CARBONIFEROUS AND PERMIAN BACTRITOIDEA (CEPHALOPODA) IN NORTH AMERICA

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CARBONIFEROUS AND PERMIAN BACTRITOIDEA (CEPHALOPODA)
IN NORTH AMERICA

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ABSTRACT

Although bactritoids have been considered a rare component of Carboniferous and Permian faunas in North America, intensive collecting during the past five years has produced almost 10,000 representatives. Reevaluation of all described North American Carboniferous and Permian taxa has been necessary to evaluate the diversity of these bactritoids. As a result of these studies, the Annulobactritidae n. ord. is proposed to accommodate Annulobactrites striplei n. gen., n. sp., and Globulobactrites loveladensis n. gen., n. sp. Within the Bactritida, the Sinuobactritidae n. fam. is proposed to accommodate Dilatobactrites missourienensis n. gen., n. sp., Sinuobactrites morrowanensis n. gen., n. sp., S. wewokensis n. sp., and Turobactrites eudoraensis n. gen., n. sp. The following mostly new taxa of the Bactritida are assigned to the Parabactritidae: Aktastioceras sp., Angustobactrites saundersi n. gen., n. sp., Eoparabactrites graffhani n. gen., n. sp., Gymnobactrites shimanskyi n. gen., n. sp., Microbactrites sp., Orbobactrites daviesensis n. gen., n. sp., O. girtyi n. sp., O. tyroensis n. sp., Ragobactrites barnettonensis n. gen., n. sp., R. imoenis n. sp., R. jackoboroensis n. sp., R. newdense (Youngquist), and R. variabilis n. sp. In addition to 32 morphotypes assigned provisionally to ?Bactrites, the following taxa are assigned to the Bactritidae: Bactrites ahlseniensis n. sp., B. costatus n. sp., B. eicupitanensis n. sp., B. fayettevillensis n. sp., B. finiensis n. sp., B. milleri n. sp., B. oweni n. sp., B. peyonensis n. sp., B. reticulatus n. sp., B. sansabaensis n. sp., B. sinuosus n. sp., B. smithwickensis n. sp., B. woodi n. sp., Ctenobactrites collinsi (Miller and Unklesbay), and C. lesienensis n. sp.

The taxonomic importance and paleobiologic significance of such morphological features as phragmocone cross section, sutural configuration, apical angle, ornament, protoconch morphology, cameral deposits, septal necks, siphuncle position, wrinkle-layer (runzelschicht), cameral ratio, septal orientation, color patterns, and abnormal or pathologic specimens are discussed.

INTRODUCTION

The first description of a North American Carboniferous bactritoid was by J. P. Smith, in 1903. The paucity of adequate specimens, however, has hampered detailed systematic and biostratigraphic work on the Carboniferous and Permian bactritoid taxa in the United States and elsewhere in the world.

Cephalopod workers in western Europe and the Soviet Union have contributed greatly to our overall understanding of the bactritoids, but western European students have tended to concentrate on Devonian forms (Ristedt, 1971; Clausen, 1968) with special emphasis on the progenitors of the ammonoids (Schindewolf, 1933; Erben, 1964a,b).

During the last thirty years, eastern European workers have concentrated on Permian bactritoid taxa from the Urals (Shimansky, 1948, 1951, 1954, 1962). In the last few years, these workers have extended their bactritoid research to Carboniferous and Devonian forms (Shimansky, 1968; Bogoslovsky, 1972). As a general rule, however, both the western European and Soviet workers have ignored or have not had available extensive collections of Carboniferous specimens, and this is the primary area of the present report.

PURPOSE AND SCOPE

Initial sampling by the author in the early and middle 1970's indicated the availability of substantial numbers of Carboniferous and Permian bactritoids. Subsequent intensive surface collecting and bulk processing of shale

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and limestone samples for microscopic bactritoids has resulted in assembly of a collection of almost 10,000 specimens that form the basis for the present study. The report on this collection is divided into five sections. The first is concerned with the material available, methods of preparation, biostratigraphy, and evolution. A detailed locality register is included to facilitate re-collecting by other workers and to allow evaluation of sampling data. The second part of the study covers morphology, including its taxonomic importance and paleobiologic significance. Morphologic features discussed include the phragmocone cross section and sutural configuration, apical angle, ornament, protoconch morphology, internal deposits, septal necks, siphuncle position, wrinkle-layer, cameral ratio, septal orientation, color patterns, and abnormal or pathologic specimens. Problems encountered in recognizing and reconstructing bactritoid ontogenies are discussed in the third part of the study. Methods of bactritoid phragmocone reconstruction and the various stages of bactritoid ontogenesis are analyzed and evaluated as to reliability and significance. The fourth part of the study covers bactritoid phylogenesis. Included is a discussion of the origin of the coleoids and morphologic features that may possibly be used for differentiating coleoids from bactritoids. The origin of the ammonoids is also examined briefly. The fifth section of the study concerns the systematics of the bactritoids; a new order, two new families, 10 new genera, and 30 new species are proposed, 30 bactritoid morphotypes are described, and all the known North American Carboniferous and Permian bactritoids are redescribed.

PREVIOUS STUDIES

Carboniferous and Permian bactritoids from North America have received little attention. J. P. Smith in 1903 described Bactrites carbonarius, the first Late Paleozoic bactritoid known to occur in North America. Smith recognized that his specimens of Bactrites were somewhat intermediate between the nautiloids and the ammonoids. Because of the presence of the ventral lobe on the suture, he placed his specimens of B. carbonarius, which he termed "the only authentic species (of Bactrites) known to occur in Carboniferous strata," with the ammonoids. Soon after Smith's discovery, Girty (1909) described two new bactritoid species from the Mississippian of Oklahoma, B. quadrilineatus and B. smithianus, and two years later (Girty, 1911a) recognized the occurrence of B. quadrilineatus and B. smithianus in Mississippian strata in Arkansas.

Following the works of Smith (1903) and Girty (1909), A. K. Miller and his associates described several new species of bactritoids, including Bactrites postremus Miller 1930, B. cherokeensis Miller and Owen 1934, B. mexicanus Miller 1944, B. wintersensis Miller, Lane, and Unklesbay 1947, and B. (=Ctenobactrites) collinsi Miller and Unklesbay 1947. Youngquist (1949a), a student of Miller, described B. (=Rugobactrites) nevadensis.

Several European workers conducted studies concurrent with those of Miller. In 1932, Schindewolf described Lobobactrites and postulated that the bactritoids were the progenitors of the ammonoids. Spath in 1933 postulated a nautiloid similar to Barrandococeras as the ancestor of the ammonoids. About thirty years later, Erben (1964a,b) concluded that Schindewolf was most probably correct. In addition, Schindewolf (1959) described the only known Lower Carboniferous bactritoids.

V. N. Shimansky, another active bactritoid worker, began publishing on Permian taxa in the Soviet Union in 1948. His continuing work has greatly modified the previously held rather simplistic interpretation of bactritoid phylogenesis.

H. K. Erben (1964a,b) has been extremely influential in his studies of early Devonian bactritoids, coleoids, and ammonoids. Especially notable is his documentation of the bactritoid origin of the ammonoids.

Mackenzie Gordon (1965) has been the most recent North American worker to publish on Carboniferous bactritoids. He surveyed the genus Bactrites and named B. gaitherensis and B. redactus.

MATERIAL

The largest collection of bactritoids in North America is probably that of the University of Iowa Geology Department (SUI); the most comprehensive Paleozoic coleoid collections are at the U.S. National Museum (USNM). Smaller but significant collections of bactritoids are available at the universities of Arkansas, Texas, Oklahoma, and Kansas.

Within the past few decades, paleontologists have increasingly realized the critical importance of exact geographic and stratigraphic occurrence data. Unfortunately, locality data for many older collections are inadequate, and the exact (and even the relative) stratigraphic positions of many specimens are unknown. In the present study, exact geographic and stratigraphic descriptions are given where possible, and a list of associated, stratigraphically significant cephalopod taxa is included in locality descriptions. Figure 1 shows general geographic locations of the Mississippian localities, and Figure 2 shows the general geographic locations of the Pennsylvanian and Permian localities.

A total of 9,100 bactritoid specimens was examined for this study. All available bactritoid material from the Devonian through the Permian was examined, but because of the lack of new or significant Devonian material, the study was limited to the Mississippian, Pennsylvanian, and Permian specimens.

The following geographic areas and stages have yielded the bactritoid specimens dealt with in this report:
Fig. 1. Generalized locality map for bactritoid-bearing Mississippian localities. Open circle, lower Chesterian localities; solid circle, middle Chesterian localities; cross, upper Chesterian localities.

UTAH.—Mississippian–Chesterian: Bactrites cf. B. carbonarius Smith; Rugobactrites nevadense (Youngquist).

IOWA.—Pennsylvanian–Desmoinesian: Orbobactrites davisensis n. gen., n. sp.

MISSOURI.—Pennsylvanian–Desmoinesian: Bactrites cherokeensis Miller and Owen; B. oweni n. sp.

KANSAS.—Pennsylvanian–Missourian: Bactrites wintersetensis Miller, Lane, and Unklesbay; B. woodi n. sp.; ?Bactrites sp.; Dilatobactrites missouriensis n. gen., n. sp.; Orbobactrites tyroensis n. gen., n. sp.; Rugobactrites cf. R. jackboroensis n. gen., n. sp.; Tubobactrites eudoraensis n. gen., n. sp.

MEXICO.—Permian–Artinskian to Guadalupian: Bactrites mexicanus Miller; Bactrites sp.

PROCEDURE AND LOCALITY REGISTER

For convenience, each locality that has reasonably good geographic and stratigraphic references has been assigned a number. Letter prefixes in front of the number indicate the geologic period: M (Mississippian), P (Pennsylvanian), and PR (Permian). An asterisk preceding the letter designation indicates that the author has collected in the locality. Numbers after a repository number indicate the quantity of specimens placed under that repository number; when only a repository number is given, a single specimen is represented. University-housed collections are indicated by the following abbreviations: Department of Geology, University of Oklahoma at Norman, OU; Department of Geology, University of Iowa, Iowa City, SUI; University of Arkansas at Fayetteville, UA; Plummer Collection at the Bureau of Economic Geology, University of Texas, Austin, TA; University of Kansas at Lawrence, KA; and SU, Stanford University, whose collections have been deposited in the California Academy of Sciences (CAS). Official U.S. Post Office abbreviations are used for the names of states. Other abbreviations include: morphotype, mtp.; railroad, R.R.; Highway, Hwy., and Farm to Market Road, FM.

MISSISSIPPAN

*M-1.—Delaware Creek Member, Caney Formation (lower Chesterian). Approximately 4.8 km (3.6 mi.) S of Ahloso, Pon-
Graham

**M-2.**—Delaware Creek Member, Caney Formation (lower Chesterian). Approximately 4 km (2.5 mi.) S of Fittstown, Pontotoc Co., OK on OK Hwy. 99 and 0.32 km (0.2 mi.) E on an unpaved section road. Concretions are in the timbered fence row and in the field S of an unpaved section road (N edge, sec. 12, T.1 N., R.6 E.; Fittstown 7½° quadrant). Bactrites ahlosoensis (SUI 43639) and B. quadrilineatus (SUI 43660-29) have been recovered at this locality. Other cephalopod genera include, but are not limited to, Goniatiat, Girtyoceras, Para-
dimorphoceras, Epicanites, Mitocracoeceras, Endolobites, and Brachycycloceras.

(Reference: Girty, 1909.)

**M-3.**—Member unknown but probably Delaware Creek Member, Caney Formation (lower Chesterian). This section is bounded by Hwy. 99, not by Hwy. 48. There is a locality at the SW1/4NW1/4, sec. 1, T.2 N., R.6 E. (Ahloso 7½° quadrant) with fossil-bearing concretions at an abandoned house on a nearly pond dam, and in the highway route ditch. This is presumably the locality collected by J. B. Owen that yielded six specimens of B. quadrilineatus (SUI 31825-4, SUI 31827-2, SUI 31831-4, SUI 31832-3). (Reference: Girty, 1909.)

**M-4.**—Delaware Creek Member, Caney Formation (lower Chesterian). Approximately 3.2 km (2 mi.) SSW of Clarita, Coal Co., OK. Concretions are located in unnamed tributaries, fields, and fence rows to the W of the Kansas, Oklahoma, and Gulf R.R. (SW1/4, sec. 22, T.1 S., R.8 E.; Wapanucka North 7½° quadrant). This locality has yielded Bactrites quadrilineatus (SUI 43891), Goniatiat, and Girtyoceras.

(Reference: Girty, 1909.)

**M-5.**—Delaware Creek Member, Caney Formation (lower Chesterian). Approximately 1.6 km (1 mi.) S of Clarita, Coal Co., OK. Concretions are located in the bed of Elm Creek (NE1/4NE1/4, sec. 15, T.1 S., R.8 E.; Wapanucka North 7½° quadrant). This locality, which was discovered by Allen Graffham, has yielded numerous specimens of Bactrites quadrilineatus (SUI 11618, 31822-2, 31833-2, 33080, and three OU unnumbered specimens). Other cephalopods from this locality include Goniatiat, Girtyo-
ceras, Epicanites, and Eoparabactrites graffhami (SUI 43743). (Reference: Girty, 1909.)

**M-6.**—Member unknown, Caney Formation (lower Chesterian). Sec. 27, T.3 N., R.6 E., OK. One specimen of Bactrites quadrilineatus (SUI 31826); collector C. E. Decker. No other data are available.

**M-7.**—Member unknown, Caney Formation (lower Chesterian). Sec. 8, T.1 N., R.7 E., OK. Two specimens of Bactrites quadrilineatus (SUI 31823). No other data are available.

**M-8.**—Delaware Creek Member, Caney Formation (lower Chesterian). Exact locality uncertain, but label indicates the single specimen of Bactrites quadrilineatus (SUI 31834) is from Tell Creek near Clarita, Coal Co., OK; collector Allen Graffham.

The University of Kansas has four lots of specimens that include Bactrites quadrilineatus. These specimens were probably derived from the Delaware Creek Member of the Caney Forma-
tion. However, the labels are inaccurate and the possibility of mixing cannot be ignored. The following specimens are identified as B. quadrilineatus:

48773, 48771—"Rynas is.; Slite gr. About 2 km. SE by E of ferry at Bron; Island of Firo, Gotland (Loc. 2 W. L. T. Geol. Cong. Guidebook, Silurian ???) Collector: R. C. Moore." No additional information is given on the label; the specimens appear to be from several localities.

49765—"Caney sh. Pennsylvanian Sec. 35, T.3 N., R.6 E., OK. Collector: R. C. Moore. Loc. Number 3382." 49764 to 49768—"Sycamore is., Mississippian, Sec. 25, T.3 N., R.6 E., OK. Collector: R. C. Moore." 49458 to 49461—"Caney Shale Mississippian. South of Fitts-
town, Arbuckle Mountains, OK.

**M-9.**—Formation unknown, possibly the Newman Formation (lower Chesterian). A single silicified specimen of Bactrites (SUI 31824) was collected by Moritz Fisher in 1892 from a now-lost locality near Crab Orchard, Rockcastle Co., KY. This locality has yielded an important cephalopod fauna, including Goniatiat, Neo-
glyphoceras, and Girtyoceras. (Reference: Knapp, 1965; Furnish & Saunders, 1971.)

**M-10.**—Helms Formation (lower Chesterian). Fossils were obtained from concretion-bearing black shale at the base of the Sierram Diablo escarpment, located about 3.2 km (1.5 mi.) NW of the Figure 2 ranch house, Culberson Co., TX. The single specimen of Bactrites (SUI 31829) from this locality is probably a specimen of B. quadrilineatus, but the poor preservation prevents a confident specific assignment. This locality has yielded a goniatiat fauna that includes Goniatiat, Girtyoceras, and Lyrogoniatiat.

(Reference: King & Knight, 1944; McCabe, Quinn, & Furnish, 1964.)

**M-11.**—Moorefield Formation (lower Chesterian). A series of large gullies located about 0.8 km (0.5 mi.) N of the Homer Smith farm house, approximately 7.2 km (4.5 mi.) ESE on Mountain Gap Road out of Batesville, Independence Co., AR. This locality is locally known as the "Buffalo Wallow" and is equivalent to the University of Arkansas locality L71M. Approximately 52 m (175 feet) of stratigraphic section is exposed; virtually all the fos-
sils are recovered as loose specimens on the lower half of the exposure (NW1/4SW1/4, sec. 29, T.13 N., R.5 W.; Salado 7½° quadrant). This locality has yielded a diverse ammonoid assemblage, including Goniatiat, Neoglyphoceras, Girtyoceras, Fergano-
ceras, Paradimorphoceras, and possibly Cravenoceras. Both straight and coiled nautiloids have been recovered; Bactrites cf. B. ahloso-
estis (SUI 43639 to 43640), B. carbonarius (SUI 43642-2, SUI 43643, 43644, 43645-5, 4366-27, 4367-12, 4368-20, 4369-2, 43974), and Bactrites sp. mtp. 13 (SUI 43785, 43694) also occur at the locality. (Reference: Drakovul, 1966, 1972.)

**M-12.**—Chainman Formation (lower Chesterian). The exact locality is uncertain. The label indicates the specimens of Bactrites cf. B. carbonarius were recovered by Youngquist and Nelson in 1949 from the "Meramec Shale" which is exposed 4.8 to 6.4 km (3 to 4 mi.) ESE of Cowboy Pass, Confusion Range, UT (SUI 9802-2, SUI 9803-3). (Reference: Miller, Youngquist, & Nelson, 1952.)

**M-13.**—Delaware Creek Member, Caney Formation (lower Chesterian). Southeast of Fittstown, Pontotoc Co., OK (NE1/4 NE1/4, sec. 11, T.1 N., R.7 E.; Harden City 7¼° quadrant). This locality has yielded one specimen of Bactrites quadrilineatus (SUI 33904), which was collected by and purchased from Allen Graffham in 1969. (Reference: Girty, 1909.)

**M-14.**—Member unknown, Caney Formation (lower Chesterian). The label states that this specimen of Bactrites quadrilineus (SUI 31828) was exchanged by J. B. Owen with the University of Oklahoma, and the locality is given as "South of Ada, Oklahoma." (Reference: Girty, 1909.)
**M-15.**—Sand Branch Member, Caney Formation (middle Chesterian). Shale outcrop with fossiliferous concretions in the stream bed of Sandy Branch Creek, approximately 1.6 km (1 mi.) downstream from the bridge on OK Hwy. 48. This bridge is approximately 4.8 km (3 mi.) SE of Wapanucka, Johnston Co., OK, and the locality is identical to Girty's locality 2082 (SW\(\frac{1}{4}\), sec. 29, T.2 S., R.9 E.; Wapanucka South 7\(\frac{1}{2}\)' quadrangle), which until this time had yielded only the holotype of Bactrites smithianus. The following bactritoids have been recovered from this locality: Crenatobactrites, Euomphloceras, Paradimarophoceras, Eogonioloboceras, and B. smithianus (SUI 43661-11, 43976). (Reference: Girty, 1909.)

**M-16.—Imo Formation (upper Chesterian).** Roadcut just S of the Van Buren Co. border on U.S. Hwy. 65, approximately 6.4 km (4 mi.) SE of Leslie, Searcy Co., AR (NE\(\frac{3}{4}\), sec. 11, T.13 N., R.15 W.; Leslie 7\(\frac{1}{2}\)' quadrangle). Saunders (1973) listed this locality as L114-65, described the exposure, and reported the ammonoid fauna. All of the bactritoids recovered thus far are from the main fossiliferous horizon (Fig. 3). Thirteen 5-kg shale samples were initially taken from the main fossiliferous horizon. Standard shale disaggregation techniques were more or less successfully applied to these 13 samples, and the microscopic bactritoids were picked from the residues. Only samples 6 and 11 yielded bactritoids. Later, over 50 kg of shale from intervals 6 and 11 were processed and the residues picked. Significantly, only intervals 6 and 11 have yielded in situ megascopic bactritoids, although loose specimens have been recovered over the entire outcrop surface below sample interval 11. The following bactritoids have been recovered from this exposure: Angustobactrites saundersi (SUI 42554, 43621, 43684-6, 43685-5, 43686-3, 43687-23, 43688-34, 43689, 43697, 43743, 43965 to 43968, 43972, 43973), Angustobactrites cf. A. saundersi (SUI 43975), Bactrites fayettevilensis (SUI 42555, 42557, 42563, 42574, 42581, 42601, 43618, 43695, 43699-10, 43776-13, B. peytonensis (SUI 42536, 42537, 42559, 42560, 42620, 43595, 43611, 43619, 43620, 43670, 43671-8, 43672-26, 43673-11, 43674-19, 43675-78, 43676 to 43678, 43679-2, 43680, 43696-22, 43701-3, 43702-8, 43707-9, 43971), B. cf. B. peytonensis (SUI 43594), Bactrites sp. mtp. 4 (SUI 43589), Bactrites sp. (SUI 42538), Rugobactrites imoensis (SUI 42539 to 42541, 42558, 42561, 42562, 43590 to 43593, 43682, 43694-33), and Rugobactrites sp. (SUI 43683).

The nearby quarry locality that Saunders (1973) listed as L114-Q (NW\(\frac{3}{4}\), sec. 12, T.13 N., R.14 W.; Leslie 7\(\frac{1}{2}\)' quadrangle) has yielded bactritoids; however, these collections have not been kept separate from the roadcut collections. Microscopic bactritoids have not been recovered from the quarry locality, and no specimens have been recovered in situ from the quarry.

As may be observed in Figure 3, intervals 6 and 11 are stratigraphically separated; the amount of stratigraphic section is estimated to be approximately 9 m (30 feet). Angustobactrites saundersi, Bactrites poytonensis, B. fayettevilensis, and Rugobactrites imoensis are found in both intervals 6 and 11. (Reference: Saunders, 1973; Saunders, Manger, & Gordon, 1977.)

**M-17.—Imo Formation (upper Chesterian).** Creek bed and banks of the Middle Fork of the Little Red River at the abandoned community of Elba, Van Buren Co., AR (SE\(\frac{3}{4}\), NW\(\frac{3}{4}\), sec. 14, T.13 N., R.14 W.; Oxley, AR 7\(\frac{1}{2}\)' quadrangle). This locality is the same as Saunders' (1973) locality L114-E. Bactrites poytonensis (SUI 43690, 43703) has been recovered from this locality as well as numerous ammonoids including Peytonoceras, Cranenoceras, Eumorphoceras, Paradimarophoceras, and Anthracoceras. This exposure is probably equivalent to the upper part of the main fossiliferous horizon at locality M-16. Several 5-kg samples failed to yield microscopic bactritoids. (Reference: Saunders, 1973.)

**M-18.—Imo Formation (upper Chesterian).** Road cut on AR Hwy. 25, approximately 16 km (10 mi.) WSW of Marshall, Searcy Co., AR (approximately at the center of sec. 3, T.17 N., R.13 W.; Snowball 15' quadrangle). This fossiliferous, concretion-bearing shale outcrop is approximately 4.5 to 6 m (15 to 20 feet) thick and is adjacent to a concrete drainage tunnel that passes under the highway. Loose specimens of Bactrites poytonensis (SUI 43691-4) have been recovered from this exposure, as well as numerous ammonoids, including Anthracoceras, Cranenoceras, and Peytonoceras. (Reference: Saunders, 1973.)

**M-19.—Imo Formation (upper Chesterian).** Fossiliferous, concretion-bearing gray shale at the type section of the Imo Formation (approximately in the center of sec. 3, T.17 N., R.13 W.; Snowball 15' quadrangle). This is locality L187 of Saunders (1973). Stratigraphically, it is the same horizon as locality M-18 of the present report; these two localities are several hundred meters apart. One specimen of Bactrites poytonensis (SUI 43692) has been recovered from this exposure. (Reference: Saunders, 1973.)

**M-20.—Fayetteville Formation, upper shale member (middle Chesterian).** Loose blocks of dark-gray fossiliferous shale in the NE corner of a farm pond located about 0.48 km (0.3 mi.) NE of Draken Creek, Madison Co., AR (SW\(\frac{1}{4}\), NW\(\frac{3}{4}\), sec. 28, T.16 N., R.27 W.; Hartwell 7\(\frac{1}{2}\)' quadrangle). This locality is the same
as the University of Arkansas locality L.180-B. The exact stratigraphic position of these shale blocks is not precisely known because the blocks were removed from the bottom of the pond during its construction. However, they are definitely known to be above the Wedington Sandstone Member of the Fayetteville Formation. A well-preserved cephalopod fauna recovered from these blocks as loose specimens includes Cravenoceras, Paracravenoceras, Tumulites, Eumorphoceras, Muensteroceras, Brackygalytocrinus, Strobrochus, and Bactrites poytonensis (SUI 43693-2). (Reference: Gordon, 1965.)

*M-21.—Fayetteville Formation, lower shale member (middle Chesterian). A series of shale exposures in the bed and banks of Trace Creek, which is NW of Leslie, Searcy Co., AR. The fossil-bearing outcrops begin in the stream near the center of sec. 22, T.14 N., R.15 W. (Leslie 7½' quadrangle) and continue upstream approximately 3.2 km (2 mi.) to the power line crossing in the north central portion of sec. 16, T.14 N., R.15 W. In this 3-km interval, Trace Creek flows over a syncline with gently dipping flank strata. As the axis is approached about 1.6 km (1 mi.) upstream, the strata become much less fossiliferous. The most common taxa of the fossils occur in phosphate nodule and concretion-bearing outcrops that are approximately 4.5 m (15 feet) above the base of the formation. Cephalopods are the most common faunal elements recovered, and the most common taxon is Rayonnoceras. Other cephalopods include Euloxoceras, Cravenoceras, Paracravenoceras, Tumulites, Ctenobactrites lehiennei (SUI 43704, 43705, 43751), and Hemaites barbara (SUI 43743, 43712 to 43723, 43722). (Reference: Gordon, 1965.)

*M-22.—Fayetteville Formation, lower shale member (middle Chesterian). A series of shale exposures on the banks and in the bed of Cove Creek beginning at approximately the E edge of the NW¼SW¼, sec. 21, T.14 N., R.15 W. (Leslie 7½' quadrangle) and continuing upstream for approximately 0.8 km (0.5 mi.) to a sharp bend in the creek. At this bend (NW¼SW¼NE¼NW¼, sec. 21, T.14 N., R.15 W.), a prolific cephalopod fauna has been recovered, including Euloxoceras, Strobrochus, Rayonnoceras, Cravenoceras, Tumulites, Eumorphoceras, Paracravenoceras, Hemaites barbara (SUI 43709 to 43711), Bactrites poytoniellensis (SUI 43756-15, 43757, 43758, 43759-2), ?Bactrites cf. B. poytonensis (SUI 43755-5), ?Bactrites sp. (SUI 43754-25, 43760-2), Ctenobactrites lehiennei (SUI 43707-5), and Rugobactrites bartonensis (SUI 42572).

The stratigraphic position of this fossil-bearing horizon is estimated to be 3 to 6 m (10 to 20 feet) above the base of the formation. Several specimens (SUI 43715, 43716) collected and subsequently donated by M. Wheeler, who lives near Denard, AR, probably came from this locality or from localities M-21 or M-22. Lithology of the specimens she donated matches that of Fayetteville taxa recovered from this group of localities. (Reference: Gordon, 1965.)

*M-23.—Fayetteville Formation, lower shale member (middle Chesterian). A series of fossil-bearing shale exposures on the banks and in the bed of Begley Creek beginning near the center of sec. 21, T.14 N., R.15 W. (Leslie 7½' quadrangle) and continuing downstream for approximately 1.6 km (1 mi.) into the city limits of Leslie, Searcy Co., AR. This series of outcrops is in the same stratigraphic position as localities M-21 and M-22. Cephalopods which have been recovered from this exposure include Hemaites barbara (SUI 43713), Paracravenoceras, Cravenoceras, Tumulites, and Rayonnoceras. (Reference: Gordon, 1965.)

*M-24.—Fayetteville Formation, lower shale member (middle Chesterian). Approximately 4.8 km (3 mi.) SE of Rosie, Independence Co., AR, on the S side of AR State Hwy. 14 (SW¼, sec. 26, T.12 N., R.5 W.; Salado 7½' quadrangle). A single specimen of Rugobactrites bartonensis (SUI 34111) was recovered with a typical Fayetteville goniaster fauna, including Tumulites and Cravenoceras. (Reference: McCaleb, Quinn, & Furnish, 1964.)

*M-25.—Fayetteville Formation, member uncertain because of structural complications but probably the lower unnamed shale member below the Wedington Sandstone Member (middle Chesterian). The fossil-bearing exposures are in the bed and banks of Town Branch Creek and Cato Springs Branch; these streams are located between 2.4 km (1.5 mi.) and 4 km (2.5 mi.) S of the UA campus, Fayetteville, Washington Co., AR. For the last 15 years, this set of exposures has been intensively collected by Geology Department students and faculty of the University of Arkansas. Thousands of cephalopod specimens have been recovered; but the locality data for these specimens has been lumped under the informal heading of “Town Branch.” Fortunately, specimens from several of the richest localities have been separately labeled during the past few years. For convenience, these individual localizations on Town Branch Creek and Cato Springs Branch are given below as subcategories of locality M-25. The cephalopod fauna recovered throughout the fossil collecting area appears to be consistently diverse. Some of the cephalopods recovered from this locality are Rayonnoceras, Cravenoceras, Paracravenoceras, Paradimorphoceras, Eugenioboloceras, Tumulites, Prorontites, Muensteroceras, Endobalsothoceras, Valhallites, Tylonautus, Dolorthoceras, Mitorisothoceras, Euloxoceras, Strobrochus, Fayetteville, Ctenobactrites lehiennei (SUI 43719 to 43721), and Hemaites barbara (SUI 43723 to 43730, 43736 to 43737). (Reference: Gordon, 1965.)

*M-25A.—A low shale bank on a tributary of Town Branch Creek (NW¼NW¼SE¼, sec. 20, T.30 W., R.16 N.). This locality (known locally as the Campbell Soup locality) has yielded numerous small cephalopods, including four specimens of Hemaites barbara (SUI 43723, 43732, 43741, 43742).

*M-25B.—A shale outcrop in the bed of Cato Springs Branch which can be collected easily only at low water during the later months of the summer (SW¼SW¼NE¼, sec. 21, T.16 N., R.30 W.). This locality has yielded a diverse cephalopod fauna, including Hemaites barbara (SUI 43740), Bactrites poytoniellensis (SUI 42573, 42574, 42582, 42583, 42600, 42601, 42634, 43748, 43762, 43763, 43766, 43770, 43771, 43772-23, 43773), B. poytonensis (SUI 42575, 42602 to 42605, 42607, 42635, 43768-5, 43769), B. smithi (SUI 42599), ?Bactrites sp. mtp. 1 (SUI 42606, 43675-34), ?Bactrites sp. mtp. 2 (SUI 42632, 42633, 43774), ?Bactrites sp. mtp. 4 (SUI 42629 to 42631, 43767-2), ?Bactrites sp. (SUI 43765-102 ±), and Rugobactrites bartonensis (SUI 43764-3).

*M-25C.—A shale outcrop on the E bank in the bed of Cato Springs Branch. Generally only collectable during low water in late summer (SE¼SW¼NE¼, sec. 29, T.16 N., R.30 W.). Like localities M-25A and M-25B, this locality has produced numerous cephalopod specimens, including Hemaites barbara (SUI 43731, 43735 to 43735, 43739), Bactrites poytoniellensis (SUI 43718, 43738, 43750), ?Bactrites sp. mtp. 4 (SUI 43749), and ?Bactrites sp. (SUI 43751 to 43753).

*M-25D.—This fossil-bearing exposure is in the bed of a tributary of Town Branch Creek, slightly N of a St. Louis–San Francisco RR spur bridge (NE¼SE¼SW¼, sec. 21, T.16 N., R.30 W.). This locality has yielded numerous ammonoids, nautiloids, and a few bactritoids, including Bactrites poytoniellensis (SUI 43747), Bactrites cf. B. poytonensis (SUI 42636, 43744-2), ?Bactrites sp. mtp. 3 (SUI 42637), ?Bactrites sp. mtp. 4 (SUI 43745), and ?Bactrites sp. (SUI 43764-8).

*M-26.—Fayetteville Formation, lower shale member (middle Chesterian). Approximately 0.3 km (0.2 mi.) NE of Durham, Washington Co., AR, in the bed and on the banks of White River. This locality has two large exposures. The first and least productive of megascopic fossils is in SW¼, sec. 20, T.15 N., R.28 W. (Durham 7½' quadrangle). This outcrop has produced specimens of Rayonnoceras, Tumulites, Cravenoceras, and Paracravenoceras. The second outcrop is upstream approximately 200 m from the
first (NW1/4, sec. 29, T.15 N., R.28 W.). This exposure is continuous for more than 0.8 km (0.5 mi.) and has yielded numerous specimens of *Rayonoceras*, well-preserved plant fossils, a fossil shark, and a diverse cephalopod fauna including *Cravenoceras, Brachycycloceras, Pararavenoceras, Tumulites, and Hemitattes barbara* (SUI 43717, 43718). (Reference: Cronies, 1926; Gordon, 1965.)

*M-27.—Fayetteville Formation, lower shale member (middle Chesterian).* Approximately 4.8 km, air line distance (3 mi.) NE of Mt. Judea, Newton Co., AR, on the E side of Lick Mountain (NE1/4, sec. 17, T.15 N., R.19 W., Mt. Judea 15° quadrangle). The outcrop is a more or less barren glade, and the fossils occur as loose specimens and in concretions. This exposure has yielded a large number of cephalopods, including *Pararavenoceras, Eumorophoceras, Tumulites, Cravenoceras, Brachycycloceras, Endobuccus, Hemitattes barbara* (SUI 43708), and *Ctenobactrites leidensis* (SUI 43714-3). (Reference: Gordon, 1965.)

*M-28.—Pitkin Formation (middle Chesterian).* Roadcut located on the S side of AR Hwy. 66, approximately 1 km (0.6 mi.) NE of Leslie, Searcy Co., AR (SW1/4 SW1/4 SE1/4, sec. 23, T.14 N., R.15 W.; Leslie 7½° quadrangle). This fossil-bearing limestone has yielded numerous cephalopods including *Tyloinanuta, Strobiloceras, Eumorophoceras, Pararavenoceras, Bactrites milleri* (SUI 43779 to 43782, 43783-60), and *Bactrites sp.* mtp. 12 (SUI 43784-2). (Reference: McCaleb, Quinn, & Furnish, 1964.)

*M-29.—Barnett Formation (lower through middle Chesterian).* This locality in central Texas has two fossil-bearing exposures. Essentially, all of the bactritoid specimens from these localities were recovered from limestone blocks dissolved in formic acid. Residues from these limestone blocks contained numerous phosphatic fossils including rich conodont faunas. The cephalopods are apparently replaced and/or filled or coated by phosphate. Acid etching effectively concentrated these phosphate molds and standard picking techniques of the microscopic residues produced hundreds of well-preserved juvenile cephalopods. (Reference: Miller & Youngquist, 1948a,b; Miller & Downs, 1950.)

*M-29A.—The most accessible exposure is a roadcut on Rough Creek Road on the N side of Chappell Hill, approximately 4.8 km (3 mi.) SE of San Saba, San Saba Co., TX (see Fig. 4A). This locality yielded only a few bactritoids, including *Bactrites sp.* mtp. 8 (SUI 42576 from sample C-2) and *Bactrites sp.* (SUI 43778-4 from sample C-2, 43777-6 from sample C-1). These specimens are not referable to any described species at this time. Associated with these *Bactrites* fragments are pieces of shell and a few partially complete internal molds which are referable to the lower Chesterian Goniolites.*

*M-29B.—The fossil-bearing units at this locality are located in an abandoned quarry approximately 0.3 km (0.2 mi.) NE of locality M-29A. Samples taken in situ from limestone lenses/concretions (see Fig. 4B) ranged in size from 10 to 30 kg and were treated in acid. Loose pieces of limestone concretions containing macroscopic, well-preserved, calcareous cephalopods were processed separately by cracking out the larger specimens and dissolving the remaining rubble in formic acid. This acidized rubble produced numerous well-preserved, microscopic cephalopods; over 50 kg of rubble sample were reduced in acid and picked. Of the in situ samples, sample 2D yielded the best-preserved and most diverse fauna. Overall, these samples (1D through 3D and float) cannot be separated biostatigraphically on the basis of cephalopods. However, this cephalopod fauna is younger (middle Chesterian) than the fauna observed at locality M-29A. The following cephalopods were obtained from this exposure: *Eumorophoceras, Paradimorphoceras, Tumulites, Cravenoceras, Pararavenoceras, Muensteroceras, Fayettevillella, and Eogonioloboceras.*

Sample 1D yielded the following bactritoids: *Bactrites santabaenensis* (SUI 42586, 42589 to 42592, 43607 to 43609, 43659, 43789-74), *Bactrites sp.* mtp. 5 (SUI 43606, 43786), *Bactrites sp.* mtp. 6 (SUI 43586), *Bactrites sp.* mtp. 10 (SUI 42595, 42598, 43788-23), *Bactrites sp.* mtp. 11 (SUI 42593, 42594, 42597).

Sample 2A yielded only a few bactritoids, including *Bactrites sp.* mtp. 10 (SUI 43784-23). Sample 2B yielded only a few bactritoids, including *Bactrites sp.* mtp. 4 (SUI 43784-23). Sample 2C yielded only a few bactritoids, including *Bactrites sp.* mtp. 8 (SUI 42576 from sample C-2).

Sample 3A yielded only a few bactritoids, including *Bactrites sp.* mtp. 9 (SUI 43784-23). Sample 3B yielded only a few bactritoids, including *Bactrites sp.* mtp. 10 (SUI 43784-23). Sample 3C yielded only a few bactritoids, including *Bactrites sp.* mtp. 11 (SUI 42593, 42594, 42597)

Sample 3D yielded only a few bactritoids, including *Bactrites sp.* mtp. 11 (SUI 42593, 42594, 42597).
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43787-23). *Bactrites* sp. (SUI 43790-66), and Rugobactrites barrettensis (SUI 42596, 42597, 45797-8).

Sample 2D yielded the following bactritoids: *Bactrites sansabarneus* (SUI 42584, 43510, 43511, 43513 to 43516, 43544 to 43546, 43612, 43795-88), *Bactrites* sp. mtp. 4 (SUI 43512), *Bactrites* sp. mtp. 5 (SUI 43614), *Bactrites* sp. mtp. 7 (SUI 42585), *Bactrites* sp. mtp. 9 (SUI 42624), *Bactrites* sp. mtp. 10 (SUI 43623, 43509, 43558 to 43585, 43792-56), *Bactrites* sp. mtp. 11 (SUI 43578, 43793-15), *Bactrites* sp. (SUI 43547), *Bactrites* sp. (SUI 43794-409), and Rugobactrites barrettensis (SUI 42674, 43582, 43791-4).

Sample 3D yielded the following bactritoids: *Bactrites yazette-villensis* (SUI 43551), *Bactrites sansabarensis* (SUI 43588), *Bactrites* sp. mtp. 10 (SUI 43795-9), *Bactrites* sp. mtp. 11 (SUI 43798-3), *Bactrites* sp. (SUI 43796-43), and Rugobactrites barrettensis (SUI 35458 to 43550, 43797-9).

Sample float (i.e., from loose cephalopod-bearing limestone blocks) yielded the following bactritoids: *Bactrites sansabarensis* (SUI 43573, 43574, 43576, 34610, 34803, 34805, 34864-43), *Bactrites* sp. (SUI 43865), *Bactrites* sp. mtp. 10 (SUI 43579, 34802, 34863-13), *Bactrites* sp. mtp. 11 (SUI 43570, 43577, 43578, 43808-12), *Bactrites* sp. (SUI 43801-135, 43804), and Rugobactrites barrettensis (SUI 43575, 34852, 43807-2).

**Pennsylvanian**

*P-1.*—Gene Autry Formation (Morrowan). A series of E-W striking gullies on the E side of an unnamed tributary of Sycamore Creek (NW 3/4 NW 1/4 SW 1/4, sec. 2, T.4 S., R.4 E.; Rv. 7 1/2' quadrangle) on the Daube Ranch, Johnston Co., OK. The fossils were recovered from a red shale that is inclined almost 90° and strikes generally N-S. Four 10-kg samples were taken at random intervals in the outcrop; all of the samples yielded cephalopods. Megasopic specimens were recovered as loose specimens on the shale surface and in concretions. The cephalopod fauna includes Proshumardites, Basithoceras, Gastroceras, Syngastrioceras, Pygmy Bransmoreoceras, Bugastrioceras, Bactrites, cf. *B. gaitherensis* (SUI 43672), and *Bactrites* sp. mtp. 14 (SUI 42544, 42546, 43601, 34871-21), *Bactrites* sp. mtp. 15 (SUI 42545, 43600, 43598, 34869-72), *Bactrites* sp. mtp. 16 (SUI 43602, 43624, 34866-6), Sinuobactrites marrowauxensis (SUI 42535), and *Bactrites* sp. (SUI 43870-22). (Reference: McCaleb, 1968.)

*P-2.*—Hale Formation, Prairie Grove Member (Morrowan). This locality is located in a north-facing roadcut on AR State Hwy. 74 approximately 4.8 km (3 mi.) W of Huntsville, Madison Co., AR (SE1/4 SE1/4 SW 1/4, sec. 6, T.16 N., R.26 W.; Hartwell 7 1/2' quadrangle). Fossils are recovered from discontinuous lenses near the base of a limestone bluff, which is about 6 m (20 feet) high. This exposure is overlaid Arkamites, Gastroceras, and Bactrites cf. B. gaitherensis (SUI 43872).

