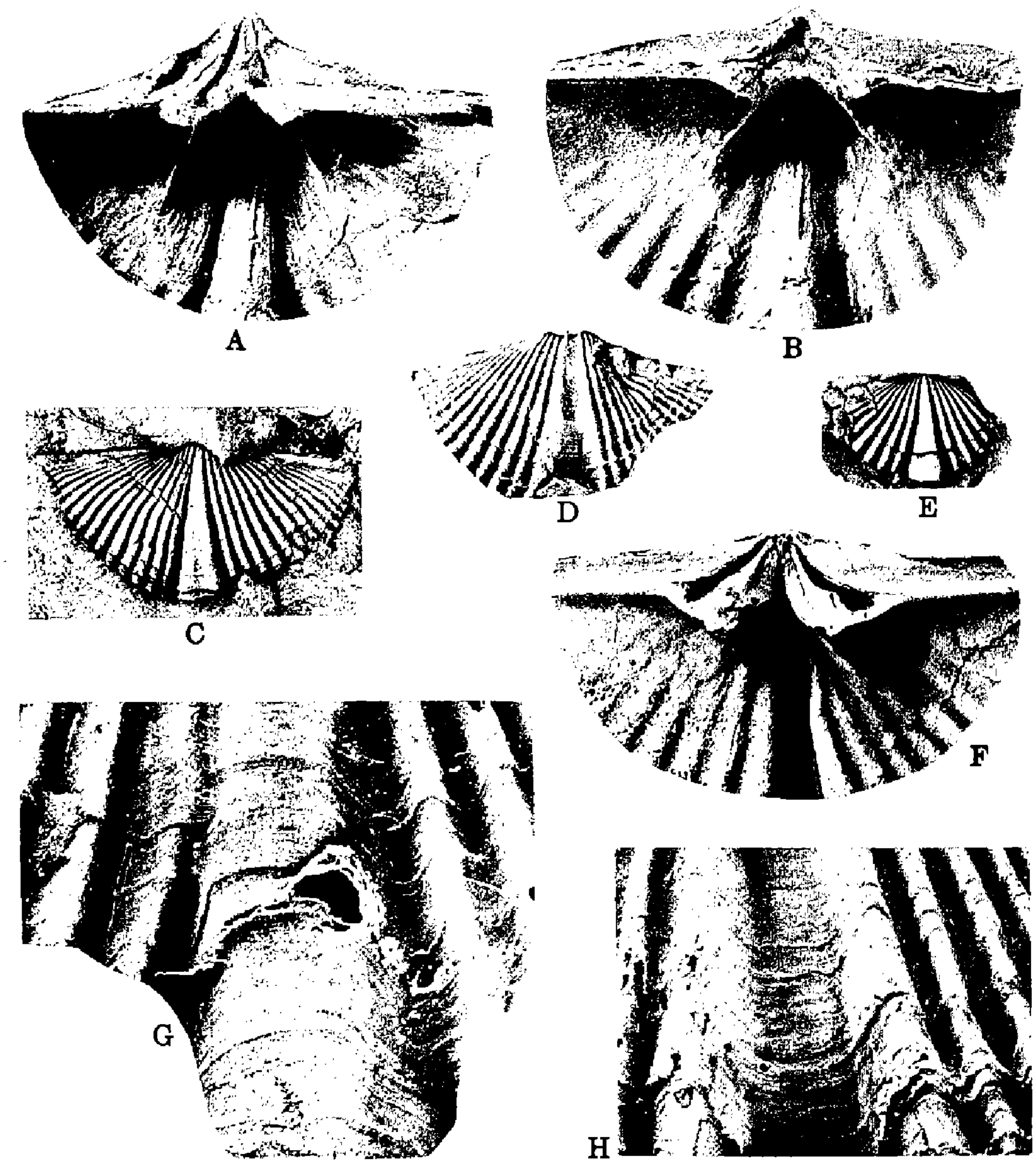
* My knowledge of the internal characters of the Sallisaw specimens is based entirely upon silicified steinkerns from the chert facies.

genus and subgenus is given in part I under *H. (A.) murchisoni.*

In 1868 Meek and Worthen described two new spirifers from the Lower Devonian of Illinois: *Spirifer hemicyclus* (p. 399-401, pl. 8, figs. 6a-6d, 7a, 7b; see pl. XVII, figs. 8-12 and text-fig. 49 of this report) and *Spirifer engelmanni* (p. 398-399, pl. 8, figs. 5a-5d; see pl. XVII, figs. 13-21 of this report; this name, preoccupied by *Spirifer engelmanni* Meek, 1860, was replaced by *Spirifer worthenanus* Schuchert, 1890). The specimens upon which these species were based came from beds described as "cherty limestone of the age of the New York Oriskany [sic] division of the Devonian," Union and Alexander Counties, Illinois; these beds are the ones now referred to the Clear Creek Formation and are believed to be younger than Oriskany (see introduction). Through the courtesy of Mrs. Lois Kent, I was able to borrow Meek and Worthen's type specimens from the Illinois Geological Survey; these include 19 specimens, four of which are referred to *S. engelmanni* (= *S. worthenanus)* and 15 to *S. hemicyclus.*

The four type specimens labelled *Spirifer engelmanni* (= *S. worthenanus)* are from the same locality (T. 12 S., R. 2 W., Union County, Illinois) and include the articulated shell figured by Meek and Worthen on plate 8, figures 5b-5d (herein designated the lectotype and reillustrated on pl. XVII, figs. 13-15, 17) and the pedicle steinkern which Meek and Worthen illustrated on plate 8, figure 5a (reillustrated on pl. XVII, fig. 19). The other two specimens are an articulated shell and a pedicle valve. All these type specimens are incomplete and partly exfoliated so that the outer shell layer is missing. However, the type specimens labelled *Spirifer hemicyclus* include a shell fragment, preserved as an external mold, which has spines arranged in concentric rows (pl. XVII, fig. 21); this specimen is too fragmentary to be compared effectively with the other, more complete, type specimens, but it is clearly not a representative of *B.? hemicyclus* (see below) and is herein interpreted as the exterior of *S. worthenanus.** Interpreted in this way, *S. worthenanus* is similar in outline, profile, and ornamentation to the shells from the Sallisaw Formation. The pedicle interiors are also similar; the brachial interiors cannot be compared as none of Meek and Worthen's type specimens shows this structure. A more detailed comparison is not feasible until the morphologic limits of this species

* It should be noted that none of Meek and Worthen's figured specimens shows this ornamentation, but this is believed to be the result of partial exfoliation; the concentric rows of granulae on almost all of the Sallisaw shells from the carbonate facies and on many of the specimens in the chert facies have been lost.



Text-figure 49. ***Brachyspirifer? hemicyclus*** (Meek and Worthen), Clear Creek and Camden Formations. All specimens are rubber casts of external and internal molds.

A. Slightly oblique view of posterior part of pedicle valve, x2, Clear Creek Formation, collected by T. W. Amsden and Fred Manley, south bank of Hutchins Creek, SE¼ sec. 1, T. 11 S., R. 3 W., Union County, Illinois (OU 4386).
B. Slightly oblique view of pedicle interior, x2, Clear Creek Formation, Illinois (this is one of Meek and Worthen's original figured specimens; for locality and other information see plate XVII, fig. 10).
C. Brachial exterior, x1, (exterior of the specimen shown in F), Clear Creek Formation, Illinois (same collection and locality as A; OU 4387).
D. H. Pedicle (x1) and enlarged surface (x5) views, Camden Formation, ½ mile north of Camden, Tennessee (YPM 22434).
E. Brachial view, x1, Camden Formation, 2 miles southeast of Camden, Tennessee (YPM 22416).
F. Slightly oblique view of posterior end of brachial interior, x3 (interior of specimen illustrated in C), Clear Creek Formation, Ill. (same collection as locality A, C; OU 4387).
G. Enlarged surface view of a pedicle valve, x5, Camden Formation, 2 miles southeast of Camden, Tennessee (YPM 22433). For other views of *B.? hemicyclus* see plate XVII, figures 8-12.

have been clarified on the basis of larger collections from the type locality. *H. (A.) worthenanus* is also present in the Camden Formation, and some of the Tennessee shells show the details of external ornamentation quite well.

The type specimens of *Spirifer hemicyclus* include the articulated shell figured by Meek and Worthen on plate 8, figures 6a, 6b, 6d (herein designated the lectotype and reillustrated on pl. XVII, figs. 8, 9, 11, 12), and the pedicle steinkern illustrated on plate 8, figure 7b (reillustrated on pl. XVII, fig. 10, and text-fig. 49B of this report); the specimens which these authors figured on plate 8, figures 6c and 7a were not positively identified among the paratypes. I also have several excellent specimens which F. H. Manley and I collected from the Clear Creek Chert near its type locality in northern Union County, Illinois, and some of these are illustrated in text-figure 49. This species is not congeneric with *H. (A.) worthenanus* (Schuchert), and I tentatively assign it to *Brachyspirifer*, although it should be noted that I am not familiar with the detailed structure of the type species of that genus; the Clear Creek species has, however, some of the characteristics commonly associated with this genus (Cooper, 1944a, p. 323; *B. audaculus* (Conrad) is illustrated as an example). *Brachyspirifer? hemicyclus* has a strongly developed, noncostate fold and sulcus, and high, narrow costae; the surface does not bear spines or granules, the only markings being closely spaced growth lines, which may become fairly prominent toward the front margin (text-fig. 49G, H). The pedicle palintrope is well developed, slightly curved, and strongly apsacline to almost catacline on some specimens (pl. XVII, figs. 8, 10; text-fig. 49A, B). In the pedicle interior the teeth are supported by short dental plates and the muscle field is only moderately impressed (pl. XVII, fig. 10; text-fig. 49A, B); the delthyrium is largely filled with a triangular wedge or plug of shell material (pl. XVII, fig. 10; text-fig. 49A, B). The brachial interior is illustrated on text-figure 49F. *B.? hemicyclus* is distinguished from *H. (A.) worthenanus* by its nonspinose exterior, high, narrow costae, deeper and more sharply defined fold and sulcus, and more prominent, strongly apsacline palintrope; also the pedicle muscle scars appear to be more deeply impressed in *H. (A.) worthenanus.* This species has not been recognized in the Sallisaw of Oklahoma, but it is common in the Camden Chert of western Tennessee; several Camden shells are illustrated in text-figure 49D, E, G, H.

Figured specimens. — Sallisaw Formation, localities S8, S10; numbers OU 4352, 4362, 4364, 4385, 4388-4396. Meek and

Worthen's type specimens from the Clear Creek Formation of Illinois are illustrated on plate XVII; number IGS 4530.

Distribution. — Meek and Worthen based their description on specimens from Clear Creek Formation of Illinois. The Sallisaw collections include about 118 specimens from the arenaceous carbonate and vitreous chert facies; these are from localities S8, S10, S11-D, S14-C.

This species is also present in the Camden Chert of western Tennessee.

Superfamily TEREBRATULACEA

GENUS *Amphigenia* HALL, 1867

Amphigenia curta (Meek and Worthen), 1868

Plate XIV, figures 11-21; plate XVII, figures 1-7; plate XX, figures 1-8; text-figure 50

Stricklandinia elongata curta Meek and Worthen, 1868, p. 402-404, pl. 8, figs. 1a-1c.

Amphigenia curta (Meek and Worthen). Dunbar, 1919, p. 86, pl. 4, figs. 14, 15; Cloud, 1942, p. 78; Boucot, 1959b, p. 764, 766, pl. 101, fig. 6.

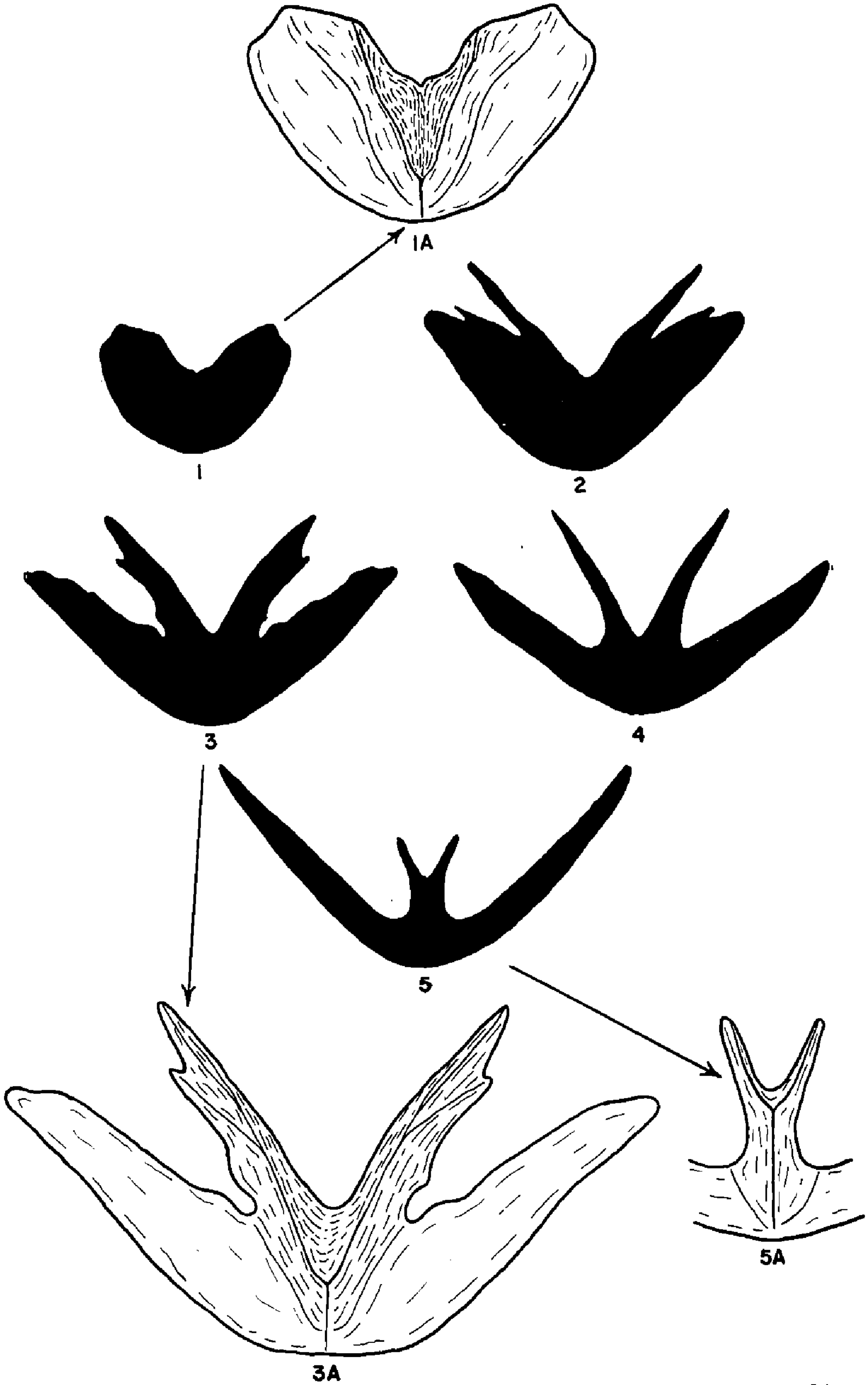
Description. — *Amphigenia curta* is one of the more common species in the Sallisaw Formation, but most of my specimens were collected from the carbonate facies and the preservation is not good. I have one articulated shell (a steinkern from the chert facies), the rest of the collection being composed of free valves, most of which are only the posterior part of the shell. The few reasonably complete valves are exfoliated and the anterior part is generally preserved as a steinkern. Complete valves are elongate elliptical in outline; the length/width ratios of two nearly complete brachial valves are 1.3 and 1.6. The profile is biconvex and the pedicle is slightly deeper than the brachial; one articulated steinkern has a pedicle-valve-depth/brachial-valve-depth ratio of 1.1. On smaller specimens the convexity of both valves is moderate; on larger individuals the valves deepen considerably, producing a stout biconvexity. This increase in convexity is produced by the following growth pattern: the curvature of the valves remained fairly uniform up to a width of 25 to 30 mm; at this size the lateral margins were deflected at a rather sharp angle so that further growth produced a strongly biconvex shell (the anterior slope remained gentle throughout growth). All specimens appear to have a smooth exterior, although it should be noted that most, if not all, are at least partially exfoliated. The shell is punctate.

It is difficult to get a precise idea of the maximum shell size owing to the fragmentation of the material. One nearly complete brachial valve is 31 mm long by 23 mm wide; another larger, but less complete, specimen has an estimated length of 34 mm and a width of 25 mm. One of the larger pedicle valves (pl. XIV, fig. 20) has a width of about 32 mm (anterior end broken). My collection includes one articulated shell (steinkern) and approximately 130 free valves; pedicle/brachial valve ratio is 0.95.

The pedicle valve has a spondylium which is sessile for much of its length, only the anterior end being supported upon a septum (pl. XIV, figs. 13, 14). Throughout its length the spondylium appears to be formed by the convergence of the two dental plates (as indicated by Boucot, 1959b, p. 737), the line of junction being well marked in transverse serial sections (text-fig. 50). Near the posterior end these plates are embedded in the thickened shell wall. The inside of the spondylium is lined with shell material which seems to have been deposited after the spondylial walls were secreted because this layer is continuous across the junction of the dental plates (text-figs. 3A, 5A, 50).* The septum, which is formed by the union of the two walls of the spondylium, extends forward beyond the spondylium (pl. XIV, fig. 14; pl. XVII, figs. 3, 4, 7). Mystrochial plates buttress the spondylium (text-fig. 50).

The brachial hinge plate is supported by two crural plates (pl. XIV, figs. 11, 17, 19; pl. XVII, figs. 2, 4; pl. XX, fig. 3). The crural plates are commonly subparallel although on some specimens they may converge slightly toward the valve floor. This relationship is variable, but on none of the specimens observed by me do the crural plates unite. The space between them is partly filled with shell material which may lap up on the inside walls of the crural plates to produce a cruraliumlike structure. A median ridge extends some distance beyond the anterior end of the crural plates; on some specimens the material filling the space between the plates appears to be a posterior extension of this ridge (pl. XX, fig. 3). Narrow, elongate, diductor scars are present on both sides of the median ridge (pl. XIV, fig. 19; pl. XX, fig. 3). The loop was not observed.

* This condition would appear to be similar to the structure of the spondylium duplex of the Pentameracea as described by St. Joseph (1938, text-figs. 1, 2, etc.), Kozlowski (1929, p. 125), and Amsden (1953, p. 130-140); however, Williams and Wright (1961, p. 164-165) stated that the spondylium of *Amphigenia* is "... quite unlike the pentameroid ones, for it is buttressed by a pair of mystrochial plates, and has been shown (Boucot, 1959, p. 737) to have developed from discrete dental lamellae as in *Rensselaeria* Hall." In the opinion of these authors there is no real difference between the structure of the pentameroid spondylium duplex and the spondylium simplex.



Text-figure 50. Transverse serial sections of the pedicle valve of *Amphigenia curta* (Meek and Worthen). Sallisaw Formation, locality S5-D (OU 3419). Numbers 1 to 5, x3; numbers 1A, 3A, 5A are enlarged drawings (approximately x5) showing the growth lines. The second set of plates which appear in 2 and 3 are probably the mystrochial plates, here cut at an oblique angle. Approximate distance from the posterior tip of the pedicle beak: 1 — 1.5 mm; 2 — 2.5 mm; 3 — 3.8 mm; 4 — 4.6 mm; 5 — 6.3 mm.

Discussion. — The genus *Amphigenia* was proposed by Hall (1867, p. 163), the genotype being *Pentamerus elongatus* Vanuxem from the Onondaga Limestone of New York. In 1942 Cloud (p. 77-80, pl. 9, figs. 18-20; pl. 10, figs. 1-11) redescribed this genus in a monograph which included excellent illustrations of the internal and external features of the type species. In his discussion Cloud stated:

> The shells here assigned to *Amphigenia* may be divided into two groups on the basis of internal characters. In the genotype the crural plates are subparallel and reach the floor of the valve as discrete plates; but in the lower Onondaga forms, such as *A. curta,* the crural plates are longer and converge anterodorsally so that they meet on either side of the myophragm. In some specimens the convergence is so strong and the myophragm so prominent that the appearance is as of a low pseudocruralium. At first these differences were thought to be generic, but *A. parva* from the Moose River sandstone has cast doubt upon this belief by showing interiors of both types.

Boucot (1959b, p. 737, 762-766, pl. 100, figs. 5-13, pl. 101, figs. 1-6, 10) in a recent study of *Amphigenia* concluded:

> Examination of well-preserved specimens belonging to *A. curta* shows that his [Cloud's] cruraliumlike structure is actually formed by the deposition of secondary material between the crural plates so as to raise the tube connecting the floor of the valve with the cardinal plate.

My own study of *A. curta,* which is based upon an examination of specimens from the Clear Creek (including Meek and Worthen's type specimens), Camden, and Sallisaw Formations, shows that the brachial cardinalia is variable, although in no specimens do the crural plates converge enough to unite. On some specimens the plates are nearly discrete except for a low callosity between them, whereas on other specimens the intervening shell material is much thicker and laps up on the inside walls of the crural plates, producing a troughlike structure. There are some brachial valves in which the shell material separating the crural plates appears to be, at least in part, a posterior extension of the median ridge which separates the muscle scars (pl. XX, fig. 3); possibly with further growth in this shell the animal would have secreted a layer of secondary material on top of that part of the ridge between the two plates, thus obscuring its connection with the forward part of the ridge.

Serial sections clearly show that the spondylium and supporting septum are formed by the union of the dental plates.

Meek and Worthen based their description of *A. curta* upon specimens from the "Cherty limestone of the age of the Oriskany sandstone [sic] of the New York Devonian series; Union County, Illinois" (believed to = strata now called the Clear Creek Formation). Through the courtesy of Mrs. Lois Kent of the Illinois Geological Survey, I was able to borrow Meek and Worthen's type specimens and these are reillustrated on plate XVII, figures 1-7. I have also examined specimens in the collections at Peabody Museum, Yale University, which were collected by T. E. Savage from the Clear Creek Chert, Union County, Illinois. In addition I have studied the Peabody Museum collections of *A. curta* from the Camden Formation near Camden, Tennessee (pl. XX, figs. 1-7); the species is abundantly represented in this formation. The shells from both the Camden and Clear Creek Formations are mostly preserved as steinkerns. The Tennessee shells are undoubtedly conspecific with those from the Clear Creek Formation, being similar in all respects, including internal characters. Meek and Worthen treated these shells as a variety (subspecies) of *A. elongata*, but all subsequent investigators have recognized them as a distinct species. As noted by Boucot (1959b, p. 764), the Onondaga specimens have a quite different lateral profile; *A. curta* is strongly biconvex, the brachial valve being nearly as deep as the pedicle, whereas in *A. elongata* the brachial valve is relatively flat in comparison to the pedicle. The deep convexity of the brachial valve is clearly apparent on Meek and Worthen's type specimens as shown in the following measurements:

Maximum depth of pedicle valve (mm)	Maximum depth of brachial valve (mm)	Ratio pedicle/brachial
12	10	1.2
16	13	1.2
18	15	1.2

The following measurements show that a similar relationship is present in the Camden shells:

13	10	1.3
12	10	1.2

One articulated shell from the Sallisaw has a pedicle-depth/brachial-depth ratio of 1.1.

It would appear reasonably certain that the Sallisaw shells are conspecific with those from the Clear Creek and Camden Formations. The internal structure of the Oklahoma shells seems to be identical to that of the Tennessee and Illinois specimens, but it is more difficult to make a precise comparison of external features as most of the Sallisaw specimens are fragmentary free valves, whereas the Camden-Clear Creek specimens are mostly the steinkerns of articulated shells. However, in so far as can be determined, these free valves are similar in size, outline, and profile to those from Illinois and Tennessee; moreover, I have one steinkern from Oklahoma (pl. XX, fig. 8) which is almost identical to those from the Camden and Clear Creek Formations.

Two of the Camden specimens at Peabody Museum have faint radial ribbing on the anterior part of the shell (pl. XX, fig. 7.) I have not observed this on any of the Clear Creek or Sallisaw specimens, but the exterior of the shell is generally at least partly exfoliated. Cloud (1942, p. 79) stated that *A. elongata* has low, simple costellae.

The spondylium of *A. preparva* Boucot (1959b, p. 765, pl. 100, fig. 5, text-fig. 5) from the Woodbury Creek Member of the Esopus Formation is relatively long and unsupported by a septum, whereas *A. elongata* (Vanuxem) (see Boucot, 1959b, p. 762, pl. 100, figs. 8-13, pl. 101, fig. 10, text-fig. 5) has a much shorter spondylium which is supported by a relatively long septum; the latter is about twice the length of the spondylium. The pedicle apparatus of *A. curta* appears to be intermediate between these two species; it possesses a median septum, but this is only slightly longer than the spondylium. Note that these comparisons between the relative length of the spondylium and septum are based upon measurements taken at or near the floor of the valve.