*P-3.*—Brentwood Limestone Member, Floyd Formation (Morrowan). Approximately 11 km (7 mi.) SW of Harrison, Boone Co., AR, on AR State Hwy. 43 (near the center of sec. 27, T.18 N., R.21 W.; Gaither, AR, 7 1/2' quadrangle). Fossils have been recovered from a sandy limestone conglomerate 0.6 to 1.5 m (2 to 5 feet) thick; many are from loose pieces of conglomerate dislodged during highway construction. This locality is the same as UA 2356 and loc. 11 of McCaleb (1968), who listed the cephalopods: Proshumardites, Basithoceras, Gastroceras, Syngastrioceras, Pygmy Bransmoreoceras, Bugastrioceras, Bactrites, cf. *B. gaitherensis* (SUI 1948) and *B. redactus* (USNM 119019, 119020). (Reference: McCaleb, 1968; Gordon, 1965.)

*P-4.*—Smithwick Formation (Atokan). Approximately 5.6 km (3.5 mi.) E and 1.4 km (0.9 mi.) S of U.S. Hwy. 190 and FM 1121 junction at Rochelle, McCulloch Co., TX (31° 13' 20" N., 99° 10' 15" W.; Rochelle 7 1/2' quadrangle). The fossil-bearing exposure has less than 4.5 m (15 feet) of relief and is confined to five generally N-S trending gullies. The westernmost gully is located about 3 m (10 feet) E of a N-S fence line. This exposure is structurally disturbed, but the attitude of the beds is uncertain because of slumping of the shale. Because of the structural complications, the stratigraphic succession cannot be determined. Therefore, the 75-kg shale sample that was disaggregated and picked for microscopic cephalopods cannot be placed in stratigraphic succession. This locality is the same as locality 153-T-6 of Plummer and Scott (1937). The following cephalopods have been recovered: Paralegoceras, Esowellieres, Bactrites, Sinuobactrites, Pseudoparalegoceras, Clistoaceras, Bactrites smithwickensis (SUI 43873 to 43879, 34874-14, TU P-7832-2, P-1230-2, and P-10122-3), *Bactrites* sp. mtp. 17 (SUI 43879, 34880), *Bactrites* sp. mtp. 18 (SUI 42549), *Bactrites* sp. mtp. 19 (SUI 42547, 42550, 34883-11), *Bactrites* sp. mtp. 20 (SUI 43615, 34884), *Bactrites* sp. mtp. 21 (SUI 42556), *Bactrites* sp. mtp. 22 (SUI 42542, 42551, 42552, 43599, 43602 to 43604, 43616, 43625, 34885), *Bactrites* sp. mtp. 32 (SUI 42548, 42553, 43626, 43627, 43868-38), and *Bactrites* sp. (SUI 43887-265, 34888-2). (Reference: Maps & Furnish, in prep.)
The fossil-bearing shale unit is located in a gully approximately 120 m (400 feet) E of a N-S paved section road in the 5½/NW 3¼ SW¼, sec. 4, T.3 N., R.7 E. (Francis 7½° quadrangle). This exposure was originally known as the Lovelady School locality; however, the original building, which is now utilized as a church. During the past fifty years, this exposure has yielded a prolific and diverse group of cephalopods and continues to produce excellent specimens despite being partly filled with trash in recent years. The fossils of the present report were recovered as loose specimens on the surface of the lower portions of the outcrop. Additional specimens were obtained by washing and sorting the mud-gravel mixture from the bottom of the gully. More than 1,000 kg of this mud-gravel mixture were processed; plant petrifications, sponges, brachiopods, molluscs, trilobites, echinoderms, conularids, and other well-preserved fossils were recovered from the richly fossiliferous gravel. The precise stratigraphic level that yields these well-preserved fossils is unknown. Channel samples 25 cm long were taken from the lower 15 m of the exposure; approximately 20 kg of shale were taken, processed, and picked for bactritoids and other cephalopods. Only the lower 9 m yielded cephalopods; bactritoids were recovered from every sample in the 9-m interval (Fig. 5C).

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*P-9.—Wewoka Formation (Desmoinesian). Fossils have been recovered from a series of exposures along the S face of an escarpment near Holdenville, OK in the N 3½ of sec. 5, T.6 N., R.9 E. (Holdenville 7 ½° quadrangle); this locality is the same as locality 2006 (Girty, 1915a). Most ammonoids and the single bactritoid (*Angustobactrites?* sp. SUI 43899) have been recovered from the lower portions of the exposure. This set of outcrops has yielded the usual diverse cephalopod fauna (see localities *P-6, *P-7, and *P-8), as well as sponges, corals, brachiopods, gastropods, bivalves, trilobites, crinoids, conularids, and other well-preserved fossils. (Reference: Girty, 1911b, 1915a.)

*P-10.—Deese Formation (Desmoinesian). Cut bank of an unnamed stream near Mannsville, OK in the SW ¼ SW ¼ SE ¼, sec. 31, T.3 S., R.4 E. (Mannsville 7½° quadrangle). Numerous limonitized cephalopod molds have been recovered, including *Eosianites*, *Wellierites*, *Bisatoceras*, *Neoachitractites*, *Gastrioceras?*, *Schohlolites*, *Mooreoceras*, and *Pseudorthoceras*. Other faunal elements, including gastropods, pelecypods, trilobites, and crinoids, are common. Bactritoids recovered from this locality include a single specimen referable to ?,*Angustobactrites* sp. (SUI 43890). Approximately 5 kg of shale were processed and picked for microscopic cephalopods; 12 specimens of *Bactrites* cf. *B. reticulatus* (SUI 43895) were recovered. More extensive sampling of this exposure will probably result in the discovery of a diverse bactritoid fauna.

*P-11.—Cherokee Group undifferentiated (lower Desmoinesian). A coal strip pit located about 0.9 km (0.6 mi.) W of spot elevation 675 and 0.9 km (0.6 mi.) S 68° W of the Pleasant Hill School (NW ¼, sec. 9, T.70 N., R.13 W.; Agency 7½° quadrangle) Davis Co., Iowa, was collected by a University of Iowa field party on March 4, 1967. A single megascopic bactritoid, *Orbactrites davisensis* (SUI 43520) was obtained as a loose specimen on the overburden dumps at the strip pit. Acidization of the matrix surrounding the megascopic specimen yielded four microscopic specimens that are also referable to *Orbactrites davisensis* (SUI 43519, 43521, 43522, 43523). Exact placement of these bactritoids within the stratigraphic succession is not presently possible.

*P-12.—Mineral Wells Formation (Desmoinesian). Conglomerate-bearing, fossiliferous shale on an excavated hillside approximately 0.4 km (¼ mi.) N of Gate Number 2 at Fort Wolters, Palo Pinto Co., TX. Cephalopods include *Neoachitractites*, *Gonioloboceras*, *Eosianites*, *Wetvokites*—*Innulobactrites* *strimplei* davisensis; *Pseudorthoceras*). A single specimen of *Eoasianites*, *Wellerites*, *Bisatoceras*, *Neoshumarchites*, *Gastrioceras?*, *Neoaganides*, *Schohlolites*, *Mooreoceras*, and *Pseudorthoceras* have been preserved. (Reference: Miller & Scott, 1937.)

*P-13.—Deese Formation, unnamed shale member (Desmoinesian). A single specimen of *Bactrites* sp. (SUI 43545) collected by H. L. Strimple from the center, sec. 29, T.3 S., R.2 E., Carter Co., OK. No other data are available.

*P-14.—Cherokee Coal Cyclothemes (Desmoinesian). The shale beds associated with coal seams in Henry Co., MO have yielded numerous cephalopods, including bactritoids. According to Miller and Owen (1939) the bactritoids have been recovered from two separate horizons.

The Excello Shale, which overlies the Mulky Coal at the following localities, has yielded specimens assignable to *Bactrites oweni*: Lear and Gregg Strip Pits (sec. 15, T.43 N., R.28 W.; SUI 10930-30, 13479-3, 13481), Ewing Strip Pit (sec. 36, T.43 N., R.28 W.; SUI 4263, 13480, 13482-9, 43932, 43933), Shideler Strip Pit (sec. 22, T.43 N., R.28 W.; SUI 10928, 10929, 13483), and Allen Strip Pit (sec. 33, T.42 N., R.28 W.; SUI 10931). These bactritoids are associated with the following cephalopods: *Imi-
toceras*, *Eosianites*, *Bisatoceras*, *Gonioloboceras*, *Neoachitract-
tes*, *Poterioceras*, *Mooreoceras*, *Brachycycloceras*, *Metacoceras*, *Parametacoceras*, *Dominaceras*, and *Solenochilus*.

Bactrites cherokeensis is limited to a single specimen (SUI 13377) recovered from a shale 3 to 5 m (10 to 15 feet) below the Jordan (?Pittsburg) Coal at the England Strip Pit (sec. 17, T.41 N., R.25 W.). This specimen is associated with the following cephalopods: *Mooreoceras*, *Ephippoceras*, *Megafossocras*, *Metacoceras*, *Dominaceras*, and *Solenochilus*. A single specimen that may be referable to *B. cherokeensis* (SUI 43935) is present in the collections; however, it has no accompanying locality data and is placed in this lot of specimens by lithic association. (Reference: Miller & Owen, 1939.)

*P-15.—Eudora Shale, Stanton Formation (upper Missourian). Road metal quarry approximately 2.1 km (1.3 mi.) N and 0.9 km (0.6 mi.) E of Tyro, Montgomery Co., KS (SE ¼ NW ¼ SE ¼, sec. 30, T.34 S., R.15 E.; Tyro 7½° quadrangle). A gray to black shale about 0.6 m thick crops out (Fig. 6) on the SE side of the quarry. More than 1,000 kg of shale were taken from the upper half of this exposure and disaggregated for microscopic fossils; the residue contained a rich juvenile cephalopod fauna including *Neoaganides*, *Schistoceras*, *Eosianites*, *Bactrites woodi* (SUI 42507 to 42512, 42514, 42521, 42525, 42529 to 42532, 43938-81, 43940-424, 43941-528, 43942, 43943-316), *Bactrites* sp. mtp. 25 (SUI 42513, 42516, 43946-51), *Bactrites* sp. mtp. 30 (SUI 42505), *Bactrites* sp. (SUI 43947-3), *Dilatobactrites mossouriensis* (SUI 42501, 42503, 42506, 42523, 42526, 43944-204), *Ornobia* *tyroensis* (SUI 42517, 42519), and *Turbotuboceras endurusensis* (SUI 42502, 42504, 42526, 42533, 43945-2).

*P-16.—Checkerboard Limestone (lower Missourian). A single fragmentary specimen of *Bactrites* sp. (KA 52305) was collected in the vicinity of Coffeyville, KS by R. C. Moore (loc. No. 5208). No other data are available.

*P-17.—Kansas City Formation, Winterset Limestone Member (Missourian). A single specimen of *Bactrites winteretenes* (KA
32079) was discovered in a quarry on the E bank of Big Blue River, 0.4 km (0.25 mi.) N of 15th Street, Kansas City, MO. No other data are available.

P.18—Stanton Formation, Eudora Shale (upper Missourian). A single poorly preserved specimen of *Rugobacteria jacksborensis* (KA 47123, loc. No. 7023) has been recovered from an exposure 8 km (5 mi.) N of Copan, Washington Co., OK. It is possible that this locality is the same as the exposure (SW 1/4, sec. 23, T.29 N., R.13 E.; Wann 7 1/4 quadrangle) 8.8 km (5.5 mi.) NNE of Copan, Washington Co., OK.

P.19—Stanton Formation, Vilas Shale Member? (Missourian). A single specimen referable to *Rugobacteria cf. R. jacksborensis* (KU 48838) was recovered by N. D. Newell from an exposure 3.6 km (2.25 mi.) W of Wann, Washington Co., OK. No other data are available.

P.20—Stanton Formation, Eudora Shale Member (upper Missourian). A single specimen of *Bactrites* sp. (SUI 43917) was collected by M. A. Senich from the “Walker Mound.” The specimen was recovered from a gray shale about 6 m (20 ft) above the Captain Creek Limestone in a road ditch (NW 1/4 NE 1/4 NE 1/4, sec. 5, T.33 S., R.15 E.; Bolton 7 1/4 quadrangle), Montgomery Co., KS. A single specimen of *Eoisaminites* was recovered at a slightly higher stratigraphic interval at the same exposure.

P.21—Caddo Creek Formation, Colony Creek Member (upper Missourian). A single specimen referable to *Bactrites* cf. *B. oweni* (SUI 43934) was recovered loose in a gully approximately 0.5 km (0.3 mi.) SSW of Lake Brownwood State Park, Brown Co., TX. The well-preserved ammonoid fauna associated with this single *Bactrites* specimen is undescribed; however, the overall composition is generally similar to that described by Miller (1930).

P.22—Dover Limestone (Virgilian). E of Piedmont, Greenwood Co., KS (loc. No. 7076). The University of Kansas has a single crushed specimen (48929) that is morphologically similar to *Microbacteria*. No other data are available.

P.23—Stanton Formation, Finis Shale Member (lower Virgilian). A series of localities within an 8 to 9.5 km (5 to 6 mi.) radius of Jacksboro, Jack Co., TX has yielded a number of well-preserved cephalopods. Unfortunately, several older collections from the University of Iowa give only generalized locality information. The cephalopods reported include *Eoisaminites*, *Sowholites*, *Schistoceras*, *Gonobaculites*, *Vidriceras*, *Eudoxoceras*, *Prothalassoceras*, *Dunbarites*, *Stenoporonorites*, *Metacoceras*, *Bactrites finisensis* (SUI 43918), and *Bactrites postremus* (SUI 4261-3, 43928). Slightly more exact locality information is available for the following specimens:

1. Ramsey Farm 4.8 km (3 mi.) E of Jacksboro, TX: *Bactrites finisensis* (SUI 43920), *B. postremus* (SUI 43922-3), and *Rugobacteria jacksborensis* (SUI 10935).

2. 5.6 km (3.5 mi.) SE of Jacksboro, TX: *Bactrites finisensis* (SUI 43919).

3. 4 km (2.5 mi.) E of Jacksboro and about 0.8 km (0.5 mi.) N of the Riley Farm; collector R. H. Downs, 1947: *Bactrites postremus* (SUI 4259-2, 43977) and *B. finisensis* (SUI 43921).

4. Gully and banks of a low escarpment 8.8 km (5.5 mi.) NE of Jacksboro, Jack Co., TX. The fossils are recovered as loose specimens on the N side of TX State Hwy. 59. The moderately well-preserved invertebrate fauna is diverse and includes *Bactrites postremus* (SUI 43926-9).

5. About 4 km (2.5 mi.) ESE of Jacksboro to the back of the Bowen Farm on the road to Wizard Wells, Jack Co., TX; collector R. H. Downs, 1947: *Bactrites postremus* (SUI 4260-3).

(Reference: Plummer & Scott, 1937; Miller & Downs, 1950.)

*P.24—Stanton Formation, Finis Shale Member (lower Virgilian). Pond dam approximately 15 m (50 ft) S of U.S. Hwy. 180, 2.9 km (1.8 mi.) E of the junction of State Road 717 and U.S. Hwy. 180 near Cadle, Stephens Co., TX (32° 42’ 51” N, 98° 01’ 11” W). A diverse fauna and flora have been recovered including limonitized plant petrifications, brachiopods, pelecypods, gastropods, trilobites, conularids, cephalopods, and a blastoid. Cephalopods include *Agathicerus*, *Vidriceras*, *Arizoceras*, *Prothalassoceras*, *Gonobaculites*, *Boeitites*, *Stenoporonorites*, *Imioceras*, *Neodimorphoceras*, *Schumardites*, *Marathonites*, *Uddenites*, *Eoisaminites*, *Schistoceras*, *Eudoxoceras*, *Pseudorthoceras*, *Mooreoceras*, *Ephippioceras*, *Metacoceras*, *Bactrites finisensis* (SUI 43979), and *B. postremus* (SUI 43923-21, 43924, 43925).

(Reference: Miller & Downs, 1950; Strimple & Mapes, 1977.)

*P.25—Stanton Formation, member unknown (lower Virgilian). Outlier 0.8 km (0.5 mi.) SW of South Bend, Young Co., TX (loc. No. 251-T-3-K-18). *Bactrites postremus* (TA 7063).

*P.26—Stranger Formation (Virgilian). The single specimen of *Bactrites cf. B. postremus* (KA 53128) is reported to have been collected 15 m (50 ft) below the Wildhorse Limestone on the Honey Hill area, the center of T.22 N., R.10 E. in OK. No other data are available.

*P.27—Graford Formation, Brownwood Shale Member (lower Virgilian). The single specimen of *Gonobactrites* sp. (KA 49784) was collected in the vicinity of Bridgeport, TX. No other data are available.

*P.28—Vamoosa Formation (Virgilian). A single specimen of *Bactrites postremus* (OU 5694) was recovered by H. L. Stimple about 3 km (2 mi.) SSW of Wynona, Osage Co., OK on a pond dam (NW 1/4 SE 1/4, sec. 28, T.24 N., R.9 E.). No other data are available.

*P.29—Stanton Formation, South Bend Shale Member (lower Virgilian). Approximately 2.4 km (1.5 mi.) SW of South Bend, Young Co., TX. The two specimens of *Bacrites* sp. (SUI 43931) were collected by H. J. Plummer in 1949 from an exposure W of an outlier. Attempts at resampling the fossil-bearing exposure have been unsuccessful because of the sparse locality information.

*P.30—Gaptank Formation (upper Virgilian). The extensive collections made by G. A. Cooper and R. E. Grant (1972, 1977) from Upper Pennsylvanian and Permian exposures in West Texas and New Mexico have provided three lots of bactritoids; all are assignable to *Bactrites costatus*. These bactritoids were recovered from Upper Pennsylvanian limestones at localities 701-R (USNM 254588, 254589-20), 701-Q (USNM 254590-2), and 700-E (USNM 254591-5). These limestones have yielded an ammonoid fauna nearly identical to that described by Miller (1930), which includes *Boeitites*, *Prouddenites*, *Stenoporonorites*, *Agathicerus*, *Schistoceras*, *Marathonites*, *Prothalassoceras*, *Dunbarites*, and *Uddenites*.

*P.31—Gaptank Formation (lower Virgilian or upper Missourian). A single specimen of *Bactrites postremus* (Peabody Museum, Yale University 12929A) was recovered by P. B. and R. E. King and C. L. Baker approximately 7.2 km (4.5 mi.) S 15° E of Lenox, Brewster Co., TX. Miller (1930) has described the diverse cephalopod fauna from this locality, which includes *Boeitites*, *Prouddenites*, *Stenoporonorites*, *Schistoceras*, *Marathonites*, *Prothalassoceras*, *Dunbarites*, and *Uddenites*.

**PERMIAN**

*P.R.1—Bone Spring Limestone (Artinskian, Roadian). NW side of a roadcut on U.S. Hwy. 62, near BM 4367, located 2.9 km (1.8 mi.) NE of the junction of U.S. Hwy. 62 and TX State Hwy. 54, Culberson Co., TX. This is nearly the same as locality 2907 of Gruber (1908). Cephalopods recovered include *Texoceras*, *Pterobachites*, and *Bactrites elcapitanensis* (SUI 43881, 43882). Both specimens of *Bactrites* were collected by A. G. Fischer around 1950. (Reference: Spinosa, Furnish, & Glenister, 1975.)
PR-2.—Las Delicias beds (Artinskian to Guadalupian). For more than fifty years, a series of beds exposed near Las Delicias, State of Coahuila, Mexico (103° 00' W, 26° 20' N.) has yielded well-preserved cephalopods.

*Bactrites mexicanus* has been recovered as loose specimens from two separate areas within this Permian outcrop belt. Two specimens referable to *Bactrites* sp. (SUI 1352 and Peabody Museum, Yale University 16277) were collected from bed 18 (Lower Permian, Artinskian) of the Malascachas flanks at locality 33 of R. E. King et al., 1944. This bed has also yielded *Medlicottia*, *Neoocrinites*, and *Perrinites*. The other area that has yielded specimens of *B. mexicanus* (SUI 1351-4, 16268, 32903, 32904, 32905-9, 43929, 43930; Peabody Museum, Yale University 15279-14, 16278) is the Difunta flanks, beds 5-7 (Upper Permian, Guadalupian, Capitanian Stage) of R. E. King et al. (1944) at locality 20 or bed 43 of Newell (1957). Cephalopods include *Strigognaticites* (includes forms referred to *Pseudogastrioceras*), *Neoocrinites* (formerly *Adrianites*), *Stacheoceras*, *Timorites*, *Waagenoceras*, *Paracelites*, *Cibolites*, and *Xenodiscus* (formerly *Xenodiscites*). (Reference: King et al., 1944; Newell, 1957.)

**BIOSTRATIGRAPHY**

The bactritoids described in the present report do not contribute appreciably to the solution of biostratigraphic problems. Ranges of species tend to be long, but cannot be regarded as established at this time.

Perhaps sampling procedures have aggravated this problem. Many samples were taken with the primary purpose of increasing the quantity of microscopic and juvenile bactritoid specimens available for study. The most fossiliferous portions of outcrops were sampled, and if bactritoid specimens were present, large quantities of sample were processed; other parts of the same outcrop may have been sampled relatively poorly. Other samples were large quantities of extremely fossiliferous gravel from lag deposits in the bed of a gulley. Only one outcrop was sampled in a systematic way. This outcrop (loc. M-16) established the occurrence of several bactritoid-bearing horizons, but only the most fossiliferous horizon was sampled extensively. Additionally, most megascopic bactritoid specimens were collected loose on the surface. These sampling conditions are less than desirable for detailed biostratigraphic purposes; however, detailed occurrence information is provided in the material section of the present report where possible.

**PATTERNS OF EVOLUTION**

The early phylogentic history of the bactritoids is somewhat controversial. Schindewolf (1932) described a straight "nautiloid" with a marginal siphuncle from lower Ordovician strata as *Eobactrites* and indicated that he believed this to be a primitive bactritoid. Other cephalopod workers (Furnish & Glenister, 1964, p. K132) interpreted *Eobactrites* as a member of the Ekeinscarida. Arguments against *Eobactrites* being a primitive bactritoid include the chronologic separation between *Eobactrites* (Early Ordovician) and the first documented *Bactrites* (Early Devonian). Additionally, it can be argued that the ventral lobe on the suture of *Eobactrites* is a response to the marginal position of the siphuncle. However, this same argument can be applied to every bactritoid that has a marginal siphuncle. Erben (1964a) believed that since *Bactrites* is known to him from Silurian units, the time separation between the Early Ordovician *Eobactrites* and the Early Devonian *Bactrites* is less significant. This disagreement about phylogenetic origins can only be resolved by the recovery of additional specimens, the reexamination of the types of *Eobactrites*, and the documentation of Silurian specimens that Erben referred to *Bactrites*. However, it seems reasonable that the subclass Bactritoidea was derived in the Early Devonian or perhaps somewhat earlier from what was probably a longiconic, orthochoanitic nautiloid with a bulbous protoconch and an eccentric siphuncle. Erben (1964a) suggested the ancestor may possibly have been a member of the Orthocerida.

Two phyletic groups appear to be included within the subclass Bactritoidea (Fig. 7), comprising the orders Bactritida and Anulobactritida n. ord. The former order was probably derived from the Orthocerida; how-

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**Fig. 7. Derivation of bactritoid families. Time of origin of families is conjectural.**
ever, the latter order is thus far unique to Middle Pennsylvanian strata of Oklahoma, where it is represented by more than 250 specimens belonging to two genera. Insofar as can be determined, it probably lacks the globular protoconch, contains relatively voluminous cameral deposits, and has an embryonic development unlike any species assigned to the Bactritida. The phylogenetic origin of the Annulobactritida is uncertain at this time, and assignment to the Bactritoidea is based primarily on siphuncle position, for convenience.

The order Bactritida contains four distinguishable phyletic groups that can be classified as families: the Bactritidae, Lobobactritidae, Parabactritidae, and Sinuobactritidae n. fam. All of these families are similar in having a bulbous protoconch and lacking voluminous cameral deposits, but each has distinctive features. On the basis of morphologic similarity, the Parabactritidae is most closely related to the Bactritidae, whereas the Sinuobactritidae has a distinctly different early ontogenesis and is probably more distantly related to the main bactritoid stock.

Phylogenesis at the generic and specific level is difficult to establish because many critical gaps preclude establishment of ancestor-descendant relationships. The problem is confounded by difficulty in ontogenetic reconstruction.

One of the clearest examples of bactritoid evolution is the Sinuobactritidae (Fig. 8). Its origin is unknown, but early ontogenetic features that change throughout the Pennsylvanian are septal spacing, protoconch size, and siphuncle position. The oldest known form, *Sinuobactrites mortuanensis* n. gen., n. sp. (Pl. 39, figs. 12–14), was recovered from Morrowan strata in Oklahoma and has wide septal spacing, especially between the third and fourth chambers, and a siphuncle that is marginal after the third chamber. The next youngest form recovered is *S. wewokensis* n. sp. from the Desmoinesian of Oklahoma (Pl. 39, figs. 1–11,15). This taxon maintains the siphuncle in marginal position after the third chamber; however, the spacing between the third and fourth septa is markedly reduced, with the fourth septum incomplete and abutted against the third. The next youngest taxa to be recovered are *Dilatobactrites missouriensis* n. gen., n. sp. (Pl. 38, figs. 1–8,11,13,14,17) and *Turbobactrites eudorensis* n. gen., n. sp. (Pl. 38, figs. 9,12,15,16,18–24) from the upper Missourian of Kansas. *Dilatobactrites missouriensis* appears to be most closely related to *S. wewokensis* because it retains essentially the same septal spacing, and the overall size of the phragmocone and protoconch are similar. However, this taxon has a submarginal siphuncle that remains eccentric throughout the known ontogeny. *Turbobactrites eudorensis* also has a submarginal siphuncle; however, this taxon has a larger phragmocone and protoconch and initial septa that are more closely spaced than in *D. missouriensis*.

Evolutionary relationships between bactritoids from lower Permian and Carboniferous units in the Soviet Union described by Shimansky and North American taxa are unclear.

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**Fig. 8.** Phylogenesis of the Sinuobactritidae. Some of the evolutionary characteristics that change are septal spacing, phragmocone and protoconch diameters, and position of the siphuncle during ontogenesis.
vided many specimens and led field trips to private localities; also to Mildred Wheeler of Dennard, Arkansas, and Craig Brown of Fayetteville, Arkansas, who provided specimens for analysis.

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SELECTED MORPHOLOGICAL FEATURES

While only indirectly applicable to the bactritoids, the discussion by Jeletzky (1966) on the taxonomic importance of various morphologic features in fossil Coleoidea provides valuable insight. The following features are considered significant in the Bactritoidea: phragmocone cross section and sutural configuration, apical angle, ornament, protoconch morphology, internal deposits, septal necks, siphuncle position, wrinkle-layer, cameral ratio, septal orientation, and color patterns. Abnormalities and pathologic states in individual specimens must also be recognizable to avoid attribution of taxonomic significance.

PHRAGMOCONE CROSS SECTION AND SUTURAL CONFIGURATION

Sutural configuration has considered an important taxonomic feature since Schindewolf (1933) described Lobobactrites; this genus with the typical bactritoid "neck" lobe at the position of the siphuncle is characterized by well-developed lateral lobes. As virtually every modern cephalopod worker has agreed, phragmocone cross section commonly has a pronounced effect on the configuration of the suture. The case of Lobobactrites is a good example, the compressed cross section being the mechanical cause of the lateral lobe. Both related features are attributed generic or specific importance.

Perhaps even more important than the common mechanical response of the suture to compressed shell form is the flat-sided phragmocone when the suture does not develop a lateral lobe. An example is Rugobactrites imoensis n. gen., n. sp. (Pl. 10, figs. 4,5,9). A lateral lobe would seem taxonomically more important when it is developed on a phragmocone that is essentially round in cross section.

Paleobiological evaluation of sutural configuration and phragmocone cross section involves two separate considerations. When the phragmocone cross section becomes compressed and the suture mechanically develops lobes as a response, the overall effect may have been toward strengthening of the shell (Westermann, 1973). However, the occurrence of sutural lobes on round phragmocones or the lack of lobes on oval phragmocones is probably more important from a paleobiologic and taxonomic viewpoint.

APICAL ANGLE

Apical angle or taper rate can be expressed as an angle or as a ratio (e.g., 1 mm of diameter expansion for 10 mm of phragmocone length or 1:10). Excluding temporarily the problems of ontogenetic variation of the apical angle, the bactritoids can be divided arbitrarily into two groups: the Bactritidae with an apical angle of 10° or less, and the Annulobactritidae, Sinuobactritidae, and Parabactritidae, which generally have an apical angle of 10° to as much as 35°. Only a few exceptions to this 10° rule are known among North American Carboniferous bactritoids. These exceptions include Eoparabactrites graffhami (10°) and Angustobactrites saundersi (6° to 11°); both species have recurved septal necks and are placed in the Parabactritidae.

Apical angle varies significantly at some point in every known ontogeny. Some examples of variation in the apical angle are instructive. Variation is common in early ontogenesis. In the Annulobactritidae, Annulobactrites strimpei n. gen., n. sp. (Pl. 40, figs. 1,3,5) has an initial angle of approximately 50°, which by the third chamber has decreased to 10° to 16° and is maintained throughout the remainder of the known ontogeny. In the Bactritidae, Bactrites fayettevillensis n. sp. has an initial
apical angle of 15°; the fourth chamber marks the maximum embryonic diameter; orad of the fourth chamber the conch has a reverse apical angle of 3°, and the early juvenile phragmocone has an apical angle of 2° to 5°. On some specimens in the Sinuobactritidae (e.g., Sinuobactrites wukokensis n. gen., n. sp., Pl. 39, figs. 1–11), an initial apical angle of 95° is found at the apical end of the first chamber; this high angle is followed by an interval of low expansion of about 5° until the ninth chamber, when a reverse apical angle of 7° occurs. This reverse apical angle is followed by the early juvenile stages of development, which have apical angles of up to 34°.

The taxonomic significance of the apical angle is considered to be limited to the generic/specific level. However, it is a useful feature for separating the Bactritidae from the other three families, which generally have higher expansion rates.

ORNAMENT

Ornament, unlike growth lines, is preserved on specimens of only a few bactritoid taxa. Almost invariably, this ornament consists of more or less transverse ribs or annulations and longitudinal lirae.

Judgment of the taxonomic importance of ornament has differed greatly among workers. Shimansky (1951, 1962, 1968) established and continues to use a family (the Ctenobactritidae) based on shell ornament. Erben (1960, 1964a) has rejected this family. Because of the ontogenetic ornament variation exhibited within Ctenobactrites and Bactrites, the feature is of taxonomic importance only at the generic/specific levels.

Paleobiologic implications of the existence of ornament have been discussed extensively for other subclasses and orders of cephalopods (Westermann, 1971; Lehmann, 1971; Cowen, Gertman, and Wiggett, 1973; Chamberlain and Westermann, 1976). Some explanations for ornament include shell strengthening, camouflage, better liquid transport to and from the siphuncle, possible protection against predation, and more effective fluid flow regime on the external shell giving more efficient mobility. All of these discussions can be applied to bactritoid ornament.

PROTOCONCH MORPHOLOGY

The cephalopod protoconch is the terminal chamber on the apical end of the phragmocone. Two basic types are present within the collections. The common type is a hemispherical to spherical form that invariably constricts at the first septum (Pl. 18, figs. 5,8,12; Pl. 38, figs. 4,5,9). This type of protoconch characterizes the Bactritida. The second type of protoconch has not been completely determined because no whole specimen has yet been recovered. Among specimens used for this report, the second type of protoconch is apparently limited to Globulobactrites lovaydensis n. gen., n. sp. and Anulobactrites strimplei n. gen., n. sp. This latter species (Pl. 18, figs. 6,10,11; Pl. 34, fig. 1) has a subcircular (height=80% of width) outline on the most apical septum. This outline is smaller than most known attachment points for members of the Bactritida. Additionally, the septal surface is inclined dorsoad, unlike the Bactritida which are directly transverse. Most probably, these two genera had a cicatrix-bearing protoconch such as those of the pseudorthoceratid Reticycloceras, which were illustrated by Windle (1973, Pl. 4), or Nautilus (fide Stenzel, 1964, fig. 63, p. K86). It should be noted that the cap type of protoconch reported by Shimansky has not been observed in the collections; however, additional comments concerning this point can be found under the Anulobactritida in the present report.

Internal morphological characteristics of the bactritoid protoconch have not been examined in detail. The most pronounced feature, found on some internal molds, is the caecum. This morphologic feature sometimes expresses itself as a mound on the ventral side of the internal mold of the protoconch (Pl. 7, fig. 12; Pl. 11, figs. 6,13). In one specimen (Pl. 32, figs. 8,9), the protoconch shell and filling have been removed to expose the caecum. This morphologic feature is of the third type reported by Ristedt (1971), and potentially could have great phylogenetic and taxonomic significance. At this time, little taxonomic significance is placed on the positioning or the dimensions of the caecum.

The closing membrane of the protoconch is with one exception smooth with no texture (Pl. 18, fig. 5). The single exception is a specimen referable to Bactrites woodi, n. sp. (Pl. 18, figs. 8,12), which has a well-developed reticulated pattern over part of the surface. This reticulated closing membrane may be a product of post-depositional deformation; however, the regular nature of the pattern suggests a paleobiological origin of unknown significance.

The presence or absence of a bulbous protoconch is a high-level taxonomic feature in the Bactritoida. The exact taxonomic level of this feature is undecided, and for the purposes of the present report, it is considered an ordinal feature. Length and width of the bulbous protoconch may also be an important taxonomic feature. Significant numbers of protoconchs are available for study and would lend themselves to statistical analysis, but reliable reconstructions would have to be prepared or intact specimens obtained to relate the protoconch to its later growth stages. Such other features as the caecum dimensions and position and the unique reticulated closing membrane of the protoconch may be important.
taxonomically, but these features have not yet been studied sufficiently.

INTERNAL DEPOSITS

The discovery of cameral deposits within the Bactritoidea provides a new morphologic feature with potentially great taxonomic significance. At the present time, episepal, hyposeptal, and mural configurations of the cameral deposits are known.

The most voluminous cameral deposits known occur in *Globulobactrites loveladyensis* n. gen., n. sp. (Pl. 41, figs. 1–5, 7–9, 11, 12, 14–16, 21). In every specimen of this species available for study, the actual carbonate deposits have been dissolved, leaving deposit scars on the internal molds. The largest deposits are relatively thin films along the cameral walls (mural deposits), although episepal and hyposeptal deposits are also probably present. The cameral deposits show an orderly decrease in volume adorally. They may be either bilaterally symmetrical and the plane of symmetry essentially coincides with the dorsoventral plane of the phragmocone. The deposit scars also show definite changes in pattern from apical chambers toward the living chamber.

A number of forms within the Bactritida have internal deposits. Most of these deposits are found at the apical end of the earliest ontogenetic stages (Pl. 11, figs. 5–7, 13; Pl. 32, figs. 7–9, 15, 16), and only rarely are they found in the more nearly mature portions of the phragmocones (Pl. 3, figs. 8–11). The deposits in the earliest ontogenetic stages seem to be of episepal and hyposeptal types with only thin mural deposit scars. In the later ontogenetic stages, the deposits are, insofar as is known, always mural.

The taxonomic importance attributable to cameral deposits varies within the Bactritoidea. The occurrence of deposits is of at least generic importance in the Annulobactritida, but in the Bactritida, the occurrence of cameral deposits is so poorly known that these morphologic features have the status of a palaeontological curiosity at this time. Eventually, the differentiation of the various configurations of deposits will allow their use as specific/generic taxonomic criteria.

Mode of life interpretations of the Bactritoidea by Shimansky (1962) are interesting speculations. The occurrence of cameral deposits in the phragmocone does not alter the concept of an active nektic or nektobenthic life mode with the shell being held in a horizontal position. This also applies to the thin-shelled forms (including *Hemibactrites*) that Shimansky indicated could have led a passive life of floating. Cameral deposits would have aided stability and probably decreased equilibrium problems if cameral fluids were controlled as in *Nautilus*. Also, the presence of cameral deposits suggests the presence of a cameral mantle. (See Fischer & Teichert, 1969.)

SEPTAL NECKS

Septal necks in the Bactritoidea apparently fall within two well-defined categories. All of the known Parabactritidae, Sinuobactritidae, and Annulobactritidae have cyrtochoanitic septal necks, whereas the Bactritidae and Lobobactritidae are orthochoanitic.

The paleobiological significance of orthochoanitic and cyrtochoanitic septal necks is uncertain. That the majority of the taxa assigned to the Parabactritidae, Sinuobactritidae, and Annulobactritidae have breviconic conchs with relatively high apical angles may imply a relationship to the cyrtochoanitic septal necks.

SIPHUNCLE POSITION

Within the cephalopods as a group, the position of the siphuncle is an important morphologic and taxonomic feature. This also holds true in the Bactritoidea. Bactritoids generally possess a marginal siphuncle, but exceptions are known.

Within the Sinuobactritidae, there are two taxa, *Turboactrites eudoraensis* and *Dilatobactrites missouriensis*, in which the siphuncle is submarginal, removed 1/6 to 1/10 of the corresponding diameter from the venter (Pl. 58, figs. 20 and 7, respectively). If it were not for the known phylogenetic origins of these two species, these taxa would probably have been placed in another subclass. Additionally, *Globulobactrites loveladyensis* n. gen., n. sp. (Pl. 41, figs. 7, 9, 12) has a siphuncle distinctly separated from the venter, although a shallow ventral lobe is present on the suture. The relationship between *Annulobactrites* n. gen. and *Globulobactrites* is only moderately close, but it is clear they are related, and *Annulobactrites* (Pl. 40, fig. 5) has a marginal siphuncle. Shimansky (1954, 1962) described an exception to the general rule that bactritoids have marginal siphuncles in that the Permian taxon *Hemibactrites* is described as having a suture without a ventral lobe; therefore, by implication, the siphuncle is separated from the venter. Erben (1964a) suppressed this genus as a primitive variant of *Bactrites*, which has a ventral lobe and marginal siphuncle.

Thus, even though it has been demonstrated that the overall concept of the Bactritoidea must accommodate specimens with nonmarginal siphuncles, the higher (subclass to ordinal) level concept of a marginal siphuncle can be retained as a general rule.

WRINKLE-LAYER

The wrinkle-layer (epidermides, couche ridée, and creuse stries of Barrande; runzelschicht, ritzstreifen, ein-
ritzung, and rizsstreifund of German authors) has been known for more than 130 years and has been reported in many fossil cephalopod groups. Within the Bactritoida, the wrinkle-layer has been reported only in Lobobactrites and a few Devonian species of Bactrites. However, in the course of the present study, the wrinkle-layer has been found in taxa belonging to the Parabactritidae, Bactritidae, and Annulobactritidae.

The function of the wrinkle-layer in bactritoids remains unclear. That there is a relatively close relationship with the wrinkle-layer in ammonoids and fossil nautiloids seems evident. The wrinkle-layer in fossil nautiloids and ammonoids has been studied by House (1971), Walliser (1970), Davis (1972), Tozer (1972), Turek (1975), and Teichert (1977); only Clausen (1968) and Ristedt (1971) have studied the wrinkle-layer in the Bactritoida. Some of these authors have suggested that the wrinkle-layer could have served for better attachment of the mantle to the body chamber.

Several authors have suggested a homologous relationship between the wrinkle-layer in ammonoids and nautiloids and the black layer on Nautilus (Sandberger and Sandberger, 1850; Foord and Crick, 1897; Nasicchuk, 1967). Others question or reject this hypothetical relationship (Turek, 1975; House, 1971).

Some Chesterian (Upper Mississippian) Bactritidae display phylogenetic changes in the form of the wrinkle-layer. Bactrites quadrilineatus Girty (lower Chesterian) has a well-developed wrinkle-layer with inclined striae where phragmocones are viewed laterally (Fig. 9; Pl. 1, fig. 9; Pl. 3, fig. 1). Striations in the wrinkle-layer of B. quadrilineatus are inclined 45° to 58° to the long axis of the phragmocone (Fig. 9a). The wrinkle-layer angles on other Chesterian and Pennsylvanian taxa were measured wherever possible. Despite exceptions, there is an overall trend away from inclined striations throughout: the Chesterian (Upper Mississippian) and Lower Pennsylvanian (Fig. 9b). The ancestor/descendant relationships among the various species during this time period remain unclear. However, if such relationships can be established, the Bactritidae could serve as a biostratigraphic tool.

The wrinkle-layer is probably a significant taxonomic feature; within this report, numerous species are established on the basis of its pattern. Overall, this morphologic feature is probably a much more reliable taxonomic guide at generic and specific levels than such other features as septal spacing and cameral ratio.

The ontogeny of the wrinkle-layer in the Bactritidae remains essentially unstudied. However, numerous well-preserved specimens provide an excellent opportunity for the study of the ontogenesis of this morphologic feature. Aside from the evolutionary sequence of the wrinkle-layer angle that, as previously discussed, becomes more directly transverse throughout the Chesterian (Mississippian), almost all bactritoids have an identifiable wrinkle-layer as impressed on the internal mold of the phragmocone and body chambers. Generally, the wrinkle-layer develops first at the apical end of the camerae on either side of the dorsal furrow (Pl. 26, fig. 7; Pl. 28, fig. 7). As ontogeny progresses, the entire dorsal surface (except for the dorsal furrow) is covered by the wrinkle-layer. Eventually, the wrinkle-layer covers the lateral and ventral portions of the conch.

In some cases, the wrinkle-layer is obscured by additional layers of shell material secreted within the body chamber, usually during later stages of ontogenesis and at maturity. This secretion within the body chamber and phragmocone in the later ontogenetic stages may have accompanied slower growth rates.