Figured specimens. — The Sallisaw specimens are from localities S3, S5-D, S10, S11-D; numbers OU 4373-4383, 4410.

Meek and Worthen's type specimens are from the Clear Creek Formation, Union County, Illinois; IGS 4548.

The specimens from the Camden Formation near Camden, Tennessee, are at Peabody Museum, Yale University; numbers YPM S-3394, 22419, 22420.

Distribution. — This is the most common brachiopod in the Sallisaw Formation; it is present in the arenaceous limestone lithofacies, arenaceous chert lithofacies, and vitreous chert lithofacies. I have approximately 130 specimens, mostly fragmentary free valves, from the following localities: S1-D, S3, S4-D, S5-D, S10-D, S11-D, S14-C. It is also present in the Camden Formation of western Tennessee. Meek and Worthen's specimens came from the Clear Creek Formation, Illinois.

PART III. — SUPPLEMENT TO THE HARAGAN (DEVONIAN) BRACHIOPODS

THOMAS W. AMSDEN

INTRODUCTION

The Haragan is a Lower Devonian (Helderbergian) formation which forms a part of the Hunton Group. It crops out over a rather large area in the Arbuckle Mountains region and Criner Hills of south-central Oklahoma. The Haragan is a thin-bedded marlstone with considerable amounts of insoluble material, mostly in the form of silt-sized, subangular quartz detritus. The quantity of detritus is highly variable, the insoluble content ranging from about 6 percent to more than 30 percent, with the average about 16 percent. It bears a large and varied fauna, and has been well known for many years as a rich source of well-preserved Lower Devonian fossils. This formation is a facies of the Bois d'Arc Formation, the marlstones of the Haragan grading laterally and vertically into the cherty marlstones and biocalcarenites of the Cravatt and Fittstown Members of the Bois d'Arc. The Haragan-Bois d'Arc Formations rest upon the Henryhouse Formation of Late Niagaran (Ludlovian) age, or, where that formation is absent, upon the Clarita (Middle Silurian), or the Cochrane or Keel (Early Silurian) Members of the Chimneyhill Formation, and locally on the Sylvan Formation (Late Ordovician). The Haragan-Bois d'Arc Formations are overlain by the Frisco Formation of Deerparkian (Oriskany) age, or, where that formation is absent, by the Woodford Formation of Late Devonian age (text-fig. 4). The lithostratigraphic and biostratigraphic relations of this formation have been described in previous papers (Amsden, 1958a, p. 9-24; 1958b, p. 7-25; 1960, p. 86-125, panels I, II, III), and some additional remarks are included in part I of this report (see under Frisco Stratigraphy, *Arbuckle Mountains region*).

The Haragan carries a large articulate brachiopod fauna. In 1958 I described 38 species representing 34 genera (Amsden, 1958a, p. 12-14, 41-157, 14 pls.), and herein are presented three additional species: *Anopliopsis pygmaea* Amdsen, new species, *Chonostrophia helderbergia* Hall and Clarke, and *Spinoplasia gaspensis*? Boucot. Two of these species, *Anopliopsis pygmaea* and *Spinoplasia gaspen-*

sis? are of particular interest because they furnish additional information on the stratigraphic range and geographic distribution of the Paeckelmanniinae and Ambocoelininae. A complete list of Haragan species is given in table 10, and the distribution of Haragan genera in the Lower Devonian strata of Oklahoma is shown in text-figure 10.

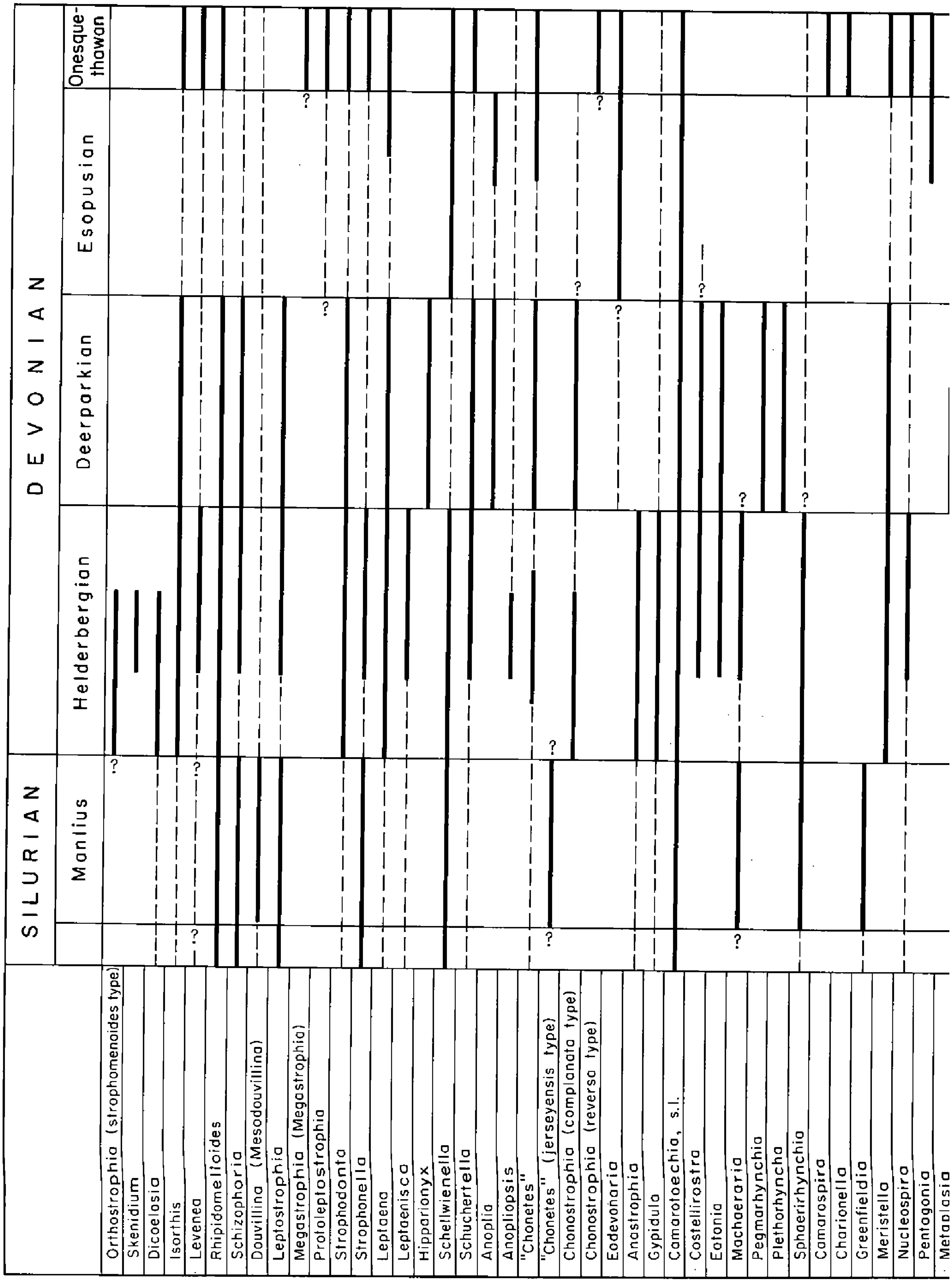
The Helderbergian aspect of this fauna is clearly brought out in the charts of text-figures 10 and 51 which show the distribution of brachiopod genera in the Lower Devonian strata of Oklahoma and of New York. All but five of the Haragan genera are present in the Helderbergian strata of New York; the missing genera are: *Lissostrophia, Plectodonta, Obturamentella, Trigonirhynchia, Rensselaerina,* and *Ancillotoechia*? (The Helderbergian species *Camarotoechia bialveata* (Hall) may be a representative of *Ancillotoechia.*) Two Haragan genera, *Orthostrophia* (of the *strophomenoides* type)* and *Skenidium,* are believed to be confined to the Helderberg in New York. Five of the Haragan genera *(Anopliopsis, Chonostrophia, Costellirostra, Meristella,* and *Spinoplasia)* first appear in the Helderberg, being unknown in the older strata of New York. Three Haragan genera *(Atrypina, Anastrophia,* and *Howellella)* are believed to terminate in the Helderberg of New York, being unknown in the overlying strata. The similarity between Haragan and Helderbergian (New Scotland) brachiopods is even more marked at the species level; this comparison is discussed at some length in my 1958 paper (Amsden, 1958a, p. 18-24).

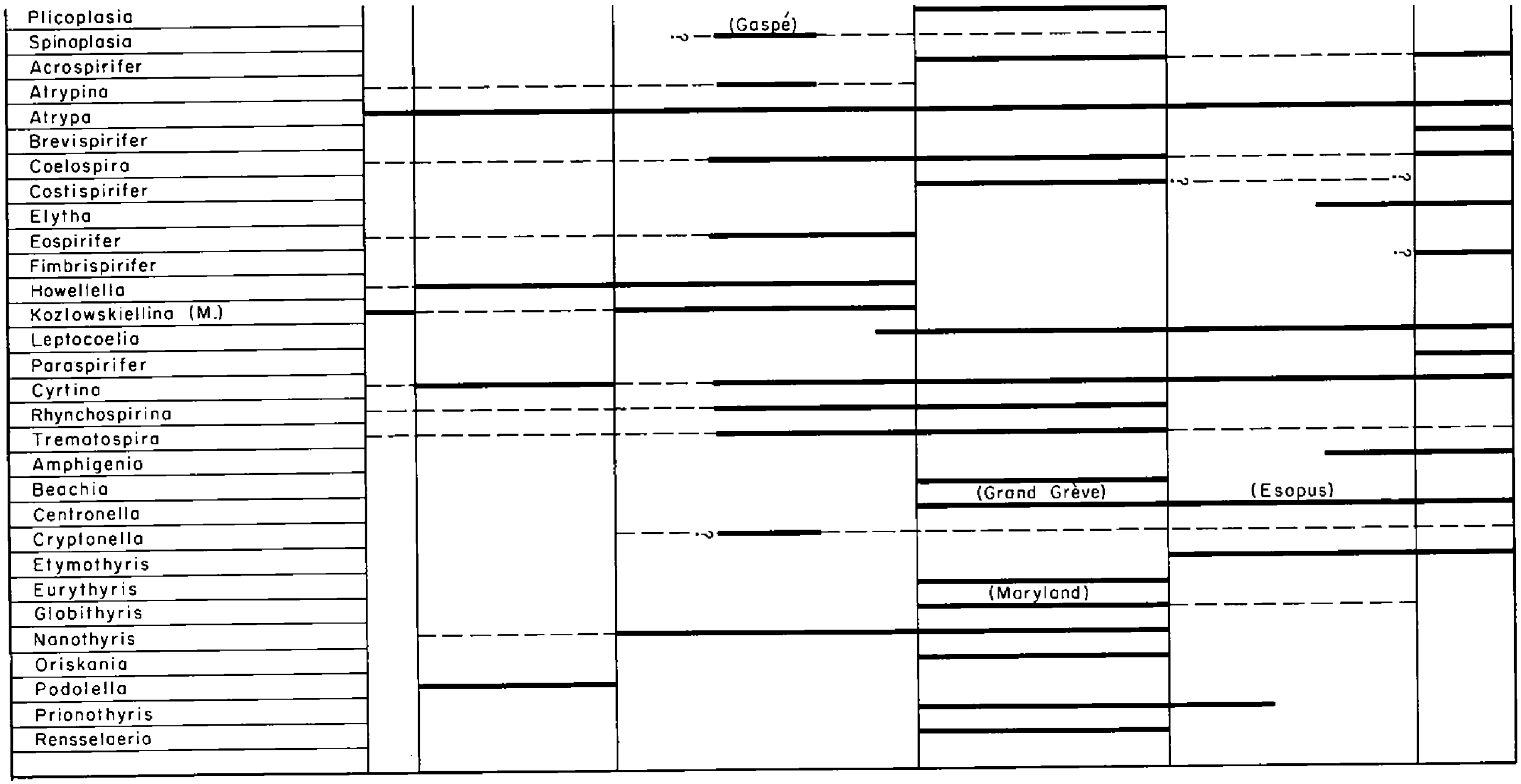
A number of other faunal elements have been described by various authors (see Amsden, 1956). Ireland (1939) described several species of arenaceous Foraminifera; Decker (1941) described four species of graptolites; Delo (1940) and Whittington (1956, 1960) described several trilobites; Roth (1929) and Coryell and Cuskley (1934) described a number of ostracodes (in 1935 Wilson studied the ostracodes from the Birdsong Shale of western Tennessee and found this fauna to be similar to that of the Haragan); Strimple (1952) described a crinoid, and Girty (1899) and Branson and

* The genus *Orthostrophia* generally is stated to range from the Silurian into the Helderbergian. Three forms have been described from North American Helderbergian strata: the genotype, *O. strophomenoides* (Hall), *O. strophomenoides parva* Amsden from the Haragan Formation, and *O. canadensis* Clarke from the St. Albans beds. All three are characterized by a pedicle fold. Four species have been described from the Silurian of North America: "O." *dartae* Schuchert and Cooper, "O." *dixoni* Foerste, "O." *newsomensis* Foerste, and "O." *brownsportensis* Amsden. These Silurian species differ from the Helderbergian species in having the pedicle fold replaced by a sulcus toward the front of the shell.

TABLE 10.—HARAGAN BRACHIOPODS

Orthostrophia strophomenoides parva Amsden
Skenidium insigne (Hall)
Levenea subcarinata pumilis Amsden
Dicoelosia varica (Conrad)
Rhipidomelloides oblatus (Hall)
Isorthis pygmaea (Dunbar)
Anastrophia grossa Amsden
Gypidula multicostata? Dunbar
Leptaena acuticuspidata Amsden
Leptaenisca concava (Hall)
Strophonella (Strophonella) bransoni Amsden
Strophodonta (Brachyprion) gibbera Amsden
Strophodonta (Brachyprion) arata Hall
Lissostrophia (Lissostrophia) lindenensis (Dunbar)
Leptostrophia beckii tennesseensis Dunbar
Schuchertella haraganensis Amsden
Schellwienella marcidula Amsden
Plectodonta petila Amsden
Chonetes? sp.
Chonostrophia helderbergia Hall and Clarke
Anopliopsis pygmaea Amsden, new species
Ancillotoechia? *haraganensis* (Amsden)
Camarotoechia? sp.
Sphaerirhynchia lindenensis (Dunbar)
Sphaerirhynchia glomerosa Amsden
Obturamentella wadei (Dunbar)
Trigonirhynchia acutirostella Amsden
Eatonia exserta Amsden
Costellirostra singularis (Vanuxem)
Atrypa oklahomensis Amsden
Atrypina hami Amsden
Coelospira virginia Amsden
Spinoplasia gaspensis? Boucot
Kozlowskiellina (Megakozlowskiellina) velata (Amsden)
Howellella cycloptera (Hall)
Meristella atoka Girty
Nucleospira ventricosa (Hall)
Cyrtina dalmani nana Amsden
Rhynchospirina maxwelli Amsden
Trematospira cf. *T. hippolyte* (Billings)
Trematospira sp.
Rensselaerina haraganana Cloud


SILURIAN
DEVONIAN
Manlius
Helderbergian
Deerparkian
Esopusian
Onesque-thawan
Orthostrophia (strophomenoides type)
Skenidium
Dicoelosia
Isorthis
Levenea
Rhipidomelloides
Schizophoria
Douvillina (Mesodouvillina)
Leptostrophia
Megastrophia (Megastrophia)
Protoleptostrophia
Strophodonta
Strophonella
Leptaena
Leptaenisca
Hipparionyx
Schellwienella
Schuchertella
Anoplia
Anopliopsis
"Chonetes"
"Chonetes" (jerseyensis type)
Chonostrophia (complanata type)
Chonostrophia (reversa type)
Eodevonaria
Anastrophia
Gypidula
Camarotoechia, s.l.
Costellirostra
Eatonia
Machaeraria
Pegmarhynchia
Plethorhyncha
Sphaerirhynchia
Camarospira
Charionella
Greenfieldia
Meristella
Nucleospira
Pentagonia
Metaplasia



Text figure 51. Chart showing the stratigraphic range for many of the brachiopod genera present in the Lower Devonian strata of New York. This has been compiled mostly from published sources; however, I am indebted to Dr. Jean Berdan of the U. S. Geological Survey for unpublished information on Manlius brachiopods. The purpose of this chart is to show the general distribution of the major brachiopod faunas in the Lower Devonian of New York for comparison with the succession of Lower Devonian faunas in Oklahoma. It is not suggested that this is complete or precise in all respects. Much more biostratigraphic data are needed, especially with respect to Helderbergian faunas. The ranges shown are somewhat generalized, particularly in the Deerparkian where it is assumed that species reported from any strata assigned to this stage range throughout. Recent studies by Rickard (1962) indicate that the Manlius should be included in the Helderbergian stage. The solid lines represent known ranges, the dashed lines inferred ranges.

Amsden (1958) described a few mollusks. All of these authors assigned the Haragan to the Helderbergian stage.*

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* In a recent article Fuller (1961, footnote, p. 1361) stated "The dating of upper Hunton-Interlake in Oklahoma as Lower Devonian (cf. Reeds, 1927, p. 12; Amsden, 1957), however, seems to be untenable on regional stratigraphic grounds, for the great pre-Devonian unconformity was erased, the surface having been further eroded before Mississippian deposition; and the post-Silurian (post-Ludlow) unconformity within the Hunton succession, alleged by Amsden (1957, fig. 4; 1960, pl. C, panel 3) is not only three-dimensionally impossible but undetected in the subsurface (cf. Oxley, 1959, figs. 4 and 5, p. 164)." Fuller gave no explanation or elaboration of what is meant by such statements as *regional stratigraphic grounds, great pre-Devonian unconformity,* or *three-dimensionally impossible,* but his article clearly implied that there is no Devonian in the Hunton of Oklahoma. I certainly cannot subscribe to this conclusion, nor is this the opinion of any of the previous investigators who have concerned themselves with the age of Hunton strata. Oxley's paper cited by Fuller did not discuss the age relationships within the Hunton Group, and his article had no bearing on the presence or absence of Devonian in the Hunton, unless one assumes that all pre-Woodford carbonate beds in Oklahoma are, by definition, Silurian or older. My reasons for assigning the Haragan, the Bois d'Arc, and the Frisco to the Lower Devonian are given in part I and part III of this report, and in my earlier publications (Amsden, 1958a, 1958b). Further discussion of this subject is pointless until such time as Fuller cites definite evidence in support of his conclusions.

BRACHIOPOD DESCRIPTIONS

Superfamily CHONETACEA

GENUS *Anopliopsis* GIRTY, 1938

Anopliopsis pygmaea Amsden, new species

Plate XXI, figures 1-12

Description. — *Anopliopsis pygmaea* has a tiny transverse shell, the width being slightly greater than the length at all observed growth stages (length/width ratio 0.76 to 0.99). The hinge line is straight and is the line of greatest width; from the cardinal extremities forward the shell is uniformly rounded. The posterior margin of the pedicle valve bears spines which are relatively stout for a shell of this size; most shells have two (a few have three) more or less erect spines on each side (pl. XXI, fig. 7). In lateral profile the pedicle valve is deeply and uniformly convex, and the brachial valve is strongly concave; thus a shallow living chamber is produced. The surface is completely smooth except for a few weak, concentric growth lines.

All of the shells referred to this species are tiny, the largest one observed being about 2.5 mm in width. Measurements of five complete specimens are given below:

Length mm	Width mm	Length/Width ratio
2.1	2.5	0.84
2.0	2.2	0.91
1.6	2.1	0.76
1.6	2.0	0.80
1.7	2.0	0.85

The pedicle interior has small teeth and a median septum which extends forward about one-third the length of the valve. At its posterior end this median septum extends into the delthyrial cavity and forms a plug which partially closes the delthyrium; the postero-lateral walls of this valve bear pustules (pl. XXI, figs. 9, 10). The brachial valve has a small cardinal process which extends posteriorly beyond the hinge line. The sockets are small, their forward edges defined by two indistinct ridges directed obliquely away from the process. A shallow trough extends forward from the base of the cardinal process and is bordered on each side by serrated ridges. The specimen illustrated on plate XXI, figure 2, has three fairly well-defined ridges on each side.

Discussion. — The genus *Anopliopsis* was established by Girty (1938, p. 281-284, figs. 6-16), with *Chonetina subcarinata* Girty (1926, p. 27-28, pl. 5, figs. 10-16) as the type species. Girty's description of the type species was based upon specimens from the Ridgetop Shale and Fort Payne Chert of western Tennessee and from the Moorefield Shale of Oklahoma (Girty, 1938, p. 281). All but one of the specimens figured in 1926 and in 1938 are from the basal part of the Fort Payne Chert in Waynesboro quadrangle, western Tennessee, and all the shells showing the internal features are from this formation (presumably one of the Ft. Payne specimens is the holotype, or will be designated the lectotype). These specimens of *A. subcarinata* are from formations of Mississippian age and are, therefore, much younger than the Haragan shells, but the two species appear to be congeneric, being similar in profile, ornamentation, hinge spines, and, in so far as can be determined from Girty's description and illustrations, in internal characters. *A. pygmaea* differs from *A. subcarinata* in having a much smaller and more transverse shell with a more uniformly rounded outline.

The genus *Paeckelmannia* Licharew, 1934, which is based upon the British Carboniferous species *Leptaena polita* McCoy (1854; Davidson, 1857, p. 190-191, pl. 47, figs. 8-11), is similar in many respects to *Anopliopsis.* This genus was first described by Paeckelmann (1930, p. 227-230, pl. 15, figs. 11-13) under the name *Tornquistia* (as a subgenus of *Chonetes*), but this name was preoccupied by *Tornquistia* Reed, 1896, and Licharew* replaced it with *Paeckelmannia. Paeckelmannia polita* is similar to *A. subcarinata* and *A. pygmaea* in most respects. It differs in having spines over the entire pedicle valve and in having only two septa on the brachial interior. According to Paeckelmann (1930, p. 224) this genus first appears in the Silurian and ranges into the Permian. Both *Paeckelmannia* and *Anopliopsis* are remarkably similar to *Anoplia* Hall and Clarke, 1892, the principal difference being that the latter is completely free of external spines (see parts I and II of this report; specimens of *A. nucleata* (Hall) from the Frisco and Sallisaw Formations are illustrated on pls. I, XI, XIII, XX; specimens of *A. nucleata* (Hall) from the Glenerie Formation of New York, showing the internal structure, are illustrated on pl. X, figs. 13-16). In 1960 Sokolskaya (p. 222) proposed Paeckelmanniinae as a new subfamily within the Chonetidae; this included *Paeckelmannia* Licharew, *Lissochonetes* Dunbar and Condra, *Chonetina* Krotow, *Quadro-*

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* I have not seen Licharew's 1934 reference and this information was obtained from Sokolskaya (1960, p. 222).

chonetes Stehli, *Anopliopsis* Girty, *Anoplia* Hall and Clarke, *Semenewia* Paeckelmann, *Notanoplia* Gill, and *Dyoros* Stehli. This subfamily (Sokolskaya, 1960, p. 166) is reported to range from the Early Silurian through the Permian. Whether all these genera are closely related may be questionable, but it would appear fairly certain that *Anoplia, Paeckelmannia, Notanoplia,* and *Anopliopsis* are close to one another in structure and in generic affinities.* In so far as I am aware, the oldest North American representatives of this subfamily are the present species *Anopliopsis pygmaea* from the Haragan (Helderbergian) of Oklahoma, and *Anopliopsis helderbergiae* (Schuchert) from the Helderberg (New Scotland) of Maryland. The genus *Anoplia* is common in strata of Deerparkian to Onesquethawan age, the oldest North American representative being *A. nucleata* (Hall) from the Oriskany Formation (Gill, 1945, p. 147, and 1946, p. 250, reported *Notanoplia australis* and *N. pherista* in the Early Devonian strata of Victoria and Tasmania). This suggests that *Anoplia* is a relatively short-lived offshoot of *Anopliopsis,* derived by the loss of the hinge spines.

In 1913 Schuchert (*in* Schuchert and Maynard, 1913, p. 340, pl. 61, fig. 21) described the species *Anoplia helderbergiae* from the New Scotland Member of the Helderberg Formation in Maryland. Schuchert noted that this species is similar in many respects, including a smooth exterior, to *A. nucleata* (Hall), from which it differs in the presence of hinge spines. I have not examined the types of Schuchert's species, but judged from the description and illustration, it would appear to be congeneric with *Anopliopsis subcarinata* and *A. pygmaea.* It differs from *A. pygmaea* in having a considerably larger shell with a much more transverse outline, the width being nearly twice as great as the length. *A. pygmaea* and *A. helderbergiae* come from strata which are closely related in age.

Figured specimens. — Haragan Formation, old Hunton townsite; stratigraphic section C1. Numbers USNM 138782-138791.

Distribution. — This species is known only from the Haragan Formation near old Hunton townsite; stratigraphic section C1 (Amsden, 1960, p. 182-188). I have studied about 60 specimens in the U. S. National Museum collections.

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* Cooper (in Girty, 1938, p. 283) commented on the structural similarity of *Anopliopsis* and *Anoplia* and suggested a close generic affinity between these two genera, much closer than between *Anopliopsis* and *Chonetina. Notanoplia* Gill (1946, p. 249; the type species, *N. pherista* Gill, is from the Lower Devonian of Tasmania) has a nonspinose shell which is much like *Anoplia.* According to Gill it is distinguished from *Anoplia* by having a longer median septum in the pedicle valve.

GENUS *Chonostrophia* HALL AND CLARKE, 1892

Chonostrophia helderbergia Hall and Clarke, 1892
Plate XXI, figures 29, 30

Chonostrophia helderbergia Hall and Clarke, 1892, p. 353, pl. 15B, fig. 14; Schuchert and Maynard, 1913, p. 342, pl. 52, fig. 3.

Description. — *Chonostrophia helderbergia* is represented by a single well-preserved pedicle valve. Near the umbo this shell is gently convex, but two or three millimeters in front of the beak this convexity is lost and the rest of the shell is almost flat to slightly concave. The hinge line is nearly straight and marks the point of greatest shell width; from the cardinal extremities forward the lateral margins have a fairly uniform curvature. It has a strongly transverse outline, the width being about 16 mm and the length only 9 mm. The surface is covered with evenly spaced, fine costellae, about 30 ribs occupying a space of 5 mm near the front margin (pl. XXI, fig. 30). The hinge bears small spines, slightly inclined away from the beak. About five spines are on each side. No interiors were observed.

Discussion. — Hall and Clarke based their description of this species upon specimens from the Helderberg (New Scotland) of Albany County, New York. In so far as I can determine, the Haragan shell is similar in outline, curvature, and ornamentation to the New York specimens. The shell figured by Hall and Clarke is slightly larger than the Haragan specimen but seems to have the same relative proportions. Schuchert and Maynard (1913) described and illustrated specimens of *C. helderbergia* from the New Scotland Member of the Helderberg Formation in Maryland. According to these authors, the center rib on the pedicle valve is more prominent than the others, but this was not mentioned by Hall and Clarke nor does my specimen show it. The illustration given by these authors suggests that the prominent center rib may be the result of crushing around the internal median septum.

Dunbar (1919, p. 53, pl. I, fig. 3) cited the species *Chonostrophia lindenensis* Dunbar from the Ross Member of his Linden Group. No mention of this species appears in his 1920 paper, and, so far as I know, it never has been described. Dunbar's illustration suggests that *C. lindenensis* may be conpecific with *C. helderbergia.*

This species differs from the Frisco specimens of *C. complanata* and Sallisaw specimens of *C. complanata*? in having a more transverse shell and considerably finer ribbing (see parts I and II). Neither *C. complanata* nor *C. helderbergia* shows any tendency toward an alternating type of rib such as is found in *C. reversa* (Whitfield).

Figured specimen. — Haragan Formation, northeast of Bromide, SW¼ SW¼ NE¼ sec. 33, T. 1 S., R. 8 E., Coal County, Oklahoma, number OU 3627.

Distribution. — A single specimen collected by W. E. Ham from the Haragan Formation.

GENUS *Chonetes* FISCHER DE WALDHEIM, 1837

Chonetes? sp.

Plate XXI, figures 27, 28

Description. — This species is represented by a single pedicle valve. In lateral profile it is gently and evenly convex. The hinge line is straight and probably near the point of maximum shell width; its outline is strongly transverse, the width being about 23 mm and the length about 13 mm. The surface is covered with fine, evenly spaced costellae, about 35 costellae occupying a space of 5 mm (pl. XXI, fig. 27). The hinge bears four small spines on each side, these being inclined away from the beak. No interiors were observed.

Discussion. — Some question exists concerning the author of *Chonetes* and the type species (see discussion by Imbrie, 1959, p. 395). The reference of the Haragan species to *Chonetes* is based entirely upon its convex pedicle valve and hinge spines. Nothing is known about the internal structure of this species, nor am I familiar with the internal structure of the type species of *Chonetes.*

Chonetes? sp. differs from *Chonostrophia helderbergia* Hall and Clarke in having a convex pedicle valve and finer costellation.

Figured specimen. — Haragan Formation, stratigraphic section C1-K, near old Hunton townsite, Coal County, Oklahoma (Amsden, 1960, p. 182-188). Number OU 958.

Distribution. — A single specimen from the Haragan Formation near old Hunton townsite.

Superfamily SPIRIFERACEA

GENUS *Spinoplasia* BOUCOT, 1959

Spinoplasia gaspensis? Boucot, 1959
Plate XXI, figures 13-26

Spinoplasia gaspensis Boucot, 1959a, p. 18-19, pl. 2, figs. 14-16.

Description. — The shell of *Spinoplasia gaspensis* is small with a subcircular to transversely elliptical outline; the width is commonly slightly greater than the length, the length/width ratio ranging from 0.87 to 1.00. The hinge line is nearly straight and close to the point of maximum shell width. It has a biconvex lateral profile, with a shallow brachial valve and a deep pedicle valve (pl. XXI, figs. 14, 16, 20, 24, 25). The pedicle palintrope is fairly well developed, slightly curved and strongly apsacline. A plug of shell material closes the delthyrium (pl. XXI, figs. 16, 24). The pedicle beak is prominent and hooked at its posterior end and the pedicle valve has a shallow, but distinct, sulcus and smooth lateral slopes (pl. XXI, figs. 13, 16, 19). A low, but distinct, fold is on the brachial valve, bordered on each side by a faint lateral plication (pl. XXI, figs. 17, 22, 23). The surface of each valve bears concentric rows of spines; on most specimens these are at least partially abraded so that only the bases remain (pl. XXI, figs. 17, 22), but on one or two specimens a few of the spines are preserved nearly intact.

Sixteen specimens are in the collections under study, the largest shell being 3.9 mm long and 4.5 mm wide. The dimensions of seven well-preserved specimens are given below:

Length mm	Width mm	Length/Width ratio	Thickness mm	Length/Thickness ratio
2.0	2.1	0.95	1.4	1.42
2.1	2.1	1.00	1.5	1.40
3.0	3.0	1.00	2.1	1.42
3.0	3.1	0.97	2.1	1.42
3.3	3.7	0.89	2.7	1.22
3.9	4.3	0.91	-- --	-- ----
3.9	4.5	0.87	-- --	-- ----

Two pedicle valves in the collections under study show the internal structure moderately well. The teeth are stout and unsupported by plates, the muscle field consists of two elongate, moderately well-defined tracks, and the delthyrial cavity is at least partly filled with shell material. In the brachial valve a low, flat cardinal process is bordered on each side by triangular crural plates which define the sockets; a low ridge begins just in front of the crural plates and extends forward between the moderately deep adductor scars (pl. XXI, fig. 18).

Discussion. — In a recent paper Boucot (1959a, p. 18-23) described two new genera of Lower Devonian ambocoeliinids, *Plicoplasia* and *Spinoplasia.* The latter, the type species of which is *S. gaspensis* Boucot, has a plicate shell like *Metaplasia* Hall and Clarke, 1894, but differs in its spinose exterior. *Plicoplasia* differs from *Spinoplasia* and *Metaplasia* in its angular plications (*Ambocoelia* Hall, 1859, has a nonplicate brachial valve).

Spinoplasia gaspensis Boucot (1959a, p. 18-19, pl. 2, figs. 14-16) was based upon specimens from strata of New Scotland age (upper Gedinnian) in southwestern Quebec. It is somewhat difficult to make a precise comparison of the Haragan shells with those described by Boucot as the Gaspé material is not well preserved; however, in so far as can be determined, these shells are similar in size, outline, and ornamentation.

A Frisco representative of this genus, *Spinoplasia oklahomensis* Amsden and Ventress is described in part I of this report. This species is easily distinguished from *S. gaspensis*? by its larger size and much better developed plications on both valves (compare figs. 1-9 of pl. XI to figs. 13-26 of pl. XXI). It is interesting to compare the preservation of the Haragan specimens with that of those from the Frisco Formation. Twelve of the 16 Haragan specimens of *S. gaspensis*? are well-preserved articulated shells, and the free valves show little evidence of abrasion or breakage (see free valve illustrated on pl. XXI, figs. 17, 18). In contrast, all but one of the Frisco specimens of *S. oklahomensis* are disarticulated (table 1) and the free valves are considerably abraded and broken. A further discussion of this topic may be found in part I, under Frisco stratigraphy, Arbuckle Mountains region; see especially text-figure 5.

The present report expands the known geographic and stratigraphic range of *Spinoplasia.* It is now reported from Helderbergian strata of Gaspé, Quebec, and Helderbergian and Deerparkian strata of Oklahoma.

Figured specimens. — Haragan Formation, southeast of White Mound, Murray County, Oklahoma; near stratigraphic section M2 (Amsden, 1960, p. 235), numbers OU 3623-3626.

Distribution. — Boucot's description was based upon specimens from strata of New Scotland age in southwestern Gaspé, Quebec. The Haragan collections include 16 specimens, all from stratigraphic sections M4 (White Mound) and M2, Murray County, Oklahoma (Amsden, 1960, p. 235, 238).

REFERENCES

Allan, R. S., 1947, A revision of the Brachiopoda of the lower Devonian strata of Reefton, New Zealand: Jour. Paleontology, vol. 21, p. 436-452, pls. 61-63.

Amsden, T. W., 1951, Brachiopods of the Henryhouse Formation (Silurian) of Oklahoma: Jour. Paleontology, vol. 25, p. 69-96, pls. 15-20, text-fig.

———— 1953, Some notes on the Pentameracea, including a description of one new subfamily: Washington Acad. Sciences, Jour., vol. 43, p. 137-147, text-figs.

———— 1954, Geology of Garrett County: Md. Dept. Geology, Mines and Water Resources, Bull. 13, 116 p., text-figs.

———— 1956, Catalog of fossils from the Hunton Group, Oklahoma: Okla. Geol. Survey, Circ. 38, 63 p.

———— 1957, Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region: Part I — Introduction to stratigraphy: Okla. Geol. Survey, Circ. 44, 57 p., 3 pls., text-figs.

———— 1958a, Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region; Part II — Haragan articulate brachiopods; Part III — Supplement to the Henryhouse brachiopods: Okla. Geol. Survey, Bull. 78, 157 p., 14 pls., text-figs.

———— 1958b, Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region; Part V — Bois d'Arc articulate brachiopods: Okla. Geol. Survey, Bull. 82, 110 p., 5 pls., text-figs.

———— 1959, *Chilidiopsis* Boucot: a recently described brachiopod genus, with some remarks on the Hunton Orthotetacea: Okla. Geol. Survey, Okla. Geology Notes, vol. 19, p. 74-77, text-figs.

———— 1960, Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region; Part VI — Hunton stratigraphy: Okla. Geol. Survey, Bull. 84, 311 p., 17 pls., text-figs.

———— 1961, Stratigraphy of the Frisco and Sallisaw Formations: Okla. Geol. Survey, Bull. 90, 121 p., 13 pls., text-figs.

Amsden, T. W., and **Huffman, G. G.**, 1958, Frisco brachiopod from a Hunton core, Pottawatomie County: Okla. Geol. Survey, Okla. Geology Notes, vol. 18, p. 73-76, text-fig.

Barrande, Joachim, 1879, Systême silurien du centre de la Bohême: Prague, vol. 5, pt. 1, 226 p., 71 pls.

Bassler, R. S., 1941, Ostracoda from the Devonian (Onondaga) chert of west Tennessee: Washington Acad. Sciences, Jour., vol. 31, p. 21-27, 37 figs.

Billings, Elkanah, 1874, Paleozoic fossils: Canada, Geol. Survey, vol. 2, pt. 1, 144 p., 9 pls.

Boucot, A. J., 1953, Life and death assemblages among fossils: Amer. Jour. Science, vol. 251, p. 25-40.

———— 1957, Revision of some Silurian and Early Devonian spiriferid genera and erection of Kozlowskiellinae, new subfamily: Senckenbergiana Lethaea, vol. 38, p. 311-334, 3 pls.

———— 1958a, Age of the Bainbridge Limestone: Jour. Paleontology, vol. 32, p. 1029-1030.

———— 1958b, Distribution of brachiopod and pelecypod shells by currents: Jour. Sed. Petrology, vol. 28, p. 321-332.

———— 1959a, Early Devonian Ambocoeliinae (Brachiopoda): Jour. Paleontology, vol. 33, p. 16-24, 2 pls.

———— 1959b, Brachiopods of the Lower Devonian rocks at Highland Mills, New York: Jour. Paleontology, vol. 33, p. 727-769, 14 pls., text-figs.

———— 1960, Lower Gedinnian brachiopods of Belgium: Institut Géologique de l'Université de Louvain, Mémoires, vol. 21, p. 283-324, 8 pls.

Boucot, A. J., and **Amsden, T. W.**, 1958, Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region; Part IV — New genera of brachiopods: Okla. Geol. Survey, Bull. 78, p. 159-174, illus.

Boucot, A. J., and **Arndt, Robert,** 1960, Fossils of the Littleton Formation (Lower Devonian) of New Hampshire: U. S. Geol. Survey, Prof. Paper 334-B, p. 41-51, 3 pls., text-figs.

Boucot, A. J., Brace, W. F., and **Demar, R. E.,** 1958, Distribution of brachiopod and pelecypod shells by currents: Jour. Sed. Petrology, vol. 28, p. 321-332, text-figs.

Boucot, A. J., and **Cumming, L. M.,** 1953, Contributions to the age of the Gaspé Sandstone [abs.]: Geol. Soc. America, Bull., vol. 64, p. 1397.

Branson, C. C., and **Amsden, T. W.,** 1958, *Conocardium* from the Hunton Group: Okla. Geol. Survey, Okla. Geology Notes, vol. 18, p. 147-149, 1 pl.

Breger, C. L., 1906, On *Eodevonaria,* a new subgenus of *Chonetes:* Amer. Jour. Science, vol. 172, p. 534-536.

Castelnau, Francis de, 1843, Essai sur le système silurien de l'Amérique Septentrionale: Paris, p. 36-44, 4 pls.

Christian, H. E., 1953, Geology of the Marble City area, Sequoyah County, Oklahoma: Okla., Univ., unpublished Master of Science thesis, 160 p., map and illus.

Clarke, J. M., 1900, The Oriskany fauna of Becraft Mountain, Columbia County, New York: N. Y. State Museum, Mem. 3, vol. 3, 128 p., 9 pls.

——— 1908, Early Devonic history of New York and eastern North America: N. Y. State Museum, Mem. 9, pt. 1, 369 p., 48 pls.

——— 1909, Early Devonic history of New York and eastern North America: New York State Museum, Mem. 9, pt. 2, 250 p., 34 pls.

Cleaves, A. B., 1939, Oriskany Group, *in* The Devonian of Pennsylvania: Penn. Geol. Survey, 4th ser., Bull. G 19, p. 92-119.

Cloud, P. E., Jr., 1942, Terebratuloid Brachiopoda of the Silurian and Devonian: Geol. Soc. America, Spec. Paper 38, 182 p., 26 pls.

Conrad, T. A., 1839, Descriptions of new species of organic remains: N. Y. Geol. Survey, 3rd Ann. Rept., p. 64-66.

——— 1841, On the palaeontology of the state of New York: N. Y. Geol. Survey, 5th Ann. Rept., p. 52-56.

Cooper, G. A., 1942, New genera of North American brachiopods: Washington Acad. Sciences, Jour., vol. 32, p. 228-235.

——— 1944a, Brachiopoda, *in* Shimer and Shrock, Index fossils of North America: New York, John Wiley & Sons, p. 277-365, pls. 106-143.

——— 1944b, Remarks on correlation of Devonian formations in Illinois and adjacent states, *in* Symposium on Devonian stratigraphy: Ill. State Geol. Survey, Bull. 68-A, p. 217-222.

Cooper, G. A., and others, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America, Bull., vol. 53, p. 1729-1794, 1 pl., 1 fig.

Coryell, H. N., and **Cuskley, V. A.,** 1934, Some new ostracods from the "White Mound" section of the Haragan shale, Murray County, Oklahoma: Amer. Museum Nat. History, Novitates, no. 748, 12 p., 18 figs.

Cram, I. H., 1930, Cherokee and Adair Counties, *in* Oil and Gas in Oklahoma: Okla. Geol. Survey, Bull. 40, vol. 3, p. 531-582.

Crickmay, C. H., 1950, Some Devonian Spiriferidae from Alberta: Jour. Paleontology, vol. 24, p. 219-225, pls. 36-37.

Davidson, Thomas, 1857, Monograph on British Carboniferous brachiopods: London, Palaeontographical Society, vol. 2, pt. 5, 210 p., 55 pls.

Decker, C. E., 1941, Graptolites from the Haragan formation (Lower Devonian) of Oklahoma: Jour. Paleontology, vol. 15, p. 164-177, text-figs.

Delo, D. M., 1940, Phacopid trilobites of North America: Geol. Soc. America, Spec. Paper 29, 135 p., 13 pls.

Dunbar, C. O., 1918, Stratigraphy and correlation of the Devonian of western Tennessee: Amer. Jour. Science, vol. 196, p. 732-755.

———— 1919, Stratigraphy and correlation of the Devonian of western Tennessee: Tenn. Geol. Survey, Bull. 21, 127 p., 3 pls. text-figs.

———— 1920, New species of fossils from western Tennessee: Conn. Acad. Arts Sciences, Trans., vol. 23, p. 109-158, 5 pls.

Eaton, Amos, 1832, Geological textbook: Albany, New York, 134 p., illus.

Fettke, C. R., 1938, Oriskany as a source of gas and oil in Pennsylvania and adjacent states: Amer. Assoc. Petroleum Geologists, Bull., vol. 22, p. 241-266, text-figs.

Fuller, J. G. C. M., 1961, Ordovician and contiguous formations in North Dakota, South Dakota, Montana, and adjoining areas of Canada and United States: Amer. Assoc. Petroleum Geologists, Bull., vol. 45, p. 1334-1363, illus.

Gill, E. D., 1945, Chonetidae from the Paleozoic rocks of Victoria and their stratigraphical significance: Victoria, Royal Soc., Proc., vol. 57 (new ser.), p. 125-150, 1 pl.

———— 1946, Preliminary account of the palaeontology and palaeoecology of the Eldon Group formations of the Zeehan area, Tasmania: Tasmania, Royal Soc., Papers and Proc. for 1946, p. 231-258, 1 pl.

Gilluly, James, 1949, Distribution of mountain building in geologic time: Geol. Soc. America, Bull., vol. 60, p. 561-590, text-figs.

Girty, G. H., 1899, Preliminary report on the Paleozoic invertebrate fossils from the region of the McAlester coal field, Indian Territory: U. S. Geol. Survey, 19th Ann. Rept., pt. 3, p. 539-593, pls. 70-72.

———— 1926, Part III. The macro-fauna of the limestone of Boone age, *in* Mississippian formations of San Saba County, Texas: U. S. Geol. Survey, Prof. Paper 146, p. 24-40, 2 pls.

———— 1938, Description of a new genus and a new species of Carboniferous brachiopods: Washington Acad. Sciences, Jour., vol. 28, p. 278-284, text-figs.

Goldring, Winifred, 1943, Geology of the Coxsackie quadrangle, New York: N. Y. State Museum, Bull. 332, 306 p., illus., maps.

Hall, James, 1843, Geology of New York. Part IV, comprising the survey of the fourth geological district: N. Y. Geol. Survey, Geology of New York, 683 p., illus., maps.

———— 1852, Descriptions of the organic remains of the lower middle division of the New York System: Palaeontology of New York, vol. 2, 362 p., 85 pls.

———— 1857, Descriptions of Palaeozoic fossils, chiefly from those constituting the third volume of the Palaeontology of New York: 10th Ann. Rept. Regents of the University, State Cabinet of Nat. Hist., p. 41-186, text-figs.

———— 1859 [text; plates dated 1861], Containing descriptions and figures of the organic remains of the lower Helderberg Group and the Oriskany Sandstone: Palaeontology of New York, vol. 3, 532 p., 120 pls., text-figs.

———— 1867a, Containing descriptions and figures of the fossil Brachiopoda of the upper Helderberg, Hamilton, Portage and Chemung Groups: N. Y. Geol. Survey, Palaeontology, vol. 4, part 1, p. 1-428, 63 pls.

———— 1867b, Notice of volume IV of the Palaeontology of New York: N. Y. State Cabinet Nat. History, Ann. Rept. 20, p. 145-168, illus.

Hall, James, and **Clarke, J. M.,** 1892, An introduction to the study of the genera of Palaeozoic Brachiopoda: Palaeontology of New York, vol. 8, pt. 1, 367 p., 20 pls., text-figs.

———— 1894, An introduction to the study of the genera of Paleozoic Brachiopoda: Palaeontology of New York, vol. 8, pt. 2, 314 p., pls. 21-84, text-figs.

Ham, W. E., 1961, Correlation of pre-Stanley strata in the Arbuckle-Ouachita Mountain region [repr.]: Okla. Geol. Survey, Okla. Geology Notes, vol. 21, p. 204-224.

Hass, W. H., 1951, Age of Arkansas novaculite: Amer. Assoc. Petroleum Geologists, Bull., vol. 35, p. 2526-2541, 1 pl.

——— 1956, Age and correlation of the Chattanooga Shale and the Maury Formation: U. S. Geol. Survey, Prof. Paper 286, 47 p., 5 pls.

Havlíček, Vladimír, 1959, Spiriferidae of the Silurian and Devonian of Bohemia: Rozpravy Ústredního ústavu Geologického, vol. 25, p. 1-218 (Czech text), 223-275 (English summary), 27 pls., text-figs.

Huffman, G. G., 1958, Geology of the [south and west] flanks of the Ozark uplift, northeastern Oklahoma: Okla. Geol. Survey, Bull. 77, 281 p., text-figs., maps.

Imbrie, John, 1959, Brachiopods of the Traverse Group (Devonian) of Michigan; Part I. Dalmanellacea, Pentameracea, Strophomenacea, Orthotetacea, Chonetacea, and Productacea: Amer. Museum Nat. History, Bull., vol. 116, art. 4, p. 349-409, pls. 48-67, text-figs.

Ireland, H. A., 1939, Devonian and Silurian Foraminifera from Oklahoma: Jour. Paleontology, vol. 13, p. 190-202, text-figs.

Kinney, D. M., 1946, Age of the Penters Chert, Batesville district, Arkansas: Amer. Assoc. Petroleum Geologists, Bull., vol. 30, p. 611-612.

Kozlowski, Roman, 1929, Les Brachiopodes Gothlandiens de la Podolie Polonaise: Palaeontologia Polonica, vol. 1, 254 p., 12 pls., text-figs.

Landes, K. K., Ehlers, G. M., and **Stanley, G. M.,** 1945, Geology of the Mackinac Straits region and subsurface geology of northern peninsula: Mich. Geol. Survey, Pub. 44, Geol. Ser. 37, 204 p., 20 pls., map, text-figs.

Maillieux, Eugène, 1936, La Faune et l'âge des Quartzophyllades Siegeniens de Longlier; Belgique, Musée Royal d'Histoire Naturelle, Mem. 73, 140 p., 3 pls.

——— 1941, Les Brachiopodes de l'Emsien de l'Ardenne: Belgique, Musée Royal d' Histoire Naturelle, Mem. 96, p. 1-73.

Martens, J. H. C., 1939, Petrology and correlations of deep-well sections in West Virginia and adjacent states: W. Va. Geol. Survey, vol. 11, 255 p.

Martin-Kaye, P., 1951, Sorting of lamellibranch valves on beaches in Trinidad, British-West Indies: Geol. Mag., vol. 88, p. 432-434.

Maxwell, R. A., 1936, The stratigraphy and areal distribution of the Hunton Formation, Oklahoma: Northwestern Univ., unpublished Ph. D. dissertation, 120 p., illus., maps; *abstract published in:* Summaries of doctoral dissertations, vol. 4, Northwestern Univ., 1936, p. 131-136.