Maturity in the Bactritidae can be detected by the change in configuration of the wrinkle-layer. A good example is provided by the Pennsylvanian Bactrites oweni n. sp. During early, middle, and late ontogenesis, the wrinkle-layer remains simple and directly transverse; however, at maturity this transverse pattern changes abruptly at the base of the body chamber (Pl. 19, figs. 4,8-10). The apical end of the internal mold of this body

Fig. 9. Angular relationship of wrinkle-layer striations to the longitudinal axis of the phragmocone.—A. Diagrammatic illustration of the angular relationship between wrinkle-layer striations and the longitudinal axis of the phragmocone. Where observable, the angular relationship θ was measured on all Carboniferous and Permian bactritoids.—B. Stratigraphic relationship of the wrinkle-layer angles from Upper Mississippian and Lower Pennsylvanian bactritoids. All known post-Atokan Bactritidae have wrinkle-layer striae that are essentially directly transverse.
chamber is smooth with no sign of the wrinkle-layer. The wrinkle-layer was probably originally present at this position, but subsequent deposition of carbonate by the mantle covered and masked the wrinkle-layer. Orad of the apical end, the wrinkle-layer is again present in a dorsal fingerprint pattern of bilaterally symmetrical lirae and nodes. Laterally and ventrally, the pattern remains more or less transverse. Near the peristome, the original transverse pattern again dominates the surface of the internal mold until it dies out a few millimeters apicad of the aperture. Such cases of a detectable mature wrinkle-layer pattern are rare and are dependent on the vagaries of preservation and masking by secretion of additional shell layers. Also, it is distinctly possible that more primitive species of Bactrites do not develop a mature wrinkle-layer pattern.

**CAMERAL RATIO**

Cameral ratio is the number of camerae that occur in the length of the corresponding dorsoventral diameter. The cameral ratio can be stated as a ratio such as 4.5:1, or the one is understood, and the cameral ratio is given as 4.5. The phragmocone position at which the dorso-lateral diameter is taken has not been considered significant by most workers; some prefer to use the oral end of a chamber, some the middle, and some the apical end of the chamber. Once the dorsoventral diameter is taken, the position at which the number of camerae is measured (i.e., apically, midway, or orally) becomes critical, especially on phragmocones with large apical angles. Because these variables commonly have not been reported, the taxonomic value of the cameral ratio has been greatly decreased. Additionally, it is well known that the bactritoids can have variable cameral ratios on the same specimen. Some variable cameral ratios are related to ontogenesis, and others are pathologic (Pl. 16, figs. 4-7). Specimens with irregularly spaced camerae do not often occur in the collections of North American Carboniferous and Permian specimens. In any event, the taxonomic value is generally considered to be specific or generic and is probably only significant when several specimens are examined.

Cameral ratio can vary markedly during ontogenesis. Within the Carboniferous taxa in the present report, the cameral ratio appears to be stable at the specific and generic levels in very early ontogenetic stages. This stability in early ontogenesis affords separation of some of the various taxa.

Cameral ratio is intimately related to phragmocone size (i.e., breviconic vs. longiconic) and the apical angle. In only a few cases are relatively high cameral ratios (up to 4:1 in Angustobactrites) encountered in the more longiconic genera. The paleobiologic reasons for a small or large cameral ratio are unknown. Perhaps there is a relationship in the overall cameral volume that can be serviced by the siphuncle.

**SEPTAL ORIENTATION**

Septal orientation has been considered a taxonomic feature for only a few Devonian bactritoids because all Carboniferous and Permian taxa known until this time have septa essentially transverse to the long axis of the phragmocone. Within the collections on which this study is based, however, septal orientation, when consistent within a population, is a valuable taxonomic feature at the generic and specific levels. Septal orientation may change during ontogenesis, and many Bactritidae have inclined septa at some consistent stage in their ontogeny. This consistency has aided in the ontogenetic reconstruction and differentiation of many taxa. Caution must be exercised in attributing taxonomic significance to septal orientation, since there are known examples of pathological specimens (Pl. 16, figs. 4-11).

**COLOR PATTERNS**

Both secondary and diagenetic color patterns have been observed within the studied bactritoid collections. In every case, the original colors have been lost and all that remains are patterns expressed in various shades of gray or brown. These same shades make up the diagenetic patterns seen on some specimens.

Color patterns on Paleozoic cephalopods have been known for more than 100 years. Barrande (1867, 1870, 1874, 1877) recorded 22 species of cephalopods with color patterns. About 70 years later, Foerste (1930) published a major paper on color markings listing 41 species (22 of Barrande plus 19 more); this publication remains the most comprehensive account of color markings on fossil cephalopods (fide Windle, 1973).

Shading patterns can be valuable indicators of life modes. The only living externally shelled model for cephalopods is Nautilus. Stenzel (1964, p. K60, fig. 43, p. K71) discussed the coloration of Nautilus and illustrated the animal in living position. Cowen, Gertman, and Wiggert (1973) reviewed the color pattern in Nautilus and arrived at the same basic conclusions as Stenzel, although they illustrated the living position of the animal incorrectly. All authors agree that Nautilus, when seen from above, has transverse color bands to disrupt the marginal shell edges, provide overall disruptive coloration, and to provide counter shading. When seen from below, the white venter of mature shells presumably blends well with overhead lighting. The total effect probably represents effective protective coloration.

The life habit of Nautilus is apparently nektobenthic, as specimens are captured in traps set on the sea floor. Most, if not all, animals have been captured during periods of darkness. Rare animals caught at the surface
during daylight hours were injured (B. F. Glenister, 1977, pers. commun.) or moribund (Macdonald, 1855).

Bactritoid shading patterns fall into two general categories: more or less transverse patterns and longitudinal patterns. Comparison with the color patterns in *Nautilus* permits speculation on the bactritoid mode of life.

Probably the first worker to seriously study the mode of life relationship with preserved color patterns of fossil cephalopods was Rudolf Ruedemann (1921). Ruedemann hypothesized that brevicomform with a high amplitude chevron pattern indicated a vertical life-orientation and that longicomform with longitudinal pattern restricted to one side of the conch indicated that the animal crawled or swam in a horizontal position.

In the bactritoid collections available for study, the oldest specimen with a shading pattern interpreted as representing a true color pattern is *Angustobactrites saundersi* n. gen., n. sp. (Pl. 17, figs. 1, 5, 11) from the Imo Formation (Mississippian) in Arkansas. The shading pattern on this species is preserved in varying degrees on at least five specimens. The pattern is a dark longitudinal band located symmetrically on the mid-flank region on each side of the conch. Dorsal and ventral surfaces are the same light gray-brown color. The width of the band varies from specimen to specimen, but on individual specimens the width of the band in proportion to the corresponding circumference remains constant.

Associated with the shading-pattern specimens of *A. saundersi* is a single juvenile specimen referable to *Rugobactrites* sp., n. gen. This single specimen is somewhat crushed and was in such poor condition that parts of the specimen disintegrated almost immediately after being photographed (Pl. 17, fig. 6). Because of the poor condition of the specimen both before and after photography, the position of the siphuncle cannot be determined. However, it is assumed that the pattern of dark transverse bands that fade on the lateral portions of the conch could have been either dorsal or ventral. The dark transverse bands are evenly spaced. The intermediate areas between bands are about as wide as the dark bands and are a conspicuously lighter color. Applying the model provided by the color pattern of *Nautilus*, it seems logical that the dark bands are located on the dorsum. If this is the case, the venter lacks a shading pattern. Such a shading pattern would suggest a dominantly horizontal mode of life.

Both *Rugobactrites* and *Angustobactrites* have cyrtocoanitic necks. Strongly recurved or cyrtocoanitic septal necks are common among genera assigned to the Parabactritidae and to several coleoid orders, including the Aulacocerida and the Belemnitida. Flower and Gordon (1959) noted the strong similarity between the coleoid phragmocones of these orders and most of the phragmocones Shimansky assigned to the Parabactritidae (*Parabactrites, Aktastioceras, Microbactrites, Tabantoceras, and Belemnitenimus*). All of these genera are essentially smooth shelled and at that time no body chambers were known. Flower and Gordon (1959) speculated that perhaps the phragmocones described by Shimansky were exfoliated coleoid phragmocones. Erben (1964a) noted that Shimansky (1960) had documented a single body chamber for one genus (*Parabactrites*) and indicated that a smooth external shell is not limited to the coleoids. Erben went on to state, "The solution of these problems (as to whether the Parabactritidae are coleoids) depends on whether the Parabactritidae were ectocochleate or endocochleate cephalopods." The occurrence of shading patterns on two separate genera assignable to the Parabactritidae seems to offer incontrovertible proof that the Parabactritidae have external shells.

Another Mississippian specimen from the same outcrop as the previously described specimens appears to be referable to *Angustobactrites saundersi*; however, the shading pattern for *A. saundersi*, which was previously described, is much different. The conch of the single specimen is a uniform dark gray with a single longitudinal band of light gray on the dorsum. Thus, despite being nearly morphologically identical, these specimens differ in the position of their color bands. This difference in shading patterns between specimens of the same species of *Angustobactrites* may represent the first known example of color difference due to sexual dimorphism reported in fossil cephalopods.

Two types of false color or shading pattern have been detected within the bactritoid collections. The oldest material is from the Moorefield Shale (lower Chesterian) of Arkansas. The best example of this false shading pattern occurs on a specimen of *Bactrites carbonarius* Smith (Pl. 17, fig. 3). The false shading pattern is represented by narrow, dark brown, transverse bands that are periodically developed on the lateral regions of a crushed body chamber. The dark bands are well separated by lighter brown shell. Investigation of other specimens of *B. carbonarius* from the same locality reveals that the shells of some specimens have a tendency to weather selectively and that weathered external tests have conspicuous narrow transverse bands that stand out in relief (Pl. 6, fig. 13). The spacing of these high-relief transverse bands is nearly identical with the dark brown bands observed as shading patterns. These dark brown bands may in fact originally have been shading patterns, but they are probably developed in response to periodic shell thickening. Thus, the thicker the shell, the browner the band. It should be noted that growth bands do not increase in frequency near the darker bands. Therefore, the animal must have selectively thickened the shell within the body chamber in a regular pattern without slackening its rate of growth.

The second type of false color or shading pattern is developed on a Permian specimen of *Bactrites mexicanus*
Miller (Pl. 17, fig. 7). The pattern is nearly transverse and is best viewed from the dorsum. From this viewpoint, a nearly bilaterally symmetrical pattern of shell recrystallization becomes apparent. Because of its nearly bilateral symmetry, this recrystallization phenomenon could be mistaken for a shading pattern.

ABNORMAL OR PATHOLOGIC SPECIMENS

Within the collections upon which this report is based, several bactritoid specimens with abnormal morphologic features have been detected. There is also a morphologic situation that appears to be pathologic, but is in fact a product of post-depositional deformation.

A review of the paleontologic literature has revealed a number of papers dealing with abnormal cephalopods. Almost without exception, these papers have concerned ammonoids, and most deal with Mesozoic forms that exhibit shell and sutural aberrances (Deloëril, 1900; Crick, 1898, 1899, 1901, 1918; Speth, 1928, 1945; Corroy, 1932; Maubeuge, 1949; Kolb, 1955; Holder, 1956; Heller, 1958; Theobald, 1958; Guex, 1967). House (1960) discusses abnormal Devonian ammonoids and Magraw (1956), abnormal Carboniferous ammonoids. Except for the paper by House, most if not all of the above cited papers attribute morphological aberrances to illness or injury. By contrast, House (1960) considers several theories to account for the series of more or less regularly disposed pits on the internal molds of some Devonian ammonoids. He tentatively concludes that the pits were caused by pearl-like shell blisters that formed while the animal was alive and were probably caused by foreign irritant particles.

The morphologic features described in ammonoids occurs also in the Bactritoidea. It would seem logical that the causes of abnormalities in ammonoids, nautiloids, and bactritoids could be similar. Shell repairs after injury are common on bactritoids when the external shell is preserved, and occasionally even the internal molds show repaired injuries. One of the best examples of repaired breaks can be observed on Bactrites peytonensis n. sp., in which exceptional preservation of the external shell reveals that this species could sustain and repair massive breaks (e.g., Pl. 8, figs. 12–14). In contrast, Angustobactrites saundersi n. gen., n. sp., from the same locality, and with exceptionally well-preserved shell on numerous body chambers, rarely shows any kind of shell repair or damage (Pl. 8, figs. 1–6). Perhaps B. peytonensis was more attractive to predators, or was less agile, or had a less effective defensive strategy than A. saundersi. A. saundersi does show infrequent small repaired breaks. Perhaps A. saundersi was not able to sustain and repair extensive shell damage, and any kind of large scale damage resulted in death. Reasons for the difference in frequency of shell breakage and repair between these two genera are unknown, but damage and the degree to which certain cephalopod species and genera can repair themselves is variable and undoubtedly of paleobiologic significance.

Various degrees of sutural asymmetry are relatively common in ammonoids. Gross asymmetry can result from the displacement of a septum. This condition has been observed in several bactritoid specimens (Pl. 16, figs. 4–7). These discordant septa probably result from asymmetric forward movement of the posterior mantle that secreted the septum. Secretion of the septum by the irregularly placed posterior mantle took place normally and apparently completely. When it was necessary to secrete another septum, the mantle assumed the correct symmetrical position and a normally oriented septum was secreted.

A false abnormality that appears similar to the previously described case occurs in some bactritoids from the Wewoka Formation (Pennsylvanian) of Oklahoma. Lithomic internal molds of some of the bactritoids from this formation show two distinct suture patterns on the same specimen (Pl. 16, figs. 1–3; Pl. 34, figs. 9–11). The deeper grooves on the surface of the internal mold are false suture lines and represent the present position of the septa after having been displaced by telescoping; if broken, the phragmocone would separate along these septa. The original suture is marked by a shallow groove. These shallow grooves or suture lines represent the mold of the original mural part of the septum, and they form continuous circles around the phragmocone and are regularly spaced. The false suture lines are usually irregularly spaced and many do not form a continuous circle around the internal mold of the phragmocone.

Insofar as is known, the development of abnormal sutures is restricted to certain genera from the Wewoka Formation in Oklahoma (Pennsylvanian, loc. P-8). Not all specimens of these genera show mechanical distortion of the septa (and in some cases of the phragmocone cross section). Affected species have a relatively high taper rate and relatively closely spaced septa. Included are Gymno-bactrites shimanskiy gen., n. sp. and Globulo-bactrites lovadynensis n. gen., n. sp. Cephalopods such as Bactrites sinuosus n. sp. and B. reticulatus n. sp. with lower expansion rates seem to have been unaffected. The conditions under which this unusual deformation occurred are unknown, but the deformation probably took place during shale diagenesis.

The last noted bactritoid abnormality involves pitting and appears to be somewhat similar to that described by House (1960). The abnormality occurs once in a collection of more than a thousand bactrioids. This single incomplete specimen of Bactrites sp. consists of part of a body chamber with one attached camera (Pl. 16, figs. 8–11). The dorsal portion of the apical end of the camera has a series of relatively pronounced pits, located near the dorsal margin just below the mural portion of the septum. The suture line at the dorsal part of the apical end of the camera is irregular. The suture on the
ventral portion of the apical end of the camera is typical, and evenly developed. The septum separating the body chamber and the single camera is well exposed. It is similar to the previous suture in being irregularly developed on the dorsum and relatively straight on the venter. The irregular portion of the suture includes a single lateral lobe that is well-developed only on one side of the conch. Significantly, there are no pits observable on the mural parts of the septa.

The relationship between the pits that House (1960) observed on ammonoids and the pits observed on this single specimen of *Bactrites* sp. merits analysis. House (1960) made four reasonable inferences concerning the origin of the pits he observed: (1) the pits are molds of mounds that were developed during the life of the animal; (2) the pits are solid; (3) they are restricted to certain positions within the body chamber; and (4) at least some of the pits were formed periodically. House proposed several possible causes for the formation of the mounds he observed in ammonoids.

The first is that the mounds are functional; the function may have been small muscle attachment, incipient false constrictions or modified conellae. The arguments presented by House against these three possible functions are conclusive, and apply to the *Bactrites* specimen as well. The asymmetry of the mounds on both the ammonoids and *Bactrites* specimen argues against small muscle attachment. Also, all specimens should have the mounds and this is not the case. Bactritoids do not have shell constrictions and therefore, because of the similarities of the mounds of both groups, there is probably no relationship of the mounds to the ammonoid constrictions. Conellae (Holder, 1952a,b) are conical with outward directed apices; the mounds have inward directed apices and are, therefore, probably different in origin.

The second possibility is that the mounds are alien organic growths. House rejected this as a possibility because the mounds lack a discrete boundary whereas those produced by organisms such as orbiculoids have sharp boundaries. Borings are also considered and this possibility is especially noteworthy because of the reactions to boring that *Nautilus* can have (Tucker and Mapes, 1978); however, House was able to exclude this as a possibility because the external test on some of his specimens is intact. In *Bactrites* sp., the external shell is missing, but in *Nautilus* the majority of borings are located ventrally not dorsally as in *Bactrites*. Reactions in *Nautilus*, although rare, are usually massive and are not restricted to small mounds. Thus, while not conclusive, the evidence seems to point strongly to some other explanation for the formation of the pits in the specimen of *Bactrites* sp.

The last and most reasonable possibility considered by House was that of localized shell thickenings. These local shell thickenings were, according to House, either due to organic infection or inorganic irritation. House rejected the former explanation because it would not explain the regular nature of the pits if the soft tissues were considerably disrupted by varying amounts of infection. House also rejected the possibility that the mounds were caused by permanent cysts or similar structures because the position of the pits is not in agreement in successive rows. Thus, House concluded that the most likely conclusion was an inorganically or organically caused irritation that was not primarily related to the shell or the soft parts. These particulate irritants were, according to House, restricted in their passage backward in the body chamber by an unknown soft part structure.

The single *Bactrites* sp. specimen has similar pits, but an identical explanation cannot be given for the pits. That an organic or inorganic irritant not primarily related to the shell or soft parts was responsible for the pits cannot be contested. However, the sutural configuration of the *Bactrites* sp. specimen indicates the position of the irritant is limited to the dorsal surface; the dorsal surface could be either the posterior mantle margin or the outer septal surface. Because the septal surface is periodically sealed off by the addition of septa, the points of irritation must have been located on the outer surface of the mantle. Only this will explain why the suture is consistently irregular.

The cause of the points of irritation on the mantle is unknown. It seems likely that inorganic particles such as sand grains would be ejected from the mantle tissue and sealed off within the mound. If this were the case, then the mounds would not form on successive septa or influence later sutural configurations. An organic irritation such as a parasite could work its way by various means to the extreme dorsal position of the posterior mantle margin. In any event, no soft tissue barrier seems to be operating in *Bactrites* as House has suggested for the ammonoids. Substantiation of a parasite infestation is not conclusive at this time. Parasites are, however, known to occur in large numbers within the pallial chamber of *Nautilus pompilis* (Willey, 1897, p. 145). Also, the body chambers of mature specimens of *N. pompilis* sometimes show small blister pearls on the internal surface. These pearls are almost certainly foreign particles (perhaps parasites) which have been sealed away from the mantle by layers of calcium carbonate.

**BACTRITOID ONTOGENESIS**

**METHODS OF RECONSTRUCTION**

In the past, investigation of Carboniferous and Permian bactritoids has been limited to occasional descriptions of new species by North American cephalopod workers. Probably the most important reason has been the lack of complete or nearly complete material. During
the field-collecting phase of this project, it became apparent that bactritoids are normally preserved as isolated segments of phragmococones or as body chambers. Because of this, a major problem has been the reconstruction of the various ontogenetic stages of development.

The most distinctive part of many bactritoids is the protoconch and succeeding 10 chambers. If the protoconch is retained, the exact stage in the ontogeny can be determined, and direct comparison of overall diameter, protoconch width and length, cameral interval, suture configuration, and septal orientation is possible. Differences in these and other morphologic features at this early stage in the ontogeny are almost certainly of specific and generic significance. The possibility that some of these differences represent sexual dimorphism seems unlikely since the specimens represent very early stages of development.

Reconstruction of specimens past the early ontogenetic stages is difficult, and requires either specimens that show transitions between various ontogenetic stages, or more or less complete specimens. Because of this difficulty, the ontogenesis of many of the taxa established in this report is known poorly, incompletely, and sometimes perhaps mistakenly. Such is the error inherent in bactritoid reconstruction that taxonomic changes can be expected with new, more complete bactritoid discoveries.

**ONTogenetic Stages**

The most complete discussion of early bactritoid developmental stages was done by Erben (1964a,b), and terminology used by him is generally used in this report. The material analyzed by Erben was recovered from Devonian-aged strata, and the specimens described herein are from Carboniferous and Permian strata. Thus, even though similar terminology is used, there may be interpretative differences in the morphologic parameters that constitute larval, embryonic or juvenile stages. It is beyond the scope of the present report to resolve these differences, and in order to facilitate description of the taxa covered in this report, the following terms will be used (Fig. 10):

Protoconch. The first portion of the embryonic shell, the protoconch is spherical to subshperical in the Bactritida and is probably conical in the Anulobactritida. The protoconch is also the first stage of development as defined by Erben (1964a,b).

Second developmental stage. This stage may be developed only on the first chamber, which may or may not be constricted at its oral end. This is the second stage of development as defined by Erben (1964a,b).

Third developmental stage. Where detectable, this stage can show a gradual decrease in diameter (i.e., a reverse apical angle or taper rate). This decrease normally takes place three to eight septa past the second stage of development (the first chamber).

Early juvenile stage. This stage begins immediately after the reverse taper rate ends. Its apical end normally coincides with the initiation of an apical angle similar to that seen at maturity. Wrinkle-layer development, which can begin in the third development stage, is more pronounced at this stage of ontogenesis.

Middle and late juvenile stages. Transition from the early juvenile stage to middle and then to the late juvenile stage is gradual. Because no marked morphologic feature denotes the transition, the assignment of bactritoid fragments to various juvenile stages is somewhat arbitrary. Morphologic features developed in late juvenile ontogenetic stages can be quite variable; the stage may be marked, for example, by either a decrease in the intensity of ornamentation or by the beginning of ornamentation. Additionally, the mantle in the body chamber secretes carbonate that masks the wrinkle-layer in the Bactritidae.

Maturity. This developmental stage is sometimes marked by pronounced changes of ornament and wrinkle-layer pattern. It is distinctly possible that some bactritoids attained maturity without any distinctive morphologic transitional features.

First septum. This septum (also primary septum, proseptum) divides the protoconch from the first chamber (second developmental stage).

**BACTRITOID PHYLOGENESIS**

The bactritoids have been regarded as ancestors of the early Coleoidea by Hyatt and Smith (1905), Grabau (1919), and Shimansky (1954). More recently, Erben (1959, 1964a) has suggested a diphyletic origin for the different subclasses of the Coleoidea from the Bactritidae and Parabactritidae. Jeletzky (1966), in the most recent and detailed examination of this problem, agreed with Erben's conclusions, differing mainly on specifics, espe-
cially on the nature of the morphological details of Upper Mississippian Aulacocerida.

Within the collections of Carboniferous bactritoids and coleoids, approximately 30 specimens of *Hematites barbarae* Flower and Gordon, 1959 (Aulacocerida, Coleoidea) are available for study. Analysis of these specimens and of the belemnoid *Eobelemnites caneyensis* Flower provides some insights into the morphologic features that can be used to distinguish most, if not all, Paleozoic Coleoidea and Bactritoidea. These morphologic differences are listed below.

1. All known Paleozoic Coleoidea have a rostrum at maturity; bactritoids do not.
2. All coleoids known to me have internal deposits. Only some bactritoid taxa have cameral deposits. It may be possible to distinguish the phragmocones of coleoids and bactritoids by the nature of the cameral deposits, but before this can be confirmed, much additional study of the coleoids and bactritoids is necessary.

### SYSTEMATIC PALEONTOLOGY

**Subclass BACTRITOIDEA Shimansky, 1951**

*Diagnosis.*—Conch longiconic to breviconic, orthoconic to cyrtoconic; septal necks orthochoanitic to cyrtochoanitic, cameral deposits rare. Siphuncle usually marginal, may be submarginal. Protoconch subospherical to possibly bluntly conical. Apical angle variable, ranging from 1° to 34° in later stages of ontogeny.

Until the early 1950’s the subclass Bactritoidea was considered somewhat less diverse than the other major groups of straight cephalopods. At that time, most of the work on this group had centered on the relationship between the early Bactritida and primitive Devonian ammonoids (Schindewolf, 1933; Erben, 1960, 1964a,b). To some extent, this trend is continued by Russian workers today (Bogoslovsky, 1972). However, Shimansky, in a series of papers beginning in 1948, reported extensively on the bactritoids from Permian and Carboniferous strata in the Soviet Union. His work has shown that this subclass is more diverse than generally realized.

In North America, little work has been done on the Carboniferous and Permian Bactritoidea. The first report of a Carboniferous species from North America was by Smith (1903). A few years later, Girty (1909) described several more Carboniferous taxa. A. K. Miller and his co-workers recorded several species in a series of papers published in the 1930’s and 1940’s. The latest work on North American Carboniferous bactritoids is by Gordon (1957, 1964, 1965), who reported on taxa from several localities. In his 1965 monograph, he summarized the then-known Carboniferous taxa from Arkansas and included an essentially complete list of references to Late Mississippian—Early Pennsylvanian occurrences.

3. Every family of the Bactritoidea (except the Sinuobactritidae n. fam. of the present report) has the wrinkle-layer developed on the dorsum. The specimens assigned to the Sinuobactritidae are in the embryonic and early juvenile stages of development; therefore, the lack of wrinkle-layer in this family may be due to the ontogenetic stage of development represented and possibly to preservation. Numerous well-preserved phragmocones of *Hematites* were examined and in no instance was the wrinkle-layer discovered. Additionally, insofar as can be determined, no worker has mentioned the wrinkle-layer as occurring on the internal mold of a coleoid phragmocone. Thus, the presence or the absence of the wrinkle-layer may be a decisive factor in the separation of bactritoid and coleoid phragmocones.

4. Septal orientation within the Bactritoidea is variable. Some taxa have transverse septa while others have inclined septa at some stage of their ontogeny. Insofar as is known, all Paleozoic coleoids have transverse septa throughout their ontogeny.

**The most recent summary works have been by Shimansky (1962) and Erben (1964a,b).** Examination of

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**Fig. 11.** Diagrams of the four distinctive patterns recognized in early ontogeny of the Bactritoidea.——*A*, Bactritidae; *B*, Para-bactritidae; *C*, Sinuobactritidae; *D*, Annulobactritidae. This last family is placed in the new order Annulobactritida. Many morphologic details of these generalized ontogenies are variable, including siphuncle position, septal spacing, suture pattern, and septal orientation. Not to scale, but A-C approximately ×11, D approximately ×5.
these summaries and comparisons of the thousands of microscopic and megascopic specimens involved in the present report indicate that this subclass is even more complex than recent studies had indicated. One of the most important conclusions of the present study is that there are four basic ontogenetic patterns recognizable within this subclass (Fig. 11). Within each of these ontogenetic patterns, the generalized pattern of early ontogenetic development (Erben, 1964a,b) can be recognized. Variation of such morphological features as septal spacing and protoconch configuration does occur in the early ontogeny of each morphotypic grouping, but the overall ontogenetic patterns remain more or less discrete. These variations are described and illustrated under the familial discussions. Of note are the phylogenetic similarities between the forms shown as A, B, and C in Figure 11, and the strikingly different form D. Forms A, B, and C appear to be phylogenetically related and fit well into the Bactritida. Form D does not seem to belong phylogenetically or morphologically to an existing order and consequently is referred to the new order Annulobactritida.

Range.—?Silurian, Lower Devonian to Upper Triassic.

Order BACTRITIDA Shimansky, 1951

Diagnosis.—Protoconch subspherical to globular. Cameral deposits rare. Conch orthococonic to cyrtoconic. Siphuncle generally marginal.

Recent workers on the Bactritida have divided this order into various superfamilies and families. Shimansky (1962, 1968) advocated the recognition of two superfamilies: the Bactitae (Hyatt, 1884), and the Parabactritidae (Shimansky, 1951). Within the Bactritae, Shimansky utilized four families: the Bactritidae (Hyatt, 1884), the Lobobactritidae (Shimansky, 1962), the Bojobactritidae (Horny, 1957), and the Ctenobactritidae (Shimansky, 1951). Erben (1960, 1964a,b) reduced the two superfamilies to familial status. In addition, he rejected the family Ctenobactritidae because he did not consider the presence or absence of ribs as a familial character; this necessitated reassignment of Ctenobactritidae Shimansky, 1951, to the Bactritidae.

The family Bojobactritidae was established on the basis of growth lines and peristome shape. As Erben (1964a) indicated, growth lines and the peristome are morphologic features that are only significant at the generic/species level; for this reason Erben suppressed the Bojobactritidae and reassigned Pseudobactritidae [Bojobactritidae (Horny, 1957) is considered a junior synonym of Pseudobactritidae Ferronnière, 1921] to the Bactritidae.

Erben (1964a,b) also rejected Shimansky’s Lobobactritidae. Lobobactritidae, the type genus of the family, is a conspicuously different taxon because of its sinuous sutureal configuration and compressed cross section. This genus is apparently the transitional form between the morphologically less complex Bactrites and the cyrtoconic bactritoids that eventually gave rise to the Ammomoida. Rejection of this family is not warranted because the group appears to comprise a discrete offshoot of forms that are not involved in the main evolutionary line of the Bactritidae.

Clausen (1968) briefly reviewed and rejected the classifications of Flower (1962) and Gordon (1965), accepting those of Erben (1960, 1964a,b) and Shimansky (1962) as being the most “natural.” The Engorthoceratidae (Flower 1962) has as its type genus Engorthoceras, for which the type species is Orthoceras wortheni; Meek and Worthen. A review of Meek and Worthen (1865) fails to reveal a cephalopod named O. wortheni; however, they did name a cephalopod with a submarginal siphuncle, O. winchelli. Assuming that O. winchelli is the species to which Flower referred, this family must be suppressed because it lacks a valid type genus.

Insofar as can be determined at this time, Erben’s classification is the most “natural” and will be followed with some modifications in the present report.

Range.—Silurian?, Lower Devonian to Upper Triassic.

Family BACTRITIDAE Hyatt, 1884

Diagnosis.—Conch longicoconic to cyrtoconic with orthocoanitic septal necks. Cameral deposits rare or absent. Apical angle usually 10° or less, and cameral ratio is usually between 0.8 and 2.1.

Recent workers have differed strongly in the assignment of genera to the Bactritidae. Shimansky [1954, 1962 (transl. 1974), 1968] placed Bactrites Sandberger (1843), Devonobactrites Shimansky (1962), Hemibactrites Shimansky (1954), and Sicilliceras Shimansky (1954) in this family. Erben (1964a) considered the following genera as belonging to this family: Bactrites, Ctenobactrites, Cyrtobactrites Erben (1960), Eobactrites Schindewolf (1932), Kokenia Holzapfel (1895), Lobobactrites Schindewolf (1932), Pseudobactrites Ferronnière (1921), and Sicilliceras. More recently, Bogoslovsky (1972) described Metabactrites, which has a cyrtoconic phragmocone. Orbobactrites n. gen. is assigned to this family because of its bactritoid morphology and ontogeny.

Erben’s assignments seem to be the most reasonable with some reservations, namely, that Lobobactrites, Cyrtoactrites, Metabactrites, and Kokenia should be assigned to the family Lobobactritidae. Lobobactrites has an oval cross section, and its distinctive sutureal pattern has a well-developed lateral lobe. Cyrtobactrites, Meta-

bactrites, and Kokenia can be distinguished from Bac-
trites and Lobobactrites by the possession of cyrtoconic phragmocones.

*Sicilioceras* was established with presence of longitudinal ridges as the distinguishing characteristic. By itself, longitudinal ornament should probably not be considered a morphologic feature of generic rank. The single illustrated specimen of the type species (Gemmellaro, 1889, Pl. 11, fig. 1-3) has the features of a *Bactrites* with longitudinal ornament; on that basis, *Sicilioceras* can be suppressed as a junior synonym of *Bactrites*.

*Devonobactrites* has dorsoad inclination of sutures with a cameral ratio of 3 to 4.5. Erben (1964a) questioned the validity of this taxon for two reasons. The first was that certain species of *Bactrites* are known to vary in septal orientation within a single specimen. The second reason was his conclusion that closely spaced septa are (Erben, 1964a, p. K503) “...caused here by normal crowding of sutures in late ontogenetic stages, which occurs in all euctocochleate cephalopods.” Septal crowding does occur in almost all euctocochleates during the late ontogenetic stages; however, in no instance is it known to affect more than the last several камер. Illustrations of the holotype of type *Devonobactrites* (Erben, 1964a, p. K503, fig. 361, 2a,b) portray a total of 17 septa that are more or less equally spaced and an incomplete body chamber. Because the more or less equally spaced septa are without noticeable septal crowding, it is unlikely that this specimen is in a late ontogenetic stage. Additionally, it would probably be incorrect to interpret all 17 septa as representing an example of septal crowding at maturity. Admittedly, some variation can be detected in septal spacing of the illustrated specimen; however, this is considered minor and well within the range of variation exhibited by other bactritoids. In any event, *Bactrites* can be distinguished by its longer camerae.

Suppression by Erben (1964a) of *Hemibactrites* as a junior synonym of *Bactrites* does not seem warranted because the siphuncle in *Hemibactrites* never became marginal and, therefore, the suture lacks a ventral lobe. Some variation in the amount of development of a ventral lobe within the same specimen has been noted, but no specimen has been observed where the siphuncle varies its position from marginal to subventral during later ontogenetic stages. However, Erben (1964a, p. K495) indicated that gerontic specimens with subventral siphuncles and “regressive” ventral lobes are known. Insofar as is known, specimens with subventral siphuncles in late ontogenetic stages are confined to the Middle Devonian, while *Hemibactrites* has been recovered only from Permian strata. In any event, the species assigned to *Hemibactrites* cannot be interpreted reasonably as gerontic, and for this reason *Hemibactrites* is considered a valid genus.

*Ctenobactrites* has transverse ribs on the external shell which distinguish this genus from all others. However, as has been previously stated, this genus should be reassigned to the Bactritidae. Shimansky (1954, p. 80-81) recognized that this form is nearly identical to *Bactrites* except for the transversely inclined ribs on the external shell.

*Pseudobactrites* has well-developed, distinctive growth lines and peristome development which are unique to this genus. In other respects, it is similar to *Bactrites*.

Erben (1964a,b) and Clausen (1968) correctly questioned the validity of *Cyclobactrites* because similar appearing bactritoid segments with ribs are known to occur within the ontogenies of described species of Devonian *Bactrites* and *Lobobactrites*. Erben (1964a) also expressed reservations concerning the assignment of *Chocchleiferoceras*. The illustration of the holotype of *Chocchleiferoceras* (Erben, 1964a, p. K503, fig. 361, 2a,b) shows a marginal siphuncle, whereas the suture does not reflect a ventral lobe. Similar conditions occur in *Hemibactrites*. In addition, the apical angle and the cameral ratio of the holotype suggest a closer relationship to the Bactritidae than to the Parabactritidae. For these reasons, it would seem reasonable to assign *Chocchleiferoceras* to the Bactritidae until additional specimens can be studied.

In regards to the early ontogenetic variation observed within the ontogenetic pattern of the Bactritidae, the Devonian specimens described and illustrated by Clausen (1968, p. 43) appear to represent high species diversity. The interpopulation variability for these Devonian forms is unknown. The early ontogenetic stages of bactritoids studied from Upper Mississippian and Pennsylvanian strata are also highly diverse, and the interpopulation variability is generally slight in each of the morphotypes (Fig. 12). Because of this interpopulation morphological stability, the early ontogenetic stages of the Carboniferous Bactritioidea provide a useful link for ontogenetic and faunal reconstructions. Unfortunately, these Carboniferous forms are of limited use at this time as biorstratigraphic indicators because they remain poorly known on a regional basis.

**Range.**—Silurian?, Lower Devonian to Upper Triassic.

**Genus BACTRITES** Sandberger, 1843

**Type species.**—*Bactrites subconicus* Sandberger, 1843; OD.


**Diagnosis.**—Protoconch spherical to subcircular, siphuncle marginal by end of fifth camera, remaining marginal throughout ontogeny. Conch orthocochleate, cross section circular to slightly compressed, apical angle 1° to 10°. Sutures varying from simple to sinuous, septa directly transverse to inclined. Cameral ratio rang-
Gordon (1965) provided a comprehensive discussion of *Bactrites* and a more or less complete synonymy for Carboniferous forms of this genus. He indicated that restudy of the type species of *Bactrites* was necessary, and consequently referred to the taxa as "*Bactrites?*." Clausen (1968) subsequently restudied the type of *Bactrites*; based on his reference, the Carboniferous Bactritidae in the present report are related to the type *Bactrites*.

The following Carboniferous and Permian species have been assigned to *Bactrites* by Miller (1944), Gordon (1965), and/or Shimansky (1954, 1968): *B. adrianensis* Gemmellaro, 1889; *B. carbonarius* Smith, 1903; *B. cherokeensis* Miller and Owen, 1934; *B. collinsi* Miller and Unklesbay, 1947; *B. gaitherensis* Gordon, 1965; *B. longocameratus* Shimansky, 1954; *B. mexicanus* Miller, 1944; *B. nevadense* Youngquist, 1949a; *B. paternoi* Gemmellaro, 1889; *B. postremus* Miller, 1930; *B. quadrilineatus* Girty, 1909; *B. redactus* Gordon, 1965; *B. sagitta* deKoninck, 1851; *B. sempiternus* Shimansky, 1954; *B. smithianus* Girty, 1909; *B. steinhaueri* Sowerby, 1812; *B. ulugonensis* Shimansky, 1954; and *B. wintersetensis* Miller, Lane, and Unklesbay, 1947. Additionally, Hansman (1955) coined three new names for three taxa that he referred to *Bactrites*. One of these names, *B. gaitherensis*, was validated by Gordon (1965). Both workers used the same specimen as the holotype. Of the remaining two taxa, one is described herein as *B. oweni* n. sp. (= *B. oweni* of Hansman) and the other is *Rugobactrites variabilis* n. gen., n. sp. (= *B. nevadense* of Hansman).

*Rugobactrites* has recurved septal necks, a large apical angle, and a comparable but significantly different ontogeny from that of the Bactritidae. It is, therefore, assigned to the Parabactritidae.

Examination of the species referred to this genus indicates that *Bactrites nevadense* from the Chesterian (Mississippian) of Utah is not a true *Bactrites*. Shimansky (1954, p. 84-85) noted the resemblance of *B. nevadense* to *Aktasitocras* Shimansky, 1948, and *Parabactrites* Shimansky, 1948, in supposedly lacking a ventral lobe and in the close spacing of the septa, but he retained the generic assignment (1954, p. 25). Gordon (1965, p. 102) removed *B. nevadense* from *Bactrites*, noted Shimansky's observations, and indicated the species could be a coleoid. Examination of *Hematites*, an upper Chesterian (Mississippian) coleoid, indicates that the shell structure is thinner and has a greater tendency to split into different layers than the shell of *B. nevadense*. However, this dissimilarity between *B. nevadense* and *Hematites* could be a function of preservation.

Examination of the types of *B. nevadense* reveals a suture with lateral lobes and a V-shaped ventral lobe; septal necks are cyrtochoanitic. In view of these morphologic observations, *B. nevadense* is reassigned to *Rugobactrites* n. gen. and is described under the Parabactritidae.

In 1944, Miller referred *Orthoceras adrianense* Gemmellaro, 1889 and *Orthoceras paternoi* Gemmellaro, 1889 to *Bactrites*. However, Shimansky differed in his evaluation of these taxa, assigning *O. adrianense* to his newly established *Hemibactrites* and *O. paternoi* to his new genus *Sicilioceras*. While it is impossible to reexamine the original specimens in question at this time, it would appear that both assignments have merit; however, *O. paternoi* (= *Sicilioceras*) is best considered a *Bactrites* with longitudinal ornament, and *O. adrianense* is referable to *Hemibactrites*.

Analysis of *Orthoceras sagitta* deKoninck, 1851 and *O. steinhaueri* Sowerby, 1812 is even more difficult. On the basis of the original description by Sowerby (1812,
p. 132), *O. steinhaueri* does not appear to have a marginal siphuncle, and on this basis it is probably not a *Bactrites*. However, the possibility that it could be a very primitive *Hemibactrites* cannot be ignored. *Orthoceras sagitta* is even more problematical. The illustration by deKoninck (1851, p. 703, pl. LIX, fig. 3a,b) clearly indicates a specimen with a subventral siphuncle. However, in 1880, deKoninck (p. 52, pl. 38, fig. 4a,b) illustrated a specimen as *O. sagitta* which has a marginal siphuncle. Schmidt (1956) failed to recognize the difference between these two specimens. Resolution of the correct identification of this latter taxon must await new data; however, that the latter specimen is referable to *Bactrites* appears to be certain.

Because *Bactrites* has been largely neglected in North America, a number of new species are recognized in the present report. These are: *Bactrites ahlosoensis* n. sp., lower Chesterian-Mississippian; *B. costatus* n. sp., upper Virgilian-Pennsylvanian; *B. elcopitanensis* n. sp., lower Permian; *B. fayettevillensis* n. sp., middle Chesterian-Mississippian; *B. finnisensis* n. sp., lower Virgilian-Pennsylvanian; *B. milleri* n. sp., upper Chesterian-Mississippian; *B. oweni* n. sp., Desmoinesian-Pennsylvanian; *B. peytonensis* n. sp., upper Chesterian-Mississippian; *B. reticulatus* n. sp., middle Desmoinesian-Pennsylvanian; *B. sanzhaensis* n. sp., upper Chesterian-Mississippian; *B. sinuosus* n. sp., middle Desmoinesian-Pennsylvanian; *B. smithwickensis* n. sp., upper Atokan-Pennsylvanian; and *B. woodi* n. sp., upper Missourian-Pennsylvanian.