Meek, F. B., 1877, Part I. Palaeontology, *in* King, Clarence, Report of the geological exploration of the fortieth parallel, volume IV: U. S. Army, Eng. Dept., Prof. Paper 18, p. 1-197, 17 pls.

Meek, F. B., and **Worthen, A. H.,** 1868, [Part II.] Palaeontology, *in* Geology and Palaeontology [of Illinois]: Ill. State Geol. Survey, vol. 3, p. 289-565, 20 pls.

Merriam, C. W., 1940, Devonian stratigraphy and paleontology of the Roberts Mountains region, Nevada: Geol. Soc. America, Spec. Paper 25, 114 p., 16 pls.

Miller, S. A., 1889, North American geology and paleontology: Cincinnati, 664 p., illus.

Miser, H. D., 1944, The Devonian system in Arkansas and Oklahoma, *in* Symposium on Devonian stratigraphy: Ill. State Geol. Survey, Bull. 68A, p. 132-138.

Muir-Wood, H. M., 1925, Notes on the brachiopod genera *Delthyris, Uncinulina* and *Meristina:* Annals Mag. Nat. History, vol. 15, 9th ser., p. 83-95, illus.

Newell, N. D., 1947, Infraspecific categories in invertebrate paleontology: Evolution, vol. 1, p. 163-171, text-figs.

Oehlert, M. D., 1884, Études sur quelques brachiopodes Dévoniens: Société Géologique France, Bull., vol. 12, 3rd ser., p. 411-441, 4 pls.

Oliver, W. A., Jr., 1954, Stratigraphy of the Onondaga Limestone (Devonian) in central New York: Geol. Soc. America, Bull., vol. 65, p. 621-652.

——— 1956, Stratigraphy of the Onondaga Limestone in eastern New York: Geol. Soc. America, Bull., vol. 67, p. 1441-1474.

——— 1960, Coral faunas in the Onondaga Limestone of New York: U. S. Geol. Survey, Prof. Paper 400-B, p. B172-B174.

Oxley, M. L., 1959, Bois d'Arc — key to Hunton oil?: Oil and Gas Jour., vol. 57, no. 20 (May 11), p. 162-166, text-figs.

Paeckelmann, Werner, 1930, Die Brachiopoden des deutschen Unterkarbons: Preussischen Geologischen Landesanstalt, Abhandlungen, new ser., vol. 122, p. 143-326, 24 pls.

Parks, W. A., 1931, Geology of Gaspé Peninsula: Geol. Soc. America, Bull., vol. 42, p. 785-800, text-figs.

Pettijohn, F. J., 1957, Sedimentary rocks: New York, Harper & Bros., 718 p., illus.

Reeds, C. A., 1911, The Hunton Formation of Oklahoma: Amer. Jour. Science, vol. 182, p. 256-268.

——— 1926, The Arbuckle Mountains, Oklahoma: Amer. Museum Nat. History, Jour., vol. 26, p. 463-474, text-figs.; Okla. Geol. Survey, Circ. 14, 15 p., text-figs.

Rickard, L. V., 1962, Late Cayugan (Upper Silurian) and Helderbergian (Lower Devonian) stratigraphy in New York: N. Y. State Museum Science Service, Bull. 386, 157 p., 28 text-figs.

Roth, R. I., 1929, Some ostracodes from the Haragan marl, Devonian, of Oklahoma: Jour. Paleontology, vol. 3, p. 327-372, pls. 35-38.

Safford, J. M., and **Schuchert, Charles**, 1899, The Camden Chert of Tennessee and its lower Oriskany fauna: Amer. Jour. Science, vol. 157, p. 429-432.

St. Joseph, J. K. S., 1938, The Pentameracea of the Oslo region, being a description of the Kiaer collection of pentamerids: Norsk Geologisk Tidsskrift, vol. 17, p. 226-236, 8 pls., text-figs.

Savage, T. E., 1908, On the lower Paleozoic stratigraphy of southwestern Illinois: Amer. Jour. Science, vol. 175, p. 431-443.

——— 1920, The Devonian formations of Illinois: Amer. Jour. Science, vol. 199, p. 169-182.

Schuchert, Charles, 1890, List of species of the American Paleozoic *Orthis*, *Spirifer*, *Spiriferina*, and *Syringothyris*: N. Y. State Geologist, 9th Ann. Rept., p. 38-55.

——— 1897, A synopsis of American fossil Brachiopoda including bibliography and synonymy: U. S. Geol. Survey, Bull. 87, 464 p.

——— 1913, Brachiopoda, *in* Zittel, K. A. von [Eastman, C. R., ed.], Text-book of palaeontology, 2nd ed.: London, Macmillan and Co., Limited, p. 355-420, illus.

——— 1922, Devonian of Oklahoma with special reference to the Oriskany and Camden Formations: Geol. Soc. America, Bull., vol. 33, p. 665-670.

Schuchert, Charles, and **Cooper, G. A.**, 1932, Brachiopod genera of the suborders Orthoidea and Pentameroidea: Yale Univ., Peabody Museum Nat. History, Mem., vol. 4, pt. 1, 270 p., 29 pls., text-figs.

Schuchert, Charles, and **LeVene, C. M.**, 1929, Brachiopoda, *in* Pompeckj, J. F. [ed.], Fossilium catalogus, Section I, Animalia: Berlin, W. Junk, pt. 42, 140 p.

Schuchert, Charles, and **Maynard, T. P.**, 1913, Lower Devonian, Brachiopoda; Md. Geol. Survey, Lower Devonian volume, p. 124-132, 57 pls.

Shannon, J. P., Jr., 1962, Hunton Group (Silurian-Devonian) and related strata in Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 46, p. 1-29, text-figs., maps.

Simpson, G. G., 1951, The species concept: Evolution, vol. 5, p. 285-299, text-figs.

Sokolskaya, A. N., 1960 [1961], Nadsemeystvo Chonetacea, *in* Osnovy Paleontologii, vol. 7, Mshanki, brakhiopody: Moscow, Izdatelstvo Akademii Nauk SSSR, p. 166, 221-223, illus.

Stewart, G. A., 1922, The fauna of the Little Saline Limestone in Ste. Genevieve County, *in* The Devonian of Missouri: Missouri Bur. Geology Mines, vol. 17, 2nd ser., p. 213-269, pls. 57-71.

Stow, M. H., 1938, Conditions of sedimentation and sources of the Oriskany Sandstone as indicated by petrology: Amer. Assoc. Petroleum Geologists, Bull., vol. 22, p. 541-564, illus.

Strimple, H. L., 1952, New species of *Lecanocrinus:* Washington Acad. Sciences, Jour., vol. 42, p. 318-323, text-figs.

Stumm, E. C., Kellum, L. B., and **Wright, J. D.,** 1956, Devonian strata of the London-Sarnia area, southwestern Ontario, Canada: Mich. Geol. Soc., Guidebook, Annual Field Trip, June 9-10, 1956.

Swartz, F. M., 1929, The Helderberg Group of parts of West Virginia and Virginia: U. S. Geol. Survey, Prof. Paper 158-C, p. 26-69, 4 pls.

Taff, J. A., 1904, Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U. S. Geol. Survey, Prof. Paper 31, 111 p., 8 pls., map, text-figs.

Thomas, Ivor, 1910, The British Carboniferous Orthotetinae: Great Britain Geol. Survey, Memoirs, Palaeontology, vol. 1, pt. 2, p. 83-134, 1 pl.

Urban, J. B., 1960, Microfossils of the Woodford Shale (Devonian) of Oklahoma: Okla., Univ., unpublished Master of Science thesis, 76 p., 9 pls.

Vanuxem, Lardner, 1842, Comprising the survey of the third district: Geology of New York, pt. 3, 305 p., illus.

Ventress, W. P. S., 1958, Stratigraphy and megafossils of the Frisco Formation: Okla., Univ., unpublished Master of Science thesis, 144 p., 7 pls., map.

Weller, J. M., 1944, Devonian System in southern Illinois: Devonian correlations in Illinois and surrounding states; A summary, *in* Symposium on Devonian stratigraphy: Ill. State Geol. Survey, Bull. 68-A, p. 89-102, 205-213, illus.

Weller, J. M., and **Ekblaw, G. E.,** 1940, Preliminary geologic map of parts of the Alton Pass, Jonesboro, and Thebes quadrangles, Union, Alexander, and Jackson Counties: Ill. State Geol. Survey, Rept. Inv. 70, 26 p., map.

Weller, Stuart, 1903, The Paleozoic faunas: N. J. Geol. Survey, Report on Paleontology, vol. 3, p. 1-462, 53 pls.

Weller, Stuart, and **St. Clair, Stuart,** 1928, Geology of Ste. Genevieve County, Missouri: Missouri Bur. Geology Mines, vol. 22, 2nd ser., 352 p., 15 pls., map.

Whitfield, R. P., 1882, Descriptions of new species of fossils from Ohio, with remarks on some of the geological formations in which they occur: N. Y. Acad. Sciences, Annals, vol. 2, p. 193-244.

———— 1891, Contributions to invertebrate palaeontology — 1. Descriptions of fossils from the Palaeozoic rocks of Ohio: N. Y. Acad. Sciences, Annals, vol. 5, p. 505-622, pls. 5-16.

Whittington, H. B., 1956, Type and other species of Odontopleuridae (Trilobita): Jour. Paleontology, vol. 30, p. 504-520, pls. 57-60.

———— 1960, *Cordania* and other trilobites from the Lower and Middle Devonian: Jour. Paleontology, vol. 34, p. 405-420, 4 pls.

Williams, Alwyn, 1953, North American and European stropheodontids; their morphology and systematics: Geol. Soc. America., Mem. 56, 67 p., 13 pls., text-figs.

Williams, Alwyn, and **Wright, A. D.,** 1961, The origin of the loop in articulate brachiopods: Palaeontology, vol. 4, pt. 2, p. 149-172, text-figs.

Williams, H. S., and **Breger, C. L.,** 1916, The fauna of the Chapman Sandstone of Maine, including descriptions of some related species from the Moose River Sandstone: U. S. Geol. Survey, Prof. Paper 89, 346 p., 27 pls.

Wilson, C. W., Jr., 1935, The ostracode fauna of the Birdsong Shale, Helderberg, of western Tennessee: Jour. Paleontology, vol. 9, p. 629-646, pls. 77-78.

———— 1949, Pre-Chattanooga stratigraphy in central Tennessee: Tenn. Dept. Conserv., Div. Geology, Bull. 56, 407 p., 28 pls.

Worthen, A. H., 1866 Devonian and Silurian systems: Ill. Geol. Survey, vol. 1, Geology, p. 118-152.

SUBJECT INDEX

(Main references are in *italics*)

PALEONTOLOGICAL INDEX

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PLATES I to XXI

The Frisco brachiopods are illustrated on plates I to XII (including some specimens from the Little Saline Formation of Missouri, and the Oriskany and Glenerie Formations of the eastern United States). The Sallisaw brachiopods are illustrated on plates XIII to XX (including some specimens from the Clear Creek Formation of Illinois and the Camden Formation of Tennessee). The Haragan brachiopods are illustrated on plate XXI. Almost all of the Frisco, Sallisaw, and Haragan brachiopods described and illustrated in this report are in the paleontological collections of The University of Oklahoma (catalog numbers indicated by the prefix OU). The repositories of specimens which were borrowed from other institutions are abbreviated as follows:

AMNH — American Museum of Natural History
IGS — Illinois Geological Survey
NYSM — New York State Museum
USNM — United States National Museum
WM — Walker Museum, University of Chicago
YPM — Peabody Museum, Yale University

The collecting localities and stratigraphic sections cited in the plate explanations have been described in earlier reports (Appendices, Amsden, 1960, 1961); brief descriptions of the locations are given on pages 60-61, 163 of this report.

None of the figures has been retouched.

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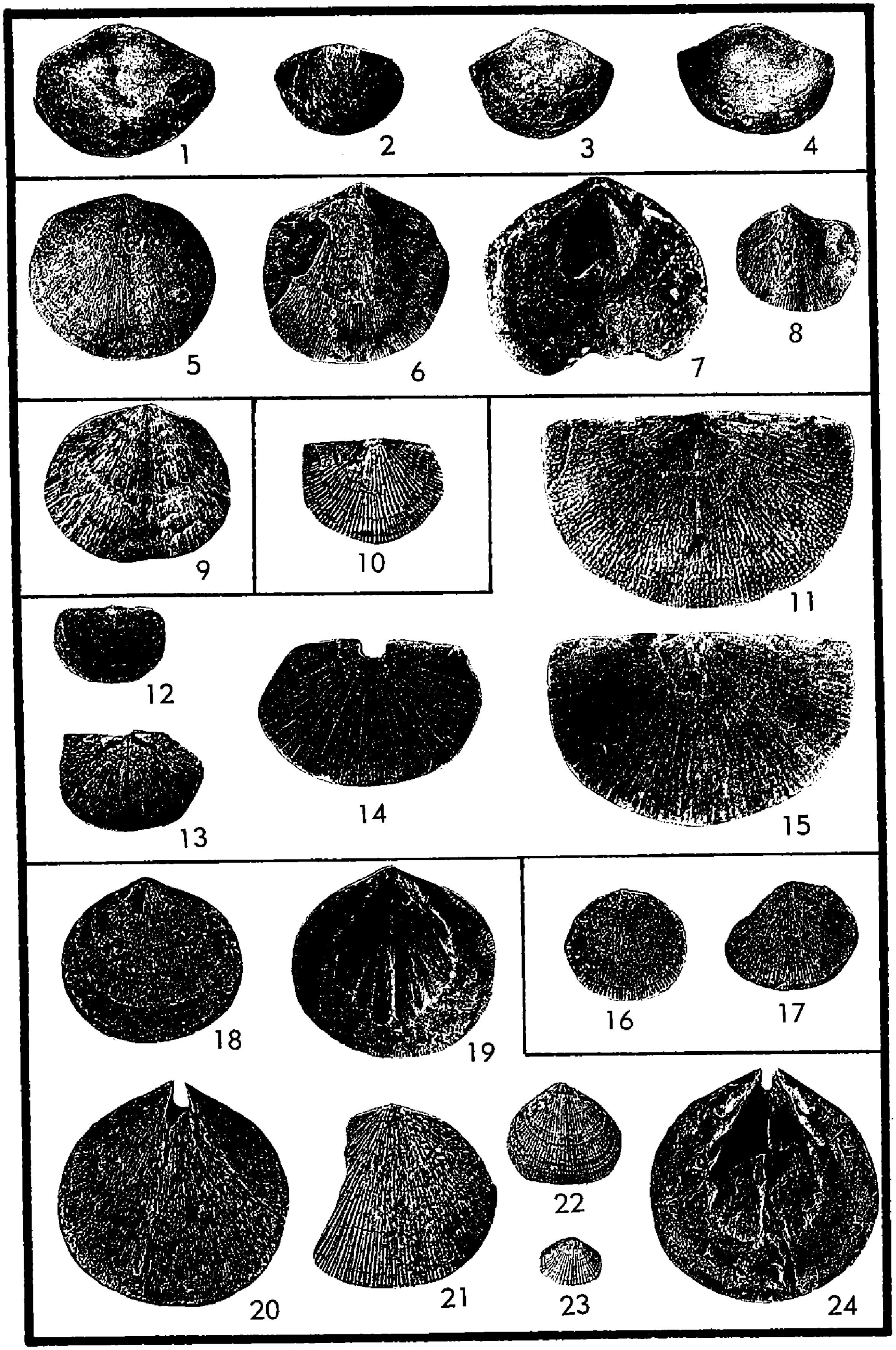
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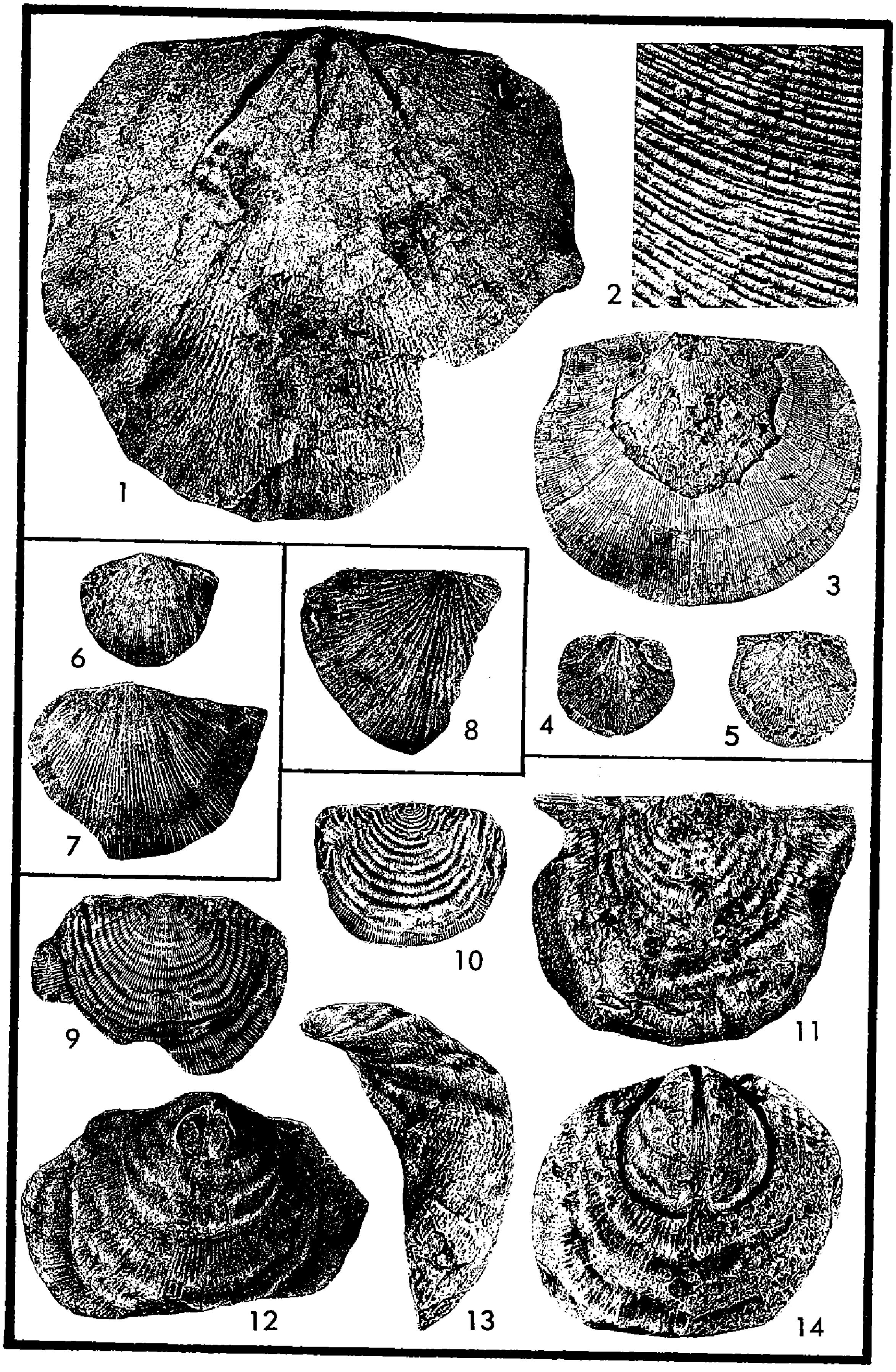
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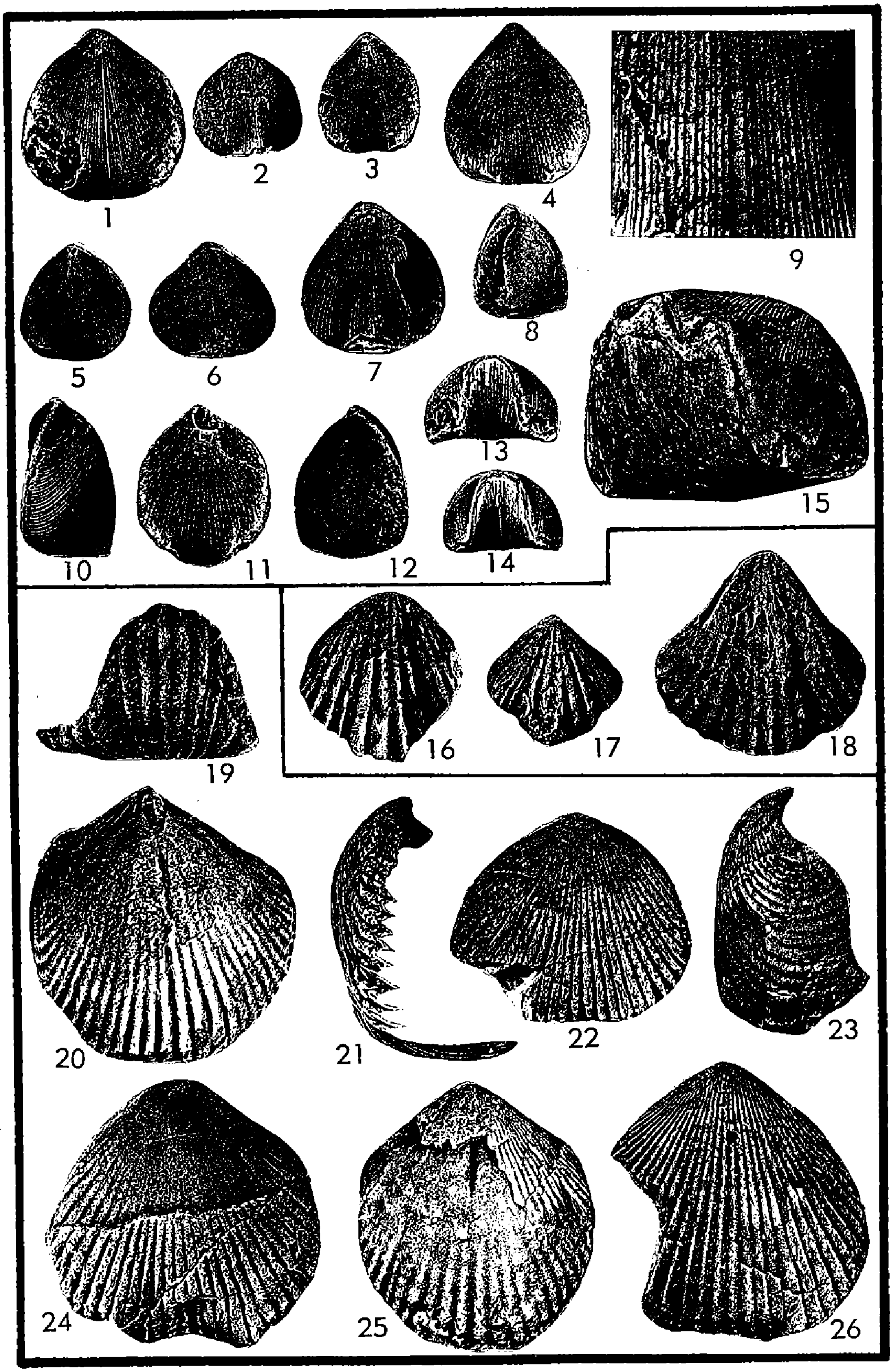
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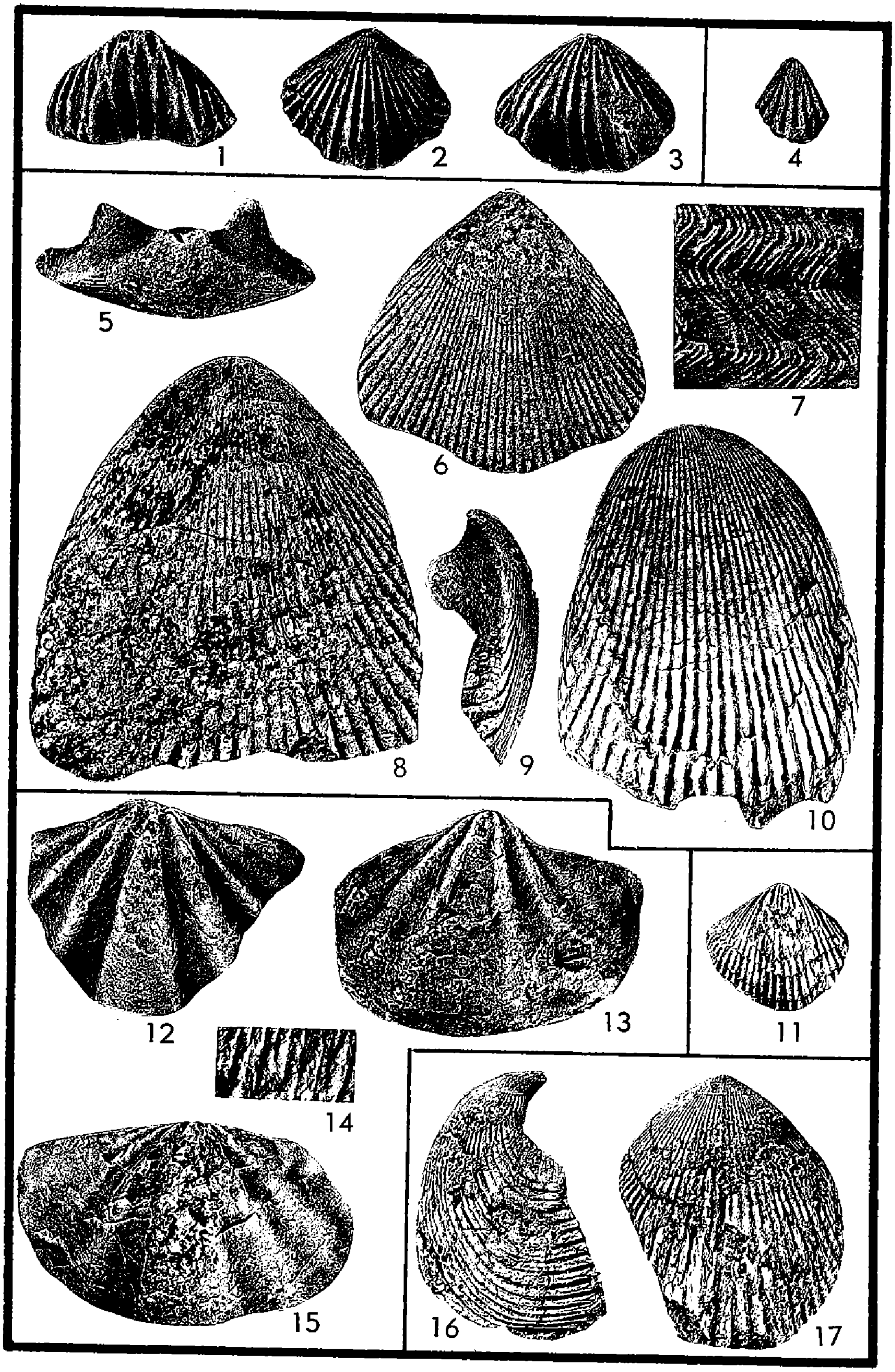
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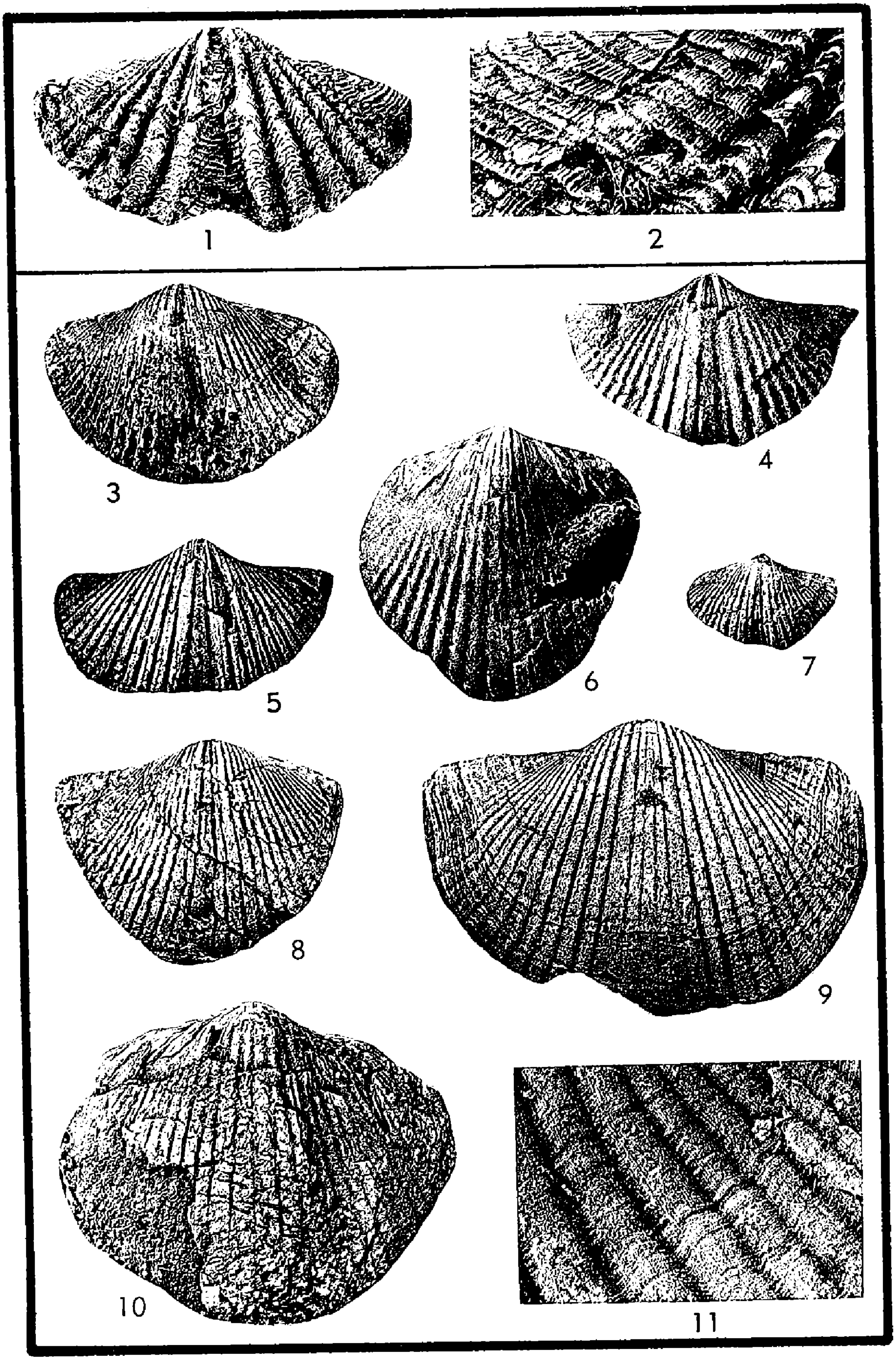
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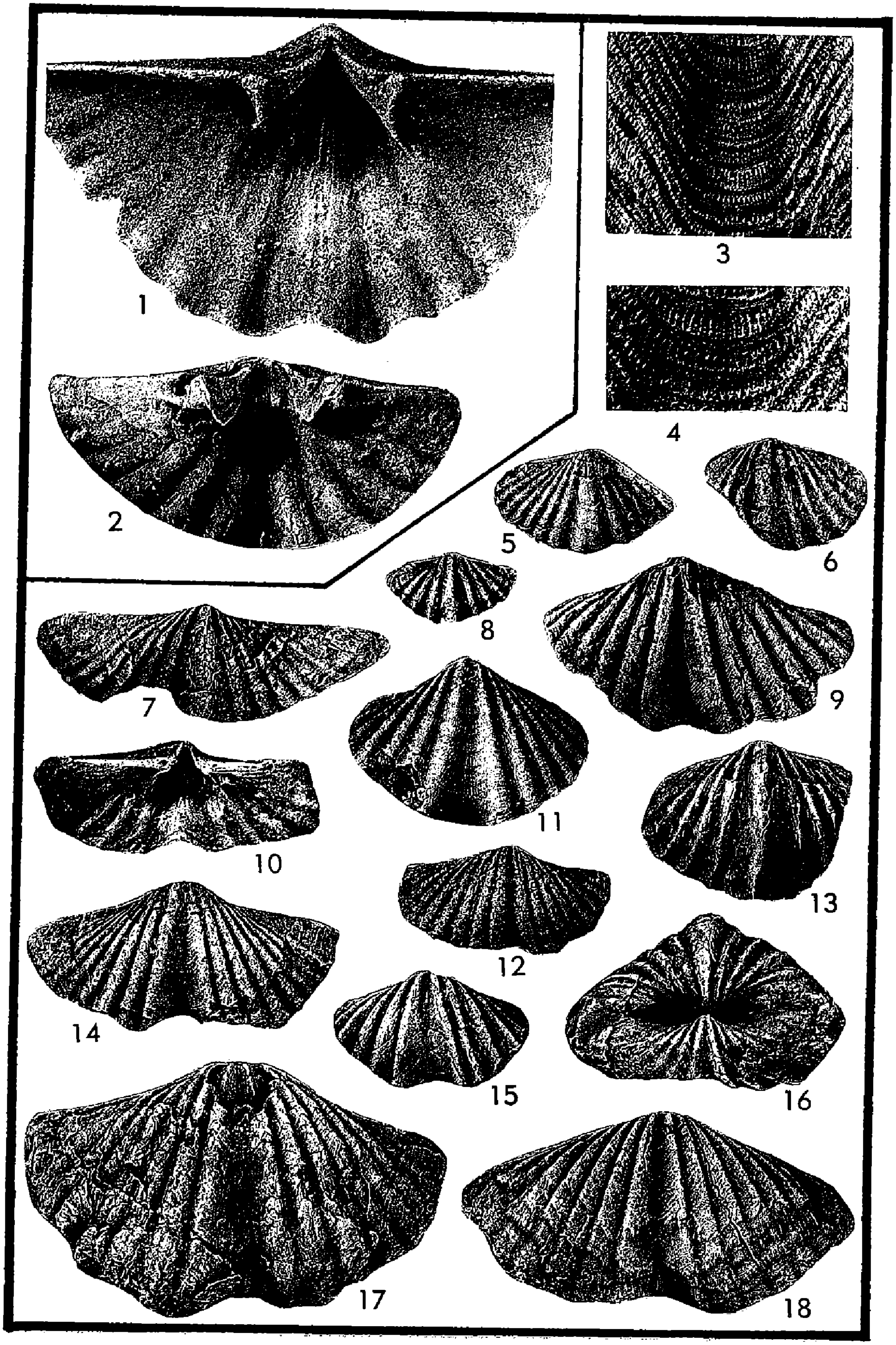
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17. Pedicle view of one of the larger specimens collected, x1, locality P8-H, Pontotoc Co. (OU 3343).
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PLATE VII

Brachiopods from the Frisco Formation

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	12. Pedicle steinkern, x1, locality P11, Pontotoc Co. (OU 3352).	
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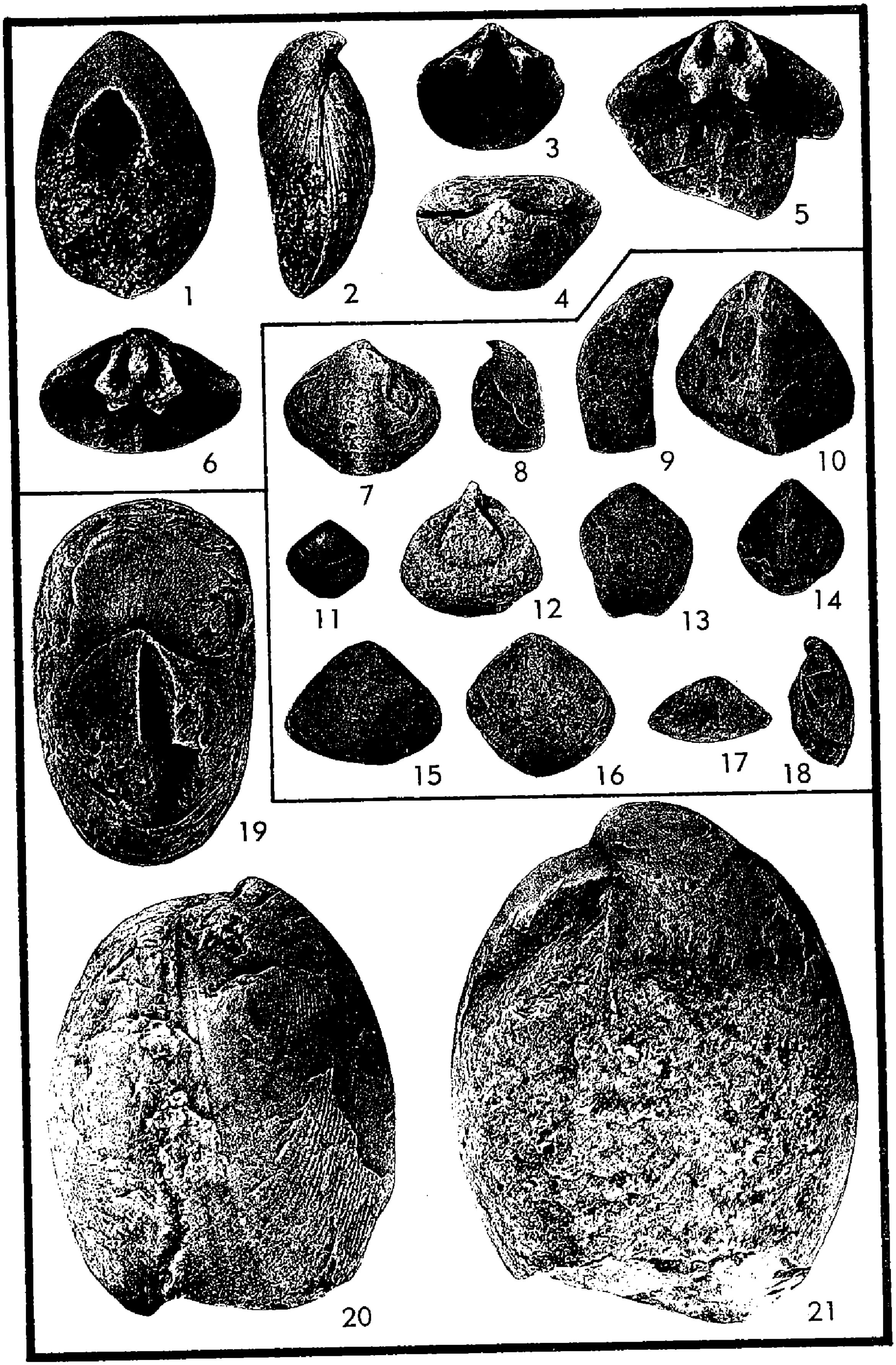
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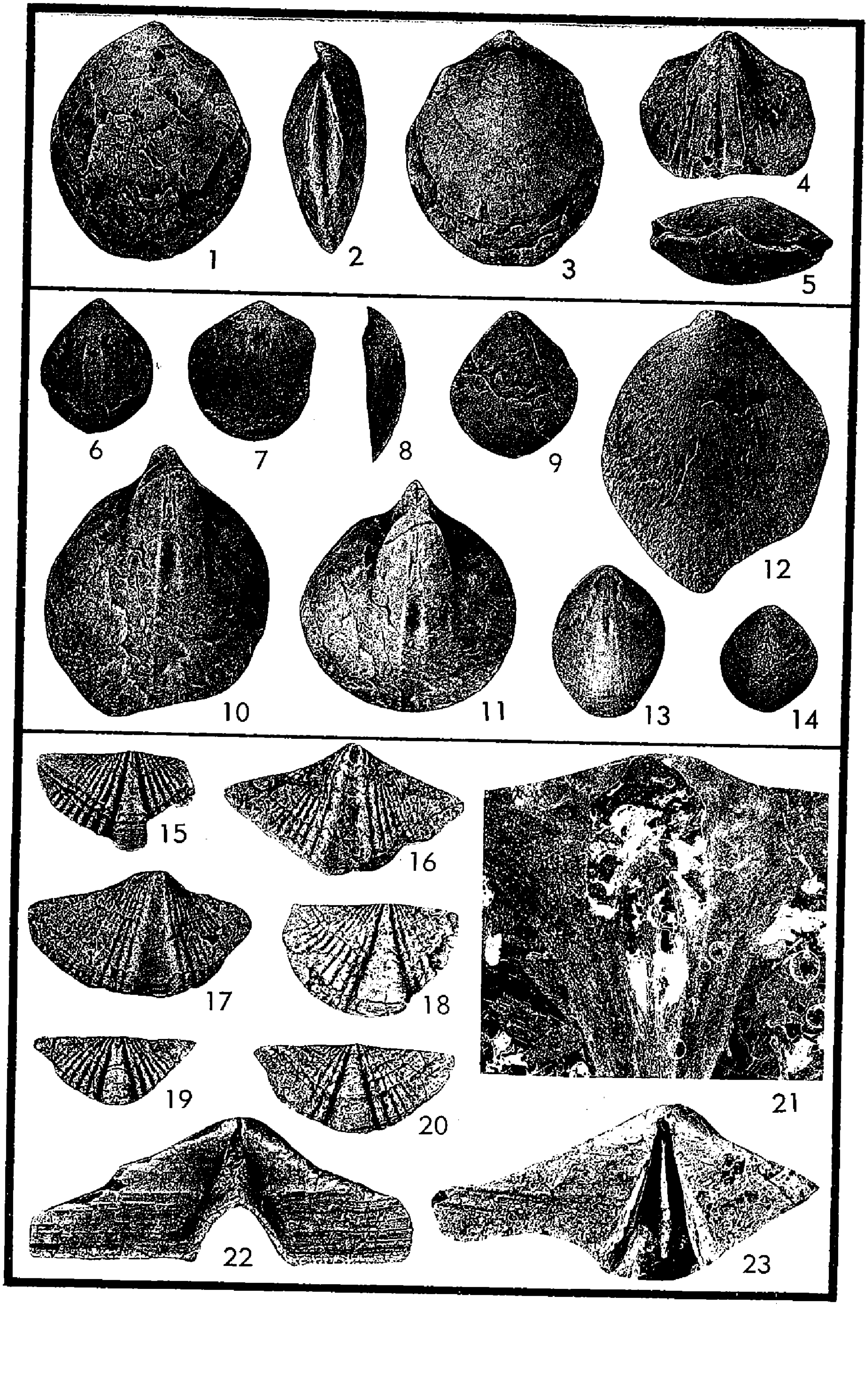
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PLATE VIII

Brachiopods from the Frisco Formation

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PLATE IX

Brachiopods from the Frisco Formation

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4. Posterior view of brachial valve showing the greatly thickened cardinalia, x1, locality, S1-B, Sequoyah Co. (OU 3381).

5, 6. Brachial and lateral views of an incomplete articulated shell, x1, locality V7, Pontotoc Co. (OU 3382).

7, 8. Lateral and pedicle views of a nearly complete valve, x1, west rim of St. Clair Lime Co. quarry, SE¼ SE¼ NE¼ sec. 14, T. 13 N., R. 23 E., Sequoyah Co. (OU 3380).

9. Posterior end of an incomplete brachial valve, x1, locality S1-B. Sequoyah Co. (OU 3383).
10. Posterior end of a fragmentary and deeply exfoliated pedicle valve, x1, locality S1-B, Sequoyah Co. (OU 3384).
11. Pedicle steinkern, x1, locality P11, Pontotoc Co. (OU 3385).
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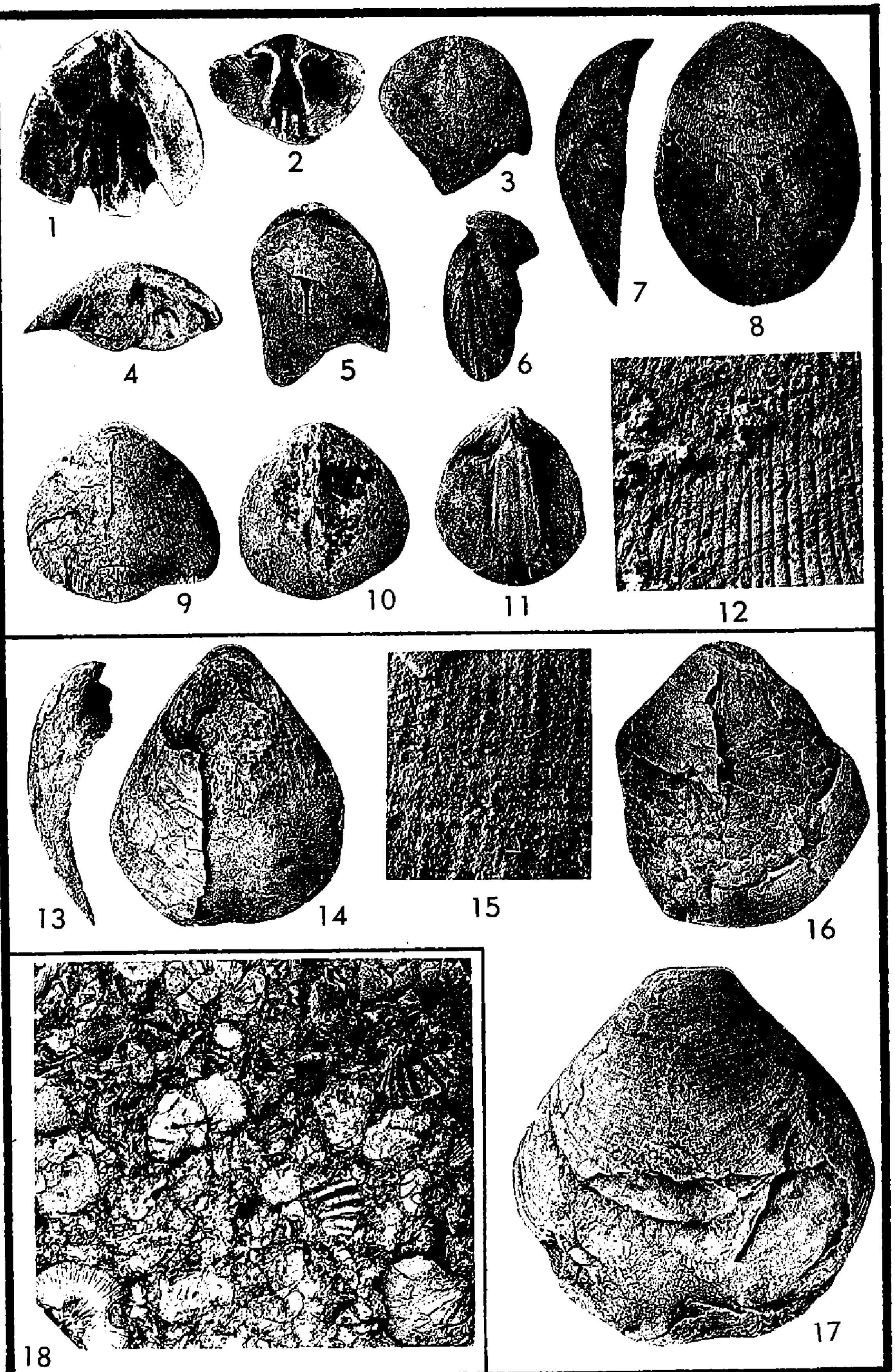
17. Large pedicle valve, x1, locality S1-B, Sequoyah Co. (OU 3390).

Clarke's type specimens of *"Meristella" vascularia* from the Oriskany Formation are illustrated on plate X, figures 1-3.