**Range and distribution.**—Questionable Silurian occurrences of *Bactrites* have been reported (Erben, 1964; Shimanisky, 1954, 1962; Termier & Termier, 1950; and others). *Bactrites* had a cosmopolitan distribution especially during the Devonian; specimens have been recovered from Australia, Europe, Africa, and North America (Erben, 1964; Shimanisky, 1954, 1962). Carboniferous occurrences are known from Belgium and Germany and are widespread in Chesterian rocks in North America (Kentucky, Arkansas: Smith, 1903; Oklahoma: Girty, 1909; Texas, Nevada: Youngquist, 1949a; Utah and Alaska: Gordon, 1957). Pennsylvanian occurrences are known from Peru (Thomas, 1928) and the Southern Ural (Shimanisky, 1968); however, the majority of such occurrences are known from central North America: Arkansas (Morrowan: Gordon, 1965), Oklahoma (Morrowan, Desmoinesian, Missourian), Texas (Atokan, Desmoinesian, Missourian, Virgilian: Miller, 1930), Kansas (Missourian), and Missouri (Desmoinesian: Miller & Owen, 1934: Miller, Lane & Unklesbay, 1947). Additionally, a Pennsylvanian occurrence has been reported (Miller & Unklesby, 1947) from Pennsylvania. Permian (Sakmarian) occurrences are known from the Southern Ural (Shimanisky, 1962) and from northern Mexico (Miller, 1944) and West Texas.

**BACTRITES AHLOSOENSIS** Maps, new species

Plate 4, figures 1-6, 11, 17-21; Plate 11, figures 2, 3

**Diagnosis.**—Phragmocone relatively rapidly expanding (7°-10°), with fine transverse wrinkle-layer. Cameral interval about 2. Test smooth except for fine growth lines, cross section essentially circular throughout ontogeny.

**Description.**—This species is represented in the collection by eight well-preserved phragmocones and body chambers, which retain at least part of the test. Nine more specimens are referred to this species with reservation. A single protoconch (Pl. 11, figs. 2,3) is assigned with reservations on the basis of frequency of association. One probably mature body chamber (Pl. 4, figs. 18-20) retains the peristome and has a well-developed muscle scar at the apical end. Thus, within the possibility of reconstructional error, all ontogenetic stages of this species are available for study.

The early portions of the phragmocone are poorly known because observations are limited to the single, partially complete protoconch-bearing specimen. The first two chambers form an apical angle of 13°. Later ontogenetic stages have a relatively high rate of expansion (7°-10°; Pl. 4, figs. 4-6,11). Throughout the ontogeny, the cross section remains essentially circular.

The protoconch believed referable to this species is globular and nearly spherical, with the length slightly less than the width. The external shell is generally smooth; however, at the constrictions corresponding to the first and second septa, there are faint, fine, discontinuous longitudinal lirae.

Constrictions in this species form only during early ontogenesis. The first constriction occurs at the oral end of the protoconch and the second constriction is at the oral end of the first camera.

The wrinkle-layer is transverse to the long axis of the conch. It is observable in the early ontogenetic stages as impressions on the internal mold. At a diameter of 2.5 mm, it forms relatively shallow transverse grooves around the entire circumference of the internal mold. The pattern persists to within 2 mm of the mature peristome (D = 7.6 mm; Pl. 4, fig. 17). The pattern is also missing on the muscle scar area at the apical end (D = 11.6 mm) of the mature body chamber (L = 28.5 mm).

The suture is transverse with a ventral lobe. Camerae are relatively closely spaced with the camera interval being approximately 2:1. Cameral internal deposits have not been observed.

*Bactrites ahlosoensis* is found in immediate association with *B. quadrilineatus*. The latter species has a sharply inclined wrinkle-layer, longitudinal ornament, and a compressed cross section at maturity; thus it differs markedly from *B. ahlosoensis*, which has a transverse wrinkle-layer, essentially no ornament, and a circular cross section. *B. carbonarius* also has an inclined wrinkle-layer. *B. smithianus* has a transverse wrinkle-layer, but the cameral interval is much less (0.8-1.1), the apical angle is smaller (2°-3°), and the cross section is oval. *B. fayettevillensis* n. sp. also has a transverse wrinkle-layer and a circular cross section; however, this species has a lower cameral interval (1.2 to 1.3).

Of the over 20 megascopic representatives of *Bactrites* recovered from the Caney Formation, only eight can be confidently assigned to *B. ahlosoensis*. Significantly, of the forty *Bactrites* sp. protoconchs recovered from the
Orthoceras carbonarius

Within the collections, there are six additional megascopic specimens that can probably be referred to B. ahlosoensis. Three are from the same exposure that yielded the holotype and all other specimens of B. ahlosoensis. Two (SUI 43636, 43637) are identical to B. ahlosoensis in every detail except size. Both specimens are significantly larger than the previously described mature body chamber; one specimen (SUI 43636) attains a maximum dorsoventral diameter of 14.5 mm and the other (SUI 43637) has an estimated maximum diameter of 9.5 mm. These larger specimens may represent sexual dimorphism.

Another specimen (Pl. 4, figs. 1-3) is an incomplete body chamber that has a slightly larger diameter (9.2 mm) than the topotype body chamber (Pl. 4, figs. 17-20). This slightly larger specimen (SUI 43638) has a well-developed muscle scar, a ventral groove, two dorsolateral grooves, and several (three?) layers on which the wrinkle-layer is developed. This specimen is unique within the collections and may represent a new species.

Also within the collections are three specimens (SUI 43639-41), from the Moorefield Shale in Arkansas that are questionably referable to B. ahlosoensis. These specimens, which are found in association with B. carbonarius, are morphologically similar to B. ahlosoensis except that their expansion rate is much lower (2.5).

Etymology.—The species is named for the community of Ahloso, Pontotoc County, Oklahoma.

Occurrence and repository.—Nine specimens of B. ahlosoensis were recovered from the Delaware Creek Member of the Caney Formation (lower Chesterian-Mississippian) near Ada, Oklahoma. Three specimens were recovered from the Moorefield Shale near Batesville, Arkansas. Locality M-1 yielded 6 specimens, locality M-2 yielded 1 specimen, and locality M-11 yielded 3 specimens.

BACTRITES CARBONARIUS Smith, 1903

Plate 6, figures 4-6, 13; Plate 10, figures 1-2;
Plate 12, figures 1,2, 5-7; Plate 17, figure 3

Bactrites carbonarius Smith, 1903, p. 31-32, Pl. 6, figs. 9-11; Girty, 1911a, p. 96, Pl. 13, figs. 3-5; Miller, Youngquist, & Nielsen, 1952, p. 152-153, Pl. 25, figs. 17, 18; Gordon, 1957, p. 20-22, Pl. 1, figs. 10-13; Gordon, 1964, p. 8, Pl. 1, figs. 10-12; Gordon, 1965, p. 103-104, Pl. 5, figs. 10-12.

Orthoceras sp. b Girty, 1911, p. 96 [part].
Orthoceras carbonarius (Smith) Thomas, 1928, p. 290, Pl. 10, figs. 3, 3a.
The assignment of the single specimen (Pl. 33, figs. 4, 6, 7) to this species is made with strong reservations. It is distinctly possible that this specimen represents a new species or even a new genus. However, it seems advisable not to erect a new taxon until additional material with adequate locality data becomes available.

**BACTRITES COSTATUS** Mapes, new species

Plate 31, figures 7-9, 13

Diagnosis.—Longiconic bactritoid with transverse lirae. Description.—*Bactrites costatus* is represented in the collection by 29 incomplete phragmocones that are in various stages of juvenile development, and one specimen that is interpreted as being mature. The embryonic phragmocone remains unknown.

In the juvenile stages, the phragmocone is slightly compressed and has an apical angle ranging from 5° to 7°. Septa are directly transverse, and the suture is simple with a ventral lobe. The cameral ratio ranges from 1.2 to 1.7. Ornament on the juvenile specimens consists of closely spaced, raised, transverse lirae, about 10 to 12 in 1 mm. This ornament is present from diameters 5 mm to 18 mm. A single specimen with a diameter of about 22 mm has a different ornament and is considered to be mature. This specimen has a small piece of test adhering to the ventrolateral surface of the phragmocone; the test is ornamented with broad, flat-bottomed, shallow striae approximately 2 mm wide. Internal deposits have not been detected. The wrinkle-layer is transverse wavy lirae and is somewhat coarser (9 to 10 lirae per millimeter) than the transverse, straight lirae of the juvenile ornament.

*Bactrites costatus* is morphologically most similar to *B. postremus*; however, this latter species lacks ornament and has a slightly smaller apical angle. Other bactritoid taxa that occur in similar aged units include *B. finiensis*, *B. elcapitanensis* n. sp., and *B. woodi*. *B. finiensis* is distinguishable from *B. costatus* by its dorsal carina and lack of ornament. *B. elcapitanensis* has longitudinal rather than transverse ornament seen on *B. costatus*. Comparison of *B. woodi* is difficult because similar stages of the ontogeny cannot be compared; however, insofar as is known, *B. woodi* lacks ornament.
**BACTRITES ELCAPITANENSIS** Maps, new species

Plate 36, figures 3, 4, 7-9

*Diagnosis.*—Longiconic bactritoid with longitudinal ornament. Septa inclined dorsorad and cameral ratio moderately large (1.7).

*Description.*—Bactrites elcapitanensis is represented in the collections by two incomplete phragmocones that have maximum diameters of 23 mm and 34 mm. The embryonic and early juvenile stages of development are unknown. It is possible that the largest specimen is mature, but there are no indications of a mature modification.

The phragmocone is slightly compressed. Septa are inclined dorsorad at an angle of about 10°; however, the suture is relatively simple with only shallow lateral lobes. The cameral ratio is 1.7, and the apical angle is 6°. The test is ornamented with well-developed longitudinal striae that are about 2 mm wide on the largest specimen. Neither growth lines, cameral deposits, or wrinkle-layer has been detected on either specimen.

*Bactrites elcapitanensis* is most similar to "Orthoceras" paternoi illustrated by Gemmellaro (1889, Pl. 11, figs. 1-3). However, this latter species from the Permian of Sicily has a smaller apical angle (4°?) and cameral ratio (approximately 1.3). Additionally, the ornamentation is not as coarse as that on *B. elcapitanensis*. Other taxa similar to *B. elcapitanensis* are *B. postremus*, *B. oweni*, and *B. finisensis*. *Bactrites postremus* is distinguished from *B. elcapitanensis* by its smooth test; *B. oweni* has a smaller apical angle and cameral ratio; and *B. finisensis* has a dorsal carina.

*Etymology.*—This species is named for the topographic feature called "El Capitan" in West Texas near which the specimens were collected.

*Occurrence and repository.*—The specimens of *B. elcapitanensis* (SUI 43881, 43882) were collected from the Bone Springs Limestone (Permian) near the foot of El Capitan in West Texas (loc. PR-1).

**BACTRITES FAYETTEVILLENSISS Maps, new species**

Plate 9, figures 9-11; Plate 10, figures 6-8; Plate 13, figures 1, 7, 8, 11, 12, 14-16; Plate 14, figure 9; Plate 15, figures 1, 2, 6, 7, 12-14

*Diagnosis.*—Longiconic bactritoid with a coarse transverse wrinkle-layer during early juvenile stages; longitudinal ornament restricted to protoconch and vicinity of first constriction.

*Description.*—Bactrites fayettevillensis is represented within the collections by 96 well-preserved protoconchs and phragmocones. The most ontogenetically advanced portions of the available phragmocones are in the early stages of juvenile development.

The protoconch is ovoid with the width somewhat greater than the length. The posterior end of the protoconch is bluntly pointed, and the anterior end is sharply constricted. The first constriction occurs at the first septum; the constriction is abrupt and deep. The oral portion of the first chamber has only a slight constriction. Ornament consisting of coarse longitudinal lirae separates finer lirae (Pl. 13, figs. 7,8,11,12), then dies out on the apical end of the first chamber. The first through third chambers have an apical angle of 15°. The oral end of the third chamber and the apical end of the fourth chamber mark the maximum diameter attained during embryonic development. From this maximum dimension until the end of the third embryonic developmental stage, the early phragmocone has a reverse apical angle of about 3°.

The early juvenile ontogenetic stages have a low apical angle (2° to 5°). Insofar as is known, there is no ornament during this stage of development. The cameral interval in the juvenile stage is relatively low (1.2 to 1.3). Septa are slightly inclined dorsorad in the later ontogenetic stages. The sutural configuration is simple, with only a ventral lobe at the position of the siphuncle. The phragmocone is essentially circular. The wrinkle-layer is well developed by the end of the third embryonic stage; it is transverse, and relatively coarse in comparison to the wrinkle-layer seen in *B. carbonarius* or *B. milleri* n. sp. Additionally, it forms wavy patterns.

Embryonic specimens of *B. fayettevillensis* from the Imo Formation (upper Chesterian), differ somewhat from those of the Fayetteville Formation (middle Chesterian). This latter group has a more gradual reverse apical angle, the protoconch is usually slightly smaller, and the convolutions are not so pronounced as in the embryonic specimens from the Imo Formation. Overall, these differences do not seem to warrant the erection of a new species.

Mature phragmocones of *B. fayettevillensis* are unknown. *Ctenobactrites lesliensis* n. sp., a contemporaneous species, is known only from relatively mature segments and has conspicuous, more or less transverse ridges or convolutions on the external shell. Some bactritoids are known to develop ridges during the later stages of ontogenetic development, and it is possible that *C. lesliensis* is in fact the mature end of the juvenile *B. fayettevillensis*. However, this must remain speculative in the absence of intermediate growth stages.

*Bactrites fayettevillensis* is most similar to *B. carbonarius*, *B. smithianus*, *B. ahlosoensis*, *B. milleri*, and *B. peytonensis*. However, *B. fayettevillensis* is distinguishable by a wrinkle-layer that is distinctly coarser than that of any other bactritoid except perhaps *B. quadrilineatus*. This latter taxon together with *B. carbonarius* and *B. milleri* has angular wrinkle-layers whereas *B. fayettevillensis* has a transverse wrinkle-layer. *Bactrites ahlosoensis* has a larger apical angle and a greater cameral ratio. *Bactrites smithianus* and *B. peytonensis* have longitudinal ornament whereas the test of *B. fayettevillensis* is smooth.

*Etymology.*—This species is named for the community of Fayetteville, Washington County, Arkansas.

*Occurrence and repository.*—The following localities in the Imo and Fayetteville formations (Chesterian-Mississippian) have yielded specimens: M-16, M-22, M-25B, M-25C, M-25D.
BACTRITES FINISENSIS Maps, new species
Plate 23, figures 4-6

Diagnosis.—Longiconic bactritoid with a dorsal carina and longitudinal striae in early juvenile developmental stages, smooth shell during later ontogenetic stages, well-developed transverse wrinkle-layer, and a relatively simple suture.

Description.—Bactrites finensis is represented in the collections by four specimens. One of these is in the early juvenile stage of development and the remaining three are in the middle and late juvenile developmental stages. The embryonic and mature developmental stages are unknown.

The single specimen of B. finensis (SUI 43979) in the early juvenile stage of development (D = 2.8 mm) is a limonitic internal mold of the body chamber. The longitudinal flat zones and a dorsal ridge on the internal mold suggest that the original test was ornamented with longitudinal striae and a dorsal carina. The terminal septum on this specimen indicates the suture is simple with a ventral lobe. The septum is directly transverse. The wrinkle-layer is not present on the internal mold of this specimen, and no internal deposits can be detected.

The three specimens that represent the middle and late juvenile stages of development range in diameter from 21 mm to 33 mm. All have directly transverse septa, and all have the same suture pattern as the previously described juvenile specimen. The apical angle ranges from 5° to 8°, and the cameral ratio from 1.5 to 1.7. The external shell is smooth except for a sharp carina on the dorsal. There are no discernable cameral deposits. The wrinkle-layer consists of a series of transverse wavy lirae that is developed on the inner shell layer and not on the internal mold.

Bactrites finensis occurs with B. postremus. This latter species is distinguished from B. finensis by the lack of a dorsal carina. Other taxa which appear similar to B. finensis are B. mexicanus and B. petyonensis. Bactrites mexicanus differs from B. finensis by having a moderately deep dorsal saddle, and B. petyonensis differs by having well-developed longitudinal ornament.

Assignment of the single early juvenile specimen (SUI 43979) to B. finensis is made with reservation. The presence of longitudinal ornament and the lack of a well-developed wrinkle-layer support the suspicion that this specimen could belong to a different taxon; however, such a reassignment must await the recovery of additional, more complete material.

Etymology.—This species is named for the Finis Shale Member of the Graham Formation, which has yielded all of the known specimens of the species.

Occurrence and repository.—All of the specimens are from the Finis Shale Member of the Graham Formation in northcentral Texas at localities P-23 and P-24.

BACTRITES GAITHERENSIS Gordon, 1965
Plate 23, figures 3, 7; Plate 31, figures 4-6; Plate 35, figures 4, 8, 12
Bactrites sp., Miller and Moore, 1938, p. 344, Pl. 43, fig. 5.

Diagnosis.—Phragmocoone longiconic with low cameral ratio (0.9 to 1.6), transverse septa, and shallow lateral saddles in suture.

Description.—The original description of B. gaitherensis was based on four fragmentary phragmocones. Additional collecting has added three specimens that seem to expand the concept of the species. The early embryonic shell remains unknown, although it is probably included herein in the morphotype descriptions.

The phragmocone in the earlier juvenile stages (D = 6 mm) have a low apical angle (2° to 3°) and low cameral ratio (0.9 to 1.6). The test is generally smooth; however, on two specimens (SUI 43867) faint longitudinal striae can be detected. The phragmocone is compressed. The septa are transverse with a simple sutural configuration. Later juvenile stages (D = 20 mm to 44 mm) have greater apical angles (up to 7°) and have septa that are inclined slightly dorsosapacid. Because of these inclined septa and the slightly compressed phragmocone, the sutural configuration develops slight lateral saddles in addition to the ventral lobe. Internal deposits and the wrinkle-layer have not been observed on the available specimens.

Bactrites gaitherensis occurs together with B. redactus; however, this latter species can be distinguished by its larger cameral ratio and the sutural configuration. Other bactritoids that are similar to B. gaitherensis are B. postremus Miller, B. milleri n. sp., B. smithwickensis n. sp., B. sinuosus n. sp., and B. woodi n. sp. Bactrites postremus differs from B. gaitherensis by having a well-developed wrinkle-layer, a slightly larger cameral ratio (1.1 to 1.7), and septa that are transverse throughout ontogeny. Bactrites smithwickensis has a higher cameral ratio (approximately 2.0) and B. sinuosus has well-developed dorsal saddle and lateral lobes. Comparison of B. reticulatus and B. woodi to B. gaitherensis is difficult because both are known from only the early juvenile stages of development; however, both appear to have more complex sutures than B. gaitherensis.

There are some differences of interpretation of the ornament on the paratypes of B. gaitherensis. Gordon (1965) noted that although the shell of one specimen (USNM 120644) showed signs of wear before burial, he believed the test was originally smooth. Close examination of this paratype shows the test to have faint longitudinal striae that probably reflect the original ornament. Two additional specimens from the Gene Autry Formation in Oklahoma (Morrowan–Pennsylvanian) are considered to be conspecific with type B. gaitherensis. Both specimens have well-developed longitudinal ornament.

Occurrence and repository.—Holotype SUI 1984 and a topotype (USNM 120644) were collected from Gaither Mountain near Harrison, Arkansas (loc. P-3). Two paratypes (SUI 43867) came from the Gene Autry Shale in Oklahoma (loc. P-1). Additionally, USGS loc. 15788 yielded paratype USNM 120646, and USGS loc. 1999 yielded paratype 120645. Details concerning these two different localities are given by Gordon (1965). One further specimen (SUI 43872) was recovered from the Hale Formation, Prairie Grove Member near Huntsville, Arkansas (loc. P-2).

BACTRITES MEXICANUS Miller, 1944
Plate 17, figure 7; Plate 31, figures 1-3; Plate 36, figures 1, 2, 5, 6
Bactrites mexicanus Miller, 1944, p. 82, Pl. 20, figs. 8, 9; Pl. 21, figs. 4-6
Diagnosis.—Phragmocone longionic, without ornament except for a prominent dorsal carina. Septa directly transverse, sutures forming dorsal saddle, phragmocone compressed.

Description.—The original description of *B. mexicanus* was based on 15 incomplete specimens; 17 additional topotype specimens are now available to augment the original description. The early embryonic and juvenile stages are unknown as all of the available specimens represent middle to late juvenile and possibly also mature? segments of phragmocones and body chambers.

The apical angle of the phragmocone is relatively high, about 5° to 8°. The phragmocone is markedly compressed, and a well-developed dorsal carina is the only sculpture on the exterior surface of the test. Cameral ratio ranges from 1.5 to 2.0. Septa are transverse, and the suture has a shallow lateral lobe and a relatively well-developed dorsal saddle. The wrinkle-layer and cameral deposits have not been detected on any of the specimens.

*Bactrites mexicanus* is most similar to *B. peytonensis* n. sp. and *B. finisensis* n. sp. because both taxa also have a well-developed dorsal carina. However, *B. peytonensis* has well-developed longitudinal ornament whereas *B. mexicanus* has none. Also, both *B. peytonensis* and *B. finisensis* have a well-developed wrinkle layer while none has been detected on *B. mexicanus*. This lack of a wrinkle-layer may be a function of preservation, or, alternatively, the feature may have been suppressed by Early Permian time. An additional distinguishing characteristic of *B. mexicanus* is the presence of a relatively high dorsal saddle. Two poorly preserved specimens of *Bactrites* cf. *B. mexicanus* were recovered from a lower stratigraphic interval than the previously described specimens. Because of poor preservation and the fragmentary condition of the specimens, assignment to *B. mexicanus* is made with reservations.

Occurrence and repository.—Holotype YPM 16278, 14 paratypes YPM 15279, and 17 topotypes (SUI 32903, 1351, 16208, 32904, 32905, and 43930) are from locality 20 (Upper Permian) of King, 1944 (loc. PR-2). The two specimens of *Bactrites* cf. *B. mexicanus* (SUI 1352, YPM 16277) are from the Malascachas flank (Lower Permian) of Las Delicias (loc. PR-2).

**BACTRITES MILLERI** Mapes, new species

Plate 10, figure 10; Plate 12, figures 4, 8-12

Diagnosis.—Longionic bactritoid with a wrinkle-layer angle ranging from 58° to 68°.

Description.—*Bactrites milleri* is represented in the collections by 64 incomplete juvenile phragmocones (D = 5 mm to 13 mm). The embryonic and mature stages of development are unknown.

The phragmocone of *B. milleri* is slightly compressed. Sutural configuration is simple. The septa are directly transverse. The shell on most specimens is missing; however, distinct longitudinal ornament is present on one specimen (Pl. 10, fig. 10). The apical angle ranges from 4° to 6°, and the cameral ratio ranges from 1.6 to 2.1.

The wrinkle-layer consists of fine, slightly wavy ridges that form an angular relationship with the phragmocone ranging from 58° to 68°. Internal deposits have not been discovered.

*Bactrites milleri* differs from all other known bactritoids by the angular relationship of the wrinkle-layer.

The most similar form is *B. carbonarius*, which has an angular range of 65° to 75°. Additional differences are apparent when other morphologic features are considered. *Bactrites smithianus* has a cameral ratio of 0.8 to 1.1, while *B. milleri* has a larger cameral ratio of 1.6 to 2.1. Similarly, *B. quadrilineatus*, *B. carbonarius*, and *B. fayettevillensis* also have smaller cameral ratios than *B. milleri*.

Etymology.—This species is named for A. K. Miller, noted North American cephalopod worker and scientist.

Occurrence and repository.—Specimens of *B. milleri* (SUI 43779-83) were obtained as part of a "crack-out" fauna from a limestone in the Pitkin Formation (middle Chesterian-Mississippian) at Leslie, Arkansas (loc. M-28).

**BACTRITES OWENI** Mapes, new species

Plate 19, figures 4, 8-13; Plate 21, figures 11, 16, 17; Plate 33, figure 5

Diagnosis.—Longionic bactritoid with a low apical angle (2° to 4°), longitudinal ornament, a cameral ratio of 1.0 to 1.3, and a well-developed transverse wrinkle-layer. The phragmocone is compressed, and a moderately deep dorsal saddle and lateral lobes are present; septa are directly transverse.

Description.—*Bactrites oweni* is represented by 22 specimens that are considered representative of the early through late juvenile stages and maturity. The embryonic stages are unknown; however, it is possible that the early embryonic stages are described (herein) as one of the Desmoinesian-aged bactritoid morphotypes.

The phragmocone of *B. oweni* is compressed in all of the known ontogenetic stages. The septa are directly transverse, and the suture has moderately deep lateral lobes and a dorsal saddle. The test has longitudinal ornament and fine growth lines that are more or less transverse, form a broad shallow dorsal salient, and a ventral sinus. The cameral ratio is relatively low and ranges from 1.0 to 1.3. The apical angle is also low and ranges from 2° to 4°. No internal deposits are known. The wrinkle-layer is well-developed throughout the known ontogeny and entirely covers the phragmocone at a diameter of 2 mm. It consists of slightly wavy transverse lirae during the juvenile stages of development and changes markedly at the mature body chamber (Pl. 19, fig. 4). On the mature body chamber, the simple transverse pattern is replaced with a more discontinuous but still bilaterally symmetrical pattern. The transverse lirae are more discontinuous in places.

*Bactrites oweni* is similar to *B. smithwickensis* and *B. sinuosus* in that all have sutures with lateral lobes and a dorsal saddle. However, both *B. smithwickensis* and *B. sinuosus* have larger apical angles and greater cameral ratios than *B. oweni*. No other known Pennsylvanian bactritoids have moderately deep lateral lobes and a dorsal saddle.

A single specimen was recovered from a stratigraphically younger unit in Texas. This specimen has a maximum diameter of 4.5 mm and consists of two camerae preserved as internal molds without shell material. The apical angle, cameral ratio, and suture pattern are nearly identical to those seen on comparable-sized specimens of *B. oweni*. However, because the specimen lacks the ex-
ternal shell and consists of only two camerae, it seems reasonable to refer this specimen to *B. oweni* with reservation.

**Etymology.**—This species is named for J. B. Owen, who collected the original lot of specimens from Henry County, Missouri.

**Occurrence and repository.**—With one exception, all of the specimens of *B. oweni* were recovered from coal strip pits excavated in the Desmoinesian Coal Cyclothems in Henry County, Missouri (loc. P-14). The single exception (B. cf. *B. oweni*, SU! 43934) was recovered from locality P-21 (Colony Creek Shale Member of the Caddo Creek Formation; Missourian–Pennsylvanian) near Brownwood, Texas.

**BACTRITES PEYTONENSIS**

Maps, new species

Plate 8, figures 4-14; Plate 9, figures 2, 3, 6-8, 12, 13, 15, 17-19; Plate 14, figures 7, 8, 10


**Diagnosis.**—Longiconic bactrioid with prominent dorsal carina, ornamented with longitudinal lirae.

**Description.**—*Bactrites peytonensis* is represented by 138 specimens. Every stage of the ontogeny is represented, from the protoconch to the mature modification.

The protocoonch of *B. peytonensis* is smooth except for the fine, irregular, longitudinal ridges on some specimens (Pl. 9, fig. 12) from the Imo Formation. The oral end of the protococonch is deeply constricted (Pl. 9, fig. 12). The second stage of embryonic development (the first chamber) is shallowly constricted anteriorly. Additional constrictions can be detected on the second and third camerae. The maximum diameter in the embryonic stage of development occurs at the third chamber. Posterior to the third camera the phragmocone has an apical angle of up to $10^\circ$; anterior of the third chamber, the phragmocone has a reverse apical angle of up to $6^\circ$. Juvenile and mature phragmocones have variable apical angles ranging from $2^\circ$ to $10^\circ$. The third stage of embryonic development terminates where the reverse apical angle is reduced to essentially $0^\circ$ past the seventh camera. The dorsal carina develops sometime after the third embryologic stage and is retained into maturity. External ornament probably develops at about the same time as the carina; only the more ontogenetically advanced specimens have pronounced longitudinal ornament (Pl. 8, figs. 12-14). The body chamber is exceptionally long. In one specimen (Pl. 8, fig. 6) it is at least 130 mm long where the diameter is 15 mm. Maturity in *B. peytonensis* was probably attained at diameters of about 40 mm or larger. One incomplete body chamber with a pronounced dorsal carina shows the transition from an almost smooth juvenile shell to a shell with coarse, nearly transverse striae (Pl. 8, figs. 7,11). The striae are about 2 mm apart and are inclined dorsolateral at about $15^\circ$. The diameter at which this ornament change occurs is 40 mm. The ornament consists of relatively sharply impressed striae in an essentially smooth shell. Another specimen with coarse striae has a maximum estimated diameter of 50 mm and has longitudinal ornament as well as the mature modification of coarse striae.

The septa in *B. peytonensis* are directly transverse in the juvenile stages, but may be inclined as much as $8^\circ$ in the embryonic stages. The sutural configuration has only the ventral lobe developed at the siphuncle. The phragmocone is circular in the embryonic stages and compressed in the later stages, and the cameral ratio varies from 1.1 to 2.0.

Internal deposits have not been discovered. The wrinkle-layer is well preserved and easily observed on the late embryonic and early juvenile specimens. It begins as transverse ridges on either side of the dorsal furrow at the apical end of the camera. As diameter increases, the wrinkle-layer covers more and more of the dorsum. Eventually, during later juvenile stages, the wrinkle-layer encircles the entire phragmocone. Detection of the wrinkle-layer in the later juvenile and mature stages is difficult because of additional shell material deposited on the inner surface of the wrinkle-layer. When the wrinkle-layer encompasses the phragmocone, it has an angular relationship of $86^\circ$ to $90^\circ$.

*Bactrites peytonensis* is most similar to *B. mexicanus* and *B. finisensis* n. sp., because all have a well-developed dorsal carina. Insofar as is known, *B. mexicanus* lacks any kind of ornament and despite intensive examination no wrinkle-layer has been detected. *Bactrites finisensis* also appears to lack ornament and has a transverse wrinkle-layer. Additionally, *B. mexicanus* has a well-developed dorsal lobe, which *B. peytonensis* lacks.

With one exception, all of the specimens identified as *B. peytonensis* from the Fayetteville Formation are in the embryonic or very early juvenile stages of development (Pl. 9, figs. 2,3,6-8). The single exception is a megascopic specimen (SUI 43693) assignable with reasonable assurance to *B. peytonensis* because it has a dorsal carina. This specimen is from the upper shale member of the Fayetteville Formation. All of the middle Chesterian embryonic and juvenile forms are from the lower shale member of the Fayetteville Formation. The early ontogenetic stages of *B. peytonensis* are, insofar as can be determined, essentially identical to those of the Imo forms. However, it is possible that the conch form from the lower Fayetteville is different from that of the Imo, and therefore, the lower Fayetteville specimens are assigned to *B. peytonensis* with reservation.

**Etymology.**—This species is named after Peyton Creek, which is about 4 miles south of Leslie, Arkansas.

**Occurrence and repository.**—Specimens of *B. peytonensis* from the Fayetteville Formation (middle Chesterian–Mississippian) were collected from localities M-20, M-22, M-25B, and M-25D. Specimens from the Imo Formation (upper Chesterian–Mississippian) were obtained from localities M-16, M-17, M-18, and M-19.

**BACTRITES POSTREMUS**

Miller, 1930

Plate 21, figures 13-15; Plate 33, figures 10-13; Plate 35, figures 1-3, 9-11

*Bactrites postremi* Miller, 1930, p. 389-390, Pl. 38, fig. 11.

**Diagnosis.**—Phragmocone longiconic, with well-developed transverse wrinkle-layer, sutural configuration simple, septa transverse, phragmocone slightly compressed, cameral ratio ranging from 1.0 to 1.7, apical angle ranging from $3^\circ$ to $6^\circ$.

**Description.**—A total of 48 specimens including the holotype are available for study. The earliest ontogenetic stages are un-
known and the available collections consist of middle and late juvenile and possibly mature stages.

The earliest ontogenetic stages available (D = 6 mm) have a relatively low apical angle (approximately 3°) and cameral ratio (1.2:1). More nearly mature developmental stages have a slightly larger apical angle (5° to 6°) and cameral ratio from 1.0 to 1.7. Throughout the known ontogeny, the phragmocone is slightly compressed. However, the sutural configuration remains simple; this has destroyed any trace of growth lines that may have been present. Several of the larger specimens in the collection have more or less traverse ridges with rounded edges on the external shell. These ridges, which are inclined dorsorad, presumably represent a mature modification.

The wrinkle-layer is especially well developed in this species. The straight and sometimes slightly wavy ridges are essentially traverse to the long axis of the phragmocone; however, some specimens have a slight angular relationship (86° to 90°). On the more mature portions of many specimens, the wrinkle-layer resembles surface ornamentation. However, this condition is produced by an extremely thick, partly exfoliated, inner shell layer whose external surface represents the wrinkle-layer; the outer and middle shell layers are thin and have been removed by weathering. When this condition occurs, the wrinkle-layer is not impressed on the internal mold of the phragmocone.

Cameral deposits of the muriel type may occur in the more apical portions of specimens (Pl. 35, figs. 1-3).

Bactrites postremus occurs together with B. finisenis n. sp.; however, the latter species has a prominent dorsal keel and a less conspicuous wrinkle-layer. Other species of Bactrites that are similar to B. postremus include B. gaitherensis, B. smithwickensis n. sp., B. reticulatus n. sp., B. woodi n. sp., B. oweni n. sp., and B. sinoanus n. sp. Of these, B. reticulatus, B. sinoanus, and B. woodi have a more complicated suture than B. postremus. B. smithwickensis has a larger cameral ratio. B. oweni and B. gaitherensis are distinguished from B. postremus by the presence of longitudinal ornament.

Occurrence and repository.—Holotype YPM 12929A was collected from the Captank Formation (lower Virgilian-Pennsylvanian) 4.5 mi. S. 15° E. of Lenox, Texas (loc. P-31). Additional specimens (SUI 4261, 43928, 4259, 4260, 43922 to 43926, 43977; OU 3694, KU 53128, TA 7063) of this taxon have been recovered from the following Upper Pennsylvanian localities: P-23, P-24, P-25, P-26, and P-28.

**BACTRITES QUADRILINEATUS** Girty, 1909

Plate 1, figures 6-9; Plate 2, figures 7-9; Plate 3, figures 1-3, 7-11; Plate 4, figures 10, 12-16; Plate 12, figure 3

**Bactrites quadrilineatus** Girty, 1909, p. 50-52, Pl. 6, figs. 1-4a.

**Diagnosis.**—Phragmocone longiconic, with wrinkle-layer angle ranging from 45° to 58°; apical angle ranging from 2° to 8°. Cameral ratio varying from 1.1 to 1.5. Ornament consisting of longitudinal striations.

**Description.**—A total of 275 specimens are available. The majority are from the Caney Formation (lower Chesterian of Oklahoma) and are juveniles, although a number of protoconch-bearing embryonic specimens are also known. The largest body chamber and phragmocone in the collections is about 30 mm in diameter; this specimen probably represents a nearly mature or mature individual. Thus, the complete ontogeny of Bactrites quadrilineatus is available for study.

The protoconch (Pl. 1, figs. 6-8) is essentially spherical, being slightly wider than long. On one specimen (Pl. 1, fig. 6), the apical end of the protoconch has faint transverse strie that probably represent embryonic growth lines. The orad end of the protoconch is strongly constricted. The second developmental stage is limited to the first chamber. It begins with a well-developed constriction that flares at an angle of about 32°. Both the orad and apical ends of the first chamber have a well-developed constriction. During the third stage of development, the embryologic phragmocone reaches its greatest diameter at the fourth chamber. From the fourth chamber to the end of the third developmental stage, the phragmocone has a reverse apical angle of 6°. Termination of the second developmental stage is gradual.

The early, middle, and late juvenile stages of development have a variable apical angle that ranges from 2° to 8°, and the cameral interval varies from 1.0 to 1.6. The test displays faint growth lines that form a broad dorsal salient and a broad ventral sinus. Ornament consists of faint longitudinal striations (Pl. 3, fig. 7).

The wrinkle-layer is well developed in this species and at a diameter of 2 mm totally covers the internal mold of the phragmocone. It has an angular relationship ranging from 45° to 58° and consists of sharply defined ridges on the internal layer of the shell (Pl. 1, fig. 9). At the dorsum, the wrinkle-layer forms an obtuse angle of about 110°. Specimens in later stages of juvenile development often do not exhibit the wrinkle-layer. Where observed, the wrinkle-layer terminates on the body chamber in a relatively rapid transition from well-developed ridges to smooth inner shell. This transition is located a few millimeters from the aperture and has a rough bilateral symmetry. The outline of the terminal edge of the wrinkle-layer forms a broad sinus on the venter. The phragmocone is slightly compressed; however, the sutural configuration does not exhibit a well-developed lateral lobe. Septa are directly traverse and the cameral ratio ranges from 1.1 to 1.5.

Mural cameral deposits are present in the juvenile part of the conch (Pl. 3, figs. 6-8-10). Overall, they are thin (less than 1 mm thick) and are confined to the mural portion of the phragmocone. The deposits exhibit a rough bilateral symmetry, are more extensive on the ventral side of the phragmocone, and decrease in volume adorally.

**Bactrites quadrilineatus** is found in immediate association with B. ahlooenesis n. sp., which differs from B. quadrilineatus on the basis of its transverse wrinkle-layer and larger cameral ratio. Other similar bactritid species are B. carbonarius, B. milleri n. sp., and B. peytonensis n. sp. Bactrites milleri has a wrinkle-layer angle ranging from 58° to 68° and B. peytonensis has a dorsal carina and an essentially transverse wrinkle-layer. B. carbonarius has a wrinkle-layer with an angular range of 65° to 75°.

**Occurrence and repository.**—Lectotype USNM 119580 and paralectotypes USNM 119580 (2 specimens) and USNM 119580A were recovered from the Delaware Creek Member, Caney Shale Formation in Oklahoma (N. side, sec. 14, T2 S., R7 E.). The University of Oklahoma and University of Kansas repositories loaned several specimens; however, the majority of the specimens are repositioned in the University of Iowa collections. All
of these specimens were collected from the Caney Shale, Delaware Creek Member (loc. M:1 to M:9). A single specimen was recovered from the Helms Formation near the Figure 2 Ranch House, Sierra Diablo escarpment, Culberson Co., Texas (loc. M:10).

**BACTRITES REDACTUS** Gordon, 1965
Plate 29, figures 1-3

*Bactrites redactus* Gordon, 1965, p. 104, Pl. 5, figs. 8,9,15.

Diagnosis.—Bactritoid with low apical angle (3° to 4°) and relatively high cameral ratio (2.2 to 2.8). Septa inclined dorsolateral, suture forming a dorsal saddle.

Description.—This taxon is represented only by the three incomplete phragmocones described by Gordon (1965). The phragmocone has a low apical angle between 3° and 4° with a relatively high cameral ratio ranging from 2.2 to 2.8. The shell of most specimens is nearly smooth; this appears to be due to mechanical abrasion prior to deposition of the specimen. However, the holotype (USNM 119019) and paratype (USNM 119020) still retain faint longitudinal striae that probably represent the original shell ornament. The phragmocone is slightly compressed. The suture forms well-developed lateral lobes and a moderately high dorsal saddle in addition to the ventral lobe. Septa are slightly inclined dorsolateral. Internal deposits and a wrinkly-layer have not been discovered.

*Bactrites redactus* is found in association with *B. gaiatherenis* Gordon. This latter species is characterized by a smaller cameral ratio (0.9 to 1.6) and lack of a dorsal saddle. Other similar appearing Pennsylvanian bactritoids include *B. postremus* Miller, *B. oweni* n. sp., *B. smithwickensis* n. sp., and *B. sinuosus* n. sp. *Bactrites postremus* and *B. oweni* can be distinguished from *B. redactus* by their smaller cameral ratios (1.2 to 1.5 and approximately 1.1, respectively). All of these bactritoids except *B. sinuosus* differ from *B. redactus* by the absence of the dorsal saddle. *Bactrites sinuosus* has a dorsal saddle; however, it can be distinguished from *B. redactus* by its slightly larger cameral ratio (3:1), better developed lateral lobes, and greater compression of the phragmocone.

Occurrence and repository.—The holotype (USNM 119019) and two paratypes (USNM 119029) were recovered from the Morrowan-aged (Pennsylvanian) Bentonwood Limestone Member of the Floyd Formation (=Witt Springs Formation) of Gordon, 1965 (loc. P:3).

**BACTRITES RETICULATUS** Mapes, new species
Plate 22, figures 4, 5, 10; Plate 26, figures 3-5, 7, 9-11; Plate 28, figures 4-7, 9, 10

Diagnosis.—Longiconic bactritoid, septa slightly inclined dorsolateral, suture with moderately deep dorsal lobe; cameral ratio ranging from 1.0 to 1.4, protoconch covered by reticulated ornamentation.

Description.—*Bactrites reticulatus* is represented within the collections by 410 specimens. These specimens are all limonitic internal molds that rarely have shell material preserved. All of the available specimens are representative of embryonic or early juvenile developmental stages. The more ontogenetically advanced stages remain unknown.

The protoconch is roughly ovoid, being slightly wider than long (Pl. 28, fig. 9). One specimen (Pl. 28, figs. 4-6,10) is covered by a well-developed reticulated ornament. The oral end of the protoconch constricts slightly, and this marks the end of the first embryonic stage. The second embryonic stage terminates at a shell constriction at the second septum. Maximum diameter of the embryonic stage occurs at the oral end of the fifth chamber. Anterior from this position on the phragmocone and until the end of the third embryonic stage, the phragmocone has a reverse apical angle of 5°. The initial apical angle is 5° to 7°. The end of the third embryonic stage is gradual and takes place at about the ninth or tenth chamber.

During the embryonic developmental stages, the phragmocone is essentially circular; however, during the early juvenile developmental stages a compressed cross section is encountered. Septa are essentially transverse until the latter part of the early juvenile phase, where they become slightly (4° to 5°) inclined dorsolateral. The embryonic suture is simple, and only gradually after the beginning of the early juvenile phase do shallow dorsal lobes and lateral lobes develop. The apical angle of the juvenile phase is about 4° and the cameral ratio ranges from 1.0 to 1.4. Internal deposits have not been observed. The wrinkly-layer is present on the apical end of the fifth camera. The single patch of lirae is located on the dorsum on either side of the dorsal furrow (Pl. 26, fig. 7). At this point in the ontogeny, the wrinkly-layer consists of only a few transverse lirae. By the end of the seventh and eighth camerae (Pl. 28, fig. 7), the wrinkly-layer consists of a number of lirae that are essentially perpendicular to the dorsal furrow and extend along the entire dorsum; however, it does not extend onto the lateral portions of the phragmocone. Later ontogenetic stages of the wrinkly-layer are unknown.