Figure 18. Typical Frisco bedding-plane surface showing the abundant, fragmentary fossil debris, x1, locality S6-A, Sequoyah Co. See also text-figure 6A.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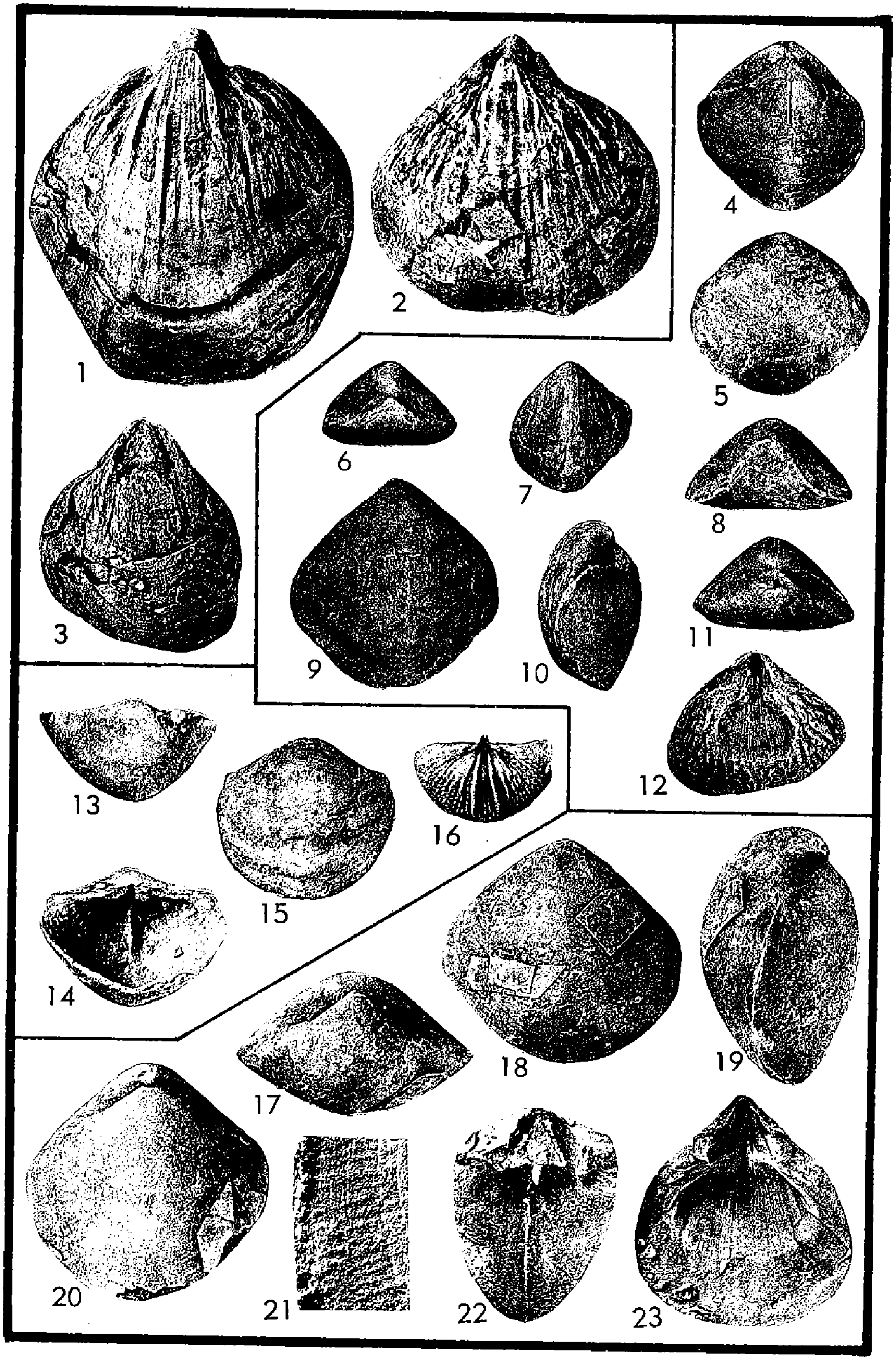
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PLATE X

Brachiopods from the Oriskany, Glenerie, and Little Saline Formations

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Figures 1-3. *Meristella? vascularia* Clarke. These are the original specimens figured by Clarke (1900, pl. 6, figs. 12-14), from the Oriskany Sandstone, Becraft Mountain, Columbia Co., New York. They are in the New York State Museum, Albany, New York. 121

1. Pedicle steinkern, x1 (specimen illustrated by Clarke, pl. 6, fig. 13, bearing NYSM 1570 and a red sticker, presumably indicating the holotype).
2. Pedicle steinkern, x1 (specimen illustrated by Clarke, pl. 6, fig. 12, NYSM 1569).
3. Partially exfoliated pedicle valve showing faint costelliae on the anterior part, x1 (specimen illustrated by Clarke, pl. 6, fig. 14, NYSM 1571).

Plaster casts of these specimens are in The University of Oklahoma collections (OU 3392-3394). Frisco specimens of "*M.*" *vascularia*? Clarke are illustrated on plate IX, figures 13-17.

Figures 4-12. *Meristella carinata* Stewart. These are the original specimens illustrated by Stewart (1922, pl. 66, figs. 12-21) from the "lower beds" of the Little Saline Limestone, Little Saline Creek, Ste. Genevieve Co., Missouri. They are in the Walker Museum, University of Chicago. 117

4, 5, 8, 10, 11. Brachial, pedicle, anterior, lateral, and posterior views of the holotype, x1 (specimen illustrated by Stewart, pl. 66, fig. 17, WM 27491A).

6. Posterior view, x1 (illustrated by Stewart, pl. 66, fig. 15, WM 27491B).

7. Brachial valve, x1 (illustrated by Stewart, pl. 66, fig. 13, WM 27491).

9. Brachial valve, x1 (illustrated by Stewart, pl. 66, fig. 12, WM 27491).

12. Pedicle interior, x1 (rubber cast of the steinkern illustrated by Stewart, pl. 66, fig. 18, WM 27491).

Plaster casts of these specimens are in The University of Oklahoma collections, (OU 3395-3399). Frisco specimens of *M. carinata* Stewart are illustrated on plate VII, figures 7-18.

Figures 13-16. *Anoplia nucleata* (Hall). Specimens from the Glenerie Limestone, New York State Highway 9W, 1 mile north of Glenerie, and 1 mile south of Cockburn, New York; they are in the collections of the U. S. National Museum. 82

13, 14, 15. Posterior, interior, and exterior views of a pedicle valve, x3 (USNM 138795).

16. Brachial interior, x3 (USNM 138796).

Frisco specimens of *A. nucleata* (Hall) are illustrated on plate I, figures 1-4; Sallisaw specimens on plate XIII, figures 16-24; a Clear Creek specimen on plate XX, figure 9.

Figures 17-23. *Meristella lata* Hall. These are the original specimens illustrated by Hall (1859, pl. 101, figs. 3a-m) from the Oriskany Sandstone, Knox, Albany Co., New York. They are in the American Museum of Natural History. 120

17, 18, 19, 20, 21. Posterior, pedicle, lateral, brachial, (x1) and enlarged surface (x5) views of the holotype (illustrated by Hall, pl. 101, figs. 3b-e, AMNH 2671/1).

22. Brachial cardinalia, x1 (rubber cast of the steinkern illustrated by Hall, pl. 101, figs. 3l,m, AMNH 2671/1).

23. Pedicle interior, x1 (rubber cast of the steinkern illustrated by Hall, pl. 101, figs. 3g,h, AMNH 2671/1).

Plaster casts of these specimens are in The University of Oklahoma collections (OU 3403-3405).

PLATE XI

Brachiopods from the Frisco and Oriskany Formations

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Figures 1-9. *Spinoplasia oklahomensis* Amsden and Ventress, new species, Frisco Formation, Oklahoma. 103

1. 3. Pedicle (x2) and enlarged surface (x5) views of the holotype, locality P9, Pontotoc Co. (OU 3934).

2. Fragment of an exfoliated pedicle valve, x3, locality P11, Pontotoc Co. (OU 3314).

4. Exfoliated brachial valve, x2, locality P11, Pontotoc Co. (OU 3315).

5. Small, exfoliated pedicle valve, x3, locality P11, Pontotoc Co. (OU 3317).

6, 8, 9. Brachial (x2), posterior (x2), and brachial (x1) views of an articulated shell, locality P9, Pontotoc Co. (OU 3316).

7. Small pedicle valve, x3, locality P11, Pontotoc Co. (OU 3935).

Figures 10-15. *Schuchertella becraftensis* (Clarke), Frisco Formation, Oklahoma. 85

10, 11. Pedicle and posterior views of an incomplete valve, x2, locality S8-C, Sequoyah Co. (OU 3936).

12. Pedicle steinkern, x2, locality S8-C, Sequoyah Co. (OU 3937).

13. Brachial valve, x2, locality S8-C, Sequoyah Co. (OU 3938).

14, 15. Lateral and pedicle views of a small valve, x2, locality S8-C, Sequoyah Co. (OU 3939).

Figures 16-20. *Schuchertella becraftensis* (Clarke). These are Clarke's type specimens from the Oriskany Formation, Becraft Mountain, Hudson, New York. The specimens illustrated in figures 16 and 19 are silicified valves, the others are wax casts of external and internal molds (originals not available). All specimens are in the New York State Museum, Albany, New York. 85

16. Brachial interior (slightly oblique view), x3 (figured by Clarke, 1900, pl. 7, fig. 25, NYSM 1661).

17. Brachial valve, x1 (not figured by Clarke, NYSM 1659).

18. Brachial interior, x2 (figured by Clarke, 1900, pl. 7, fig. 22, NYSM 1665).

19. Posterior view of a pedicle valve, x2 (figured by Clarke, 1900, pl. 7, fig. 27, NYSM 1669).

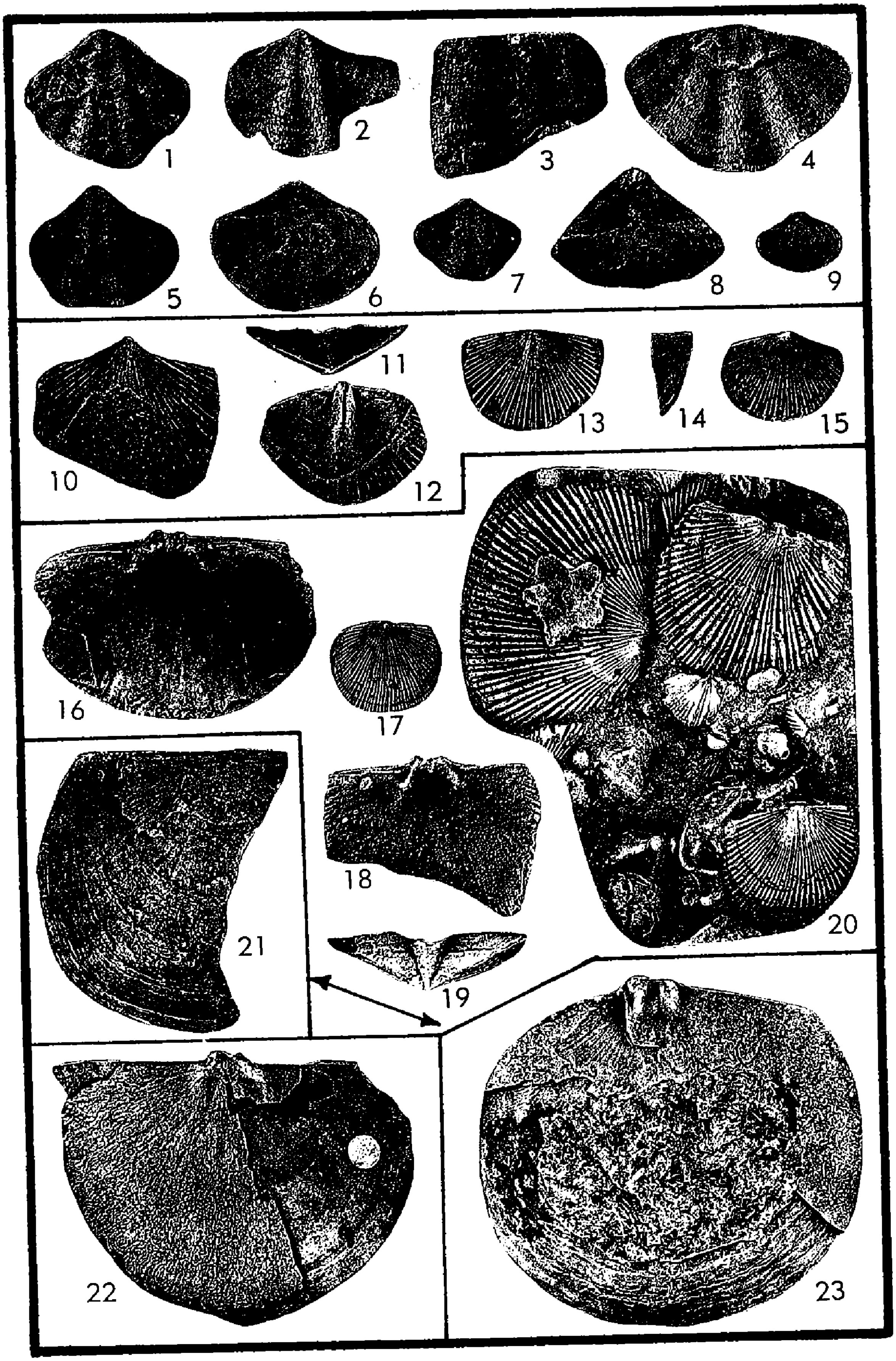
20. Small slab with specimens of *Schuchertella befraftensis* and *Anoplia nucleata,* x2 (pedicle valve in upper right may be the one figured by Clarke, 1900, pl. 7, fig. 20; other two specimens are brachial valves, NYSM 1663).

Figures 21, 23. *Pholidostrophia?* sp. Frisco Formation, Oklahoma. 72

21. Incomplete pedicle valve showing the smooth exterior, x1, locality S6, Sequoyah Co. (OU 3940).

23. Brachial interior with anterior portion of shell broken away to show an external mold of the surface, x1 (specimen collected by C. O. Dunbar from the Frisco Formation near Marble City; original at Peabody Museum, Yale University, YPM 21751; a cast of this valve is in The University of Oklahoma collections, OU 3941).

Figure 22. *Pholidostrophia? lincklaeni* (Clarke) [not Hall, 1859]. This is the specimen figured by Clarke, 1900, plate 7, figure 37; from the Oriskany Formation, Becraft Mountain, Hudson. New York. Brachial interior of a specimen partly exfoliated on the right side to show an external mold of the outer surface, x1 (NYSM 1468). A cast of this specimen is in The University of Oklahoma collections (OU 3942). 73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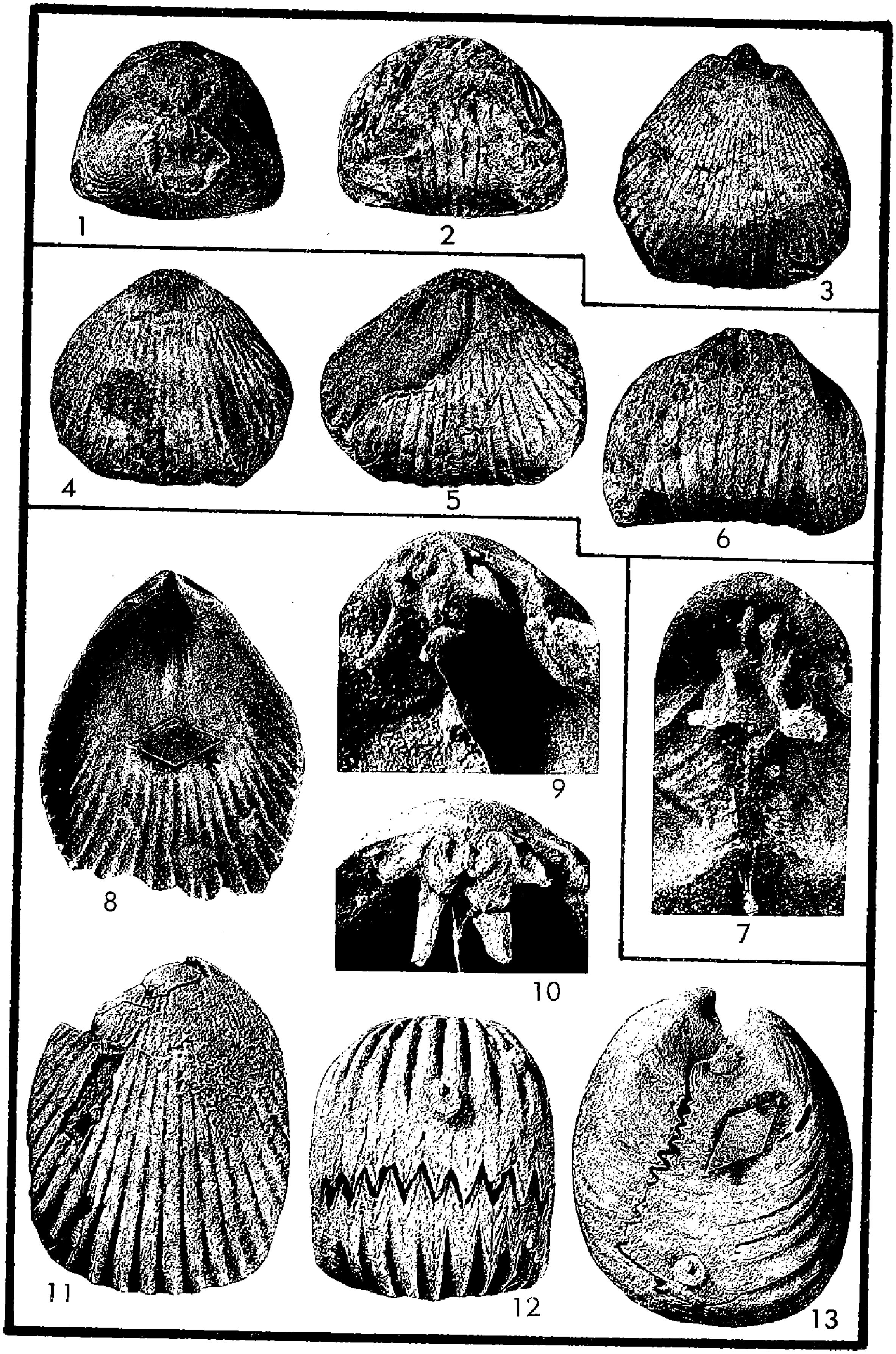
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PLATE XII

Brachiopods from the Little Saline and Oriskany Formations

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Figures 1-3.	*Plethorhyncha? welleri* (Stewart). This is the holotype from the Little Saline Limestone, Little Saline Creek, Missouri. Posterior, anterior, and pedicle views of the holotype, x1 (figured by Stewart, 1922, pl. 63, fig. 13, WM 27465A). Frisco specimens of *P.? welleri* are illustrated on plate III.	96
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Figure 7.	*Plethorhyncha barrandi* (Hall). Rubber cast of the posterior portion of Hall's type specimen (a steinkern) from the Oriskany Formation, Knox, Albany Co., New York. Brachial cardinalia, x2 (probably the specimen illustrated by Hall, 1859, pl. 103, figs. 5, 6, 7, AMNH 2675). Frisco specimens of *Plethorhyncha* cf. *P. barrandi* are illustrated on plate IV, figures 5-10.	95
Figures 8-13.	*Plethorhyncha speciosum* (Hall). These are Hall's type specimens from the Oriskany Formation, Cumberland, Maryland (this is the type species of *Plethorhyncha).* All of these specimens are at the American Museum of Natural History and bear AMNH 2734. 8. Pedicle interior, x1 (specimen figured by Hall, 1859, pl. 103A, fig. 4a). 9, 10. Two views of the brachial cardinalia, x2 (specimen figured by Hall, 1859, pl. 103A, figs. 6a,b). 11, 12, 13. Pedicle, anterior, and lateral views of the lectotype, x1 (this is the specimen figured by Hall, 1859, pl. 103A, figs. 2a-d; the posterior end of this specimen has been broken since the illustration was prepared for Hall; herein designated the lectotype).	95

PLATE XIII

Brachiopods from the Sallisaw Formation

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Figures 1-15. *Eodevonaria intermedia* Amsden, new species. 166

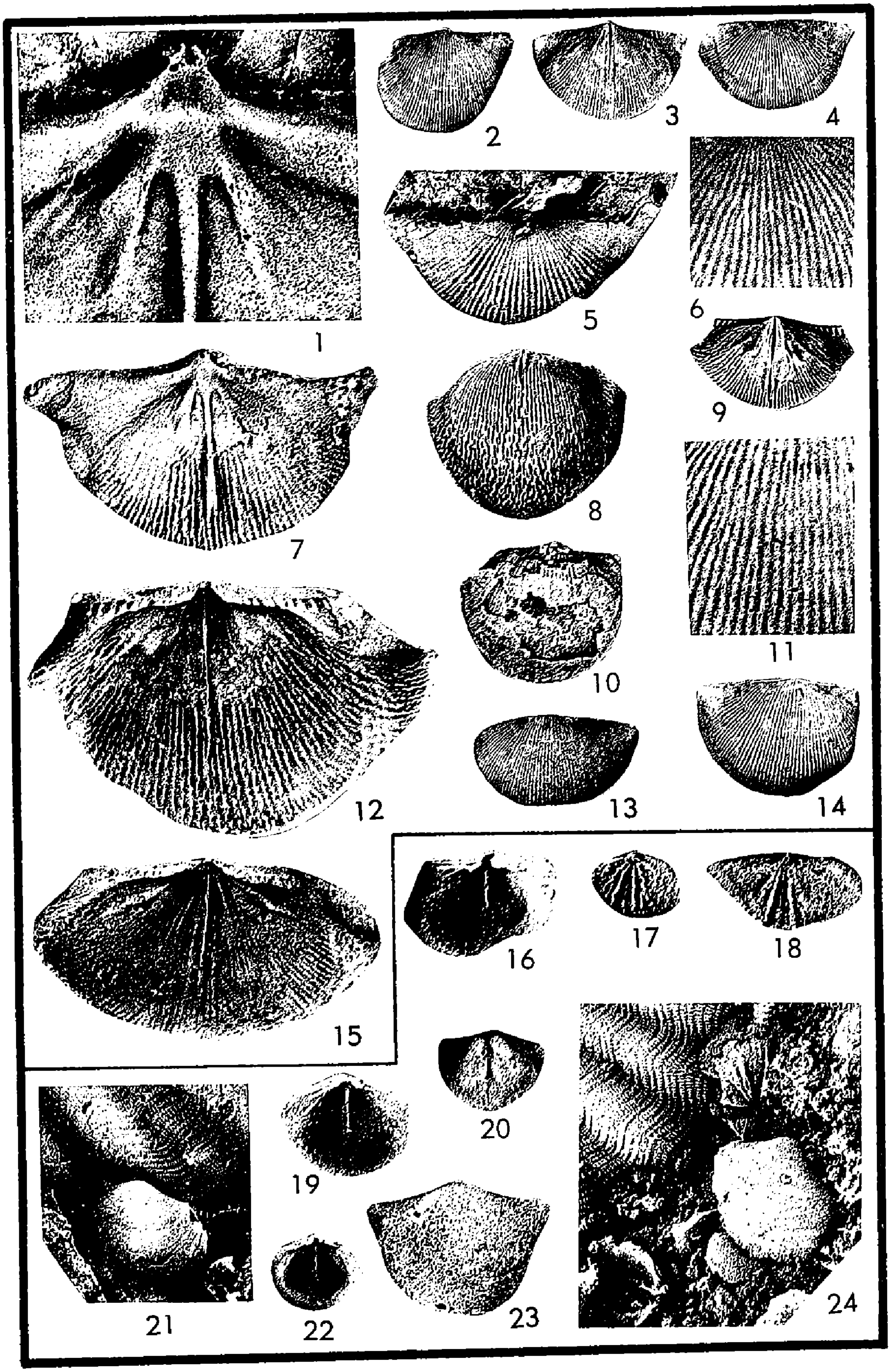
1. Posterior portion of a brachial interior; rubber cast of a chert mold, x6, locality S10-D (OU 4354).
2. Pedicle exterior; rubber cast of a chert mold, x1, locality S10-D (OU 4353).
3. Posterior view of a pedicle steinkern, x1, locality S10-D (OU 4358).
4, 6. Pedicle exterior (x1) and enlarged surface (x3) views, locality S10-D (OU 4359).
5. Pedicle exterior showing cardinal spine; rubber cast of a chert mold, x2, locality S10-D (OU 4355).
7. Brachial interior; rubber cast of a chert mold, x2, locality S10-D (OU 4355).
8, 9, 12. Pedicle and posterior views (x1) of a pedicle steinkern, and a rubber cast (x2) of this steinkern, locality S10-D (OU 4357).
10. Pedicle view of a partly exfoliated specimen from the arenaceous limestone facies of the Sallisaw, x1, locality S10-D (OU 4356).
11, 14. Enlarged surface (x3) and pedicle (x1) views of the holotype; rubber cast of a chert mold, locality S10-D (OU 4352).
13. Pedicle exterior; rubber cast of a chert mold, x1, locality S10-D (OU 4355).
15. Oblique view of pedicle interior; rubber cast of a chert mold, x2 (OU 4360) (collected by H. E. Christian, SW¼ SE¼ NE¼ sec. 22, T. 13 N., R. 23 E.).

A specimen from the Camden Formation of Tennessee, provisionally referred to this species, is illustrated on plate XX, figure 10. Compare with the Onondaga specimens of *Eodevonaria acutiradiata* (Hall) and *E. arcuata* (Hall) illustrated on plate XV.

Figures 16-24. *Anoplia nucleata* (Hall). 172

16. Pedicle interior; rubber cast of a chert mold, x5 (OU 4361) (collected by H. E. Christian, NE¼ NE¼ sec. 22, T. 13 N., R. 23 E., Sequoyah Co.).
17. Brachial interior; rubber cast of a chert mold, x5 (OU 4362) (collected by H. E. Christian, SW¼ SE¼ NE¼ sec. 22, T. 13 N., R. 23 E., Sequoyah Co.).
18. Brachial interior; rubber cast of a chert mold, x5, locality S10-D (OU 4385).
19. Pedicle interior; rubber cast of a chert mold, x5 (OU 4362) (collected by H. E. Christian, same locality as fig. 17).
20. Pedicle steinkern, x5, locality S10-D (OU 4358).
21. Pedicle exterior, x5, locality S10-D (OU 4362).
22. Pedicle interior; rubber cast of a chert mold, x3, locality S10-D (OU 4363).
23. Pedicle exterior; rubber cast of a chert mold, x5 (OU 4362) (collected by H. E. Christian, same locality as fig. 17).
24. Pedicle view, x5 (OU 4364) (collected by H. E. Christian near S10; see also pl. XVI, fig. 16).

A specimen of *A. nucleata* from the Clear Creek Formation of Illinois is illustrated on plate XX, figure 9; specimens from the Frisco Formation are illustrated on plate I, figures 1-4; specimens from the Glenerie Formation of New York are illustrated on plate X, figures 13-16.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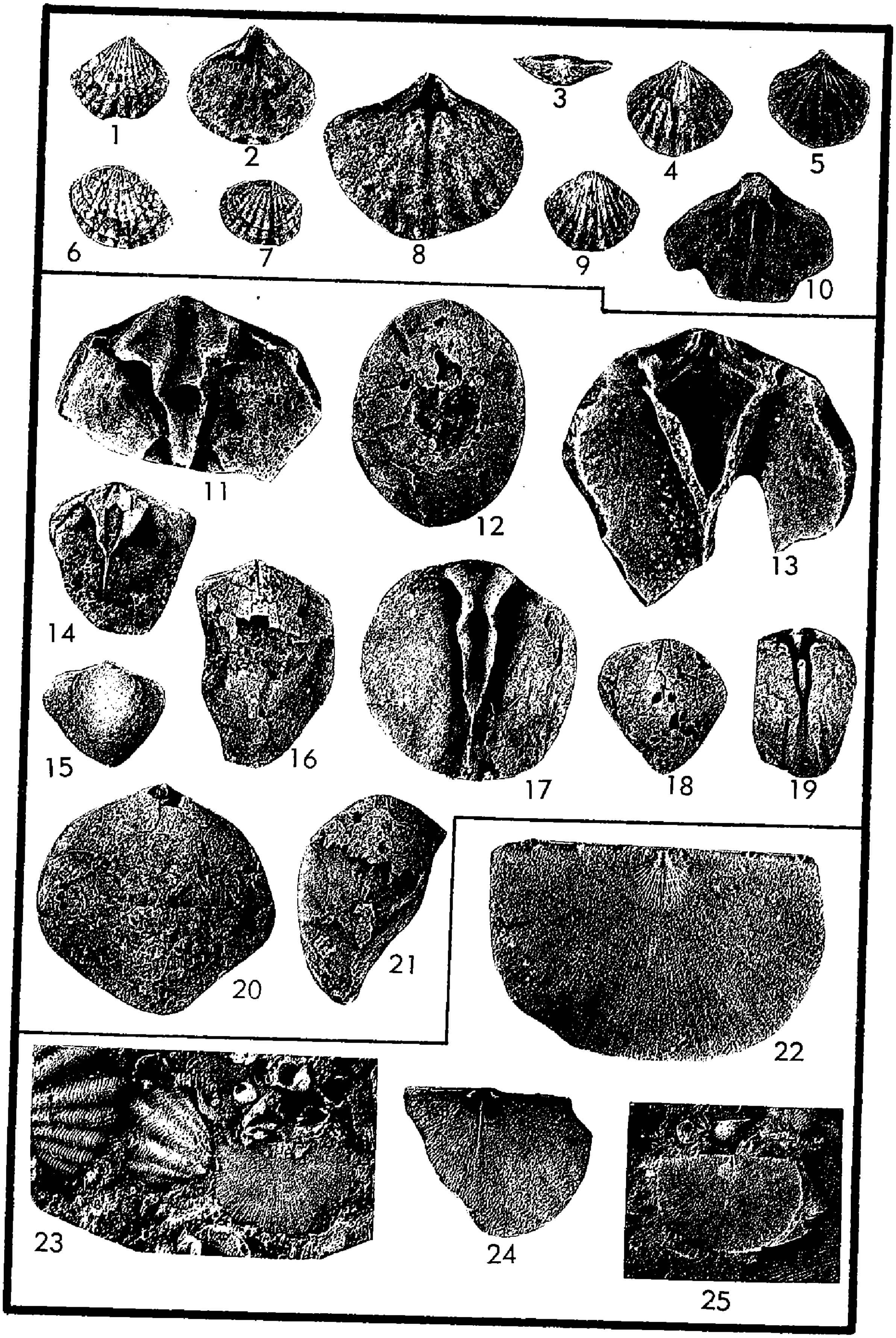
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PLATE XIV

Brachiopods from the Sallisaw Formation

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Figures 1-10. *Leptocoelia flabellites*? (Conrad). 176

1. Pedicle view, x1, locality S10-D (OU 4365).
2. Pedicle interior; rubber cast of a steinkern, x1, locality S10-D (OU 4366).

3, 4, 5. Posterior, pedicle, and brachial views of a small articulated shell, x2 (OU 4367) (collected by H. E. Christian, NE¼ NE¼ sec. 22, T. 13 N., R. 23 E., Sequoyah Co.).

6. Brachial view on an incomplete valve, x1, locality S10-D (OU 4368).
7. Brachial view, x1, locality S10-D (OU 4369).
8. Brachial steinkern, x2, locality S10-D (OU 4370).
9. Pedicle exterior view, x1, locality S10-D (OU 4371).
10. Brachial interior; rubber cast of a steinkern, x2, locality S10-D (OU 4372).

Specimens of *L. flabellites*? (Conrad) from the Camden Formation of western Tennessee and the Clear Creek Formation of Illinois are illustrated on plate XX, figures 11-17.

Figures 11-21. *Amphigenia curta* (Meek and Worthen). 187

11. Posterior portion of a brachial valve, x2 (OU 4373) (collected by H. E. Christian, NE¼ NE¼ sec. 22, T. 13 N., R. 23 E., Sequoyah Co.).
12. Brachial valve, x1, locality S10-D (OU 4374).
13. Posterior end of a pedicle valve, x2 (OU 4375) (collected by H. E. Christian, same locality as fig. 11).
14. Pedicle interior; rubber cast of a silicified steinkern, x1 (OU 4376) (collected by H. E. Christian, same locality as fig. 11).
15. Posterior portion of a pedicle valve, x1, locality S4-D (OU 4377).
16. Fragmentary pedicle valve, x1, locality S10-D (OU 4378).
17. Posterior portion of a brachial interior; rubber cast of a silicified steinkern, x2, locality S3 (OU 4379).
18. Posterior portion of a brachial valve, x1, locality S11-D (OU 4380).
19. Brachial steinkern, x1, locality S5-D (OU 4381).
20. Posterior portion of a pedicle valve, x1 (OU 4382) (collected by H. E. Christian, same locality as fig. 11).
21. Incomplete and partly exfoliated brachial valve, x1, locality S10-D (OU 4383).

Meek and Worthen's type specimens of *A. curta* are illustrated on plate XVII, figures 1-7. Specimens from the Camden Formation are illustrated on plate XX, figures 1-7; another Sallisaw specimen is illustrated on plate XX, figure 8.

Figures 22-25. *Chonostrophia complanata*? (Hall). 170

22, 25. Two external views of a pedicle valve; rubber cast of a chert mold, x4.5 and x2, locality S10-D (OU 4384).

23. Pedicle view; rubber cast of a chert mold, x2, near locality S10 (OU 4364) (note specimens of *Hysterolites (A.) worthenanus*? and *Anoplia nucleata;* see pl. XVI, fig. 16).
24. Pedicle interior; rubber cast of a chert mold, x3, locality S10-D (OU 4385).

Specimens of *C. complanata*? from the Camden Formation of Tennessee are illustrated on plate XX, figures 18, 19; specimens from the Frisco Formation on plate I, figures 11-15.

PLATE XV

Eodevonaria acutiradiata (Hall) and *E. arcuata* (Hall) from the Onondaga Formation of New York

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Figures 1-6. *Eodevonaria acutiradiata* (Hall). These specimens are in the Hall collection at the American Museum of Natural History. The specimens shown in figures 1, 2, 5, 6 were illustrated by Hall in 1867. 168

1. Rock slab, x1, with two specimens figured by Hall (1867, pl. 20, figs. 5a, 5b, 5c), "Upper Helderberg limestone" (Onondaga Limestone), East Buffalo, New York (AMNH 3046/1).
2. Pedicle view, x2, of a specimen illustrated by Hall (1867, pl. 20, fig. 5b). This is the specimen shown in the upper left hand corner of figure 1.

3, 4. Lateral and pedicle views, x2, of a specimen from the Onondaga Limestone, Williamsville, N. Y., (in the Hall collections of the American Museum, but it is not known to have been figured previously).

5, 6. Enlarged surface (x3) and pedicle (x2.5) views of a specimen illustrated by Hall (1867, pl. 20, figs. 5a, 5c). This is the specimen just left of center in figure 1.

Figures 7-17. *Eodevonaria arcuata* (Hall). These specimens are in the Hall collections at the American Museum of Natural History. Those shown in figures 7-16 were illustrated by Hall in 1867 (pl. 20, figs. 7a-7f). 168

7, 10, 12. Pedicle (x1), enlarged surface (x3) and lateral (x1) views of a specimen illustrated by Hall (1867, pl. 20, figs. 7c,d), "Upper Helderberg limestone" (Onondaga Limestone), Williamsville, New York (AMNH 3049/2).

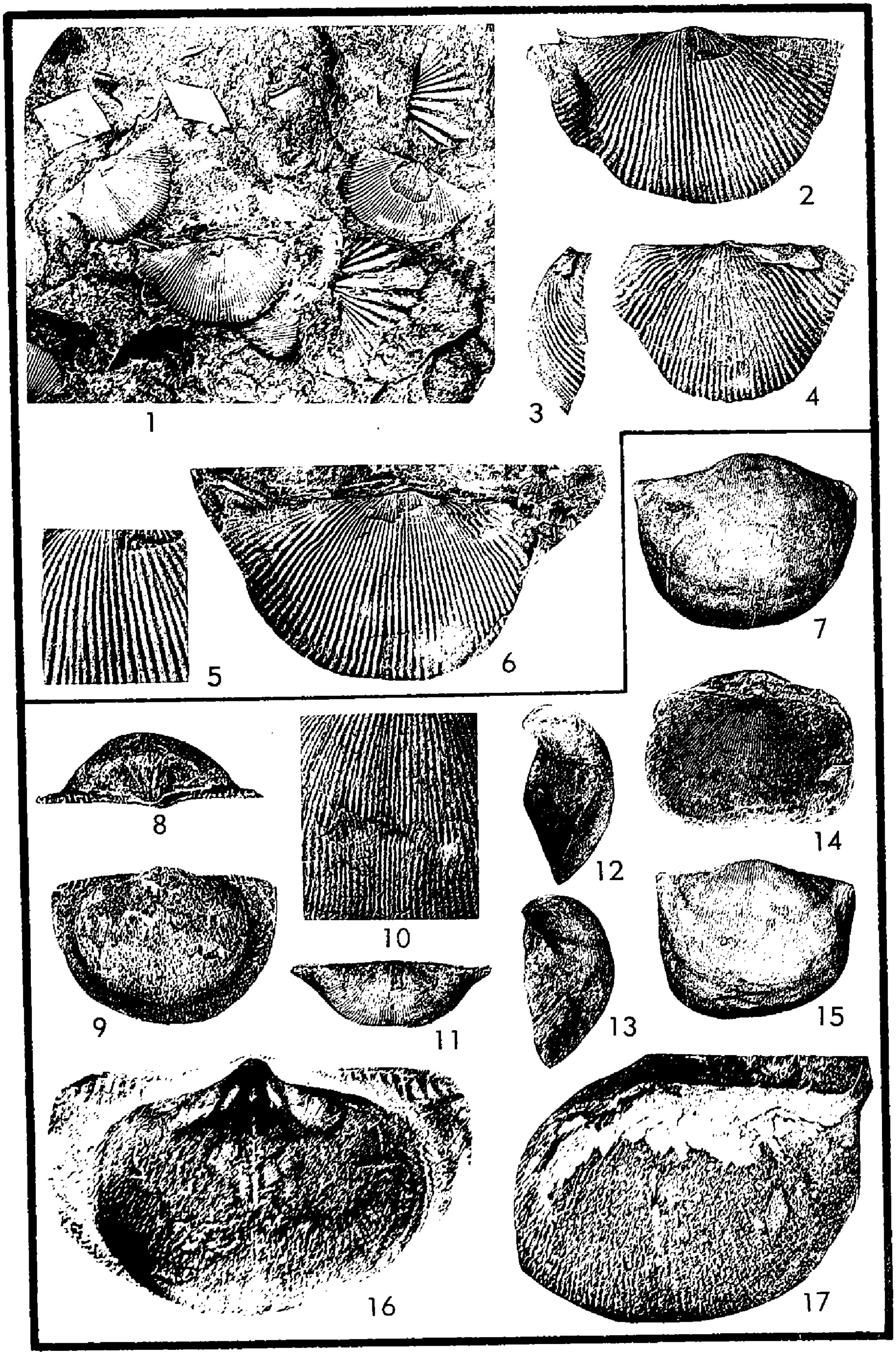
8, 9. Posterior and pedicle views, x1, of the steinkern illustrated by Hall (1867, pl. 20, figs. 7e,f), "Upper Helderberg limestone" (Onondaga Limestone), Clarence Hollow, New York (AMNH 3049/1; see also fig. 16).

11, 13, 15. Posterior, lateral, and pedicle views, x1, of the specimen illustrated by Hall (1867, pl. 20, fig. 7b), "Upper Helderberg limestone" (Onondaga Limestone), Williamsville, New York (AMNH 3049/2).

14. Brachial view, x1, of a specimen figured by Hall (1867, pl. 20, fig. 7a), "Upper Helderberg limestone" (Onondaga Limestone), Williamsville, New York (AMNH 3049/2).

16. Rubber cast, x2, of the steinkern illustrated in figures 8, 9.

17. Pedicle view, x2, of a specimen showing the hinge spines (specimen included with Hall's figured specimens but it was not illustrated in 1867), "Upper Helderberg limestone" (Onondaga Limestone), Clarence Hollow, New York (AMNH 3049/1).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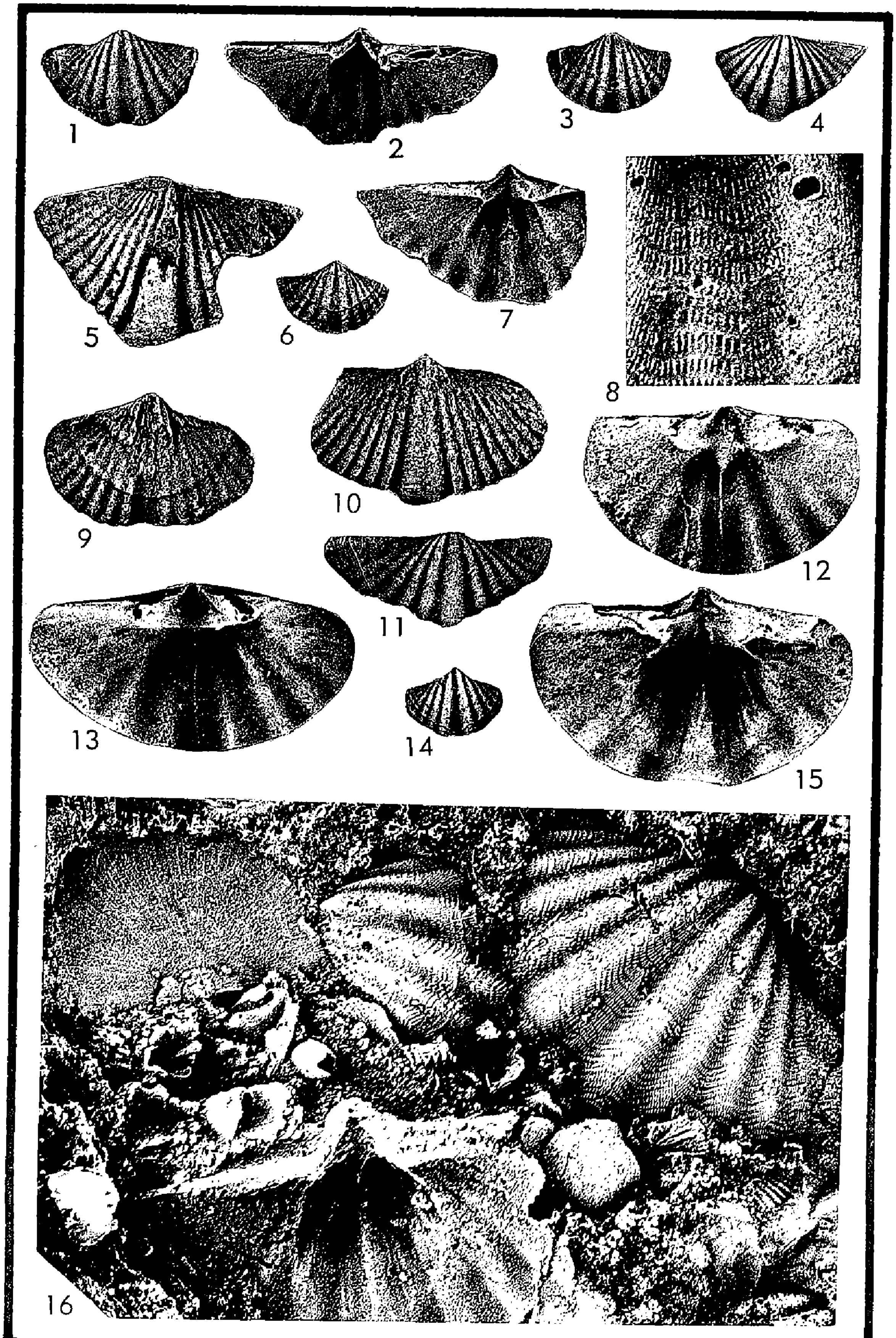
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PLATE XVI

Brachiopods from the Sallisaw Formation

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Figures 1-16. *Hysterolites (Acrospirifer) worthenanus*? (Schuchert). 182

1. Pedicle view; rubber cast of an external chert mold, x1, locality S10 (OU 4385).
2. Pedicle interior; rubber cast of a steinkern, x2, locality S10 (OU 4355).
3. Pedicle view of a partly exfoliated specimen from the arenaceous carbonate facies, x1, locality S10-D (OU 4388).
4. Brachial view; rubber cast of an external chert mold, x1, locality S8 (OU 4362).
5. Brachial view of an incomplete valve from the arenaceous carbonate facies, x1, locality S10-D (OU 4389).
6. Small pedicle valve from the arenaceous carbonate facies, x1, locality S10-D (OU 4390).
7. Pedicle interior; rubber cast of a steinkern, x2, locality S10 (OU 4391).
8. Enlarged surface view; rubber cast of an external chert mold, x12, locality S8 (OU 4362).
9. Exfoliated pedicle valve from the arenaceous carbonate facies, x1, locality S10-D (OU 4392).
10. Large brachial steinkern; chert facies, x1, locality S10 (OU 4393).
11. Brachial view; rubber cast of an external chert mold, x2, locality S10 (OU 4394).
12. Brachial interior; rubber cast of a steinkern, x5, locality S10 (OU 4395).
13. Brachial interior: rubber cast of a steinkern, x5, locality S10 (OU 4352).
14. Pedicle valve from the arenaceous carbonate facies, x1, S10-D (OU 4396).
15. Pedicle interior; rubber cast of a steinkern, x6, locality S10 (OU 4355).
16. Rubber cast, x4, of a chert block showing a pedicle interior and two pedicle exteriors (note also specimens of *Chonostrophia complanata*? and *Anoplia nucleata;* see pl. XIII, fig. 24 and pl. XIV, fig. 23), near S10 (OU 4364).

The type specimens of *H. (A.) worthenanus* from the Clear Creek Chert of Illinois are illustrated on plate XVII, figures 13-21.

PLATE XVII

Brachiopods from the Clear Creek Formation

Page

These are Meek and Worthen's type specimens from the Clear Creek Formation of Illinois. They were described in volume 3, Geology and Paleontology, Geological Survey of Illinois (1868), and are in the collections of the Illinois Geological Survey.

Figures 1-7. *Amphigenia curta* (Meek and Worthen). 190

1, 3. Brachial and posterior views, x1, of a steinkern figured by Meek and Worthen (pl. 8, fig. 1a).

2. Rubber cast, x1, of the steinkern illustrated in figures 1, 3.

4. Rubber cast, x1, of the steinkern illustrated in figures 5-7.

5-7. Lateral, brachial, and posterior views, x1, of the steinkern illustrated by Meek and Worthen (pl. 8, figs. 1b,c); this specimen is herein designated the lectotype.

Both of these steinkerns are from the "Devonian, Oriskany [sic], Union County, Illinois" (IGS 4548). Sallisaw specimens of *A. curta* are illustrated on plate XIV, figures 11-21, and plate XX, figure 8; Camden specimens are illustrated on plate XX, figures 1-7.

Figures 8-12. *Brachyspirifer? hemicyclus* (Meek and Worthen). 186

8, 9, 11, 12. Lateral, anterior, pedicle, and brachial views, x1, of a specimen figured by Meek and Worthen (pl. 8, figs. 6a,b,d); this specimen, which is here designated the lectotype, is from the "Oriskany group [sic], Union and Alexander Counties, Illinois" (Meek and Worthen, 1868, p. 401, indicated this shell is from Union County).

10. Rubber cast, x1, of the steinkern figured by Meek and Worthen (pl. 8, fig. 7b); label states, "Oriskany group [sic], Union and Alexander Counties Illinois" (Meek and Worthen, 1868, p. 401, stated it is from Alexander County); another view of this specimen is shown on text-figure 49B (both specimens numbered IGS 5905).

Other specimens of *B.? hemicyclus* from the Clear Creek and Camden Formations are illustrated in text-figure 49.

Figures 13-21. *Hysterolites (Acrospirifer) worthenanus* (Schuchert). These are the type specimens of *Spirifer engelmanni* Meek and Worthen, 1868, not *Spirifer engelmanni* Meek, 1860 (= *Spirifer worthenanus* Schuchert, 1890). 183

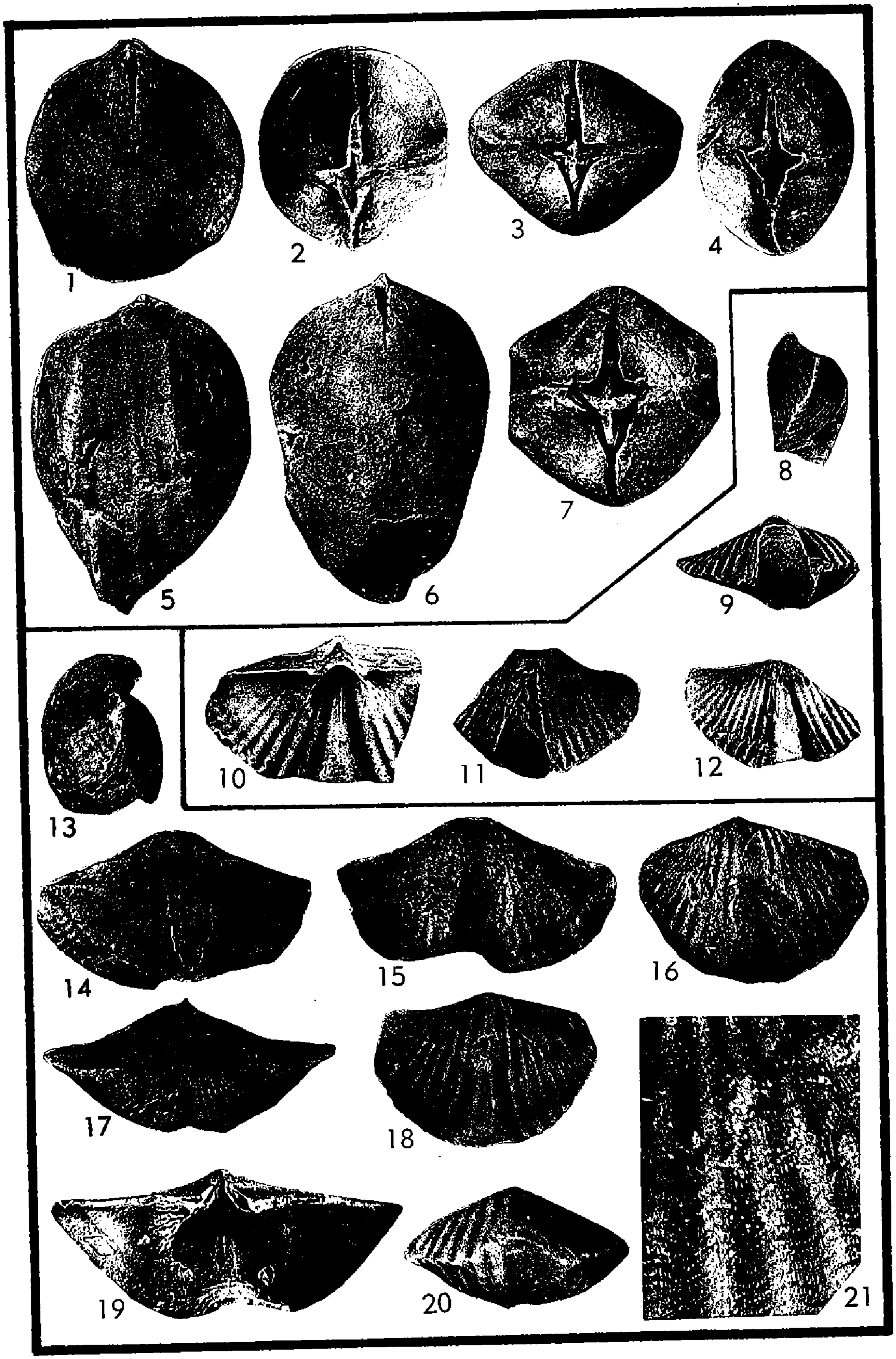
13, 14, 15, 17. Lateral, brachial, pedicle, and posterior views, x1, of a specimen illustrated by Meek and Worthen (pl. 8, figs. 5b-d); it is herein designated the lectotype.