*Bactrites reticulatus* is most similar to *B. oweni* n. sp., *B. redactus*, and *B. smithwickensis*. These latter two taxa have larger cameral ratios (2.2 to 2.8 and 1.9 to 2.1, respectively) than *B. reticulatus* (1.1 to 1.4). *B. oweni* has much better development of the wrinkly-layer that consists of coarser lirae and covers more of the phragmocone at comparable sizes.

The reticulated pattern developed on the protoconch of *B. reticulatus* constitutes a nearly unique morphological feature. The only other nearly similar pattern is developed on *Bactrites* sp. morphotype 16; however, a close examination shows the latter patterns to be less coarse and less well defined.

It should be noted that *B. reticulatus* occurs with *B. sinuosus*; however, these two taxa are distinguishable by their sutural configurations.

Etymology.—This species is named for the reticulated ornament that covers the protoconch.

Occurrence and repository.—All of the specimens of *Bactrites reticulatus* were obtained from the Wewoka Formation (Desmoinesian–Pennsylvanian) of Oklahoma at localities P-6, P-7, and P-8. Additionally, 12 specimens assignable to this species with reservation have been recovered from the Deese Formation in southern Oklahoma (loc. P:10).

**BACTRITES SANSABAENSIS** Mapes, new species
Plate 11, figures 1, 4-13

Diagnosis.—Longiconic bactritoid, septa inclined during juvenile developmental stages, protoconch with longitudinal ornament,
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cameral deposits present in early ontogenesis, siphuncle becoming marginal at end of third chamber.

**Description.**—*Bactrites sansabaensis* is represented by 232 protoconch-bearing segments of early juvenile phragmocones. Later ontogenetic stages are unknown. Almost all specimens are phosphatic internal molds recovered from formic acid resistant residues, and almost all of the specimens are missing their outer shells.

The protoconch is wider than long and bluntly pointed at the apex. Longitudinal lirae on the internal mold extend from the apex onto the first camera (Pl. 11, figs. 6.13) and presumably reflect longitudinal shell ornament. The oral end of the protoconch has a poorly developed constriction, as does the oral end of the first chamber (the latter representing the end of the second stage of development). The maximum diameter attained during embryonic ontogenesis is developed by the third camera in the third embryonal developmental stage. The apical angle posterior of the third chamber is 10°, and anterior to this chamber the phragmocone has a reverse apical angle of 3°. The third constriction or end of the third embryonal developmental stage is broad and shallow and occurs at about the seventh chamber. Isolated segments of juvenile phragmocones that are placed in *B. sansabaensis* have apical angles of 4° to 8°. Throughout embryonic ontogenesis, the septa remain directly transverse; however, during early juvenile development the septa become inclined dorsosopicad as much as 15°. The phragmocone is essentially circular during the embryonic stages of development and becomes somewhat more oval during juvenile development. The suture develops a distinct dorsal lobe and ventral saddle. Cameral ratio ranges from 1.1 to 1.6.

Cameral deposits of the mural type are well developed on the first, second, and third chambers of some specimens (Pl. 11, fig. 5). Additionally, it is possible that episephal and hyposephal deposits may be present on the early septa. Despite the fact that the internal molds are well preserved, no wrinkle-layer has been detected.

*Bactrites sansabaensis* is distinguished from all other known Mississippian bactritoids by a combination of features: overall diameter, cameral spacing and septal orientation in the embryonic phragmocone, and protoconch morphology. *Bactrites sansabaensis* is similar to the embryonic phragmocone of *B. quadrilineatus*, *B. peytonensis*, and *B. fayetteellensis*; however, these taxa have protoconchs with smaller diameters and the first constriction is deeper. Distinguishing *B. sansabaensis* from *B. milleri* n. sp. can be accomplished by noting the septal inclination; *B. sansabaensis* has inclined septa whereas *B. milleri* has transverse septa.

**Etymology.**—This species is named for the community of San Saba, San Saba County, Texas.

**Occurrence and repository.**—All specimens of *Bactrites sansabaensis* were recovered from the Barnett Formation (middle Chesterian-Mississippian) near San Saba, Texas (see loc. M-29).

**BACTRITES SINUOSUS** Mapes, new species

Plate 25, figures 8-10

**Diagnosis.**—Bactritoid with essentially circular cross section, suture with moderately deep lateral lobes and dorsal saddle. Cameral ratio relatively high (2.8); septa inclined dorsosopicad.

**Description.**—*Bactrites sinuosus* is represented in the collections by the holotype. This single specimen is a moderately well-preserved limonitic internal mold that is missing the test. Two additional specimens (SUI 43908) are assigned with reservations to this species. The embryonic and mature developmental stages of this taxon are unknown.

The holotype is essentially circular, although the lateral regions of the phragmocone are slightly flattened. The holotype is 14 mm long with maximum and minimum diameters of 4.6 mm and 3.1 mm, respectively. The septa are inclined dorsosopicad and the cameral ratio is relatively high (2.8). The suture has moderately deep lateral lobes and a dorsal saddle. The ventral lobe is somewhat weathered; however, a well-developed ventral lobe from the marginal siphuncle is to be expected.

The dorsolateral surface of the internal mold has a wrinkled appearance that forms a roughly bilaterally symmetrical pattern. The function of these wrinkles is unknown. Neither internal deposits nor wrinkle-layer has been detected.

Two specimens that are assigned to *B. sinuosus* with reservations have less well-developed suture patterns and lower cameral ratios (1.5). However, these two specimens are smaller in diameter (*D = 2 mm*) and may represent the early juvenile developmental stages.

*Bactrites sinuosus* is unique in its septal inclination and suture pattern. Other bactritids including *B. oweni* n. sp., *B. redactus*, and *B. mexicanus* have complex sutures; however, none of these species develops the highly sinuous suture of *B. sinuosus*.

**Etymology.**—The species is named for its characteristically sinuous suture.

**Occurrence and repository.**—The holotype of *Bactrites sinuosus* (SUI 10981) was recovered from the Wewoka Formation near Preston, Oklahoma (loc. P-7) as a surface find. Intensive re-collection of this exposure has failed to produce an additional conspecific specimen. The two specimens of *B. cf. B. sinuosus* were recovered from the Wewoka Formation, Lovelady School locality (loc. P-8).

**BACTRITES SMITHIANUS** Girty, 1909

Plate 14, figure 11; Plate 15, figures 3-5; Plate 21, figure 12

*Bactrites smithianus* Girty, 1909, p. 53-54 [part], Pl. 6, fig. 5 (not fig. 6); Girty, 1911, p. 96-97.

**Diagnosis.**—Phragmocone lenticular, with a low apical angle (2° to 3°), wrinkle-layer transverse, cameral ratio low (0.8 to 1.1).

**Description.**—The original description of *B. smithianus* was based on a single incomplete specimen (Pl. 14, fig. 11). Additional collecting has produced 12 topotypes that significantly revise the concept of *B. smithianus*. All of these topotypes represent incomplete juvenile stages and most are poorly preserved. The embryonic and mature stages of development are unknown.

The apical angle and the cameral ratio of the phragmocone are low, ranging from 2° to 3° and 0.8 to 1.1, respectively. The shell displays faint longitudinal striae; growth lines have not been detected. The phragmocone is slightly compressed. The suture reflects the cross section in developing shallow lateral lobes. Septa are directly transverse.

Internal deposits have not been discovered. The wrinkle-layer is transverse with both wavy and straight ridges.
The phragmocoine of B. smithtvickensis resembles those of B. quadrilineatus, B. carbonarius, B. ahlosensis n. sp., and B. milleri n. sp. Bactrites quadrilineatus has an angular wrinkle-layer as do B. carbonarius and B. milleri. Bactrites ahlosensis has a higher cameral ratio and a larger apical angle than B. smithtvickensis.

The overall concept of this species is markedly different from that presented by Gordon (1965). These differences are due to the relatively poor preservation of the holotype.

Occurrence and repository.—Holotype USNM 119581 was recovered from the Sand Branch Member of the Caney Formation in Oklahoma (loc. M-15). Additionally, 12 toptype (SUI 43661, 43976) were recovered from the same locality as the holotype. One additional specimen (SUI 42599) has been recovered from the Fayetteville Formation in Arkansas (loc. M-25B).

BACTRITES SMITHWICKENSIS
Plate 25, figures 1, 5, 6; Plate 29, figures 7, 10, 11; Plate 31, figures 10-12; Plate 33, figures 8, 9

Diagnosis.—Longiconic bactritoid, apical angle moderately large (7° to 9°), cameral ratio relatively large (1.9 to 2.1), wrinkle-layer transverse, phragmocoine essentially circular.

Description.—Bactrites smithtvickensis is represented in the available collections by 100 partial juvenile (D = 2.55 mm to 10.55 mm) phragmocoines. The embryonic and mature stages of development are unknown. However, the former is almost certainly one of the bactritoid morphotypes described herein. Actual association of the correct protoconch and juvenile phragmocoine must await more complete and better preserved specimens. All of the specimens are limonitic internal molds and are without well-preserved external shell.

The phragmocoine of B. smithtvickensis is nearly circular. The cameral ratio ranges from 1.9 to 2.1. The septa are inclined slightly dorsoapical on the more mature specimens and are directly transverse on the more juvenile specimens. The suture has slight lateral lobes with a dorsal saddle and a ventral lobe. No cameral lirae.

Bactrites smithtvickensis is similar to B. milleri n. sp., B. sinusus n. sp., B. reticulatus n. sp., B. gaitherensis, B. redactus, and B. woodi n. sp. Bactrites milleri and B. gaitherensis can be distinguished from B. smithtvickensis by their lack of lateral lobes. Bactrites sinusus has distinctly inclined septa and a more complex suture and B. redactus has a greater cameral ratio (2.2 to 2.8) than B. smithtvickensis (1.9 to 2.1). Bactrites reticulatus and B. woodi have smaller cameral ratios (1.0 to 1.4 and 0.9 to 1.2, respectively) than B. smithtvickensis.

Etymology.—This new species is named for the Smithwick Formation from which all of the specimens were collected.

Occurrence and repository.—Of the 100 specimens of Bactrites smithtvickensis, all but six were recovered from the Smithwick Formation near Rochelle, Texas (loc. P-4). The remaining six specimens were collected from the ?Smithwick Formation at the base of the Sierra Diablo escarpment, Culberson County, Texas (loc. P-5) and are assigned to B. smithwickensis with reservations because of poor preservation.

BACTRITES WINTERSETENSIS Miller, Lane, and Unklesbay, 1947

Bactrites wintersetensis Miller, Lane, and Unklesbay, 1947, p. 4, Pl. 1, fig. 4.

This species is based on a single, crushed, poorly preserved specimen in which the test is missing entirely. All of the septa are distorted, and the siphuncle has been poorly exposed due to improper preparation. Assignment of new specimens to this taxon is considered impossible, and for this reason, this species is considered a nomen dubium.

Occurrence and repository.—Holotype KU 32079 (old number 558) was recovered from the upper Winterset Limestone (Missourian–Pennsylvanian) on the east bank of the Big Blue River, ½ mile north of 15th Street in Kansas City, Kansas (loc. P-17).

BACTRITES WOODII
Plate 18, figures 5, 7, 8, 12, 13; Plate 27, figures 4-6, 12-19

Diagnosis.—Longiconic bactritoid with longitudinal lirae on protoconch, protoconch longer than wide. Septa becoming inclined dorsoapical at end of fifth camera, directly transverse in early juvenile stages.

Description.—The collections contain 1,394 specimens of B. woodii. These specimens are well-preserved pyritized internal molds that sometimes retain impressions of the ornament. Most of the specimens are in the embryonic developmental stages; only a few can be considered juveniles. The more ontogenetically advanced juvenile and mature stages remain unknown.

The protoconch of B. woodii is subspherical, being slightly longer than wide. Most protoconchs have a smooth or slightly roughened surface (Pl. 18, figs. 7, 13); however, a few specimens (Pl. 18, fig. 12) have distinctive longitudinal lirae on their surfaces. The oral end of the protoconch terminates in a moderately deep constriction. This constriction coincides with the first septum of the phragmocoine and with one exception, the concave portion of the septum is smooth. The single exception is present on a protoconch (Pl. 18, fig. 8) with longitudinal ornament. The concave septal surface on this protoconch has a distinctive reticulated pattern. Insofar as can be determined, the siphuncle does not penetrate this septum, so the symmetry of the reticulated pattern cannot be determined. Because the symmetry is uncertain, it is unknown whether the pattern is a preservational feature or a significant paleobiologic feature. The second constriction on the embryonic phragmocoine is less pronounced than the first one and occurs at the oral end of the first chamber. The maximum diameter of the embryonic phragmocoine is attained at the fourth camera. The septa beyond the fourth camera (fifth septum) are inclined dorsoapical whereas the earlier septa are directly transverse. Oral of the fourth camera, the phragmocoine gradually decreases in diameter with a reverse apical angle of 10° until the eighth chamber. At the eighth chamber the reverse apical angle...
approaches 0°. The septal inclination decreases markedly where the juvenile developmental stage begins.

The early juvenile stage has an apical angle ranging from 2° to 4°. The initial septa in the early juvenile stage are inclined dorsoapical. The suture reflects the septal inclination with a shallow dorsal lobe; however, this lobe is suppressed as the septa become more transverse. Eventually, the sutural configuration has only the single ventral lobe developed on the siphuncle. The cameral ratio of the slightly compressed phragmocone in the early juvenile stage ranges from 0.9 to 1.1. Internal deposits have not been discovered. The wrinkle-layer develops at some unknown point (probably during the third embryonic stage); in the early juvenile stage (D = 1 mm), the wrinkle-layer is limited to a narrow band of transverse lirae on either side of the dorsal furrow.

Bactrites woodi is difficult to compare with several other species of Bactrites because of the relatively limited number of comparative morphologic features. Perhaps the taxon most morphologically similar to B. woodi is B. oweni. However, this latter species can be distinguished from B. woodi by its more compressed cross section, lack of transverse septa, and more encompassing wrinkle-layer at equivalent diameters. Bactrites sinuosus and B. smithwickensis can be distinguished from B. woodi by differences in the suture patterns. Bactrites reticulatus has a distinctive reticulated ornament on the protoconch, and this allows separation of the protoconchs of B. woodi which have longitudinal lirae.

Hundreds of protoconch-bearing specimens of B. woodi are present in the collections, but only a few have longitudinal ornament. Examination and comparison of ornamented and nonornamented protoconchs has established that the two variations differ only slightly in size. However, subtle as this distinction is, it is with some reservation that these ornamented protoconchs are included in B. woodi. It is possible, since the ornamented specimens are all relatively incomplete, that additional more complete specimens will demonstrate that these ornamented protoconchs should be placed in a new genus or species.

Etymology.—This species is named for Robert Wood, who first discovered specimens assignable to this species during routine examination of a conodont-bearing shale sample.

Occurrence and repository.—All specimens are reposited at the University of Iowa. All of the specimens of B. woodi were recovered from the Stanton Formation, Eudora Shale Member by processing of over 1,000 kg of shale for microfossils. This shale was obtained at a quarry approximately 1.6 km north of Tyro, Kansas. SUI repository numbers are listed under loc. P-15.

Genus ?BACTRITES sp., Indeterminate Specimens

Among the 9,100-specimen bactritoid collection, more than 3,000 specimens cannot be referred to any known species, genus, or family. The majority of these fragmentary specimens are well-preserved limonitic, pyritic, or possibly phosphatic phragmocones. Almost all of the conchs are in the embryonic and early juvenile stages of development and, with the exception of about four specimens, these conchs are less than 4 mm wide and 1 cm long.

Examination and comparison of these well-preserved conchs with the reconstructed early ontogenetic stages for various species in the present report reveals that these indeterminate bactritoids exhibit many distinctive morphological features. Sorting by morphologic feature produced about 32 groups of specimens. Description of these distinctive groups seem warranted because they provide additional ontogenetic data for the bactritoids. Furthermore, these forms will probably form the basis for future bactritoid reconstructions.

At this stage in the study of the bactritoids, these indeterminate embryonic bactritoids cannot be given routine taxonomic treatment. Many of the specimens that exhibit one or more distinctive morphologic characters are too fragmentary to allow a realistic ontogenetic reconstruction. Some of the specimens are relatively nondescript. The similarity of the embryonic stages of the Bactritidae and the Parabactritidae prevents familial assignment of many of the groups composed only of embryonic phragmocones.

Open nomenclature allows communication of data about these specimens without burdening the literature with names. Thus, these groups are described herein as morphotypes. Even after this treatment, almost 2,000 bactritoid specimens remain unassignable.

?BACTRITES sp. morphotype 1
Plate 9, figure 16; Plate 15, figure 15

Diagnosis.—Embryonic phragmocone and living chamber, without ornament; embryonic constriction shallow, apical angle low (1° or less) in early embryonic stage, changing rapidly to as much as 15° to 20° in early juvenile stage.

Description.—This morphotype is represented by 35 poor to moderately well-preserved embryonic and early juvenile phragmocones. Details of the protoconch morphology are unknown. The shell is smooth and the initial apical angle for this morphotype approaches 0° in the early embryonic stages. The living chambers of some specimens flare abruptly and attain angles of 15° to 20°. Several constrictions that probably separate different embryonic stages are detectable on the phragmocone. Cameral ratio, septal orientation, and the suture pattern are displayed poorly. Septa are directly transverse during the early embryonic stages and may become inclined dorsoapical during the later embryonic stages; details are obscured by the test. Also because of the test, the nature or presence of any cameral deposits remains unknown.

?Bactrites sp. mtp. 1 is found in association with the early embryonic stages of Bactrites fayettevillensis, B. peytonensis, and ?B. sp. mtps. 2, 3, and 4. ?Bactrites sp. mtp. 1 can be distinguished from all of the above bactritoids by its overall smaller diameter. Additionally, its lack of ornament distinguishes this morphotype from
B. peytonensis. Also, the lack of conspicuous constrictions separates ?B. sp. mtp. 1 from ?B. sp. mtp. 3 and 4, B. peytonensis, and B. fayettevillensis.

The overall embryologic pattern and early juvenile apical angles of ?B. sp. mtp. 1 suggest that it should be placed in the Parabactritidae. Of the Mississippian taxa assigned to the Parabactritidae, only Rugobactrites nevadense n. gen., n. sp. and Aktastioceras sp. (herein) have not had their early ontogenetic stages discovered and described. Thus, it is possible that ?B. sp. mtp. 1 could eventually be reassigned to one or the other of these genera.

Occurrence and repository.—All of the 35 specimens of ?Bactrites sp. mtp. 1 (SUI 42606 and 43775) were collected from the Fayetteville Formation in northern Arkansas (loc. M-25B).

?BACTRITES sp. morphotype 2
Plate 9, figures 5, 14

Diagnosis.—Embryonic bactritoid, without pronounced constriction between first chamber and protoconch.

Description.—This morphotype is represented by three moderately well to poorly preserved embryonic specimens. The protoconch is nearly spherical and is slightly wider than long. The first constriction is shallow; less pronounced constrictions are present at the oral ends of the first, second, and third chambers. The protoconch is ornamented with fine longitudinal lirae that are confined to the position of the first constriction; no additional ornament has been detected. The first three septa are relatively widely spaced with a cameral ratio of 2.5. The initial septa are directly transverse, and the phragmocone is circular. No internal deposits have been observed; however, since all of the specimens are more or less test covered, undetected deposits may be present.

?Bactrites sp. morphotype 2 has been recovered with embryonic specimens of Bactrites fayettevillensis, B. peytonensis, and ?B. sp. mtp. 4 and 1. ?Bactrites sp. mtp. 1 can be distinguished from the above taxa by its smaller diameter. Additionally, the bactritoids listed above have a deeper constriction at the first septum than ?B. sp. mtp. 2.

Occurrence and repository.—?Bactrites sp. morphotype 2 (SUI 42632, 42633, 43774), was collected from the Fayetteville Shale in northern Arkansas (loc. M-25B).

?BACTRITES sp. morphotype 3
Plate 15, figure 16

Diagnosis.—Embryonic bactritoid, protoconch unornamented, semispherical, with a pronounced constriction between protoconch and first chamber.

Description.—?Bactrites sp. mtp. 3 is represented by a single embryonic phragmocone. The protoconch is almost spherical, but is slightly wider than long. No ornament is present on the conch. The first constriction is moderately deep at the apical end of the first chamber. Additional constrictions correspond with the positions of the second and third septa. They are not as deep as the first. The cameral ratio of the initial chamber is about 2.0 and the septa appear to be directly transverse. The phragmocone is compressed, but this is probably due to postdepositional deformation of the conch. Because the internal mold is covered with test, no internal deposits have been detected.

?Bactrites sp. mtp. 3 has been recovered with embryonic specimens of B. peytonensis, B. fayettevillensis, and ?B. sp. mtp. 4. Bactrites fayettevillensis is distinguished from ?B. sp. mtp. 3 by the presence of ornament on the protoconch. ?Bactrites sp. mtp. 4 has a larger phragmocone and protoconch and has a larger cameral ratio (4.5) than ?B. sp. mtp. 3. Bactrites peytonensis has a more pointed protoconch and attains its maximum embryonic diameter at the third camera, whereas ?B. sp. mtp. 3 has a round protoconch and attains its maximum embryonic diameter at the second camera. This latter morphologic characteristic of ?B. sp. mtp. 3 is unique in all of the Mississippian protoconchs, and may be due to the slight postmortal distortion.

Occurrence and repository.—?Bactrites sp. morphotype 3 (SUI 42637) was collected from the Fayetteville Formation in northern Arkansas (loc. M-25D).

?BACTRITES sp. morphotype 4
Plate 7, figures 1-3, 6-8, 13, 19, 20

Diagnosis.—Bactritoid, cameral ratio relatively large (4.0 to 5.5), phragmocone and protoconch relatively large and unornamented, septal necks cyrotochoanitic.

Description.—There are nine embryonic and early juvenile phragmocones that can be assigned to ?Bactrites sp. mtp. 4.

The protoconch of ?Bactrites sp. mtp. 4 is probably the largest recovered from Mississippian or Pennsylvanian strata. It is wider than long and unornamented. The oral end of the protoconch is sharply constricted. One juvenile specimen (Pl. 7, figs. 1-3) exhibits a series of four features that can be interpreted as constrictions. This specimen is anomalously small and could belong to a different taxon, although its large cameral ratio (4.5) is similar to that of other specimens (4.5 to 5.5). The septa of ?B. sp. mtp. 4 appear to be directly transverse and the phragmocone is circular in cross section. Sutures form broad, moderately deep, dorsal and ventral lobes and relatively high lateral saddles (Pl. 7, figs. 7,8,13). Septal necks are cyrotochoanitic as early as the third camera (Pl. 7, fig. 8). The apical angle is relatively large (approximately 16°) in the early juvenile phragmocone. There are no indications of cameral deposits where the test is missing on the phragmocone.

Because of the cyrotochoanitic septal necks, large apical angle, and large cameral ratio, ?Bactrites sp. morphotype 4 almost certainly belongs within the Parabactritidae or the Sinuobactritidae n. fam. This taxon is sufficiently different to warrant naming; however, it could represent the embryonic and early juvenile stages of either Aktastioceras sp. or Rugobactrites nevadense.

The single specimen (SUI 43512) that is either annulate or shows multiple constrictions has an overall smaller phragmocone than other specimens of ?B. sp. mtp. 4. For these reasons, this specimen is assigned with reservation to ?B. sp. mtp. 4.

Occurrence and repository.—?Bactrites sp. morpho-
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type 4 has been recovered from the Fayetteville Formation (SUI 42628 to 42631, 43767, loc. M-25B; SUI 43749, loc. M-25C; SUI 43745, loc. M-25D) and Imo Formation (SUI 43589, loc. M-16) in northern Arkansas. An additional specimen (SUI 43512) was recovered from the Barnett Formation in central Texas (loc. M-29B, sample 2D).

?BACTRITES sp. morphotype 5
Plate 7, figures 4, 5, 10, 14

Diagnosis.—Embryonic bactritoid, apical angle low (approximately 0°), cameral ratio high (approximately 3.0 to 5.0).

Description.—?Bactrites sp. mtp. 5 is represented by three incomplete phragmocones. The phragmocone is circular and the septa are directly transverse. The suture is simple. No constrictions are apparent on the phragmocone. The apical angle is nearly 0° and the cameral ratio is moderately high (3.0 to 5.0:1). The external test is missing, and there is no indication of ornament or cameral deposits.

?Bactrites sp. mtp. 5 is found in conjunction with the embryonic stages of Bactrites sansabaensis n. sp., Rugobactrites barnettensis n. gen., n. sp., and ?B. sp. mtps. 6, 7, 8, 9, 10, and 11. None of these taxa is known to have a short caecum as does ?B. sp. mtp. 6. Additionally, B. sansabaensis has longitudinal ornament; however, this taxon can be distinguished from ?B. sp. mtp. 6 by its more bluntly pointed protoconch.

Occurrence and repository.—The single specimen of ?B. sp. mtp. 6 (SUI 43586) was recovered from the Barnett Formation in northcentral Texas (loc. M-29B, sample 1D).

?BACTRITES sp. morphotype 7
Plate 7, figure 11

Diagnosis.—Embryonic bactritoid, protoconch nearly spherical, first constriction deep.

Description.—?Bactrites sp. morphotype 7 is represented in the collections by a single embryonic phragmocone. The protoconch is almost spherical, slightly wider than long. The phragmocone has a deep constriction at its orad end. The second constriction, which occurs at the orad end of the first camera, is shallower. The test is missing, and no ornament can be detected. Septa are directly transverse, and the suture is simple. The cameral ratio is 1.7, and the initial apical angle is 15°. There is no indication of internal deposits. The septal necks are orthochoanitic.

?Bactrites sp. mtp. 7 was recovered in association with the embryonic phragmocones of Rugobactrites barnettensis n. sp., n. gen., ?B. sp. mtps. 4, 5, 9 to 11, and B. sansabaensis n. sp. Insofar as is known, the nearly spherical protoconch and the overall small dimensions of the phragmocone distinguishes ?B. sp. mtp. 7 from all of the above taxa.

The orthochoanitic septal necks of ?Bactrites sp. mtp. 7 strongly suggest that this morphotype belongs within the Bactritidae. However, later stages of the ontogeny must be obtained before ?B. sp. mtp. 7 can be assigned to this family with confidence.

Occurrence and repository.—?Bactrites sp. mtp. 7 (SUI 42585) was recovered from the Barnett Formation in northcentral Texas (loc. M-29B sample 2D).

?BACTRITES sp. morphotype 8
Plate 7, figure 9

Diagnosis.—Embryonic bactritoid, protoconch longitudinally ornamented, longer than wide.

Description.—?Bactrites sp. mtp. 8 is represented in the collections by a single slightly crushed, embryonic specimen. The protoconch is almost spherical, being slightly longer than wide. At the orad end of the proteconch, the constriction is shallow, as is the second constriction, which occurs at the orad end of the first camera. The phragmocone is an internal mold with no test remaining. However, the protoconch is covered by longitudinal lirae, which are considered to represent remnants of the original ornament. The septa are directly transverse, and the cameral ratio is about 2.0. The phragmocone is circular at the first two camerae; the remaining camerae are crushed. The apical angle of the initial camerae is 20°, and the suture is simple. Mural cameral deposits may have been present on the first chamber.

?Bactrites sp. mtp. 8 was not recovered in association.
with any other embryonic bactritoid. The presence of the longitudinally ornamented protoconch suggests an identity with B. sansabaensis n. sp., or Bactrites sp. mtp. 6; however, neither of these taxa have a protoconch that is longer than wide, as does ?B. sp. mtp. 8. Additionally, ?B. sp. mtp. 8 does not expose the caecum, as do B. sansabaensis and ?B. sp. mtp. 6.

Occurrence and repository.—?Bactrites sp. mtp. 8 (SUI 42576) was recovered from the acid resistant residues of a limestone taken from the Barnett Formation at Chappel Hill near San Saba, Texas (loc. M-29A sample 2C).

?BACTRITES sp. morphotype 9
Plate 7, figures 15-18

Diagnosis.—Strongly compressed phragmocone, cameral ratio 2.5; septa inclined dorosoapical, suture with a moderately deep dorsal lobe.

Description.—?Bactrites sp. mtp. 9 is represented in the collections by a single early juvenile phragmocone. The phragmocone is moderately compressed and has an apical angle of 8°. The septa are inclined dorosoapical with an angle of 20°. The cameral ratio ranges from 2.0 to 2.5. The suture forms a moderately deep dorsal lobe that is probably developed as a response to the septal inclination. No internal deposits have been detected, and since the external test is missing, the ornament is unknown. The wrinkle-layer is well developed as transverse lirae on the dorsum of the conch. The septal necks appear to be orthochoanitic.

?Bactrites sp. mtp. 9 is associated with ?B. sp. mtps. 4, 5, 7, 10, and 11, and Bactrites sansabaensis n. sp. Direct comparison to these taxa is impossible because of the lack of comparable ontogenetic stages. Other Mississippian bactritoids, such as B. carbonarius, B. quadrilineatus, B. fayettevillensis, and B. peytonensis, are all distinguishable from ?B. sp. mtp. 9 by the strongly inclined septa and the dorsal lobe of the suture.

Occurrence and repository.—?Bactrites sp. mtp. 9 (SUI 42624) was recovered from an acid resistant residue from a limestone taken from the Barnett Formation near San Saba, Texas (loc. M-29B sample 2D).

?BACTRITES sp. morphotype 10
Plate 9, figures 1, 4; Plate 15, figures 8-11

Diagnosis.—Embryonic bactritoid, first chamber relatively well-rounded, cameral deposits present, septa transverse, apical angle low (about 5°).

Description.—?Bactrites sp. mtp. 10 is represented in the collections by 106 embryonic phragmocones. All of the specimens are internal molds and lack protoconchs.

The initial chamber, as defined by contractions and relative diameter, is semirounded with a deep constriction on the apical end and a shallow one on the oral end. Additional contractions are present at the oral ends of the second and third chambers. The phragmocone is round, septa are directly transverse, and sutures are simple. The apical angle developed by the early chambers is about 5°, and the cameral ratio is 1.8 to 2.0. The siphuncle is not marginal by the end of the third chamber (4th septum), although the suture develops a faint ventral lobe by this stage of the ontogeny. Mural cameral deposits appear to have been present on the first chamber of some specimens.

?Bactrites sp. mtp. 10 is most similar to and occurs with ?B. sp. mtps. 11 and 6, and B. sansabaensis n. sp. However, ?B. sp. mtp. 10 can be distinguished from these taxa by its smaller initial apical angle and less well-rounded first chamber.

One specimen (Pl. 9, fig. 4) has a long body chamber, which does not flare as do the phragmocones of the Parabactritidae and Sinubactritidae. Because of this, ?B. sp. mtp. 10 may belong to the family Bactritidae.

Occurrence and repository.—All specimens of ?Bactrites sp. mtp. 10 were obtained from the Barnett Formation near San Saba, Texas (loc. M-29). Sample 1D yielded 26 specimens (SUI 42595, 42598, 43788), sample 2D yielded 61 specimens (SUI 43623, 43509, 43583-43585, 43792), sample 3D yielded 5 specimens (SUI 43799), and sample float yielded 15 specimens (SUI 43579, 43802, 43863).

?BACTRITES sp. morphotype 11
Plate 13, figures 2-6, 9, 10, 13

Diagnosis.—Embryonic bactritoid, initial apical angle relatively large (12°), first chamber relatively short.

Description.—?Bactrites sp. mtp. 11 is represented in the collections by 58 embryonic phragmocones; only fragments of the protoconch remain on several of these specimens. The embryonic phragmocone is round. A deep constriction is present at the apical end of the first camera, and moderate constrictions are present at the apical ends of the second, third, and fourth chambers. The apical angle of the initial camera is about 12°. Septa throughout the known ontogeny are transverse, and the suture is simple. The siphuncle becomes marginal by the oral end of the first chamber. Septal necks are orthochoanitic, and cameral deposits appear to have been present on the first and second chambers of some specimens.

?Bactrites sp. mtp. 11 is most similar to and occurs with ?B. sp. mtp. 10. However, this latter taxon is distinguishable by its smaller initial apical angle and more rounded first chamber. Other taxa which are also associated with ?B. sp. mtp. 11 are B. sansabaensis n. sp., Rugobactrites barnettensis n. gen., n. sp., and ?B. sp. mtp. 7. B. sansabaensis has a larger embryonic phragmocone, and the mural cameral deposits form different outlines on the initial chambers than those on ?B. sp. mtp. 11. Rugobactrites barnettensis differs from ?B. sp. mtp. 11 by having septa that become inclined by the third chamber (fourth septum). The difference between ?B. sp. mtp. 7 and ?B. sp. mtp. 11 lies in the fact that the latter taxon has a slightly smaller initial apical angle (12° vs. 15°) and a longer first chamber.

Occurrence and repository.—All of the specimens of ?B. sp. mtp. 11 were recovered from acid resistant residues from limestones from the Barnett Formation near San Saba, Texas (loc. M-29B). Sample 1D yielded 25 specimens (SUI 42593, 42594, 43787), sample 2D yielded
16 specimens (SUI 43578, 43793), sample 3D yielded 3 specimens (SUI 43798), and sample float yielded 15 specimens (SUI 43570, 43577, 43578, and 43808).

?BACITRITES sp. morphotype 12
Plate 2, figures 6, 10

Diagnosis.—Longiconic bactritoid, relatively long cameral ratio (1.3), low apical angle (2° to 3°). Suture forming relatively deep lateral lobes on essentially circular phragmocone.

Description.—?Bacrites sp. mtp. 12 is represented in the collections by two partly complete juvenile phragmocones.

The phragmocone is essentially circular. The test is missing so that the ornament is unknown. The septa are directly transverse, and the cameral ratio is about 1.3. The apical angle is low (2° to 3°). The suture is relatively complex in that there are relatively deep lateral lobes and an acute dorsal saddle. The ventral saddle has a developed ventral lobe at the position of the siphuncle. Neither cameral deposits nor wrinkle-layer has been detected on either specimen. The septal necks are orthochoanitic.

?Bacrites sp. mtp. 12 has been found in association with Bactrites milleri n. sp. This latter taxon can be distinguished from ?B. sp. mtp. 12 by its cameral ratio (1.6 to 2.1), wrinkled-layer, and lack of lateral lobes. Bacrites carbonarius is similar to ?B. sp. mtp. 12 in that both have a suture with relatively deep lateral lobes; however, B. carbonarius has a well-developed angular wrinkle-layer (65° to 75°).

Although the morphologic features of ?Bacrites sp. mtp. 12 are unique, the overall poor condition of the two specimens makes it advisable at this time to describe the taxon as a morphotype within the Bactritidae.

Occurrence and repository.—Both specimens of ?B. sp. mtp. 12 (SUI 43784) were collected as part of a “crack-out” fauna from the Pitkin Formation in north-central Arkansas (loc. M-28).

?BACITRITES sp. morphotype 13
Plate 2, figures 14-16

Diagnosis.—Body chamber of a relatively mature bactritoid, with pronounced transverse ornament and nearly transverse wrinkle-layer.

Description.—?Bacrites sp. mtp. 13 is represented in the collections by two incomplete body chambers. Both have diameters of approximately 14 mm. The apical angle is about 6°. Ornament is pronounced and sinuous. On the apical end of the body chamber, the ornament consists of broad, well-developed striae; each stria is about 0.3 mm wide and 1 mm apart. On the oral end of the same body chamber, the ornament consists of coarse lirae spaced approximately 1 mm apart. The ornament between the oral and apical end of this body chamber is transitional. Septal orientation, cameral ratio, suture, and internal deposits remain unknown morphologic features for this taxon. The wrinkle-layer is well developed and consists of slightly wavy, nearly transverse lirae.

?Bacrites sp. mtp. 13 is found in association with Bacrites carbonarius and Bacrites cf. B. ahloosensis n. sp. Bacrites carbonarius lacks well-defined transverse ornament at comparable diameters. Specimens of B. cf. B. ahloosensis of comparable size have a smooth shell with faint growth lines. ?Bacrites sp. mtp. 13 is the only known bactritoid in the Mississippian with transverse ornament except Bacrites poytonensis, which has the transverse ornament as a mature modification. The ornament of ?B. sp. mtp. 13 may be a mature modification, but until more complete specimens are recovered, this will remain uncertain.

Occurrence and repository.—Both specimens of ?Bacrites sp. mtp. 13 (SUI 43785, 43964) were recovered as surface finds in the Moorefield Formation near Batesville, Arkansas (loc. M-11).

?BACITRITES sp. morphotype 14
Plate 30, figures 1-6, 8-10

Diagnosis.—Longiconic embryonic phragmocone, septa inclined dorsiopacal beginning with fifth septum, low apical angle.

Description.—?Bacrites sp. mtp. 14 is represented in the collections by 24 embryonic phragmocones and body chambers.

The protoconch is subspherical and wider than long. It is bluntly pointed on the apical end. Testiferous specimens show the protoconch to be unornamented, as is the remainder of the conch. The oral end of the protoconch is only slightly constricted; other constrictions are not readily apparent. The initial septa are directly transverse until the fifth septum. The fifth septum and all other known septa are inclined dorsiopical at angles of up to 25°. The apical angle of the initial chambers is about 5° or less, and the apical angle for the remainder of the known phragmocone is 2° to 3°. Where the septa are inclined, the suture forms a deep dorsal lobe and the ventral saddle has a ventral lobe developed at the siphuncle position. Cameral deposits of the mural type may be present on the initial chambers of some specimens.

?Bacrites sp. mtp. 14 occurs with embryonic forms of ?B. sp. mtps. 15 and 16. These latter two morphotypes can be distinguished from ?B. sp. mtp. 14 by lack of inclined septa (mtp. 15) and presence of ornament on the protoconch (mtp. 16). ?Bacrites sp. mtp. 19, from the Smithwick Formation, is morphologically similar to ?B. sp. mtp. 14 in that both have dorsiopical inclined septa. However, ?B. sp. mtp. 19 has a more pronounced protoconch and is smaller in overall dimensions.

Bacrites gaitherensis has been recovered from the same exposures that yielded ?B. sp. mtp. 14, and it is possible that this morphotype constitutes the early embryonic stages for this species. That ?B. sp. mtp. 14 is a bactritoid seems reasonably certain because of the very low angle of inclination present at the oral end of an exceptionally complete embryonic specimen (Pl. 30, fig. 8-10).

Occurrence and repository.—All specimens of ?B. sp. mtp. 14 (SUI 42544, 42546, 43601, 43871) were recovered from a single shale exposure in the Gene Autry Formation in southern Oklahoma (loc. P-1).

?BACITRITES sp. morphotype 15
Plate 20, figures 13-17

Diagnosis.—Embryonic bactritoid, initial apical angle low, septa essentially transverse throughout known ontogeny.
Description.—?Bactrites sp. mtp. 15 is represented in the collections by 75 embryonic phragmocones. The majority of the specimens are internal molds, but some are testiferous.

The protoconch is subcircular and wider than long. It has a bluntly pointed apex. The test on the protoconch and phragmocone is smooth. The protoconch is separated from the first chamber by a moderately deep constriction, and a shallow constriction separates the first and second chambers. The initial apical angle for the first several chambers is about 5°. The latter part of the third embryonic stage has a slight reverse apical angle of about 2° to 3°. Septa are essentially transverse throughout the known ontogeny. There is, however, a suggestion that the sixth and seventh septa may be inclined slightly dorsopacically. The cameral ratio varies from 15 to 3.2. The overall sutural configuration is simple with a ventral lobe, although the sixth and seventh sutures may have a slight dorsal lobe. Septal necks are orthochoanitic. Internal deposits have not been detected.

?Bactrites sp. mtp. 15 is found in association with and most closely resembles ?B. sp. mtp. 14. However, this latter morphotype differs in having strongly inclined septa that begin at the fifth septum, whereas in ?B. sp. mtp. 15 the septa remain transverse or nearly transverse through the seventh septum. ?Bactrites sp. mtp. 15 is also found in association with ?B. sp. mtp. 16; however, this latter morphotype is distinguished by having an ornamented protoconch.

Occurrence and repository.—All specimens of ?B. sp. mtp. 15 (SUI 42545, 43600, 43598, 43860) were recovered from a single exposure in the Gene Autry Formation in southern Oklahoma (loc. P-1).

**?BACTRITES sp. morphotype 16**
Plate 22, figures 1, 3, 6

Diagnosis.—Embryonic bactritoid, protoconch and initial chambers with reticulated ornament.

Description.—?Bactrites sp. mtp. 16 is represented in the collections by eight embryonic phragmocones.

The protoconch is wider than long and covered with well-developed reticulated ornament (Pl. 22, figs. 1, 6). The ornament extends past the protoconch beyond at least the third chamber. The first constriction, which is located at the orad end of the protoconch, is moderately well developed. The second constriction, at the orad end of the first chamber, is poorly developed. Septa are transverse initially. At some point, probably at the fifth and sixth chambers, the septa become strongly inclined dorsopacically and at about 15° to 20°. The suture is simple until the septa become inclined; when the septa are inclined, the suture develops a broad dorsal lobe and ventral saddle. Cameral ratio ranges from 1.5 to 3.0. Internal deposits have not been detected.

?Bactrites sp. mtp. 16 is found in association with the embryonic stages of ?B. sp. mtps. 14 and 15. However, the latter morphotypes lack an ornamented protoconch and are generally smaller in overall dimensions. ?Bactrites sp. mtp. 22 has an ornamented protoconch; however, the ornament is predominantly longitudinal rather than the reticulated pattern seen in ?B. sp. mtp. 16. *Bactrites reticulatus* n. sp. has a protoconch with reticulated ornament; however, this reticulated ornament is coarser and is better defined than that of ?B. sp. mtp. 16.

Occurrence and repository.—All specimens of ?B. sp. mtp. 16 (SUI 43602, 43624, 43868) were recovered from a single exposure in the Gene Autry Formation in southern Oklahoma (loc. P-1).

**?BACTRITES sp. morphotype 17**
Plate 19, figures 1–3

Diagnosis.—Longiconic bactritoid, cameral ratio low (0.8), apical angle approximately 1°. Suture relatively sinuous.

Description.—?Bactrites sp. mtp. 17 is represented in the collections by two incomplete juvenile? phragmocones. Both are limonitic internal molds without shell material.

The phragmocone is slightly compressed, and the septa are directly transverse. The cameral ratio is low (0.8), as is the apical angle (approximately 1°). The suture has deep lateral lobes and a dorsal saddle; the ventral lobe is developed on the siphuncle. The septal necks are orthochoanitic, and the connecting rings are straight. No internal deposits have been detected.

?Bactrites sp. mtp. 17 is found with Bactrites smithwickensis n. sp. and five bactritoid morphotypes (?B. sp. mtps. 18, 19, 20, 21, and 32). Bactrites smithwickensis can be distinguished from ?B. sp. mtp. 17 by its smaller cameral ratio and its more complex suture. The morphotypes are not directly comparable because they represent different ontogenetic stages. It is distinctly possible that one of these five embryonic bactritoid morphotypes is in fact the early ontogenetic stage of ?B. sp. mtp. 17.

Occurrence and repository.—Both specimens of ?B. sp. mtp. 17 (SUI 43879, 43880) were surface finds from a single exposure in the Smithwick Formation in northern-central Texas (loc. P-4).

**?BACTRITES sp. morphotype 18**
Plate 22, figures 7–9

Diagnosis.—Embryonic bactritoid, annulations at end of embryonic stage and beginning of juvenile stage.

Description.—?Bactrites sp. mtp. 18 is represented by a single embryonic phragmocone and living chamber.

The initial stages of the embryonic phragmocone are partly covered with a boxworklike covering that obscures the protoconch and initial chambers. This covering may represent remnants of the original test. The septa appear to be essentially transverse and are slightly sinuous. The cameral ratio is about 2.0, and the phragmocone is circular. The apical angle on the initial portion of the phragmocone is about 15°. A reverse apical angle of about 5° is present in the third embryonic stage. The early juvenile stage is represented by a part of the body chamber. This stage is marked by an apical angle of 7° and is annulate. Septal neck and internal deposits have not been observed.

?Bactrites sp. mtp. 18 is almost unique among Pennsylvanian bactritoids in that it has annulations in the early juvenile stages. The only other taxon with annulations in the early juvenile stages is *Orbobactrites davisensis* n. gen., n. sp.; however, this latter taxon can be dis-
tistinguished from ?Bactrites sp. mtp. 18 by the longitudinal ornament on its protoconch.

Occurrence and repository.—The single specimen of ?B. sp. mtp. 18 (SUI 42549) was recovered from a shale exposure of the Smithwick Formation in northcentral Texas (loc. P-4).

?BACTRITES sp. morphotype 19
Plate 40, figures 6, 12, 14, 15

Diagnosis.—Embryonic bactritoid, protoconch spherical, septa becoming inclined at fifth septum, directly transverse by end of embryonic developmental stage.

Description.—?Bactrites sp. mtp. 19 is represented by 13 embryonic specimens. Essentially, all of the specimens are internal limonite molds and the few testiferous specimens are smooth.

The protoconch, which is preserved on only one specimen, is spherical in that it is as long as it is wide. The orad end of the protoconch contracts to form a deep constriction at the first septum. The second constriction, which is located at the orad end of the first chamber, is less well developed. The apical angle at the apical end of the first chamber is about 65°; this angle rapidly decreases so that by the fifth septum there is a slight (3°) reverse apical angle. The septa are directly transverse until about the fifth septum, which is inclined doroapicad 20° to 25°. By the ninth or tenth septum, the septa are again transverse. The suture is simple except where the septa are inclined; at these inclined septa, the suture forms a relatively deep dorsal lobe. Mural cameral deposits may have been present on the initial camerae.

?Bactrites sp. mtp. 19 is found in association with the embryonic phragmocones of ?B. sp. mtps. 18, 20, 21, and 22. These latter morphotypes are distinguishable from ?B. sp. mtp. 19 by the inclination of the fifth septum, the essentially spherical protoconch, and the overall size of the phragmocone, which is larger than ?B. sp. mtps. 21 and 22, and smaller than ?B. sp. mtps. 18 and 20.

Occurrence and repository.—All specimens of ?B. sp. mtp. 19 (SUI 42547, 42550, 43883) were recovered from a single exposure of the Smithwick Formation in northcentral Texas (loc. P-4).

?BACTRITES sp. morphotype 20
Plate 20, figure 3

Diagnosis.—Embryonic bactritoid, protoconch subspherical, apical angle near 0°, essentially no first constriction.

Description.—?Bactrites sp. mtp. 20 is represented by two embryonic limonitic internal molds.

The protoconch is subspherical, being slightly wider than long. The first constriction at the orad end of the protoconch is very shallow, which gives the protoconch a U-shaped appearance in plain view. The second constriction, at the orad end of the first chamber, is less well developed. Septa are directly transverse, and the suture is simple. The cameral ratio is about 2.5 for the initial chambers, but this can be expected to change in the later embryonic and juvenile stages. The apical angle is nearly 0°. No internal deposits have been observed.

?Bactrites sp. mtp. 20 is found in association with the embryonic phragmocones of ?B. sp. mtps. 18, 19, 21, and 22. These latter taxa are distinguishable from ?B. sp. mtp. 20 by their deeper first constriction, larger initial apical angle, and overall phragmocone size. Another morphotype which is similar to ?B. sp. mtp. 20 is ?B. sp. mtp. 29. However, this latter morphotype can be identified by its extensive mural cameral deposits and larger initial cameral ratio (3:1).

Occurrence and repository.—Both specimens of ?B. sp. mtp. 20 (SUI 43615, 43884) were collected from an exposure of the Smithwick Formation in northcentral Texas (loc. P-4).

?BACTRITES sp. morphotype 21
Plate 20, figure 1

Diagnosis.—Bactritoid with moderate initial apical angle (14°), without cameral deposits. Septa becoming inclined at fourth septum.

Description.—?Bactrites sp. mtp. 21 is represented by a single embryonic phragmocone that lacks a protoconch.

The embryonic phragmocone is essentially circular, and there is no trace of ornament or test. The initial septa are directly transverse; however, this condition rapidly changes at the fourth septum, which is slightly inclined doroapicad. The fifth septum is moderately inclined at an angle of 10°. The suture is simple until the septa become inclined; when that occurs, the suture develops a shallow dorsal lobe. The apical angle of the initial chamber is 14° and the later elements of the embryonic phragmocone expand at an angle of 5°. No internal deposits are apparent on the specimen.

?Bactrites sp. mtp. 21 is most similar to ?B. sp. mtp. 22; however, this latter morphotype has well-developed cameral deposits around the siphuncle in the early chambers and is larger in overall dimensions. Other bactritoids, including ?B. sp. mtps. 24 and 22, have inclined septa beginning about the fourth or fifth septum. These two morphotypes differ from ?B. sp. mtp. 21 by being larger in overall proportions and having larger cameral ratios.

Occurrence and repository.—The single specimen of ?B. sp. mtp. 21 (SUI 42556) was recovered from an exposure in the Smithwick Formation in northcentral Texas (loc. P-4).

?BACTRITES sp. morphotype 22
Plate 18, figure 14; Plate 20, figures 6-12; Plate 34, figures 3, 6-8

Diagnosis.—Bactritoid with extensive cameral deposits around septal necks in early embryonic stages. Initial apical angle relatively large (14° to 18°); septa essentially transverse during embryonic stages, becoming inclined doroapicad in juvenile stages.

Description.—?Bactrites sp. mtp. 22 is represented by 76 embryonic and early juvenile phragmocones.

The protoconch is essentially spherical, being as wide as it is long. The diameter of the orad end of the protoconch decreases gradually and, in conjunction with the apical end of the first chamber, forms a deep and relatively wide constriction. A single specimen, which retains well-preserved test at the first constriction, shows the protoconch and first chamber ornamented with longitudinal lirae. Additional constrictions are not readily apparent. The initial apical angle is moderately high, ranging from 14° to 18°; no internal deposits are apparent on the specimen.
to 18°; the juvenile stage has an apical angle of 5°. The septa during the embryonic stages are directly transverse; however, during the late embryonic and juvenile stages the septa are inclined dorsoapical at a 10° angle. The suture reflects the septal inclination in being simple where the septa are transverse and developing a shallow dorsal lobe where they are inclined. The camera ratio ranges between 1.8 and 2.2. Extensive camera deposits are well developed around the septal necks of many specimens; however, they appear to be limited to the first three chambers. It cannot be determined at this time whether the deposits are mural, epiSeptal, or hypoSeptal.

**?Bactrites** sp. mtp. 22 is most similar to ?B. sp. mtp. 21; however, the latter morphotype lacks camera deposits and is smaller in overall dimensions. Another morphotype from the same locality and which develops similar camera deposits is ?B. sp. mtp. 32. This morphotype differs from ?B. sp. mtp. 22 by having a larger protoconch with more closely spaced longitudinal ornament and a less pronounced first constriction. The apical angle of ?B. sp. mtp. 22 varies among individuals in the later embryonic stages of development (Pl. 34, figs. 7-8). The reason for this variation is unknown; but initial chambers seem to be consistent in their expansion rate.

**Occurrence and repository.**—All specimens of ?B. sp. mtp. 22 (SUI 42542, 42551, 42552, 43599, 43602 to 43604, 43616, 43617, 43625, 43885) were recovered from an exposure of the Smithwick Formation in northcentral Texas (loc. P-4).

**?BACTRITES** sp. morphotype 23

**Plate 32, figures 10-13**

**Diagnosis.**—Embryonic bactritoid, phragmocone relatively large. Septa becoming inclined dorsoapical at seventh septum.

**Description.**—?Bactrites sp. mtp. 23 is represented by 529 embryonic phragmocones that lack tests and protoconchs. The phragmocone is essentially circular. Shallow constrictions are present at the first through fifth septa; some of these may be of embryological significance. The initial apical angle is high (22°); however, this angle decreases rapidly so that by the third chamber a reverse apical angle of about 4° is established. The initial septa are transverse until the seventh septum, where the septa develop a dorsoapical inclination of up to 10°. The suture is simple in the initial embryonic stages; however, when the septa become inclined, the suture develops a shallow dorsal lobe. The first camera is relatively short with a camera ratio of 5.5; however, the other cameras have a camera ratio range of 2.0 to 2.5. It is possible that mural camera deposits have been present on the initial chambers.

**?Bactrites** sp. mtp. 23 is probably most similar to ?B. sp. mtp. 26 and ?B. woodi n. sp. However, both ?B. woodi and ?B. sp. mtp. 26 are distinguishable from ?B. sp. mtp. 23 by the position at which the septa become inclined. Additionally, both of these taxa are smaller in overall proportions than ?B. sp. mtp. 23.

**Occurrence and repository.**—All specimens of ?B. sp. mtp. 23 were recovered from the Wewoka Formation in central Oklahoma; locality P-6 yielded specimens numbered SUI 42655 and 43895, and locality P-8 yielded specimens numbered SUI 43564, 43598, and 43905.

**?BACTRITES** sp. morphotype 24

**Plate 20, figures 2, 4, 5**

**Diagnosis.**—Embryonic bactritoid, initial camera asymmetrically placed, initial apical angle relatively large. Septa becoming inclined at fifth septum.

**Description.**—?Bactrites sp. mtp. 24 is represented by a single embryonic internal mold that lacks a protoconch.

The phragmocone is circular. Shallow constrictions are present at the first through fifth septa; these constrictions probably have some unknown embryologic significance. The apical angle of the initial camerae is 30°. The initial camerae are placed asymmetically in terms of the longitudinal symmetry of the phragmocone. The remaining part of the phragmocone anterior of the third chamber has a reverse apical angle of about 4°. Septa in the initial portion of the phragmocone are transverse, and the sutures are simple. However, the septa become inclined dorsoapical past the fifth septum and the suture develops a shallow dorsal lobe. Cameral deposits may have been developed on the apical camera, but poor preservation prevents their positive identification.

?Bactrites sp. mtp. 24 is similar to B. woodi and ?B. sp. mtps. 26, 23, and 21; however, this morphotype can be distinguished by the asymmetrical placement of the first two camerae, the position at which the septa become inclined (fifth septum), and the high initial apical angle.

**Occurrence and repository.**—The single specimen of ?B. sp. mtp. 24 (SUI 43565) was recovered from the Wewoka Formation in central Oklahoma (loc. P-8).

**?BACTRITES** sp. morphotype 25

**Plate 30, figure 14; Plate 32, figures 1-3, 5; Plate 37, figures 3-8**

**Diagnosis.**—Relatively small embryonic phragmocone. Septa inclined dorsoapical beginning at fifth septum. Juvenile stage with relatively large apical angle.

**Description.**—?Bactrites sp. mtp. 25 is represented by 56 internal molds of the embryonic and early juvenile phragmocone. The protoconch is unknown.

The phragmocone is circular. Abrupt constrictions are located at the oral and apical ends of the first chamber. The camera ratio ranges from 2.3 to 3.5. The initial septa are transverse and the sutures are simple; however, when the septa become inclined dorsoapical at the fifth septa, the suture develops a shallow dorsal lobe. The initial apical angle is about 30°. Past the third chamber, a reverse apical angle of about 4° is developed. The early juvenile stage has an apical angle ranging from 12° to 13°. Internal deposits have not been detected in this morphotype.

?Bactrites sp. mtp. 25 is most similar to ?B. sp. mtp. 28; however, ?B. sp. mtp. 28 has an overall larger phragmocone and the initial apical angle is smaller (16°).

Other bactritoid morphotypes have larger embryonic phragmocones. The relatively large apical angle of the juvenile phragmocone (12° to 13°) suggests a close association with the Parabactritidae; however, this cannot be confirmed because the septal necks cannot be discerned. It is also possible that the Desmoinesian-aged specimens (Wewoka Formation) and the Missourian-aged speci-
mens (Eudora Shale) may represent different taxa. However, confirmation of this must await the recovery of more mature and complete specimens.

Occurrence and repository.—Of the 56 specimens of ?B. sp. mtp. 25, 53 were recovered from the Eudora Shale Member of the Stanton Formation near Tyro, Kansas (loc. P-15). The remaining three specimens (SUI 42642 to 42644) were recovered from the Wewoka Formation in central Oklahoma (loc. P-8).

?BACTRITES sp. morphotype 26
Plate 30, figures 7, 11-13, 15-17

Diagnosis.—Embryonic bactritoid, initial cameral ratio of about 2.0 in early embryonic stage, 3.0 in later embryonic stage.

Description.—?Bactrites sp. mtp. 26 is represented by eight internal molds of embryonic phragmocones. An additional specimen consisting of a protoconch and two camerae is assigned to this morphotype with reservation.

The single protoconch is subospheral, being slightly wider than long. The oral end of the protoconch and the apical end of the first chamber decrease in diameter and form a moderately deep constriction at the position of the first septum. Less pronounced constrictions are present at the positions of the second, third, and fourth septa. The initial septa are transverse and the sutures are simple. However, oral of the fifth septum, the septa are inclined dorsiopical at an angle of 20° and the suture develops a shallow dorsal lobe. The phragmocone cross section remains circular throughout the known ontogeny. Mural cameral deposits appear to have been present on the initial chambers.

?Bactrites sp. mtp. 26 is similar to such morphotypes with inclined septa as*B. woodi* n. sp. and ?B. sp. mtp. 24 and 21. However, ?B. sp. mtp. 26 is distinguishable from similar appearing taxa by its rapid change in cameral ratio from the initial embryonic camerae (2.0) to the late embryonic camerae (3.0).

Occurrence and repository.—All specimens of ?B. sp. mtp. 26 were recovered from the Wewoka Formation in central Oklahoma. Eight of the nine specimens (SUI 42651, 42652, 43908) were recovered from locality P-8 and the single specimen referred to ?B. sp. mtp. 26 with reservation (SUI 42654) was recovered from locality P-6.

?BACTRITES sp. morphotype 27
Plate 40, figures 4, 9, 10

Diagnosis.—Embryonic bactritoid with a relatively small conch, septa transverse; initial apical angle 16°; apical angle of juvenile stage about 15°.

Description.—?Bactrites sp. mtp. 27 is represented by 10 embryonic phragmocones.

The phragmocone is circular; shallow constrictions are present at the first through fourth septa. A total of five septa are present, and all are directly transverse. The suture is simple. The initial apical angle is 16° and by the fourth chamber a slight reverse apical angle is attained. In the early juvenile phase the phragmocone expands rapidly at about a 15° angle and a slight ridge suggests the beginning of an annulate juvenile phase.

Direct comparison of ?B. sp. mtp. 27 is difficult because of its lack of diagnostic features; however, the phragmocone is only slightly larger than ?B. sp. mtp. 25, and in this respect, it may be considered unusual because of the overall small size. ?Bactrites sp. mtp. 27 differs from ?B. sp. mtp. 25 by its much smaller initial apical angle (15° vs. 30°, respectively). All other known bactritoids have embryonic phragmocones larger than that of ?B. sp. mtp. 27.

The rapid expansion of the early juvenile stage suggests that this morphotype is the embryonic phragmocone of a parabactritid. Also, if the single ridge on the early juvenile stage is, in fact, the beginning of an annulate phase, this morphotype could be considered similar to *Microbactrites*.

Occurrence and repository.—All specimens of ?B. sp. mtp. 27 (SUI 42653, 43899) were recovered from the Wewoka Formation in central Oklahoma (loc. P-6).

?BACTRITES sp. morphotype 28
Plate 40, figures 2, 7, 8, 16

Diagnosis.—Embryonic bactritoid, protoconch smaller than first chamber and placed asymmetrically on phragmocone.

Description.—?Bactrites sp. mtp. 28 is represented by a single protoconch-bearing embryonic conch.

The protoconch of ?B. sp. mtp. 28 is semispherical, being slightly longer than wide. Additionally, the phragmocone diameter is about 2/3 that of the first camera. The oral end of the protoconch in conjunction with the apical end of the first chamber forms a deep constriction at the first septum. Constrictions that are less well developed are present at the second, third, and fourth septa. The three visible septa are directly transverse, and the sutures are simple. The initial apical angle is 16°; the remainder of the phragmocone forms a reverse apical angle of about 6°. Mural cameral deposits may have been present in the initial chambers. The surface textures of the protoconch exhibit a rough bilaterally symmetrical pattern; the significance of this pattern has not been determined.

?Bactrites sp. mtp. 28 is unique among the morphotypes in the relationship of the protoconch diameter to that of the first chamber. Similar relationships between the first chamber and the protoconch occur in the Sinubactritid family; however, the taxa so far referred to this family have embryonic phragmocones of much larger size and distinctive sutural patterns. Of all the morphotypes, only ?B. sp. mtp. 25 is similar to ?B. sp. mtp. 28 *sans* protoconch. However, ?B. sp. mtp. 28 is larger in overall conch proportions than ?B. sp. mtp. 25, and has a smaller initial apical angle.

Occurrence and repository.—The single specimen of ?B. sp. mtp. 28 (SUI 42650) was recovered from the Wewoka Formation in central Oklahoma (loc. P-7).

?BACTRITES sp. morphotype 29
Plate 18, figures 3, 4; Plate 26, figure 8; Plate 34, figures 4, 5

Diagnosis.—Embryonic bactritoid; protoconch spherical, with a long marginal caecum. Cameral deposits well developed.

Description.—?Bactrites sp. mtp. 29 is represented by 12 frag-
mentary embryonic phragmocones. All of the specimens are internal molds with only traces of poorly preserved test.

The protoconch is equidimensional, length being approximately equal to width. The caecum, while not directly exposed, extends to the ventral apical end of the protoconch, where it lies adjacent to the surface. The apical end of the caecum is marked by a mound or high point on the inner mold of the protoconch.

The first constriction is developed at the first septum and is moderately deep. Additionally poorly developed constrictions are present at the second and third septa. The septa are transverse for the entire length of the known phragmocone (approximately nine camerae). The sutures are simple. The initial apical angle is about 6° with the maximum dimensions of the embryonic phragmocone being attained at about the fourth camera. Past the fourth camera, there is a reverse apical angle of about 6°. Mural deposit scars are extensive on some camerae (Pl. 18, figs. 3, 4), and it appears that some specimens may have had either hyposeptal or episeptal deposits on the first several septa.

?Bactrites sp. mtp. 29 is almost unique among Pennsylvanian embryonic bactritoids for its caecum development. Additionally, this morphotype has probably the largest known mural deposit scars of any Pennsylvanian member of the Bactrida. Other morphotypes that appear similar are ?B. sp. mtp. 32 and Bactrites reticulatus n. sp. ?Bactrites sp. mtp. 29 can be distinguished from B. reticulatus by its smaller initial cameral ratio, which is based on the length of the first chamber. ?Bactrites sp. mtp. 32 can be recognized by its heavier episeptal/hyposeptal deposit scars.

Occurrence and repository.—All of the specimens of ?B. sp. mtp. 29 were collected from the Wewoka Formation in central Oklahoma; locality P-6 yielded four specimens (SUI 43897), locality P-7 yielded two specimens (SUI 43904), and locality P-8 yielded six specimens (SUI 42481 to 42467, 43563, 43569, 43596).

?BACTRITES sp. morphotype 30

Plate 18, figures 1, 2

Diagnosis.—Bactritoid body chamber with a deeply constricted aperture.

Description.—?Bactrites sp. mtp. 30 is represented by a single internal mold of a body chamber. The body chamber is circular. The apical septum is directly transverse and the suture is simple. The orad end of the body chamber is deeply constricted.

The single specimen of ?B. sp. mtp. 30 is unique. The constriction of the aperture remains a problematic feature of uncertain paleobiologic significance. Had this specimen been of megascopic size, an acceptable explanation would have been that the constriction is a mature modification. However, the size of the phragmocone (< 1 mm in diameter) would appear to argue against this interpretation.

Occurrence and repository.—The single specimen of ?B. sp. mtp. 30 (SUI 42505) was recovered from the Eudora Shale Member of the Stanton Formation near Tyro, Kansas (loc. P-15).

?BACTRITES sp. morphotype 31

Plate 22, figure 2; Plate 26, figures 1, 2, 6, 8

Diagnosis.—Juvenile bactritoid camerae with compressed cross section, suture with well-developed dorsal saddle, wrinkle-layer confined to dorsum.

Description.—?Bactrites sp. mtp. 31 is represented by 15 fragmentary juvenile phragmocones. All of the fragments are septate and some are testiferous.

The phragmocone is compressed and has an apical angle of about 7°. The septa are directly transverse, and the cameral ratio ranges from 1.5 to 3.0. The suture has a shallow dorsal saddle and deep lateral lobes. The septal necks are orthochoanitic, and there is no trace of internal deposits. The wrinkle-layer is well displayed as lirae on either side of the dorsal furrow. The lirae are restricted to the dorsal surface.

?Bactrites sp. mtp. 31 is probably most similar to B. oweni n. sp.; however, this latter taxon has a wrinkle-layer that completely surrounds the phragmocone at comparable sizes. Bactritoid morphotypes that have similar sutures are ?B. sp. mtps. 21, 24, and 26. However, all of these morphotypes have inclined septa.

Occurrence and repository.—All specimens of ?B. sp. mtp. 31 were recovered from the Wewoka Formation in central Oklahoma (loc. P-8 = SUI 42566, 43520, 43526, 43564, 43978; and loc. P-7 = SUI 43552, 43553).

?BACTRITES sp. morphotype 32

Plate 32, figures 4, 6-9, 14-16

Diagnosis.—Embryonic bactritoid with relatively thick episeptal/hyposeptal deposits. Protoconch subterminal, covered with closely spaced longitudinal lirae. Late embryonic phragmocone with a low cameral ratio (1.0 to 1.2); septa directly transverse throughout known ontogeny.

Description.—?Bactrites sp. mtp. 32 is represented by 45 embryonic phragmocones. The majority of the specimens are internal molds, but some are testiferous.

The protoconch is subterminal, being wider than long, and is ornamented with closely spaced longitudinal lirae. The first constriction is moderately deep and is developed at the first septum. Additional poorly developed, shallow constrictions are present at the second and third septa. The septa are directly transverse throughout the known ontogeny (six camerae), and the suture is simple. The initial apical angle is 10° and by the third camera the apical angle is nearly 0°. The phragmocone is circular. Mural as well as episeptal and/or hyposeptal deposits are well developed on the initial camerae. Also, in one specimen the caecum is exposed; it is longer than wide and has an egg-shaped appearance (Pl. 32, figs. 8, 9).

?Bactrites sp. mtp. 32 is most similar to ?B. sp. mtp. 29 in the amount of cameral deposits; however, ?B. sp. mtp. 32 has a larger cameral ratio in the late embryonic stage. Additionally, the protoconchs of ?B. sp. mtps. 15 and 29 and B. reticulatus are similar; however, none of these taxa has longitudinal lirae as ornament.

Occurrence and repository.—All of the specimens of ?B. sp. mtp. 32 (SUI 42548, 42553, 43626, 43627, 43605, 43886) were recovered from the Smithwick Formation in northcentral Texas (loc. P-4).
Genus *CTENOBACTRITES* Shimansky, 1951

*Type species*—*Ctenobactrites costatus* Shimansky, 1951; OD.


*Diagnosis*—Longicongic bactritid with orthochoanitic septal necks, apical angle less than 10°, marginal siphuncle, external test on phragmocone covered by coarse transverse lirae or striae.

Shimansky (1951, 1954, 1962, 1968) has referred the following taxa to this genus: *Ctenobactrites costatus* Shimansky, 1951; *C. in honoris* Shimansky, 1968; *C. mirus* Shimansky, 1954; and *C. obliquuesulcatus* (Gemmellaro), 1889. Additional taxa in the collections under study which can be referred to this genus include: *Ctenobactrites collinsi* (Miller and Unklesbay), 1947; *C. lesliensis n. sp.;* and *Ctenobactrites* sp.

*Ctenobactrites* is similar to *Bactrites* in every known morphological feature except external ornament, having coarse transverse lirae and/or costae whereas *Bactrites* almost always has a smooth or longitudinally ornamented test. Several generic assignments are problematical. One encompasses two nonseparate specimens referred to herein as ?*Bactrites* sp., morphotype 13. Both may eventually, with the recovery of additional, more complete specimens, be referred to *Ctenobactrites* because of their coarse transverse lirae. The other exception is *Bactrites costatus* n. sp.; this taxon has relatively fine transverse striae as ornament and could be placed in either *Bactrites* or *Ctenobactrites*.

The most distinctive character of *Ctenobactrites* is, as has been stated, the coarse transverse ornament. Shimansky (1954) stated that this ornament should not be reflected on the surface of the internal mold; however, this is probably not a significant morphologic observation. Several specimens including *Bactrites cherokeensis* and *C. collinsi* have ridges on the internal mold that probably reflect to some degree the presence of transverse ornament. In fact, *C. collinsi* has a single patch of test on the phragmocone (Pl. 33, fig. 3) that is ornamented with coarse transverse lirae.

Another important morphologic feature in *Ctenobactrites* is that the coarse costae and/or lirae must occur on a septate part of the conch. It is distinctly possible that some species of *Bactrites* develop coarse transverse lirae as a mature modification. A good example of this is *B. peytonensis* n. sp. (Pl. 8, figs. 7,11). Thus, morphologic overlap between more ontogenetically advanced specimens of *Bactrites* and *Ctenobactrites* is reduced by this morphologic requirement. A single specimen illustrated by Shimansky (1968, pl. 20, figs. 5a,b) indicates the juvenile shell of *Ctenobactrites* is smooth. Therefore, because of the smooth juvenile shell and the overall similarity of the morphologic characteristics of *Bactrites* and *Ctenobactrites*, the early ontogenetic stages should be nearly identical. Distinguishing the early embryonic and juvenile stages of these two genera will remain a problem until good reconstructions can be made.

Shimansky (1954) also has established subgenera within *Ctenobactrites*. These subgenera are based on the consideration of whether the lirae of *Ctenobactrites* (ribs of *Erben, 1964a) are flattened or rounded. This treatment may have been ill advised. The available collections contain specimens with flattened coarse lirae and rounded coarse lirae, but there are also specimens with acute sharp lirae and one taxon, *C. lesliensis* n. sp., includes specimens with both types of lirae. Because of this variation, generic subdivision of *Ctenobactrites* is inappropriate.

The early ontogeny of *Ctenobactrites* remains unknown. The single illustrated embryonic conch assigned to *Ctenobactrites* by Shimansky (1958, p. 702; 1964, pl. 7, figs. 10a,b) according to Erben (1964a) does not belong in the Bactritida. If this specimen has a marginal siphuncle, then with its conical protoconch it probably belongs in the *Anulobactritida* n. ord.

*Range and distribution*—In the Soviet Union, *Ctenobactrites* is limited to a few Permian and Carboniferous occurrences in the Southern Urals (Shimansky, 1951, 1954, 1968). Additionally, Shimansky noted the possible occurrence of *Ctenobactrites* from Upper Permian strata in Sicily. North American Mississippian occurrences are restricted to *C. lesliensis* n. sp. from the Fayetteville Formation in northern Arkansas. Additionally, two Pennsylvanian specimens have been recovered; *C. collinsi* from the Brush Creek Limestone in western Pennsylvania and *Ctenobactrites* sp. from the Finis Shale Member of the Graham Formation in northcentral Texas.

**CTENOBACTRITES COLLINSI** (Miller and Unklesbay, 1947)

*Plate 33, figures 1-3.*


*Diagnosis*—Bactritid with ornament consisting of nearly flat-bottomed striae.

*Description*—*Ctenobactrites collinsi* is represented by a single fragmentary phragmocone that is probably mature or nearly mature. The specimen consists of a single fragmentary camera that almost completely lacks the test.

The partially complete camera is circular and has an estimated apical angle of about 10°. The apical septum is directly transverse. The single piece of test is located on the venter and exhibits two transverse striae 2 mm wide, the striations separated by 2 mm of test. The striae are straight sided and nearly flat-bottomed. The intervening test between the striae is flat topped. The septal neck appears to have been orthochoanitic. The internal mold is smooth. Neither wrinkle-layer nor internal deposits has been detected.

Overall preservation of the holotype of *C. collinsi* is poor, and it may prove to be impossible to refer additional taxa to this species. The significance of this taxon is that it was, until now, an unrecognized representative of *Ctenobactrites*. Examination of the original plate...
CTENOBACTRITES LESLIENSIS Maps, new species

Plate 6, figures 1, 7, 8, 10-12

Diagnosis.—Longiconic bactritid, ornament consisting of both rounded and flattened ribs forming a ventral sinus.

Description.—Ctenobactrites lesliensis is represented by 14 incomplete phragmocones in the late juvenile stages of development. Most of the specimens are moderately well preserved and retain at least some test.

The phragmocone is circular with the largest uncushed specimen having a maximum diameter of 28 mm, and the smallest a maximum diameter of 20 mm. Ornament consists of both flat-topped and round-topped ribs that form a broad, shallow, ventral sinus. Ribs range from 1 mm to 2 mm in width. The apical angle ranges from 9° to 10°. The cameral ratio is about 1.8. Septa are orthochoanitic and no cameral deposits are apparent. The internal mold is essentially smooth and does not reflect the ornament.

Ctenobactrites lesliensis is most similar to C. inhonorus Shimansky; however, direct comparison is not possible because the ontogeny of neither species is known and several critical morphological features remain undescribed for the latter taxon. It is possible that C. lesliensis is conspecific with C. inhonorus. The ornament of other species of Ctenobactrites appears to have more pronounced sinuses and salients than C. lesliensis. Ctenobactrites lesliensis is found in association with Bactrites fayettevillensis n. sp., B. peytonensis n. sp., and ?B. sp. morphotypes 1 through 4. These taxa are known mostly by their embryonic and early juvenile phragmocones; in only one case (B. peytonensis) has the late juvenile and mature form been identified. Thus, it is distinctly possible that the embryonic conch of C. lesliensis has been recovered and described (herein), and the complete ontogenetic reconstruction only awaits the recovery of the missing links.

Etymology.—This species is named for the community of Leslie, Searcy Co., Arkansas.

Occurrence and repository.—All of the specimens of C. lesliensis were recovered from the lower shale member of the Fayetteville Formation (middle Chesterian–Mississippian). Locality M-21 yielded six specimens (SUI 43704 to 43706), locality M-22 yielded two specimens (SUI 43707), locality M-25 yielded three specimens (SUI 43719 to 43721), and locality M-27 yielded three specimens (SUI 43714).

CTENOBACTRITES sp.

Plate 23, figures 1, 2

Diagnosis.—Bactritid with flattened striae transversely inclined 15°.

Description.—The single specimen is distorted but was probably nearly circular when intact. Ornament consists of striae about 1 mm wide with relatively flat sides and bottom. The ridges separating the striae are flat topped and are 2.0 to 2.5 mm wide. The striae are inclined dorsorad at a 15° angle and form at the venter a shallow, broad sinus. A single septum that is covered by crushed phragmocone and test appears to be directly transverse with a simple suture.

This single, partly crushed, incomplete (L = 36 mm, D = 40 mm est.) specimen can be referred to Ctenobactrites; however, the poor preservation precludes assignment at the specific level. This specimen probably represents a new species, but until the recovery of additional specimens, it seems best to leave it in open nomenclature.

Ctenobactrites sp. differs from C. lesliensis by the inclination of the ornament and relatively broad dorsal salient and ventral sinus.

Occurrence and repository.—The single specimen of Ctenobactrites sp. (KU 49784) was collected from the Brownwood Shale Member of the Graford Formation near Bridgeport, Texas (loc. P-27).

Family PARABACTRITIDAE Shimansky, 1951

Diagnosis.—Conch orthoiconic and breviconic, apical angle usually greater than 10°, sepal necks cytrochoanitic, siphuncle generally marginal, cameral ratio generally larger than 2.

Comparison of relatively recent summary works by Shimansky (1962) and Erben (1964a) reveals only slight differences in the number of genera assigned to this family. Both authors agree on the familial assignment for the following genera: Aktaostioceras Shimansky, 1948; Belemnitorimus Shimansky, 1954; Microbactrites Shimansky, 1948; Parabactrites Shimansky, 1948; and Tantantaloceras Shimansky, 1954.

The only taxon which was treated somewhat differently by these workers was Cochleiferoceras Shimansky, 1962. Shimansky (1962) stated the systematic position for the genus was not clear and placed it in the Parabactritidae. Erben (1964a) suggested it may not belong in the Bactritidae and placed it in a "doubtful genera" category. The taxonomic placement of Cochleiferoceras remains uncertain.

Analysis of the available collections reveals the following genera assignable to the Parabactritidae: Aktaostioceras Shimansky, 1948; Angustobactrites n. gen.; Eo-parabactrites n. gen.; Gymnobactrites n. gen.; Microbactrites Shimansky, 1954; Orbobactrites n. gen. and Rugobactrites n. gen.

Of the genera listed above, the ontogenesis only of Orbobactrites and Rugobactrites are known. Compari- 

(Miller & Youngquist, 1947, pl. 1, figs. 1,2) shows a specimen with prominent annulations on an internal mold. These annulations are not present on the holotype and are not discussed, although the ornament of the test is described. It is assumed that the annulations shown by Miller and Youngquist are due to retouching.

Occurrence.—Holotype Ctenobactrites collinsi (Carnegie Museum 25800) is from the Brush Creek Limestone at the Harvey Brick Company in Glassmere, Pennsylvania.
son of the early ontogenetic stages of these taxa with the ontogenetic stages of other families shows striking differences in overall conch morphology (Fig. 13). The protoconchs were large in proportion to the initial camerae, and the initial septa were transverse. Later in the embryonic stages, septa became inclined doroapically. Beginning with the juvenile phase of the embryonic stages, septa became inclined. Morphologic differences between various taxa are a function of ontogenetic development. Later ontogenetic stages are uncertain, but in no known case do the annulations persist into the late juvenile or mature stages.

Fig. 13. Diagrams of early ontogenetic stages in the Parabactritidae. Each illustration is a generalized reconstruction of a species or genus. Morphologic differences between various parabactritid taxa are a function of protoconch shape, ornamentation, septal spacing and inclination, and siphuncle position, etc.—A, Rugobactrites imoensis n. gen., n. sp.; lateral view; B, Rugobactrites barnetensis n. gen., n. sp.; lateral view; C, Ornobactrites girtyi n. gen., n. sp.; ventral view. All approximately X21.

Range and distribution.—The oldest occurrence that is probably attributable to the Parabactritidae is “Orthoceras” pygmaeum de Koninck (1844) from Lower Carboniferous strata in Belgium. Mississippian genera from North America include: Eoparabactrites (lower Chesterian) from Oklahoma, Rugobactrites from Chesterian strata in Utah, Arkansas, and Texas, Aktaustioeceras (middle Chesterian) from California, and Angustobactrites (upper Chesterian) from Arkansas. The only other report of a Carboniferous parabactritid was by Shimansky, 1968, who described a poorly preserved specimen of Aktaustioeceras from the Southern Urals. Pennsylvanian occurrences in North America include Ornobactrites from Iowa, Kansas, and Oklahoma, Gymnobioceras from Oklahoma, Rugobactrites from Texas, Kansas, and Oklahoma, and Microbactrites from Kansas. Permian occurrences are limited to the original reports by Shimansky (1948, 1954) of Parabactrites, Microbactrites, Aktaustioeceras, Tabantaloceras, and Belemnitomimus from the Southern Urals.

Genus AKTASTIOECERAS Shimansky, 1948

Type species.—Aktaustioeceras kraglovi Shimansky, 1948; OD.


Description.—Parabactritid with a relatively low apical angle (10° to 12°). Phragmocone compressed, cameral ratio approximately 3.0 to 4.0, septa directly transverse, suture with shallow lateral lobe, test smooth.

Aktaustioeceras has been described (Shimansky, 1948, 1968) from two poorly preserved specimens. The single specimen of the present report is also fragmentary and poorly preserved. Thus, the ontogenetic development and range of variation of morphologic features of this taxon remain poorly understood.

Perhaps the parabactritid most similar to Aktaustioeceras is Angustobactrites n. gen., which differs mainly in having longitudinal ornament. With the eventual recovery of additional more complete specimens of Aktaustioeceras, it is possible that Angustobactrites will be superseded.

Range and distribution.—The original specimen of Aktaustioeceras kraglovi described by Shimansky (1948) was recovered from Lower Permian strata in the Southern Urals. Later Shimansky (1968) referred a specimen from the Carboniferous of the Southern Urals to this taxon. The single American specimen that may be referable to Aktaustioeceras is from Mississippian (middle Chesterian) strata in California.

AKTASTIOECERAS sp.

Plate 4, figures 7-9.


Description.—The single specimen referable to this species consists of several camerae (D = 6 mm est.) that are missing most of the test. The phragmocone is compressed, the apical angle is about 12° to 14°, and the cameral ratio is 5:5. There is no trace of either ornament or wrinkle-layer. The septa are transverse, and the suture has broad, shallow lateral lobes and a dorsal saddle. The septal necks are flared.

The actual taxonomic position of this specimen is uncertain because of the incomplete ontogeny and relatively poor preservation. The assessment by Gordon (1964) that this specimen may be the internal phragmocone of an endocochleate cephalopod is distinctly possible. Only the recovery of additional and more complete specimens can resolve this problem. However, it is important to note that if this single specimen does belong within the Bactritida, then the range of Aktaustioeceras is considerably extended.

Occurrence and repository.—Gordon (1964) described the locality where Aktaustioeceras sp. (SU 9155) was recovered as being the top limestone bed, Perdido Formation (middle Chesterian–Mississippian), 2,100 feet (640 m), S.3° E. at Rest Spring, Cottonwood Mountains,
Panamint Range, Inyo County, California (Stanford University loc. 2776).

**Genus ANGUSTOBACTRITES** Mapes, new genus

*Type species.*—*Angustobactrites saundersi* Mapes, new species.

**Diagnosis.**—Orthoconic parabactritid with a low apical angle (6° to 11°), cameral ratio 2.5 to 4.0, phragmocone circular to compressed, septa transverse to inclined, sutures developing broad moderately deep lateral lobes when phragmocone is compressed.

*Angustobactrites* is morphologically similar to *Aktastioceras*; this latter taxon is distinguished by its lack of ornament, while many of the phragmocones of *Angustobactrites* have longitudinal ornament, and have a lower apical angle. Recovery of additional, more nearly complete and better preserved specimens of *Angustobactrites* and *Aktastioceras* will probably reveal additional taxonomic differences. However, it is possible that as the range of morphologic variation within *Aktastioceras* becomes known, it may be necessary to suppress *Angustobactrites* as a junior synonym.

**Etymology.**—From the Latin *angusto*, narrow, in reference to the relatively low apical angle.

**Range and distribution.**—*Angustobactrites* has been recovered from Mississippian (upper Chesterian) strata in northcentral Arkansas. Additionally, two fragmentary specimens that are morphologically similar are from the Deece and Wewoka formations (Pennsylvania–Desmoinesian) in southeastern and central Oklahoma.

**ANGUSTOBACTRITES SAUNDERSI** Mapes, new species

*Plate 6, figures 2, 3; Plate 8, figures 1–3; Plate 14, figures 1–6; Plate 17, figures 1, 2, 4, 5, 9–11*

**Diagnosis.**—Phragmocone compressed throughout juvenile ontogenetic stages, apical angle low (6° to 11°), cameral ratio ranging from 2.5 to 4.0, septa directly transverse.

**Description.**—*Angustobactrites saundersi* is represented by 76 moderately well-preserved phragmocones and body chambers. The later stages of the embryonic phragmocone have been tentatively identified, but the protoconch remains unknown.