16, 18, 20. Pedicle, brachial. and anterior views, x1, of a paratype not figured by Meek and Worthen.

19. Rubber cast, x1, of the pedicle steinkern figured by Meek and Worthen (pl. 8, fig. 5a).

21. Rubber cast, x5, of an external mold included with the Meek and Worthen type specimens; it was with the specimens assigned to *Spirifer hemicyclus* but is herein placed with *H. (A.) worthenanus;* it is labelled "Devonian, 5 miles from Jonesboro on the road to Bennetts Landing, Union County, Illinois" (IGS 4970).

The specimens shown in figures 13-20 are labelled "Lower Helderberg [sic], Union County, Illinois" (all numbered IGS 4530).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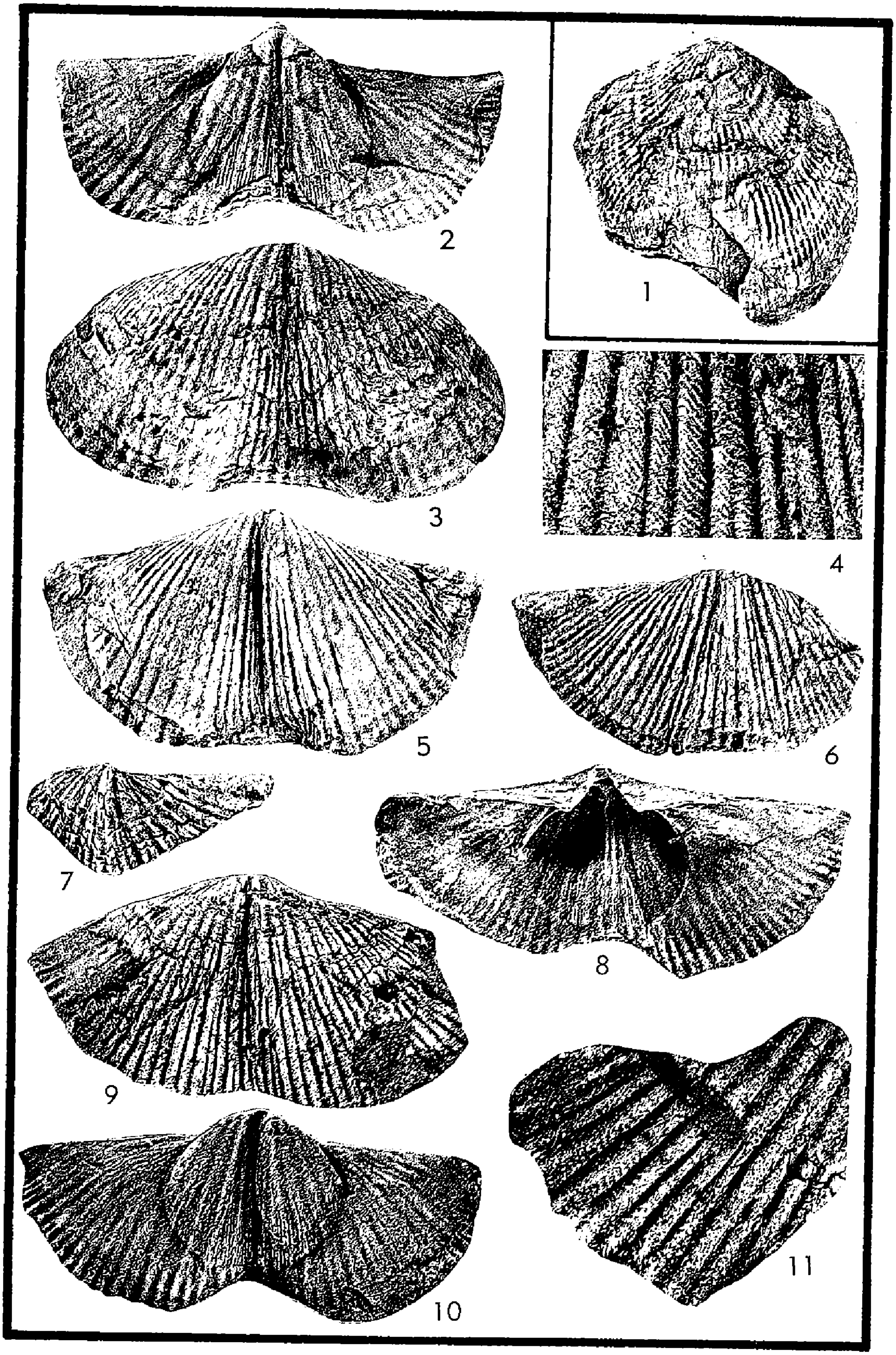
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PLATE XVIII

Brachiopods from the Sallisaw Formation

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Figure 1.	*Atrypa* sp. Fragment of a pedicle valve, x1, locality S14-C (OU 4397).	179
Figures 2-11.	*Fimbrispirifer* cf. *F. divaricatus* (Hall).	180

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3. Pedicle valve, x1, locality S14-C (OU 4399).
4. Enlarged surface view, x3, of the specimen illustrated in figure 9.
5. Nearly complete pedicle valve, x1, locality S14-C (OU 4401).
6. Fragment of a brachial valve, x1, locality S14-C (OU 4402).
7. Fragment of a small brachial valve, x1, locality S14-C (OU 4403).
8. Rubber cast, x1, of the pedicle steinkern illustrated in figure 10.
9. Pedicle exterior, x1, locality S14-C (OU 4400) (enlarged surface view of this specimen illustrated in figure 4).
10. Pedicle steinkern, x1, locality S14-C (OU 4404) (rubber cast of this specimen illustrated in figure 8).
11. Enlarged view of a pedicle valve showing the split ribs, x3, locality S14-C (OU 4405).

PLATE XIX

Brachiopods from the Sallisaw, Clear Creek, and Camden Formations

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Figures 1-5.	*Protoleptostrophia blainvillei* (Billings). Sallisaw Formation, Oklahoma.	164
	1. Oblique posterior view, x2, of brachial interior; rubber cast of a steinkern, locality S10 (OU 4385).	
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	3. Pedicle steinkern, x1, locality S14-C (OU 4406).	
	4. Fragment of a pedicle valve, x1, locality S14-C (OU 4407).	
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Figures 11-16.	*Schellwienella*? sp. Sallisaw Formation, Oklahoma; all of these specimens are rubber casts of external molds.	174
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	13. Fragment of a brachial valve, x1, near locality S8 (OU 4362).	
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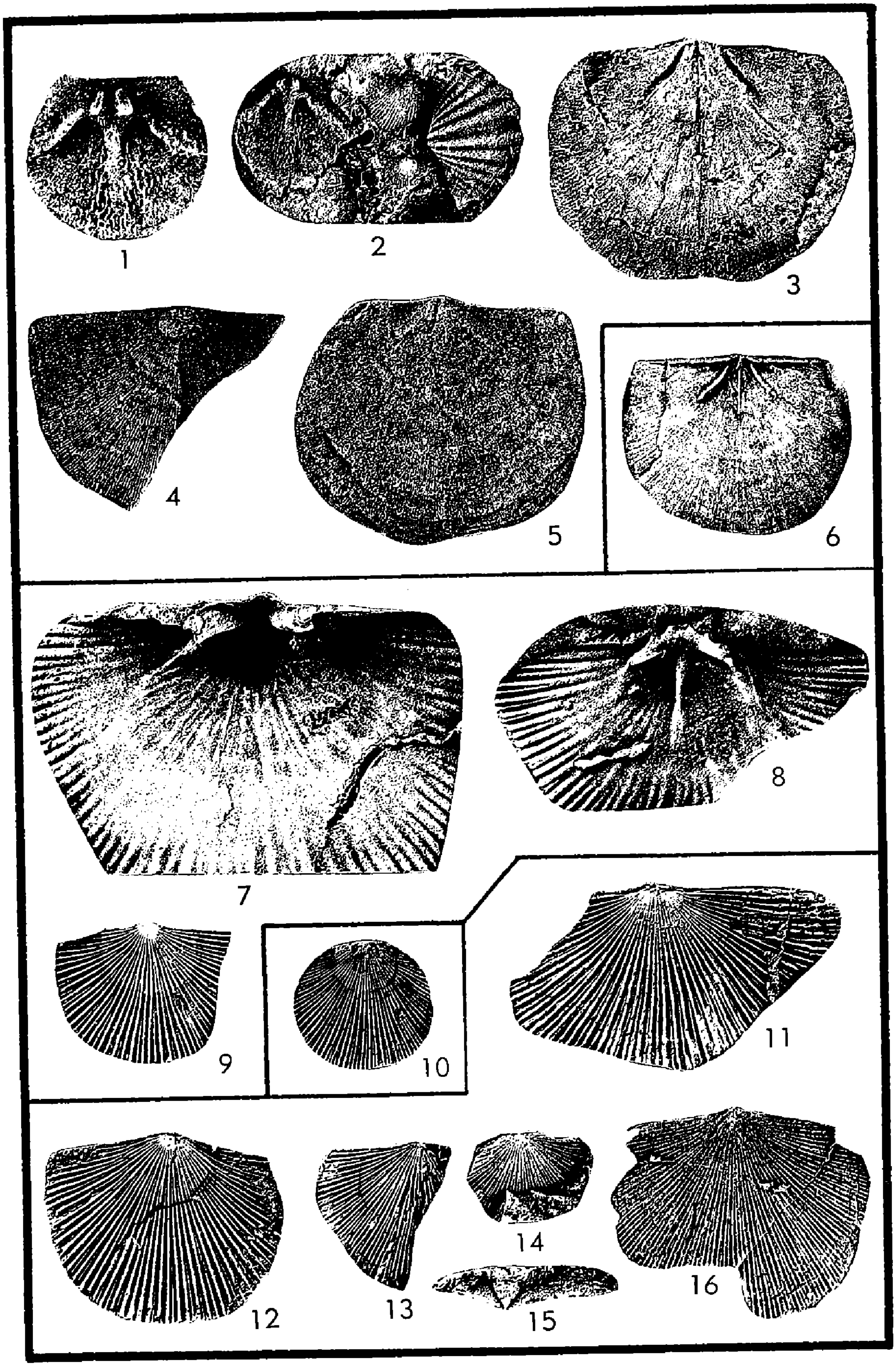
	15, 16. Posterior and pedicle views of a large pedicle valve, x1, near locality S9 (OU 4409).	
	The specimen illustrated in figures 13-16 were collected by H. E. Christian.	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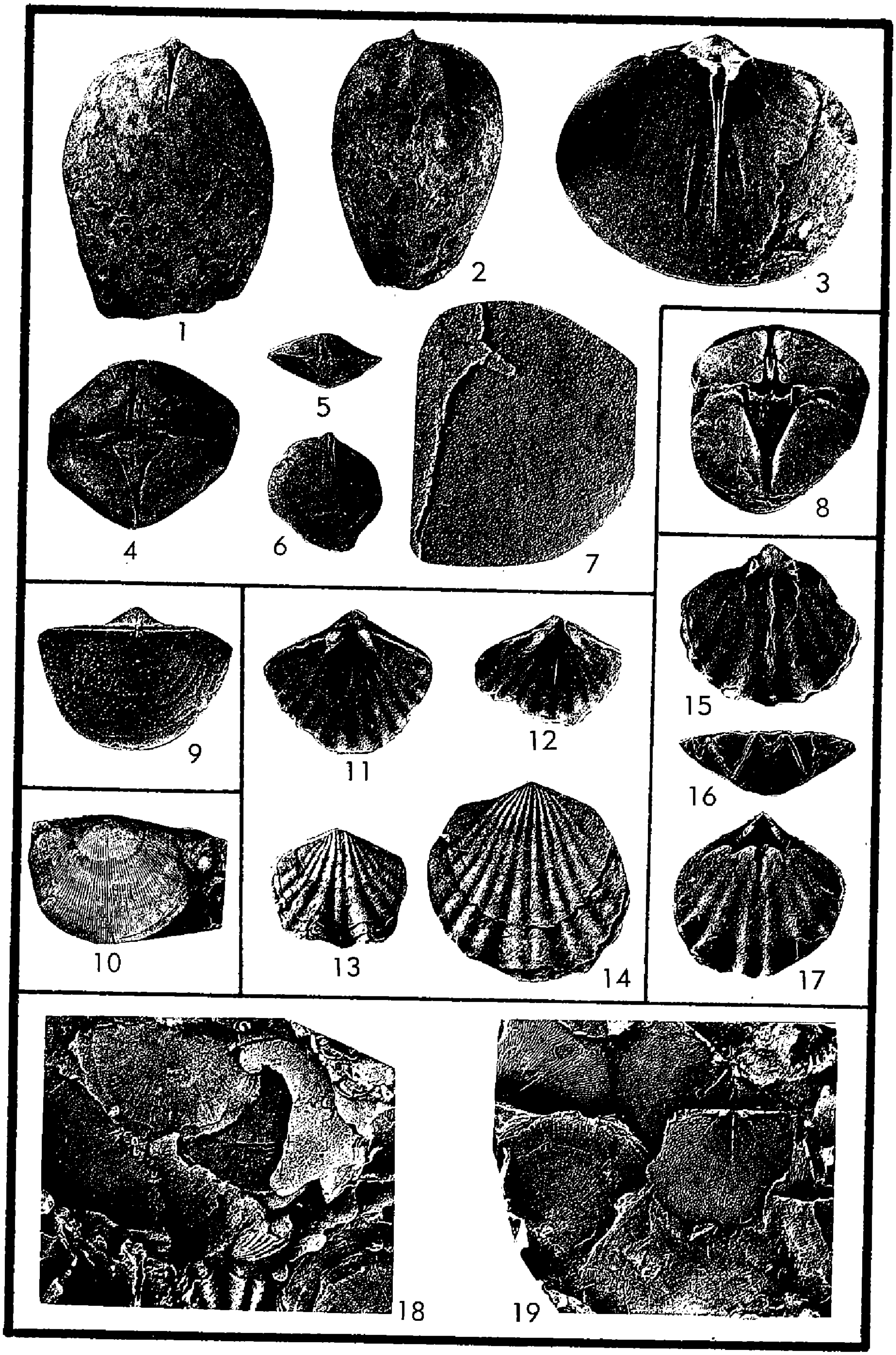
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PLATE XX

Brachiopods from the Sallisaw, Camden, and Clear Creek Formations

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Figures 1-7. *Amphigenia curta* (Meek and Worthen). Camden Formation, western Tennessee. 190

1, 2, 4. Pedicle, lateral, and posterior views of a silicified steinkern, x1, Camden, Tennessee (YPM S-3394).

3. Brachial interior, x2; rubber cast of a silicified steinkern, Camden, Tennessee (YPM S-3394).

5, 6. Posterior and brachial views of a small silicified steinkern, x1, 2 miles south of Camden, Tennessee (YPM 22419).

7. Enlarged surface view, x5, of a partly exfoliated pedicle valve (note punctae and faint radial ridges), 2 miles south of Camden, Tennessee (YPM 22420).

Meek and Worthen's type specimens of *A. curta* are illustrated on plate XVII, figures 1-7; Sallisaw specimens are illustrated on plate XIV, figures 11-21.

Figure 8. *Amphigenia curta* (Meek and Worthen). Sallisaw Formation, Oklahoma. Posterior view of an incomplete pedicle steinkern, x1 (OU 4410) (collected by H. E. Christian near S10). 187

Figure 9. *Anoplia nucleata* (Hall). Clear Creek Formation, southwestern Illinois. Brachial view, x5; rubber cast of an external mold, Union County, Illinois (YPM 22421). 172

Other illustrations of *A. nucleata* are on plates I, X, XIII.

Figure 10. *Eodevonaria intermedia*? Amsden. Camden Formation, western Tennessee. Pedicle view, x1, of a specimen provisionally referred to this species (note fine costellae); rubber cast of an external mold, Camden, Tennessee (YPM 22428). 166

Specimens of *E. intermedia* from the Sallisaw Formation are illustrated on plate XIII, figures 1-15.

Figures 11-14. *Leptocoelia flabellites*? (Conrad). Camden Formation, western Tennessee. All of these are rubber casts of internal and external molds, and all were collected near Camden, Tennessee. 176

11. Pedicle interior, x2 (YPM 22422).
12. Pedicle interior, x2 (YPM 22423).
13. Pedicle valve, x1 (YPM 22424).
14. Brachial exterior, x2 (YPM 22425).

Sallisaw specimens of *L. flabellites*? are illustrated on plate XIV, figures 1-10.

Figures 15-17. *Leptocoelia flabellites*? (Conrad). Clear Creek Formation, Union County, Illinois. 176

15. Brachial interior, x2; rubber cast of a silicified steinkern (YPM 22426).

16, 17. Anterior and brachial views of a silicified steinkern, x2 (YPM 22427).

Figures 18-19. *Chonostrophia complanata*? (Hall). Camden Formation, ½ mile north of Camden, Tennessee. These are rubber casts of external and internal molds. 170

18. Slab showing several pedicle exteriors, x2.
19. Slab showing several pedicle interiors, x2 (both on the same specimen, YPM 22429).

Sallisaw specimens of *C. complanata*? are illustrated on plate XIV, figures 22-25.

PLATE XXI

Brachiopods from the Haragan Formation

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Figures 1-12.	*Anopliopsis pygmaea* Amsden, new species. These specimens are from the Haragan Formation near old Hunton townsite; NW¼ SW¼ sec. 8, T. 1 S., R. 8 E., Coal Co., Oklahoma (near stratigraphic section C1; Amsden 1960, p. 182). All are in the collections of the U. S. National Museum.	199

1. Brachial view, x10 (USNM 138784).
2. Brachial interior, x10 (USNM 138782).
3. Pedicle interior, x10 (USNM 138783).

4, 7. Pedicle views, x1 and x10, of the holotype (USNM 138784).

5. Posterior view, x10 (USNM 138785).
6. Brachial view, x10 (USNM 138786).
8. Brachial view, x10 (USNM 138787).
9. Pedicle interior, x10 (USNM 138788).
10. Pedicle interior, x10 (USNM 138789).
11. Pedicle view, x10 (USNM 138790).
12. Pedicle view, x10 (USNM 138791).

Figures 13-26.	*Spinoplasia gaspensis*? Boucot. These specimens were collected by Allan Graffham from the Haragan Formation about 1,000 feet southeast of White Mound; NE¼ sec. 20, T. 2 S., R. 3 E., Murray County, Oklahoma (near stratigraphic section M2; Amsden, 1960, p. 235).	204

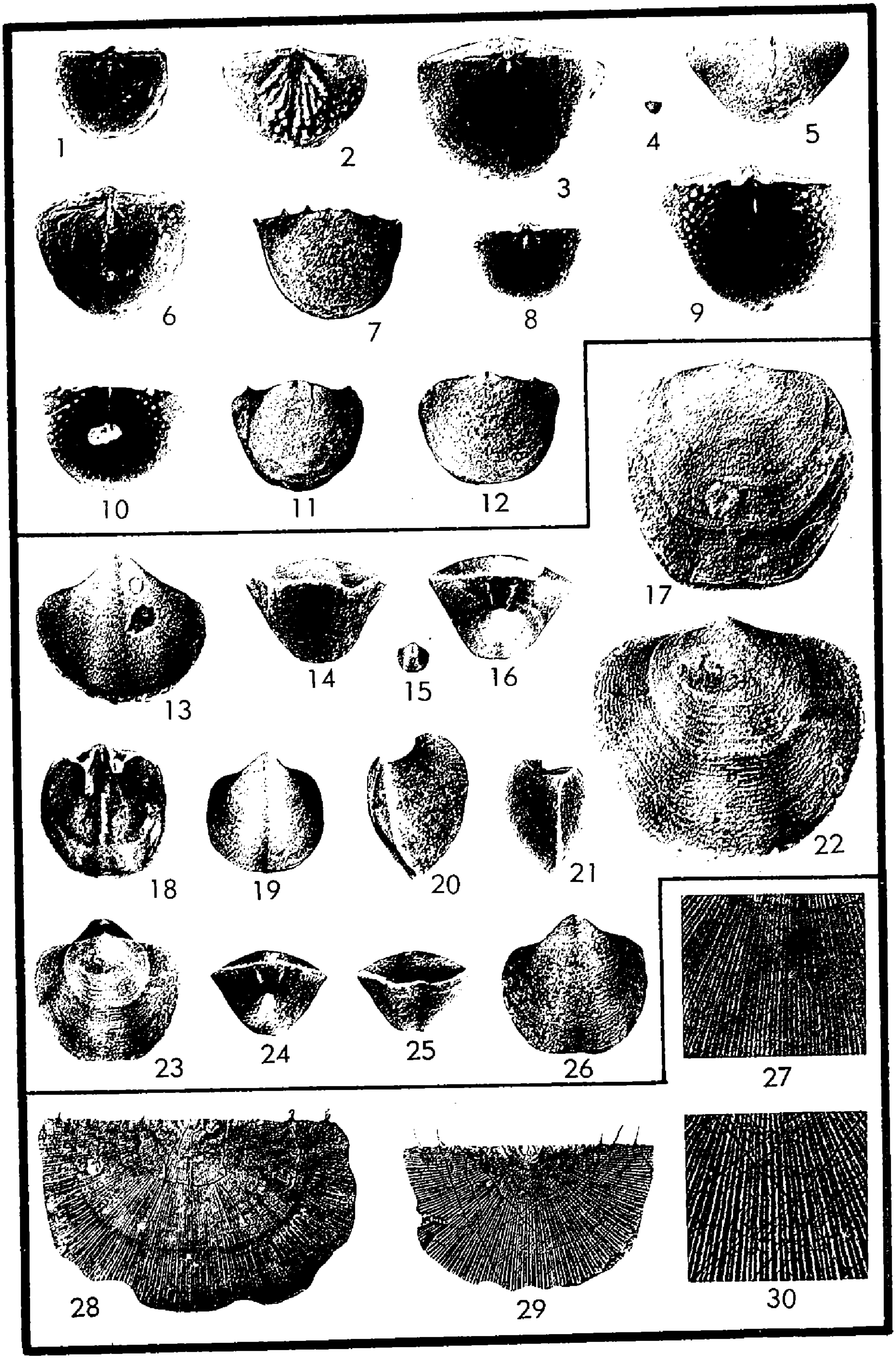
13. Pedicle view, x5 (OU 3623).

14-16, 20, 22, 23, 26. Anterior (x5), pedicle (x1), posterior (x5), lateral (x5), brachial (x10), brachial (x5), and pedicle (x5) views of a well-preserved specimen (OU 3624).

17, 18. Brachial exterior (x10) and interior (x5) views of a free valve (OU 3625).

19, 21, 24, 25. Pedicle, lateral, posterior, and anterior views of a small shell, x5 (OU 3626).

Figures 27-30.	*Chonetes*? sp. and *Chonostrophia helderbergia* Hall and Clarke.	
	27, 28. *Chonetes*? sp. Enlarged surface (x5) and exterior (x2) views of pedicle valve from near old Hunton townsite, stratigraphic section C1-K (Amsden, 1960, p. 186) (OU 958).	203
	29, 30. *Chonostrophia helderbergia* Hall and Clarke. Pedicle valve (x2) and enlarged surface view (x5) of a specimen collected by W. E. Ham, SW¼ SW¼ SE¼ sec. 33, T. 1 S., R. 3 E., near stratigraphic section C2 (Amsden, 1960, p. 189) (OU 3627).	202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