The phragmocone is circular in the late embryonic stages, and becomes more compressed during later ontogenetic stages. Ornament ranges from pronounced wide (max. 1 mm) longitudinal striae on some specimens to a smooth test on others. Inclined growth lines form a broad ventral sinus and dorsal salient on all of the better preserved specimens. Septa are directly transverse throughout the known ontogeny. Cameral deposits are not exposed.

The wrinkle-layer is well exposed and consists of fine wavy lines that are confined to the dorsal portion of the conch.

One specimen (SUI 43890) is slightly crushed (dorsoventral D = 4.4 mm, lateral D = 3.5 mm), but several morphologic features can be determined. The apical angle is about 8° and the phragmocone was probably compressed. The cameral ratio is 2.5, the septa are directly transverse, and the suture has broad shallow lateral lobes and a dorsal saddle. The wrinkle-layer is well exposed and consists of fine wavy lines that are confined to the dorsal portion of the conch.

The other specimen (SUI 43889) has five chambers. The phragmocone (D = 4 mm) is compressed, the apical angle is about 6°, and the cameral ratio is about 4.0. The inclination of the septa is variable in that some septa are inclined and others are transverse. Because of the variation in septal inclination, the suture is also variable. The wrinkle-layer is well exposed and consists of fine wavy lines that are confined to the dorsal portion of the conch.
Both of the specimens are similar to *A. saundersii*. Specimen SUI 43889 has a slightly more compressed phragmocone. Specimen SUI 43890 has a slightly smaller cameral ratio than *A. saundersii*.

In order adequately to refer these two specimens to a species, it will be necessary to discover more complete and better preserved specimens.

**Occurrence and repository.** Specimen SUI 43889 was recovered from the Wewoka Formation (Desmoinesian–Pennsylvanian) in central Oklahoma (loc. P-9). Specimen SUI 43890 was recovered from the Deese Formation (Desmoinesian–Pennsylvanian) in southeastern Oklahoma (loc. P-10).

**Genus EOPARABACTRITES** Mapes, new genus

**Type species.**—Eoparabactrites graffhami Mapes, new species.

**Diagnosis.**—Parabactritid with a low apical angle (approximately 10°) and a high cameral ratio (7.5:1).

Eoparabactrites has been recovered from lower Chesterian strata that are approximately the same age as the units in Utah (Chainman Shale) that yielded *Rugobactrites nevadense*. This latter taxon differs from *Eoparabactrites* by its larger apical angle and more complex suture.

Eoparabactrites graffhami is one of the oldest known parabactritids in North America. Its relatively low apical angle is considered to be a primitive feature; many younger parabactritids have larger apical angles. The early ontogeny of this genus remains unknown, as is its ancestry. Strong similarities to the internal phragmocones of aulacocerid coleoids suggest that perhaps the parabactritids split to give rise to one or more of the early coleoid orders.

**Etymology.**—From the Greek word eos, early, in reference to its occurrence in lower Chesterian strata.

**Range and distribution.**—The only known occurrences of *Eoparabactrites* are from Upper Mississippian (lower Chesterian) shales in central Oklahoma.

**EOPARABACTRITES GRAFFHAMI** Mapes, new species

**Diagnosis.**—Breviconic conch with a very fine transverse wrinkle-layer.

**Description.**—Eoparabactrites graffhami is established on the basis of two incomplete phragmocones. The smaller specimen (SUI 43866) is 11 mm long and has minimum and maximum diameters of 4.8 mm and 7.8 mm, respectively. The apical angle is 10°, and the cross section is essentially circular throughout the length of the phragmocone. The siphuncle is marginal.

The larger specimen (SUI 43743) is compressed and has maximum and minimum dorsoventral diameters of 9.5 mm and 7.0 mm, respectively. The apical angle is 12°, and the siphuncle is submarginal. The body chamber constitutes 11 mm of the overall 28 mm length. Traces of an incompletely developed septum at the apical end of the body chamber are present and because of this, the conch must be considered immature.

The shell on the phragmocone of the smaller specimen has faint longitudinal lirae; growth lines form a broad dorsal salient and a broad ventral lobe, but they are so faint as to be virtually undetectable. The larger specimen has well-developed growth lines on the dorsum, where a pronounced salient is developed; ventrally, the test is missing. The wrinkle-layer is present on the internal molds of both specimens. The individual lirae of the wrinkle-layer are sinuous in appearance and are essentially transverse to the long axis of the conch. There are approximately 70 grooves per millimeter. The sepa of *E. graffhami* are directly transverse and the suture has moderately deep lateral lobes and a broad shallow dorsal saddle. The cameral ratio is about 7.0. Where visible, the septal necks are cyrtochoanitic. Cameral and siphuncular deposits have not been detected.

This species occurs with and can be distinguished from *Bactrites quadrilineatus* and *B. ahlsoensis* by the larger cameral ratio, the suttural pattern, and the cyrtochoanitic septal necks. The belemnite *Eobelemnites Flower*, 1945 differs from *E. graffhami* by having a ros- trum, larger apical angle, and suborthchoanitic to subcyrtochoanitic septal necks. *Eoparabactrites graffhami* is probably most similar to *Rugobactrites nevadense* (Youngquist) in that both have cyrtochoanitic septal necks. However, *R. nevadense* can be distinguished from *E. graffhami* by its greater apical angle. The problem of variable siphuncle position can be solved only by collection of more specimens.

**Etymology.**—This species is named for Allen A. Graffham, who collected the holotype.

**Locality and repository.**—Both specimens were recovered from the Delaware Creek Member of the Caney Formation in central Oklahoma; locality M-1 yielded SUI 43866 and locality M-5 produced specimen SUI 43743.

**Genus GYMNOBACTRITES** Mapes, new genus

**Type species.**—Gymnobactrites iberus Mapes, new species.

**Diagnosis.**—The generic diagnosis is the same as that of the type species for this monotypic genus.

*Gymnobactrites* occurs with and is most morphologically similar to *Rugobactrites*. This latter taxon is distinguishable from *Gymnobactrites* by its compressed cross section with rounded sides; *Gymnobactrites* is also compressed, but its sides are flat. *Orbobactrites* can be distinguished from *Gymnobactrites* by its smaller apical angle. *Tabantoloceras* has a similar phragmocone with flat sides; however, it is distinguishable from *Gymnobactrites* by a lower cameral ratio and smaller apical angle.

**Etymology.**—From the Latin gymno, naked, in reference to the lack of test on all known specimens.

**Range and distribution.**—*Gymnobactrites* has been
recovered from the Middle Pennsylvanian (Desmoinesian) in central Oklahoma.

GYMNOBACTRITES SHIMANSKYI Maps, new species
Plate 34, figures 9-11; Plate 37, figures 9-14; Plate 41, figures 17-20

Diagnosis.—Breviceon parabactrid with a single specimen referable with reservations to this genus from Upper Pennsylvanian (Virgilian) strata in Kansas.

MICROBACTRITES sp.
Plate 21, figure 10

Description.—The single specimen that is referable with reservation to Microbactrites is an external mold of a phragmocone. The phragmocone is compressed with rounded sides at the apical end; the remainder of the phragmocone is crushed. The specimen has an estimated apical angle of 20°, cameral ratio of 5.5, simple sutures, and septa inclined dorsoapicad. No ribs are apparent on the specimen.

Assignment of this specimen is difficult because of crushing. The large apical angle and cameral ratio suggest a similarity to Gymnobactrites and Tabantaloceras; however, these latter taxa have flat sides. Microbactrites has been described as having ribs, and this specimen has none. Ribs or annulations are probably a critical generic level morphologic trait. However, rather than erect a new genus on the basis of such a poor specimen, it seems more reasonable to make the assignment to Microbactrites with strong reservations. When additional well-preserved specimens become available, then this specimen can be reevaluated taxonomically.

Occurrence and locality.—The single specimen of
Microbactrites sp. (KU 48929) was recovered from the Dover Limestone, Wabaunsee Group (Virgilian–Pennsylvanian) in Greenwood County, Kansas (loc. P-22).

Genus ORBOBACTRITES Mapes, new genus

Type species.—Orbobactrites davisensis Mapes, new species.

Diagnosis.—Bactritid with annulations during its later ontogenetic stages. Early embryonic phragmocones with marked dorsal depressions at position of third and fifth septa. Initial chambers ornamented with longitudinal striae. In later ontogenetic stages, compressed phragmocone, apical angle about 13°, cameral ratio about 6:0. Septal necks cyrtochoanitic, connecting rings expanded.

Orbobactrites is probably most similar to Augustobactrites because of its low apical angle. However, it differs from Augustobactrites by having annulations and a larger apical angle. Certain species of Bactrites are also similar; however, in no instance do they have annulations and cyrtochoanitic septal necks. Another annulate taxon that could be confused with Orbobactrites is Annulobactrites; however, this latter taxon probably has a conical protoconch and a higher embryonic apical angle in the early embryonic stages of development.

Three species belonging to Orbobactrites are described in the present report. These are: Orbobactrites davisensis n. sp., O. girtyi n. sp., and O. tyroensis n. sp.

Orbobactrites may be related to Cochleiferoceras from the Middle Devonian of Europe. According to Erben (1964a, fig. 3a,b), this taxon has an annulate phase, relatively large apical angle (90°), and a cameral ratio of 2:3. The cameral ratio and apical angle are similar to those of Bactrites and are less than those of the only comparable species, O. davisensis.

Etymology.—From the Latin orbis, circle or ring, in reference to the annulations, which more or less encircle the phragmocone.

Range and distribution.—North American occurrences are limited to the Middle and Upper Pennsylvanian of Oklahoma, Kansas, and Iowa. Middle Pennsylvanian taxa are Orbobactrites davisensis (Iowa) and O. girtyi (Oklahoma), and the Upper Pennsylvanian form is O. tyroensis (Kansas).

ORBOBACTRITES DAVISENSIS Mapes, new species

Plate 19, figures 5-7; Plate 27, figures 7-11

Diagnosis.—A species of Orbobactrites with moderate dorsal valley at third and fourth septal positions. Initial apical angle large (est. 70°), juvenile apical angle 13°.

Description.—Orbobactrites davisensis is represented by a single well-preserved pyritized megascopic phragmocone that is interpreted as representing the early through late juvenile ontogenetic stages. Additionally, three embryonic phragmocones without protoconchs are referable to this species.

The initial chamber of the phragmocone is circular. The first three camerae are ornamented with relatively deep striae that are interpreted as being molds of the ornamental lirae (Pl. 27, fig. 11). Faint irregularly spaced lirae cross the striae and give a subrecticulate appearance, but this is considered to be a diagenetic feature. The initial constriction is not apparent because of the lack of a protoconch, but the pronounced rapid initial apical angle of 70° (est.) on the apical end of the first camera suggests the first constriction was deep. The second constriction, located at the second septum, is shallow and weakly developed. At the position of the fourth and fifth septa, the dorsal surface develops moderately deep depressions. Septa are more or less directly transverse except at the dorsal depression, where they become inclined dorsal-epicardial at an angle of up to 20°. Orad of the depression and during the juvenile and later stages of ontogeny, the septa are again directly transverse. The cameral ratio for the strongly compressed juvenile phragmocone is about 5:0, and the apical angle is about 13°. Annulations begin at approximately the ninth or tenth camera and have a broad shallow dorsal salient even though they are essentially transverse to the lateral portions of the conch. In the later stages of the ontogeny, the annulations become reduced and are limited to the lateral position on the phragmocones. The suture is simple in the early juvenile stages, but as the phragmocone becomes more compressed, the suture develops broad shallow lateral lobes and a broad shallow dorsal saddle. Septal necks are cyrtochoanitic and connecting rings are flared.

Orbobactrites davisensis is closely related to O. girtyi n. sp. and O. tyroensis n. sp. Both of the latter taxa are only known from the early embryonic and early juvenile phragmocones, and therefore, only the early ontogenetic stages of these species can be compared. Orbobactrites davisensis can be distinguished from O. girtyi by its larger initial apical angle and less pronounced dorsal depression. Additionally, the second camera of O. girtyi is consistently larger than that of O. davisensis. Orbobactrites tyroensis is distinguishable from O. davisensis by its lack of ornament and by more closely spaced and inclined septa during the late embryonic stages of development.

Etymology.—This species is named for Davis County, Iowa.

Occurrence and repository.—All specimens of O. davisensis (SUI 43519 to 43523) were from the over-burden piles of an abandoned strip mine in Davis County, Iowa (loc. P-11).

ORBOBACTRITES GIRTYI Mapes, new species

Plate 24, figures 1, 3, 5, 7-9, 11-16

Diagnosis.—Embryonic phragmocone with longitudinal ornament, relatively long second camera, moderately large apical angle (about 25°).

Description.—Orbobactrites girtyi is represented by 1,661 embryonic phragmocones and body chambers. The majority of the specimens are internal molds and only a few retain the protoconch. The protoconch is subspherical, being slightly wider than long. The ornament consists of fine longitudinal lirae that cover the initial chambers; the degree to which the juvenile phragmocone and protoconch are ornamented remains unknown. The first constriction is deep and is located at the first septum. Between the fourth and fifth septa, the phragmocone has a strong dorsal depression. The cameral ratio varies significantly during the ontogeny. The second chamber is always longer than the first and third chamber. During the early juvenile stage of development, when the phragmocone begins to develop annulations, the
cameral ratio is 1.3. More advanced stages of the ontogeny probably have much higher cameral ratios. The septa are generally transverse except at the depressed portion of the phragmocone; at that position the septa can be inclined dorsoapicad up to about 20°. Sutures are simple except where the septa are inclined; at these septa, the suture develops a shallow dorsal lobe. Throughout the known ontogeny, the phragmocone is circular. The initial apical angle is about 25° and in the early juvenile stage of development about 2°. Neither cameral deposits nor the wrinkle-layer has been detected.

Orbobactrites girtyi is most similar to O. davisensis n. sp. and O. tyroensis n. sp. Orbobactrites davisensis can be distinguished from O. girtyi by its smaller initial apical angle and smaller cameral ratio. Orbobactrites tyroensis differs from O. girtyi by retaining inclined septa during the later part of the embryonic ontogeny.

Etymology.—This species is named after George H. Girty, an early North American bactritid worker.

Occurrence and repository.—All specimens of O. girtyi are from the Wewoka Formation in central Oklahoma. Locality P-6 yielded 29 specimens (SUI 43898), locality P-7 yielded 1,607 specimens (SUI 43554 to 43557, 43562, 43900), and locality P-8, 24 specimens (SUI 43567, 43568, 43907).

OROBACTRITES TYROENSIS Mapes, new species

Plate 27, figures 1-3, 20-22

Diagnosis.—Embryonic phragmocone with later juvenile stage having dorsoapical inclined septa.

Description.—Orbobactrites tyroensis is represented by two well-preserved embryonic phragmocones. Neither phragmocone retains the protoconch.

The phragmocone is circular in section and is without apparent ornament. A deep constriction is present at the first septum. At the position of the fourth and fifth septa, the dorsum of the phragmocone is slightly to moderately deeply depressed. The initial septa are directly transverse; but orad of the dorsal depression the septa are inclined dorsoapical with angles of up to 15° throughout the remainder of the known ontogeny. The sutures are simple until the septa become inclined, then they develop shallow dorsal lobes. The cameral ratio for the initial camerae is low (approximately 2.5); characteristically the second chamber is longer than the first or third chambers. The initial apical angle is about 27°; during the early juvenile stage it is about 16°.

Orbobactrites tyroensis is most similar to O. girtyi and O. davisensis; however, neither of these taxa has inclined septa in the late embryonic stages of development. ?Bactrites sp. morphotype 25 is similar to O. tyroensis and may be conspecific. The major difference between these two taxa is the degree of dorsal depression at the fourth and fifth chambers. ?Bactrites sp. mtp. 25 has essentially no dorsal depression, whereas O. tyroensis has a shallow to moderate dorsal depression.

Etymology.—This species is named for the community of Tyro, Montgomery County, Kansas.

Occurrence and repository.—Both specimens of Orbobactrites tyroensis (SUI 42517, 42519) were recovered from the Eudora Shale Member of the Stanton Formation, which is exposed in a quarry about 1.2 km north of Tyro, Kansas (loc. P-15).

Genus RUGOBACTRITES Mapes, new genus

Type species.—Rugobactrites imoensis Mapes, new species.

Diagnosis.—Breviconic parabactritid with an apical angle ranging from 12° in early juvenile stages to 23° in more ontogenetically advanced stages; phragmocone circular to compressed, septa usually directly transverse, suture simple to complex, cameral ratio in early juvenile stages as low as 1.5, in more advanced stages up to 6.0.

Rugobactrites is a highly variable taxon. In the future, the recovery of more complete specimens will probably require the separation of components of Rugobactrites into several new genera. To date, the following taxa have been assigned to this genus: Rugobactrites barnettensis n. sp.; R. imoensis n. sp.; R. jacksboroensis n. sp.; R. nevadense (Youngquist), and R. variabilis n. sp.

Rugobactrites is similar to Microbactrites; however, this latter taxon has annulations during most of the juvenile stages of the ontogeny, and Rugobactrites has annulations only during the early phases of juvenile growth. Belemnitomimus is also similar to Rugobactrites, but it can be distinguished by its slightly cyrtocoenic conch and larger apical angle. Parabactrites is probably the taxon most similar to Rugobactrites. However, the concept of Parabactrites is not clear; assigned taxa have siphuncles that vary in position from marginal to submarginal, and the apical angles vary extremely (12° to 20°), as do the cameral ratios (3.0 to 7.0). Additionally, information concerning sutural configurations and septal inclinations is not available. Because of these problems, it seems reasonable to disregard Parabactrites until the types can be restudied. Such a study will undoubtedly result in reassessment of one or more taxa assigned to Parabactrites and Rugobactrites.

Etymology.—From the Latin ruga, wrinkled or creased, in reference to the annulate early juvenile stage of development.

Range and distribution.—The oldest taxa assigned to Rugobactrites have been recovered from lower Chesterian strata in Utah and Oklahoma. Slightly younger taxa (middle and upper Chesterian) have been recovered from Arkansas and Texas. Recovery of Pennsylvanian forms is limited to Desmoinesian occurrences in Oklahoma and lower Virgilian occurrences in Oklahoma and Texas.

RUGOBACTRITES IMOENSIS Mapes, new species

Plate 1, figures 1-5; Plate 5, figures 9, 10, 12, 14-17; Plate 10, figures 4, 5, 9

Diagnosis.—A species of Rugobactrites with coarse reticulated ornament on initial chambers changing to fine lirae in later embryonic ontogenetic stages, later ontogenetic stages smooth; initial
apical angle low (8°), phragmocone compressed. Suture without lateral lobes.

Description.—

**Rugobactrites imoensis** is represented by 60 embryonic and early juvenile conchs and a single nearly mature phragmocone (D max = 13 mm, D min = 9 mm, length = 17 mm). Several embryonic specimens have attached protoconchs. The protoconch is essentially spherical and is as large as or larger than the first chamber. Insofar as is known, the protoconch is without ornament. The first constrictions at the first septum are deep; two additional shallower constrictions are present at the second and third septa. The initial septa are directly transverse; however, in the later embryonic stages they become inclined dorsoapicad. Sutures are relatively simple except when the septa are inclined dorsoapicad; these sutures have a broad moderately deep dorsal lobe. The embryonic and early juvenile phragmocones are circular, but later juvenile stages have a compressed phragmocone with a simple suture. The initial apical angle ranges from 50° to 55°; the middle and late embryonic stages have an apical angle of about 0°. Early juvenile stages have apical angles ranging from 8° to 11° and this increases to as much as 23° in the later stages of the ontogeny. Cameral deposits have not been detected. The wrinkle-layer is present as fine transverse lirae. Observations regarding ornament are limited to two specimens in the late embryonic stage of development. The wrinkle-layer has not been detected in more ontogenetically advanced stages.

Because **Rugobactrites imoensis** is represented primarily by embryonic specimens, it is probably more informative to compare the embryonic stages to **R. barnettensis**. **Rugobactrites barnettensis** can be distinguished from **R. imoensis** by its smaller embryonic phragmocone and lack of ornament. Ontogenetically advanced stages of **R. imoensis** can be distinguished from **R. nevadensis** (Youngquist) and **R. jacksboroensis** n. sp. by the simpler suture.

Etymology.—This species is named for the Imo Formation, which has yielded all of the known specimens of this species.

Occurrence and repository.—All specimens of **Rugobactrites imoensis** were collected from the Imo Formation (upper Chesterian) in northcentral Arkansas (loc. M-16).

**RUGOBACTRITES BARNETTENSIS**

**Maps,** new species

| Plate 5, figures 1-8, 11-13; Plate 10, figures 3, 11, 12 |

Diagnosis.—A species of **Rugobactrites** with septa inclined dorsoapicad during later embryonic stages of development and transverse in juvenile stages of development; phragmocone essentially circular throughout known ontogeny; later juvenile stages ornamented with faint longitudinal striae.

Description.—**Rugobactrites barnettensis** is represented by 33 embryonic juvenile phragmocones. The protoconch of **R. barnettensis** remains unknown. However, the initial apical angle of 20° suggests that the first constrictions is moderately deep. Additional constrictions occur at the second and third septa. Later embryonic stages have nearly parallel sides with only an occasional specimen exhibiting a reverse apical angle of 1° or 2°. Juvenile and later ontogenetic stages develop apical angles ranging from 19° to 23°. Initial cameral ratios are low (2.0), but this changes rapidly at the fourth septum. The fourth septum and later embryonic septa are inclined dorsoapicad; the fourth septum and later embryonic septa are inclined dorsoapicad and at angles of up to 15°, and the cameral ratio increases to 3.5 and higher. The phragmocone remains essentially circular throughout the known ontogeny. Sutures are simple in the early embryonic and juvenile stages, where the septa are directly transverse. However, when the septa are inclined dorsoapicad, a broad, moderately deep dorsal lobe is present. Ornament is smooth in the early ontogenetic stages. Observations regarding ornament are limited to two specimens in the later ontogenetic stages of development; both exhibit faint longitudinal striae. Cameral deposits have not been detected.

**Rugobactrites barnettensis** can be distinguished from other species of **Rugobactrites** by its simple suture in the later ontogenetic stages. Early embryonic specimens of **R. barnettensis** can only be compared with **R. imoensis**. **Rugobactrites imoensis** has a much larger embryonic phragmocone and more pronounced reticulated ornament than **R. barnettensis**.

**RUGOBACTRITES JACKSBOROENSIS**

**Maps,** new species

**Occurrence and repository.**—**Rugobactrites barnettensis** has been recovered from middle Chesterian strata in Arkansas and Texas. The Arkansas specimens are from the lower shale member of the Fayetteville Formation at localities M-22 (SUI 42572) and M-24 (SUI 34111). The Texas specimens are from the Barnett Formation at locality M-29B; Sample 1D yielded 10 specimens (SUI 42596, 42597, 43571), sample 2D yielded 6 specimens (SUI 42674, 43582, 43791), sample 3D yielded 8 specimens (SUI 43548 to 43550, 43797), and sample float yielded 3 specimens (SUI 43575, 43582, 43807).

**Diagnosis.**—**Rugobactrites** with an apical angle ranging from 21° to 23°, suture with moderately deep lateral lobes and dorsal saddle; phragmocone compressed.

**Description.**—**Rugobactrites** *jacksboroensis* is represented by four relatively mature phragmocones. The early ontogenetic stages are unknown.

The phragmocone is moderately compressed, and the apical angle ranges from 21° to 23°. The test is smooth, septa are directly transverse, and the suture has deep broad lateral lobes. One specimen referred to this species with reservation has an apical angle of 16°, but in all other respects is similar to **R. jacksboroensis**.

**Rugobactrites jacksboroensis** is most similar to **R. nevadense**; however, this latter taxon has a smaller apical angle and a less compressed phragmocone. **Rugobactrites imoensis** and **R. barnettensis** can be differentiated from **R. jacksboroensis** by their simpler suture.

**Etymology.**—This species is named for the community of Jacksboro, Jack County, Texas.
Occurrence and repository.—Two of the specimens of *R. jacksboroensis* (SUI 10935, 43918) were recovered from the Finis Shale Member of the Graham Formation (lower Virgilian–Pennsylvanian), locality P-23, in Texas. One specimen (KU 7023) is from the Eudora Shale Member of the Stanton Formation (upper Missourian–Pennsylvanian), P-18, in northern Oklahoma, and the specimen referred to this species with reservation (KU 48838) is from the Vilas Shale Member, Stanton Formation (Missourian–Pennsylvanian) in northern Oklahoma.

**RUGOBACTRITES NEVADENSE** (Youngquist), 1949

Plate 2, figures 4, 5; Plate 6, figure 9; Plate 10, figures 13-15

Bactrites nevadense Youngquist, 1949a, p. 289-290.

**Diagnosis.**—Rugobactrites with compressed phragmocone, apical angle ranging from 14° to 15°.

**Description.**—Rugobactrites nevadense is represented by five moderately well-preserved phragmocones that are in the middle or later stages of juvenile development.

The phragmocone is compressed, septa are directly transverse, and the apical angle ranges from 14° to 15°. The cameral ratio ranges from 4.0 to 5.5. Ornament is present on the venter of the holotype as subdued diagonal ridges (Pl. 10, fig. 13). Septa are transverse and sutures have moderately deep lateral lobes.

**Rugobactrites nevadense** is most similar to *R. jacksboroensis* by its greater apical angle and more compressed phragmocone.

**Rugobactrites nevadense** was originally referred to Bactrites by Youngquist. Both Shimansky (1954) and Gordon (1965) have speculated about the probable reassignment of *R. nevadense* to the parabactritids or possibly to the coleoids. Reexamination of the types of *R. nevadense* supports the former case because of the presence of ornament; however, the possibility of a coleoid reassignment cannot be completely ruled out.

Occurrence and repository.—All specimens of Rugobactrites nevadense (SUI 4957 to 4960, 10934) were collected from the Chainman Shale (lower Chesterian–Mississippian) in the Snake Range, White Pine Co., Nevada (loc. M-30).

**RUGOBACTRITES VARIABILIS** Mapes, new species

Plate 25, figures 7, 13, 17; Plate 37, figures 1, 2; Plate 40, figures 13, 17, 18; Plate 41, figures 6, 10, 13

**Diagnosis.**—Rugobactrites with a highly variable conch. Apical angle varying from 6° in early juvenile stages to 23° in more ontogenetically advanced specimens, cameral ratio ranging from 1.5 to 5.5, septa varying from directly transverse to inclined dorsosapidic.

**Description.**—Rugobactrites variabilis is represented by 60 early to late juvenile phragmocones. The early embryonic stages of development are unknown.

The phragmocone is essentially circular throughout the early ontogenetic stages and is only slightly compressed in the later juvenile stages of development. The degree of septal inclination is variable; some specimens have directly transverse septa and others have septa inclined dorsosapidic up to 7°. Sutures are also variable, being simple when the septa are transverse and having a dorsal lobe when septa are inclined. The cameral ratio can vary greatly on a single specimen, from 1.5 to 4.0; however, the overall tendency is that more juvenile specimens have lower cameral ratios and more adult specimens have cameral ratios up to 5.5. Some early juvenile specimens have faint lateral annulations. Neither cameral deposits nor wrinkle-layer has been detected.

**Rugobactrites variabilis** is difficult to compare with other species of Rugobactrites because of the lack of similar ontogenetic stages. Perhaps the most comparable taxa are *R. barnettensis* and *R. imoensis* because both have similar septal inclinations and sutural configurations. These two taxa can be differentiated from *R. variabilis* by their slightly larger cameral ratios and less compressed phragmocones in the later stages of the ontogeny.

Overall, the great morphological variability exhibited within *R. variabilis* poses difficult problems in separating similar appearing but different parabactritids. One possible solution to this problem is that additional well-preserved specimens will better delimit the range of morphologic features in this species, and thereby possibly reduce the amount of morphologic variability presently exhibited within *R. variabilis*.

**Etymology.**—This species is named for its great range of morphologic variability.

Occurrence and repository.—All specimens of *R. variabilis* were recovered from the Wewoka Formation (Desmoinesian–Pennsylvanian) in central Oklahoma (locs. P-6, P-7, and P-8).

**Family SINUOBACTRITIDAE** Mapes, new family

**Diagnosis.**—Conch breviconic with asymmetrically placed protoconch. Apical angle may be as much as 34° in juvenile ontogenetic stages. Phragmocone circular in initial development stages, may become compressed. Septal necks cyrtocochoanitic.

The early ontogeny of this family is somewhat variable in its suture pattern, expansion rate, siphuncle position, and protoconch/conch configuration. However, it is unique in its basic early ontogenetic pattern. Two patterns of ontogenetic development are evident. One pattern is typified by *Sinuobactrites* n. gen.; this taxon has a siphuncle that becomes marginal after the third camera. The other pattern, which is exemplified by *Turbobactrites* n. gen. and *Dilatobactrites* n. gen., exhibits a siphuncle that remains submarginal throughout the known ontogenetic stages.

On the basis of morphological characteristics, this new family is most closely related to the Parabactritidae because the later ontogenetic stages of both families are similar in suture pattern, phragmocone cross section, apical angle, cameral ratio, and septal neck configuration.
However, despite these similarities in the later ontogenetic stages of development, the strikingly different early ontogenetic developmental stages of the Parabactritidae and Sinuobactritidae indicate a relatively large degree of phylogenetic separation. Thus, the establishment of a new family seems warranted.

Aside from the three new genera previously mentioned, the assignment of other taxa is problematic. Several of the genera (i.e., Aktastoceras, Bolemniominus, Tabantuloceras, etc.) assigned by Shimansky (1962) and Erben (1964a,b) to the Parabactritidae, could conceivably be placed in this new family. However, the early ontogenetic stages of development are unknown for all of these taxa. Also, the later ontogenetic stages of development for the genera assigned to the Sinuobactritidae are poorly known. For these two reasons, it is probably best to assign only the reconstructed genera described herein to this new family. These genera are as follows: Dilatobactrites n. gen., Sinuobactrites n. gen. and Turbo- 

bactrites n. gen.

Range and distribution.—Pennsylvanian (Morrowan through Missourian) of Oklahoma and Kansas.

Genus SINUOBACTRITES Mapes, new genus

Type species.—Sinuobactrites wewokensis Mapes, new species.

Diagnosis.—Siphuncle becoming marginal at fourth septum and remaining marginal throughout remaining known ontogeny.

For a comparison of genera most similar to Sinuobactrites see the discussion under the genus Dilatobactrites.

Two species are assigned to this genus. Both are similar in siphuncle position; however, each species can be determined by the sutural configuration at the end of the third septum as well as the apical angle in later ontogenetic stages.

Etymology.—From the Latin sinuo, curved, in reference to the curved sutural pattern developed during certain stages of the ontogeny.

Range and distribution.—Sinuobactrites has been recovered from southcentral Oklahoma (Morrowan) and central Oklahoma (Desmoinesian).

SINUOBACTRITES WEWOKENSIS Mapes, new species

Plate 38, figure 10; Plate 39, figures 1-11, 15

Diagnosis.—Sinuobactrites with suture of fifth septum exhibiting an exceptionally deep dorsal lobe and terminating dorsally against fourth septum; early juvenile stage with a relatively high apical angle (34°).

Description.—Sinuobactrites wewokensis is represented by 793 embryonic and juvenile internal molds of phragmocones and body chambers.

The protoconch is essentially spherical. The phragmocone is circular in the initial stages of the ontogeny, but becomes compressed by the fourth septa. The initial chambers have a cameral ratio of about 3.5, the cameral ratio increases to as much as 13.0 at the fourth septum, and then gradually decreases to 6.0 in the early juvenile stages of development. Septa are directly transverse until the fourth septum; between the fourth septum and the directly transverse septa of the early juvenile stage, the septa are inclined dorsorad at angles of up to 25°. During this period of the ontogeny, the septa are separated except for the fifth septum, which terminates against the fourth septum. Sutures are simple where the septa are transverse; however, where the septa are inclined, the sutures develop a deep dorsal lobe. The initial apical angle is about 95°, the later embryonic stages have a lower apical angle of about 3°, and at the end of the embryonic stage a reverse apical angle of about 7° is present. The early juvenile stage of development has a maximum apical angle of 34°; annulations that are inclined dorsorad are also present at this stage of the ontogeny. The phragmocone is initially circular, but by the fourth septum it is compressed. The wrinkle-layer and cameral deposits have not been detected. The siphuncle is marginal after the third camera.

Sinuobactrites wewokensis is most similar to S. morrowanensis, but this latter form differs from S. wewokensis by its larger initial apical angle, smaller juvenile apical angle, lack of reverse apical angle during the embryonic development stage, and sutural configuration and septal orientation at the fourth and fifth septum. Dilatobactrites missouriensis is also similar but has a submarginal siphuncle.

Etymology.—This species is named for the Wewoka Formation that outcrops in central Oklahoma.

Occurrence and repository.—All specimens of S. wewokensis have been recovered from the Wewoka Formation (Desmoinesian-Pennsylvanian) in central Oklahoma; locality P-6 has yielded 715 specimens and locality P-7 has yielded 78 specimens.

SINUOBACTRITES MORROWANENSIS Mapes, new species

Plate 39, figures 12-14

Diagnosis.—Sinuobactrites in which septa remain separated throughout entire ontogeny, juvenile apical angle moderately low (17°).

Description.—Sinuobactrites morrowanensis is represented by a single moderately well-preserved internal mold of a phragmocone that is missing the protoconch.

The initial chambers have a cameral ratio of about 3.0; at the fourth septum, the cameral ratio increases to as much as 9.0, and then gradually decreases to about 4.0 in the early juvenile stage. Septa are initially transverse until the fourth septum; between the fourth septum and the essentially transverse septa of the early juvenile stage, the septa are inclined dorsorad at angles of up to 20°. During this period of the ontogeny, the septa are distinctly separated (especially the fourth and fifth septa). Sutures are simple where the septa are transverse; however, where the septa are inclined, the suture develops a moderately deep dorsal lobe. The initial apical angle is about 65°, the later embryonic stages have an 8° angle, and the only known juvenile specimen has an apical angle of 17°. Neither cameral deposits nor wrinkle-layer has been detected. The initial phragmocone is circular, but orad of the fourth septum it is compressed. The siphuncle is marginal after the third camera.

Sinuobactrites morrowanensis is probably most closely
similar to S. wewokensis n. sp.; however, S. morrowanensis can be distinguished by the septal separation between the fourth and fifth septa and lower apical angle in the juvenile stages of development. *Sinuobactrites morrowanensis* is superficially similar to *Dilatobactrites missouriensis*, but this latter taxon has a submarginal siphuncle.

**Etymology.**—This species is named for the Lower Pennsylvanian Morrowan stage.

**Occurrence and repository.**—The holotype of *S. morrowanensis* (SUI 42535) was recovered from a shale exposure in the Gene Autry Formation (Morrowan-Pennsylvanian) from southwestern Oklahoma (loc. P-1).

**Genus DILATOBACTRITES** Mapes, new genus

*Type species.* *Dilatobactrites missouriensis* Mapes, new species.

*Diagnosis.* *Sinuobactritid* with a subventral siphuncle and relatively small apical angle.

*Dilatobactrites*, *Sinuobactrites* n. gen., and *Turboactrites* n. gen. are closely related. Separation of these genera is based on conch configuration and position of the siphuncle. *Sinuobactrites* is distinguishable from *Dilatobactrites* and *Turboactrites* by the presence of a marginal siphuncle, which is attained by the fourth septum; *Dilatobactrites* and *Turboactrites* are markedly different because their siphuncles remain in a subventral position throughout their known ontogeny. *Dilatobactrites* can be distinguished from *Turboactrites* by its smaller apical angle and cameral ratio and larger protoconch.

*Etymology.*—From the Latin dilatus, spread, in reference to the rapid spread or large apical angle developed during certain stages of the ontogeny.

**Range and distribution.**—*Dilatobactrites* is known only from upper Missourian (Pennsylvanian) strata in southern Kansas.

**DILATOBACTRITES MISSOURIENSIS** Mapes, new species

*Plate 38, figures 1-8, 11, 13, 14, 17*

*Diagnosis.* *Dilatobactrites* with a moderate initial cameral ratio (3.5).

*Description.*—*Dilatobactrites missouriensis* is represented by 209 well-preserved embryonic and early juvenile phragmocones. The protoconch is subpherical, being slightly wider than long. It is placed asymmetrically (ventrally) on the phragmocone. No ornament has been detected on the embryonic phragmocone. The initial portion of the phragmocone has directly transverse septa and simple sutures; the cameral ratio is about 2.5. In the embryonic stage, at the fourth septum, the siphuncle becomes marginal; the cameral ratio increases to as much as 11.0, the septa are strongly inclined dorsoapical at angles of up to 30°, and the sutures form a pronounced deep dorsal lobe. During the early juvenile stages, the cameral ratio is about 4.5, and the sutures are simple. Also, ornament in the form of inclined dorsoapical annulations is present. The phragmocone is initially circular but is compressed by the fourth septum. The wrinkle-layer and cameral deposits have not been detected. The siphuncle remains subventral in position throughout the known ontogeny.

*Dilatobactrites missouriensis* is probably most similar to *Sinuobactrites wewokensis* n. gen., n. sp. and *S. morrowanensis* n. sp. Morphologic separation of these latter two taxa from *D. missouriensis* is based primarily on the siphuncle position, which is a generic or higher level taxonomic feature. In other morphological respects, these two taxa are remarkably similar to *D. missouriensis* in overall appearance and are probably closely related phylogenetically.

**Etymology.**—This species is named for the state of Missouri.

**Occurrence and repository.**—All specimens of *Dilatobactrites missouriensis* were recovered from the Eudora Shale Member of the Stanton Formation (upper Missourian-Pennsylvanian) of locality P-15.

**Genus TURBOBACTRITES** Mapes, new genus

*Type species.* *Turbobactrites eudoraensis* Mapes, new species.

*Diagnosis.* *Sinuobactritid* with a subventral siphuncle and a relatively large apical angle.

For a comparison of genera most similar to *Turboactrites*, see the discussion under the genus *Dilatobactrites*.

**Etymology.**—From the Latin turbo, conical, in reference to the rapid rate of expansion of the phragmocone during certain stages of the ontogeny.

**Range and distribution.**—*Turboactrites* is known from the upper Missourian (Pennsylvanian) of Kansas.

**TURBOBACTRITES EUDORAENSIS** Mapes, new species

*Plate 38, figures 9, 12, 15, 16, 18-24*

*Diagnosis.* *Turboactrites* in which initial chamber is relatively long, remaining early chambers short with a cameral ratio of about 20.0.

*Description.*—*Turboactrites ervadoraensis* is represented by seven relatively incomplete but well-preserved embryonic phragmocones. Only traces of the protoconch remain; these traces indicate the protoconch was relatively large in comparison with other known protoconchs in the *Sinuobactritidae*. The reconstructions of the late embryonic and juvenile stages are uncertain. The initial apical angle of the phragmocone is 34°, and the early juvenile phragmocone has an apical angle of 34°. The septa are initially directly transverse; however, there are indications that in later embryonic stages, the septa can become inclined dorsoapical at angles of up to 25°, and in the juvenile stages become essentially transverse. Sutures are simple except where the septa are inclined; the sutures associated with inclined septa have dorsal lobes. Cameral ratios vary markedly throughout the ontogeny. The first camera is relatively long and has an equivalent cameral ratio of about 3.5. The next several chambers are short and have a cameral ratio of about 20.0. Later embryonic stages have a cameral ratio of about 5.5, and the early juvenile stage has a ratio of 7.5. The phragmocone appears to be circular or slightly compressed. Neither the wrinkle-
Carboniferous and Permian Bactritoidea in North America

Turbobactrites eudoraensis is most similar to Sinubactrites wewokensis; however, this latter taxon is distinguishable by its overall smaller phragmocone and lower cameral interval in the early stages of the ontogeny.

The ontogenetic reconstruction of this species is made with some degree of reservation, because several phragmocone segments are slightly compressed and others which may be at the same ontogenetic stages are circular. Additionally, there seems to be some degree of variation in the cameral ratio. These reconstructional problems may be resolved by the establishment of several new taxa when more nearly complete specimens are obtained.

Etymology.—This species is named for the Eudora Shale Member of the Stanton Formation, which has yielded all of the known specimens.

Occurrence and repository.—All specimens of Turbobactrites eudoraensis were recovered from the Eudora Shale Member of the Stanton Formation (upper Missourian–Pennsylvanian) near Tyro, Kansas (loc. P-15).

Order ANNULOBACTRITIDA Mapes, new order

Diagnosis.—Protoconch probably conical, internal deposits common; siphuncle marginal to slightly submarginal; conch slightly cyrtoconic at inception, becoming orthoconic during later ontogenetic stages; wrinkle-layer confined to dorsum of phragmocone during ontogeny; septal necks cyrtochoanitic.

Establishment of this order seems warranted because of the substantial morphologic differences between the early ontogenies of the genera assigned to the Bactritida and those observed in Annulobactrites n. gen. and Globulobactrites n. gen. (Fig. 14). These two genera probably have a conical "first" chamber (protoconch) rather than the spherical to subpherical "first" chamber seen in the Bactritida. In addition, they have relatively voluminous cameral deposits as compared to Bactritida.

Verification of the conical protoconchs of these two genera must await additional sampling. It is unfortunate that the sample fraction size that contained the conical protoconchs was discarded before examination, and that no complete specimens were recovered in the larger size fractions of the prepared samples. However, recovery of these conical protoconchs becomes even more problematic because the protoconchs of both genera should contain voluminous carbonate deposits. This is significant in that the specimens from localities P-7 and P-8 (the only localities which have yielded Annulobactrites and Globulobactrites), are limonitized and have been subjected to extensive leaching of carbonate deposits as can be seen by the massive deposit scars (Pl. 41, figs. 7-9, 11, 12, 14-16). Thus, the carbonate-filled protoconchs may well have been destroyed by carbonate dissolution effects of ground water and by acid reactions produced by in situ chemical changes.

Because of these differences, the possibility must be considered that Annulobactrites and Globulobactrites belong to a subclass other than the Bactritida, even though they have marginal or nearly marginal siphuncles. Examination of the major subclasses described in the Treatise on Invertebrate Paleontology, Volume K, R. C. Moore, ed. (1962), indicates that the closest subclass, with the most similar morphologic features, is the Nautiloidea. Within the Nautiloidea, only the Orthocerida appears similar to these two genera. The order Orthocerida contains genera with extremely diverse morphologies including taxa with marginal or nearly marginal siphuncles, extensive and varied cameral and siphuncular deposits, and conical protoconchs. That Annulobactrites and Globulobactrites are somehow related to this subclass appears undeniable, although the closeness of this affinity is debatable. Because the ontogenies of Annulobactrites and Globulobactrites are similar, and none of the orthoceratids so far examined have comparable early ontogenies, it appears that the phylogenetic relationship may be distant. Consequently, these two taxa are treated as belonging in the Bactritoidea, as the new order Annulobactritida. Confirmation of this assignment must await a greater understanding of the early ontogenies of many genera in the Orthoceratida and Bactritoidea.

Shimansky (1958) illustrated the apical portion of an orthoconic cephalopod that he described as the protoconch of Ctenobactrites. This is the only previously described specimen that appears to be assignable to the Annulobactritida. The protoconch is conical and slightly
cyrtococonic; this corresponds well to the anticipated protoconch characteristics in the Annulobactritida. The cameral ratio, internal deposits, and siphuncle position are unknown on this specimen. If with additional examination it is determined that this specimen belongs within the Annulobactritida, it will undoubtedly be a new genus because of its ornament and size. It should be noted that Erben (1964a) recognized the unusual configuration of this specimen and indicated that if the protoconch really belongs to Ctenobactrites, the entire genus should be excluded from the Bactritida.

**Range and distribution.**—Pennsylvanian (Desmoinesian) of Oklahoma and Texas.

**Family ANNULOBACTRITIDAE** Mapes, new family

**Diagnosis.**—Conch slightly cyrtococonic initially, becoming orthococonic in later ontogenetic stages. Early apical angles high (30° to 50°). Cameral ratio initially high followed by two long chambers, followed by a number of closely spaced septa.

**Genus ANNULOBACTRITES** Mapes, new genus

**Type species.**—Annulobactrites strimplei Mapes, new species.

**Diagnosis.**—Annulobactritid with annulations and marginal siphuncle. The two genera referred to this family are Annulobactrites and Globulobactrites. Both are monospecific. Annulobactrites can be distinguished from Globulobactrites by its annulations.

**Etymology.**—From the Latin annulus, ring, in reference to the conspicuous annulations that encircle the phragmocone during certain stages of the ontogeny.

**Range and distribution.**—Pennsylvanian (Desmoinesian) of central Oklahoma and Texas.

**ANNULOBACTRITES STRIMPLEI** Mapes, new species

Plate 21, figures 1-3; Plate 25, figures 2-4; Plate 28, figures 1-3; Plate 34, figures 1, 2; Plate 40, figures 1, 3, 5

**Diagnosis.**—Brevicoconic conch with relatively large cameral ratio (6.0 to 8.5) in later ontogenetic stages.

**Description.**—Annulobactrites strimplei is represented by 158 well-preserved internal molds of phragmocones and body chambers. The terminal apical segment (protoconch) is missing on all specimens.

The phragmocone is slightly cyrtococonic at its inception, but becomes orthococonic during the later stages of development. The test is not preserved, and the ornament is unknown. Annulations are present that are inclined dorsoapical. The annulations begin at a conch diameter of 1.5 mm and are well developed at 2.0 mm. In advanced ontogenetic stages, the annulations become subided on the dorsum and venter. The septal inclination and suture pattern varies throughout the known ontogeny. The initial two septa are inclined dorsal and have a deep dorsal saddle. The next septum is more or less transverse, and the suture has a shallow dorsal saddle. The remaining septa are more or less directly transverse and the sutures have a shallow dorsal lobe. The cameral ratio varies markedly throughout the ontogeny (2.0 to 8.5); however, in the later ontogenetic stages the ratio seems to stabilize between 5.0 and 8.0. The phragmocone is depressed in the early ontogenetic stages, and in more ontogenetically advanced specimens becomes more circular. The apical angle during the early ontogeny is approximately 50°; in later ontogenetic stages the angle is about 10° to 16°. Mural and possibly epipetal and hyposeptal deposits are present on the initial chambers and septa. The wrinkle-layer is composed of fine wavy transverse lines on the dorsum; the first occurrence during the ontogeny is on the apical end of the third camera. Septal necks are cyrtococonic, and the siphuncle is marginal.

For a comparison of similar taxa see the generic discussion.

The internal deposits of Annulobactrites strimplei are not as well developed as those of Globulobactrites loveladyensis n. sp. Additionally, the mural deposits form different outlines in the initial septa. With additional study, the differences of the morphologies of the cameral deposits will probably become a useful taxonomic feature.

**Etymology.**—This species is named for H. L. Strimple, who collected the first well-preserved specimen.

**Occurrence and repository.**—All but one of the specimens of Annulobactrites strimplei were recovered from the Wewoka Formation (Desmoinesian—Pennsylvanian) in central Oklahoma; locality P-7 yielded 11 specimens (OU 3663; SUI 10975, 10976, 10979, 10980, 42615, 42616, 43910, 43952); locality P-8 yielded 146 specimens. A single specimen of A. strimplei was collected from the Mineral Wells Formation at Mineral Wells, Texas (loc. P-12, SUI 43951).

**Genus GLOBULOBACTRITES** Mapes, new genus

**Type species.**—Globulobactrites loveladyensis Mapes, new species.

**Diagnosis.**—Annulobactritoid with a subcentral siphuncle.

For the comparison of Globulobactrites with other taxa in the Annulobactritida, see the generic discussion of Annulobactrites.

**Etymology.**—From the Latin globulus, bead, in reference to the beadlike remnants of the internal mold of the phragmocone at the siphuncle after the cameral deposits have been removed.

**Range and distribution.**—Pennsylvanian (Desmoinesian) of central Oklahoma.

**GLOBULOBACTRITES LOVELADYENSI** Mapes, new species

Plate 21, figures 4-9; Plate 24, figures 2, 4, 6, 10; Plate 25, figures 14-16; Plate 41, figures 1-5, 7-9, 11, 12, 14-16, 21

**Diagnosis.**—Brevicoconic phragmocone with voluminous epipetal, hyposeptal, and mural cameral deposits; wrinkle-layer confined to dorsum.

**Description.**—Globulobactrites loveladyensis is represented by 124 moderately well-preserved embryonic and juvenile phragmocones. The protoconch is missing on all of the available specimens;
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however, it is probably conical with a cicatrix similar to that found on the first chamber of Nautilus. Initially, the phragmocone is slightly cyrtococonic but becomes orthococonic in later ontogenetic stages. Septal inclination and sutural configuration varies somewhat because of the masking effect produced by the removal of cameral deposits. In the early ontogenetic stages, septa are directly transverse with simple sutures, but later ontogenetic stages have directly transverse and inclined septa with simple and complex sutures. The cameral ratio also changes throughout the ontogeny from 2.2 to 9.1; however, in the later embryonic stages the cameral ratios are less variable and range from 4.5 to 6.0.

The phragmocone is depressed during early ontogenesis and becomes more circular in the later ontogenetic stages. The apical angle in the later ontogenetic stages ranges from 10° to 16°. Internal molds of many specimens indicate the presence of voluminous mural, hypoapical, and epiapical deposits. The wrinkle-layer appears to be restricted to the dorsum; however, observation of this feature is complicated by the large cameral deposit scars. The wrinkle-layer consists of fine transverse wavy lines. Lack of mural deposits on the dorsum has created a distinctive, broad U-shaped pattern that is divided in the identification of many fragmentary phragmocoones. Septal necks are cyrtococonic, and although the siphuncle is submarginal, the suture has a broad shallow ventral lobe (Pl. 41, fig. 9).

For a comparison of Globulobactrites loveladyensis and Annulobactrites strimplei see the generic discussion under Annulobactrites.

Distinguishing fragmentary specimens of G. loveladyensis and other breviconic taxa with large cameral ratios, like Cymnobactrites shimanskyi and Rugobactrites variabilis, is difficult in the intermediate stages of the ontogeny. Many specimens of G. loveladyensis that lack heavy deposits with the U-shaped wrinkle-layer impressed on the dorsum cannot be readily distinguished from G. shimanskyi or R. variabilis. However, ontogenetic reconstructions aid in the separation of these latter taxa from G. loveladyensis because of the profound morphologic differences in the early ontogeny.

Etymology.—This species is named for the classic Wewoka Formation locality known informally as the Lovelady locality, which is near the Lovelady Church near Ada, Oklahoma, in central Oklahoma. This locality has yielded hundreds of cephalopods including Globulobactrites loveladyensis.

Occurrence and repository.—All of the known specimens of Globulobactrites loveladyensis have been recovered from the Wewoka Formation (Desmoinesian-Pennsylvanian) in central Oklahoma; locality P-7 has yielded seven specimens and locality P-8 has yielded 117 specimens.

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EXPLANATION OF PLATES

Several camera systems and techniques were employed. Photographs of smaller specimens were produced by use of a polaroid camera in connection with a Cambridge Scanning Electron Microscope (SEM). The figures on plates 1, 3, 5, 7, 9, 11, 13, 15, 16, 18, 20, 22, 24, 26-28, 30, 32, 34, and 37-41 were produced by this method. Positive reproductions of these figures were developed on Kodak Medalist F-3 paper. Where necessary, individual figures have been retouched.

Conventional photographic methods using a 35-mm camera, Panatomic X film, and Agfa-Gevaert Brovira high contrast 6 paper were used to produce the figures on plates 2, 4, 6, 8, 10, 12, 14, 19, 21, 23, 25, 29, 31, 33, 35, and 36. All of the specimens reproduced on these plates were coated with ammonium chloride. The figures on Plate 17 were photographed using the same kind of film and paper, but a variety of techniques were employed to emphasize the color patterns. Figures 2, 4, 9, and 10 on Plate 17 were photographed using conventional SEM/polaroid techniques, figures 1 and 5 were photographed under mineral oil, 3 and 7 were photographed with a water-dampened surface, and 6, 8, and 11 were photographed under ethyl alcohol. All figures on Plate 17 except 6 and 8 were photographed with the same 35-mm camera used to photograph the ammonium chloride-coated specimens; 6 and 8 were photographed with a Zeiss Tessovar camera/dissecting microscope combination.

PLATE 1

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<th>FIGURE</th>
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<tr>
<td>5</td>
<td>Ventral view of juvenile phragmocone showing the apical boxwork ornament and the beginning constriction of the annulate phase on the oral end (paratype, SUI 43592). All ×33.</td>
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<tr>
<td>6-9</td>
<td><em>Bacterites quadrilineatus</em> Girty, Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation. 6-7. Ventral? views of the protoconch and initial chambers, loc. M-1 (hypotype, SUI 42641). ×83, ×33. 8. Ventral? view of the protoconch, several cham-</td>
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here, and the essentially complete body chamber, loc. M-1 (hypotype, SUI 42640), ×33.—9. Dorsal view of wrinkly layer on internal mold of phragmocone at a diameter of 1 mm, loc. M-8 (hypotype, SUI 31834), ×83.

**PLATE 2**

**FIGURE 1-3,11-13.** Esoparabactrites grafhoni Mapses, n. gen., n. sp. Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation.—1-3. Dorsal, ventral, and lateral views of the phragmocone and body chamber, loc. M-5 (holotype, SUI 43743), ×2.5.—11-13. Ventral, dorsal, and lateral views of an incomplete phragmocone, loc. M-1 (paratype, SUI 43866), ×2.5.

**4.5.** Rugobactrites nealadens (Youngquist). Upper Mississippian, middle Chesterian, Chainman Shale, loc. M-30. Lateral and dorsal views of a phragmocone (paratype, SUI 4959), ×2.5.


**7-9.** Bactrites quadrilineatus Girty. Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation, loc. M-5. Ventral, dorsal, and lateral views of an immature phragmocone (hypotype, SUI 31833), ×1.7.

**14-16.** ?Bactrites sp. morphotype 13. Upper Mississippian, lower Chesterian, Moorefield Shale, loc. M-11.—14. Uncertain orientation, portion of a body chamber showing shell ornament (SUI 43875), ×1.3.—15,16. Uncertain orientation, portion of a body chamber showing the wrinkle-layer on the internal mold and surface ornament (SUI 43964), ×6.6, ×2.5.

**PLATE 3**

**FIGURE 1-3,7-11.** Bactrites quadrilineatus Girty. Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation.—1-2. Dorosilateral views of the internal mold of a body chamber with the imprint of the wrinkly layer, loc. 2083 of Girty, 1915 (paralecotype, USNM 119580A), ×9,1, ×2.5.—3. Incomplete phragmocone with three camerae and the body chamber, loc. 2083 of Girty, 1915 (lectotype, USNM 119580), ×2.5.—7. Body chamber and phragmocone showing well-preserved external shell ornament, loc. M-5 (hypotype, SUI 11618), ×1.3.—8-10. Lateral, ventral, and dorsal views showing a phragmocone with mural deposits partly exposed by removal of shell, loc. M-1 (hypotype, SUI 43681), ×2.5.—11. Dorsal view of oral end, loc. M-1 (hypotype, SUI 43681), ×7.5.

**4-6.** B. carbonarius Smith. Upper Mississippian, lower Chesterian, Moorefield Shale, loc. M-11. Dorsal, lateral, and ventral views of a specimen with a single camera and an incomplete body chamber (SUI 43644), ×4.2.

**FIGURE 1-3,21.** Bactrites cf. B. ahlosoensis Mapses, n. sp. Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation.—1-3. Dorsal, lateral, and ventral views of a mature body chamber, loc. M-1 (SUI 43638), ×2.5.—21. Ventral view of an immature phragmocone, loc. M-11 (SUI 43641), ×4.2.

4-6,11,17-20. B. ahlosoensis Mapses, n. sp. Upper Mississippian, lower Chesterian, Delaware Creek Member, Caney Formation, loc. M-1.—4-6. Ventral, dorsal, and lateral views of an incomplete phragmocone (holotype, SUI 43628), ×2.5.—11. Uncertain orientation showing the phragmocone and body chamber (paratype, SUI 43630), ×2.5.—17. Lateral view of oral end of a mature body chamber (paratype, SUI 43629), ×8.3.—18-20. Lateral, ventral, and dorsal views of the mature body chamber (paratype, SUI 43629), ×2.5.

7-9. Aktanitoceras sp. Upper Mississippian, Chesterian, Perdido Formation. Dorsal, ventral, and lateral views of the single fragmentary phragmocone, near Rest Spring, Cottonwood Mountains, Panamint Range, Inyo Co, California (SU 9155), ×2.5.

**PLATE 5**

**FIGURE 1-8,11,13.** Rugobactrites barnettenis Mapses, n. gen., n. sp. Upper Mississippian, middle Chesterian, loc. M-29B.—1-3. Ventral, dorsal, and lateral views of the initial camerae and body chamber, sample float (paratype, SUI 43575), ×33.—4-13. Ventral and lateral views of the initial camerae and body chamber, sample 1D (paratype, SUI 42596), ×33.—5-7. Ventral, dorsal, and lateral views of the initial camera and body chamber, sample 3D (paratype, SUI 43549), ×33.—8. Ventral view showing the annulate portion of the body chamber, loc. M-29B, sample 3D (paratype, SUI 43550), ×33.—11. Lateral view of a phragmocone and body chamber in matrix, loc. M-22 (holotype, SUI 42572), ×16.

9,10,12,14-17. R. imoensis Mapses, n. gen., n. sp. Upper Mississippian, Upper Chesterian, Imo Formation, interval 6, loc. M-16.—9. Ventral view showing a protoconch attached to the initial chambers (paratype, SUI 43591), ×33.—10,12. Ventral views of a protoconch and first chamber (paratype, SUI 43593), ×33, ×83.—14,15. Ventral views of the ornament on the initial portion of the phragmocone (paratype, SUI 42561), ×83, ×33.—16,17. Ventral views of the ornament on the initial portions of the phragmocone (paratype, SUI 42562), ×33, ×83.

**FIGURE 1,7,8,10-12.** Ctenobactrites lelensis Mapses, n. sp. Upper Mississippian, middle Chesterian, Fayetteville Formation.—1. Ventral view showing long, straight siphuncle necks, loc. M-21 (paratype, SUI 43704), ×7,11. Lateral and ventral views, loc. M-21 (holotype, SUI 43705).—8,10,12. Ventral, lateral, and dorsal views showing a portion of the phragmocone, loc. M-25 (topotype, SUI 43720). All ×1.3.

2,3. Angulobactrites sanborni Mapses, n. gen., n. sp. Upper Mississippian, upper Chesterian, Imo Formation, loc. M-16. Lateral and dorsal views of a body chamber (topotype, SUI 43965), ×2.5.
4-6.3. *Bactrites carbonarius* Smith. Upper Mississippian, lower Chesterian, Moorefield Formation, loc. M-11—4-6. Dorsal, lateral, and ventral views of a portion of the phragmocone (hypotype, SUI 43643), X54—13. Lateral view of part of a phragmocone showing a distinctive weathering pattern that parallels growth lines (hypotype, SUI 43649), X0.8.


**PLATE 7**

**FIGURE**


12. *Bactrites* sp. morphotype 6. Upper Mississippian, middle Chesterian. Ventral view of the protoconch and early camerae showing the short caecum, loc. M-29B, sample 1D, Barnett Formation (SUI 43556), X33.


**PLATE 8**

**FIGURE**


4-14. *Bactrites puytonensis* Mapes, n. sp. Upper Mississippian, upper Chesterian, Imo Formation. loc. M-16—4,5. Lateral and dorsal views of a septate segment of phragmocone showing the dorsal carina (paratype, SUI 43677), X1.3—6. Dorsal view of a somewhat fragmented body chamber with a dorsal carina (paratype, SUI 43678), X1.3—7,11. Dorsal and lateral views of a mature body chamber showing the dorsal carina and the transition from essentially smooth shell to annulate shell (paratype, SUI 43676), X0.8—8.10. Ventral, lateral, and dorsal views showing a partially complete phragmocone (holotype, SUI 43970), X2.5—12,14. Dorsal, ventral, and lateral views of a body chamber that has converging longitudinal ornament on the dorsum and a well-defined repaired break (paratype, SUI 43679), X2.5.

**PLATE 9**

**FIGURE**


5,14. *Bactrites* sp. morphotype 2. Upper Mississippian, middle Chesterian, Fayetteville Formation, loc. M-25B. Ventral views of the protoconch and initial camera showing the lack of constrictions (SUI 42633), X17.


16. *Bactrites* sp. morphotype 1. Upper Mississippian, middle Chesterian, Fayetteville Formation, loc. M-25B. Ventral? view of apical end showing the protoconch and initial camera (SUI 42606), X33.

**PLATE 10**

**FIGURE**

1,2. *Bactrites carbonarius* Smith. Upper Mississippian, lower Chesterian, Moorefield Formation. Dorsal and lateral views showing septal spacing. Recovered from the "Fayetteville" Shale in the vicinity of Moorefield, Arkansas (paratype, SUI 5611), X2.5.
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4.5.9. R. imoensis Mapes, n. gen., n. sp. Upper Mississippian, upper Chesterian, Imo Formation, loc. M-16. Dorsal, ventral, and lateral views of the partially complete phragmocone (holotype, SUI 43682), ×2.5.

6-8. B. fayettevillensis Mapes, n. sp. Upper Mississippian, middle Chesterian, loc. M-25C. Dorsal, lateral, and ventral views of a partially complete phragmocone (holotype, SUI 43738), ×2.5.


PLATE 11

FIGURE 1,4-13. Bactrites sanisabaensis Mapes, n. sp. Upper Mississippian, middle Chesterian, Barnett Formation, loc. M-29B. — 1. Ventral view of the protoconch and juvenile phragmocone, sample ID (paratype, SUI 42586), ×33. — 2. Ventral view of the protoconch and early phragmocone, sample ID (paratype, SUI 43609), ×33. — 3. Ventral views showing the protoconch and early initial chambers with shallow mural deposit scars, sample 2D (holotype, SUI 43510), ×33. — 4. Ventral view of a protoconch with mural deposit scars around the siphuncle, sample 2D (paratype, SUI 43511), ×33. — 5. Ventral view of a protoconch partly covered by longitudinally striated shell, sample ID (paratype, SUI 42589), ×33. — 6. Ventral views of a protoconch and the initial camerae showing growth lines and several constrictions (paratype, SUI 43505), ×33. — 7. Ventral view showing a protoconch and juvenile camerae with longitudinal striae at the first constriction (paratype, SUI 43607), ×33. — 8. Ventral view showing the slightly inclined septa, sample ID (paratype, SUI 42591), ×33. — 9. Ventral view of the initial chambers with their septal spacing and a reverse apical angle, sample 2D (paratype, SUI 43516), ×33. — 10. Ventral views of the initial camerae with the marginal siphuncle at the fourth septa, remnant longitudinal striate impressions on the protoconch, and faint mural deposit scars on the first camera, sample ID (paratype, SUI 43607), ×33. — 11. Ventral views of three camerae showing the slightly inclined septa, sample ID (paratype, SUI 42591), ×33. — 12. Ventral view of the initial chambers with their septal spacing and a reverse apical angle, sample 2D (paratype, SUI 43516), ×33. — 13. Ventral views of protoconch with faint longitudinal striae at the first constriction (paratype, SUI 42639), ×33. — 14. Ventral views of the incomplete phragmocone recovered from the "Fayetteville" Shale in the vicinity of Moorefield, Arkansas (holotype, USNM 5610), ×7, ×1.3, ×1.3.

PLATE 12

FIGURE 1,2,5-7. Bactrites carbonarius Smith. Upper Mississippian, lower Chesterian, Moorefield Shale. — 1. Lateral views of a somewhat crushed body chamber showing impression of wrinkle-layer on the internal mold, loc. M-11 (hypotype, SUI 43642), ×12, ×2.5. — 2. Lateral views and a ventral view of the incomplete phragmocone recovered from the "Fayetteville" Shale in the vicinity of Moorefield, Arkansas (holotype, USNM 5610), ×7, ×1.3, ×1.3.


9. B. fayettevillensis Mapes, n. sp. Upper Mississippian, middle Chesterian, Fayetteville Formation, loc. M-25B. Ventral view of a protoconch; the initial camerae, which are telescoped; and an essentially complete but crushed body chamber (paratype, SUI 43762), ×5.

11. B. smithianus Girty. Upper Mississippian, middle Chesterian, Sand Branch Member, Caney Formation, loc. M-15. Lateral view showing septal spacing (holotype, USNM 119582), ×2.5.
1,2,6,7,12-14. **Bactrites jayettvilleensis** Mapes, n. sp. Upper Mississippian, middle to upper Chesterian.—12. Ventral and dorsal views of a fragment of a body chamber with wrinkle-layer impressions on the internal mold, interval 6, loc. M-16, Imo Formation (paratype, SUI 42555), ×17. ——6.7. Dorsal and ventral views showing faint longitudinal striae at the apical end, interval 6, loc. M-16, Imo Formation (paratype, SUI 43618), ×33.—12-14. Ventral, lateral, and dorsal views showing septal spacing and wrinkle-layer impressions on internal mold, loc. M-25B, Fayetteville Formation (paratype, SUI 42583), ×33.

3.5. **B. smithianus** Girty. Upper Mississippian, middle Chesterian, Fayetteville Formation, loc. M-25B. Lateral, ventral, and dorsal views showing a smooth internal mold (SUI 42599), ×33.


**PLATE 16**

1-3. **Globulobactrites loveladyensis** Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Lateral, ventral, and dorsal views showing pseudo-sutures (deep grooves) and real sutures (shallow grooves) (paratype, SUI 42667), ×17.


5.6. **Bactrites** sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Dorsal and lateral views of several abnormally situated septa (SUI 42666), ×33.


**PLATE 17**

1,2,4,5,9-11. **Angustobactrites saundersi** Mapes, n. gen., n. sp. Upper Mississippian, upper Chesterian, Imo Formation, loc. M-16.—1. Lateral view showing body chamber with a single relatively wide dark band paralleling length of specimen (paratype, SUI 43973), ×4.2.—4,10. Ventral, dorsal, and lateral views of juvenile portions of phragmocone showing cameral length, interval 6 (paratype, SUI 43621), ×33.—5. Lateral view of a body chamber with a single relatively narrow dark band paralleling the long axis of the specimen (paratype, SUI 43972), ×4.2. ——9. Dorsal view showing wrinkle-layer (paratype, SUI 42554), ×33.—11. Other side of same specimen seen from a ventralateral position which, through parallax, shifts and widens the dark band, ×4.2.

3. **Bactrites carbonarius** Smith. Upper Mississippian, lower Chesterian, Moorefield Formation, loc. M-11. False "color" pattern developed in response to differential weathering and preservation due to periodical shell thickening (hypotype, SUI 43974), ×1.3.


7. **Bactrites mexicanus** Miller, Upper Permian, Guadalupian, Capitanian Stage, loc. PR-2, beds 5-7 of King et al. (1944). Dorsal view showing nearly bilaterally symmetrical light and dark patterns (topotype, SUI 43930), ×1.3.

8. **Angustobactrites** cf. **A. saundersi**. Upper Mississippian, upper Chesterian, Imo Formation, loc. M-16. Dorsolateral view showing a pale longitudinal band on dorsum (left side of figure) of body chamber (SUI 43975), ×5.8.

**PLATE 18**

1.2. **Bactrites** sp. morphotype 30. Upper Pennsylvanian, upper Missourian, Eudora Shale Member, Stanton Formation, loc. P-15. Ventral and dorsal views of a problematic body chamber that appears to have a mature modification (SUI 42505), ×33.

3.4. **Bactrites** sp. morphotype 29. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Ventral views of protoconchs and initial chambers of two specimens (SUI 43563, 42646) showing cameral deposit scars, both ×83.

5,7,8,12,13. **Bactrites windsi** Mapes, n. sp. Upper Pennsylvanian, upper Missourian, Eudora Shale Member, Stanton Formation, loc. P-15.—5. Orad view of first septum on protoconch with a smooth concave surface (paratype, SUI 42525), ×83.—8,12. Orad and lateral view of longitudinal ornament on protoconch, with a reticulated pattern on the concave surface of the first septum (paratype, SUI 42521), ×83, ×17.12. Ventral views of two specimens (paratypes, SUI 42507, 42508) showing protoconch and initial chambers, both ×33.

9,15,16. **Globulobactrites loveladyensis** Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Dorsal, lateral, and ventral views of the apical end, showing sutural configuration (paratype, SUI 42513), ×33.

6,10,11. **Annulobactrites sraplesi** Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Ventral, lateral, and dorsal views of a fragmentary phragmocone that has been distorted so as to appear cyrtocomic (paratype, SUI 42616), ×33.


**PLATE 19**

1-3. **Bactrites** sp. morphotype 17, Lower Pennsylvanian, upper Atokan, Smithwick Formation, loc. P-4. Lateral, dorsal,
and ventral views showing septal spacing (SUI 43879), X2.5.

4.8-13. Bactrites oweni Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Cherokee Cyclothsoms, loc. P-15.——4.10. Dorsal view of body chamber and apical end of same body chamber showing mature bilateral wrinkle-layer development, X2.5.——8.9. Ventral and lateral views of body chamber, showing fine longitudinal ornament and a ventral ridge on internal mold (paratype, SUI 10931), X2.5. ——11-13. Dorsal, lateral, and ventral views showing shell ornament, septal spacing, and sutural configuration (holotype, SUI 43935), X2.5.

5.7. Orbobactrites davisensis Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Cherokee Cyclothsoms, loc. P-11. Lateral, ventral, and dorsal views showing annulations (holotype, SUI 43520), X2.5.

PLATE 20

FIGURE


6-12. ?Bactrites sp. morphotype 22. Lower Pennsylvanian, upper Atokan, Smithwick Formation, loc. P-4.——6.9. Dorsal, ventral, lateral, and ventral views of protoconch and initial chambers (SUI 42542), X33, X33, X33, X83.——10-12. Ventral, dorsal, and lateral views of juvenile portions of phragmocone showing septal orientation and sutural configuration (SUI 43625), all X17.


PLATE 21

FIGURE
1-3. Annulobactrites sinuolices Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Dorsal, ventral, and lateral views showing sutural configuration, septal spacing, and annulations on internal mold of incomplete phragmocone and body chamber (paratype, SUI 43910), X4.2.

4-9. Globalobactrites lovadensis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.——4.6. Lateral, ventral, and dorsal views of immature, incomplete phragmocone showing septal spacing and dorsal furrow, loc. P-7 (paratype, SUI 10978), X4.2.——7-9. Dorsal, ventral, and lateral views of nearly mature segment of phragmocone showing sutural configuration and septal orientation, loc. P-8 (paratype, SUI 43912), X4.2.

10. ?Microbactrites sp. Upper Pennsylvanian, Virgilian, Dover Limestone, loc. P-22. Lateral view (siphuncle on right side) of single crushed specimen referable to this genus, showing closely spaced septa (KA 48929), X5.

11,16,17. Bactrites oweni Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Cherokee Coal Cyclothsoms, loc. P-14. Ventral, dorsal, and lateral views showing sutural configuration on segment of phragmocone (paratype, SUI 43932), X4.2.


PLATE 22

FIGURE
1-3,6. ?Bactrites sp. morphotype 16. Lower Pennsylvanian, Morrowan, Gene Autry Formation, loc. P-1.——3.6. Ventral views showing reticulated ornament on protoconch (SUI 43602), X33, X33, X83.——3. Lateral view of juvenile portion of phragmocone (SUI 43624), X33.


4,5-10. B. reticulatus Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Dorsal, lateral, and ventral views showing septal spacing (paratype, SUI 43536), X33.


PLATE 23

FIGURE
1.2. Ctenobactrites sp. Upper Pennsylvanian, lower Virgilian, Brownwood Shale Member, Graford Formation, loc. P-27. Lateral and ventrolateral views of coarse transverse bands on incomplete phragmocone (KA 49784), X1.3.

3.7. Bactrites gaitherensis Gordon. Lower Pennsylvanian, Morrowan, Gene Autry Formation, loc. P-1.——3.7. Lateral and ventral views of incomplete phragmocone showing faint longitudinal ornament (hypotype, SUI 43867), X1.3.

4-6. B. finnasenius Mapes, n. sp. Upper Pennsylvanian, lower Virgilian, Finis Shale Member, Graham Formation, loc. P-23, Ramsey Farm, Texas. Ventral, lateral, and dorsal views showing dorsal carina and septal spacing (holotype, SUI 43920), X1.3.

PLATE 24

FIGURE
1,3,5,7-9,11-16. Orbobactrites girtyi Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.——1,3,5,7. Ventral, lateral, dorsal, and ventral views showing septal spacing, ribs on oral portion of juvenile phragmocone and longitudinal striae on initial chambers, loc. P-7 (holotype, SUI 43556), X33, X33, X33, X83.——8. Ventral view of a protoconch and initial chambers, loc. P-7 (paratype, SUI 43562), X33.——9. Dorsal? view
of protoconch, first camera, and body chamber, loc. P-7 (paratype, SUI 43555), ×83.—11-13. Lateral, dorsal, and ventral views showing early ontogenetic stages with characteristically large second camera, loc. P-7 (paratype, SUI 43557), ×33.—14-16. Lateral, dorsal, and ventral views of early ontogenetic stages with characteristically large second camera, loc. P-8 (paratype, SUI 43568), ×33.

2.4,6.10. Globalobactrites loveladyensis Mapes, n. gen., n. sp. Middle Pennsylvania, Desmoinesian, Wewoka Formation, loc. P-8.—2. Ventral view of incomplete phragmocone showing deposit scars (paratype, SUI 42610), ×33.—4,6,10. Ventral, dorsal, and lateral views showing septal spacing and mural deposit scars (paratype, SUI 42570), ×17.

PLATE 25

FIGURE

1,5,6. Bactrites smithwickensis Mapes, n. sp. Lower Pennsylvanian, upper Atokan, Smithwick Formation, loc. P-4. Ventral, lateral, and dorsal views showing septal spacing (paratype, SUI 43475), ×5.

2-4. Annulobactrites trimplei Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Lateral, ventral, and dorsal views of a relatively complete conch showing annulations and cyrtocoenic phragmocone in early ontogenetic stages (paratype, OU 3663), ×5.

7,13,17. Rugobactrites variabilis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Lateral, dorsal, and ventral views of incomplete phragmocone showing septal spacing and repaired "wound" on dorsum (paratype, SUI 4262), ×4.2.


PLATE 26

FIGURE

1,2,6,8. ?Bactrites sp. morphotype 31. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8.—1,6,8. Lateral, dorsal, and ventral views of partly complete juvenile phragmocone (paratype, SUI 43526), ×17.—2. Dorsal view showing the impression of wrinkly-layer (SUI 42564), ×62.

3-5,7,9,13. B. reticulatus Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.—3-5. Ventral, dorsal, and lateral views showing sutural configuration, loc. P-7 (paratype, SUI 43540), ×17.—7. Dorsal view of apical end showing wrinkly-layer impressions on internal mold, loc. P-8 (paratype, SUI 43566; see Pl. 28, fig. 7 for dorsal view of oral end), ×83.—10,12. Ventral and dorsal views of same specimen showing variation in taper rate and septal spacing, ×33.—9,11,13. Dorsal, ventral, and lateral views of incomplete phragmocone, loc. P-8 (paratype, SUI 43622), ×17.

PLATE 27

FIGURE


7-11. Orbobactrites davisensis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Cherokee Group undifferentiated, loc. P-11.—7-9. Dorsal, lateral, and ventral views showing initial chambers of early phragmocone (paratype, SUI 43522), ×33.—10,11. Ventral view of initial chambers showing well-developed longitudinal striations (paratype, SUI 43519), ×33, ×83.

PLATE 28

FIGURE


4-7,9,10. Bactrites reticulatus Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.—4,7,10. Lateral, dorsal, and ventral views showing early ontogenetic stages, septal spacing, and sutural orientation, loc. P-7 (holotype, SUI 43517), all ×33.—6. Lateral view of same specimen showing the protoconch with reticulated ornament, ×83.—7. Dorsal view of oral end of SUI 43566 showing impressions of wrinkly-layer on internal mold, loc. P-8, ×83.—9. Ventral view of protoconch showing septal spacing of initial chambers, loc. P-7 (paratype, SUI 43518), ×33.

8. ?Bactrites sp. morphotype 29. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Ventral view showing septal spacing at an early ontogenetic stage (SUI 42647), ×33.

PLATE 29

FIGURE

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4.5, 13. *Angustobactrites* sp. Middle Pennsylvanian, Desmoinesian, Deser Formation, loc. P-10. Lateral, dorsal, and ventral views showing septal spacing and sutural configuration (SUI 43890), X5.


**PLATE 30**

**FIGURE**

1-6, 8-10. *Bactrites* sp. morphotype 14. Lower Pennsylvanian, Morrowan, Gene Aurora Formation, loc. P-1.——1-3. Dorsal, lateral, and ventral views showing septal spacing and sutural orientation (SUI 42601), X3—4, 6. Ventral, dorsal, and lateral views showing septal spacing (SUI 42546), X3—8, 10. Ventral, lateral, and dorsal views showing body chamber (SUI 42544), X3.

7, 11-13, 15-17. *Bactrites* sp. morphotype 26. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.—7. Ventral view of the protoconch and initial two chambers, loc. P-6 (SUI 42654), X3—11, 13. Lateral, dorsal, and ventral views showing initial chambers (SUI 42651), X3—15, 17. Dorsal, lateral, and ventral views showing sutural configuration and septal spacing, loc. P-7 (SUI 42652), X3.


**PLATE 31**

**FIGURE**


**PLATE 32**

**FIGURE**

1-3, 5. *Bactrites* sp. morphotype 25. Middle and Upper Pennsylvanian.—1-3. Lateral, ventral, and dorsal views of the initial camerae and body chamber, loc. P-15, upper Missourian, Eudora Shale Member, Stanton Formation (SUI 42515), X3—5. Ventral view of initial camerae and body chamber, loc. P-8, Desmoinesian, Wewoka Formation (SUI 42643), X3.

4, 6, 9, 14-16. *Bactrites* sp. morphotype 32. Lower Pennsylvanian, upper Atokan, Smithwick Formation, loc. P-4.——4. Uncertain orientation of slightly distorted protoconch showing longitudinal ornament (SUI 43627), X8, 15. 6. Uncertain orientation of protoconch, initial camerae, and body chamber (SUI 43626), X3—7, 15, 16. Dorsal, lateral, and ventral views showing septal spacing and cameral deposit scars (SUI 42553), X3—8, 9. Ventral view of caecum and cameral deposit scars (SUI 43605), X83, X3—14. Ventral view of a protoconch and initial camerae showing septal spacing without cameral deposit scars (SUI 42548), X3.


**PLATE 33**

**FIGURE**

1-3. *Ctenobactrites collinsii* (Miller and Unklesby). Upper Pennsylvanian, Missourian, Brush Creek Limestone, Harvey Brick Co. Quarry, Glassmere, Pa. Lateral, dorsal, and ventral views showing small patch of shell with transverse ridges as ornament (holotype, Carnegie Museum 25800), X0.8.

4, 6, 7. *Bactrites* cf. *B. cherokeensis*. Exact age and locality unknown, but probably Middle Pennsylvanian, Desmoinesian, Cherokee Coal Cyclothemes, loc. P-14. Ventral, lateral, and dorsal views showing well-developed lateral lobe and dorsal saddle (SUI 43935), X1.7.

*Bactrites oweni* Mapes, n. sp. Middle Pennsylvanian, Desmoinesian, Cherokee Coal Cyclothemes, loc. P-14. Lateral view of incomplete phragmocone (paratype, SUI 10929), X2.5.


**PLATE 34**

**FIGURE**

1, 2. *Annulobactrites strimplei* Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.

1. Apical view of earliest known chamber with an oval-shaped outline, loc. P-7 (paratype, SUI 42615), X66.——2. Ventral view showing annulations and deposit scars, loc. P-8 (paratype, SUI 45524), X35.

3, 6-8. *Bactrites* sp. morphotype 22. Lower Pennsylvanian, upper Atokan, Smithwick Formation, loc. P-4.——3. Lateral view of protoconch and initial chambers showing longitudinal striae at first constriction (SUI 42552), X8.5.
—6. Ventral view of internal mold of protoconch and initial chambers showing cameral deposit scars (SUI 43616), ×83.—7. Ventral view of initial chambers without deposits or deposit scars (SUI 42551), ×33.—8. Ventral view of initial chambers with cameral deposit scars on apical camera (SUI 43617), ×53.

4.5. ?Bacrites sp. morphotype 29. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Dorsal and ventral views showing protoconch and initial septa without cameral deposit scars (SUI 42645), ×33.


PLATE 35

FIGURE
1-3,9-11. Bacrites postremus Miller. Upper Pennsylvanian, lower Virgilian, Finis Shale Member, Graham Formation.—1-3. Lateral, ventral, and dorsal views showing faint wrinkle-layer impressions on depressed mural area of camera, loc. P-24 (hypotype, SUI 43925), ×5.—9-11. Ventral, dorsal, and lateral views showing septal spacing, loc. P-23 near the Riley Farm (hypotype, SUI 43977), ×1.3.

4,8,12. B. cf. B. gutherensis. Lower Pennsylvanian, Morrowan, Prairie Grove Member, Hale Formation, loc. P-2. Ventral, dorsal, and lateral views showing sutural configuration and septal orientation (SUI 48872), ×1.5.

5-7. B. cherokeensis Miller and Owen. Middle Pennsylvanian, Desmoinesian, Cane Kees Creek Cyclothem, loc. P-14. Ventral, dorsal, and lateral views showing ornament? change on internal mold (holotype, SUI 13377), ×0.8.

PLATE 36

FIGURE
1,2,5. Bacrites mexicamus Miller. Upper Permian, Guadalupean, Capitanian Stage, loc. PR-2. Ventral, dorsal, and lateral views showing septal spacing (holotype, Peabody Museum, Yale University 16278), ×0.8.


3,4,7,9. B. eclectanalis Mapes, n. sp. Lower Permian, Artinskian, Roadian, loc. PR-1.—3,4,8. Dorsal, lateral, and ventral views showing septal spacing and longitudinal ornament (holotype, SUI 43881), ×1.3.—7,9. Dorsal and ventral views showing longitudinal ornament (paratype, SUI 43882), ×1.3.

PLATE 37

FIGURE
1,2. Rugobacrites variabilis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Ventral and lateral views showing septal spacing and inclination (paratype, SUI 43529), ×17.

3-8. ?Bacrites sp. morphotype 25. Middle to Upper Pennsylvanian.—3-5. Ventral, dorsal, and lateral views of the initial camerae and body chamber, loc. P-15, upper Missourian, Eudora Shale Member, Stanton Formation (SUI 42516), ×33.—6-8. Lateral, ventral, and dorsal views showing septal configuration, loc. P-8, Desmoinesian, Wewoka Formation (SUI 42644), ×33.


PLATE 38

FIGURE
1-8,11,13,14-17. Dilobobacrites missouriensis Mapes, n. gen., n. sp. Upper Pennsylvanian, upper Missourian, Eudora Shale Member, Stanton Formation, loc. P-15.—1-17. Lateral, dorsal, ventral, and apical views showing siphuncle position, sutural configuration and septal spacing (paratype, SUI 42526).—4. Apical view of initial chambers showing protoconch attachment scar (paratype, SUI 42506).—5-6,8. Ventral, lateral, and dorsal views showing protoconch, initial chambers, and sutural configuration (paratype, SUI 42501).—11,13. Lateral and dorsal views of partially complete phragmocone (holotype, SUI 42503).—14,17. Lateral and ventral views of a phragmocone showing septal spacing and orientation and ribs (paratype, SUI 42523). All ×33.


PLATE 39

FIGURE
1-11,15. Simubacrites wewokensis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation.—1-3. Dorsal, lateral, and ventral views showing inclination rate, ribs, and marginal siphuncle, loc. P-6 (paratype, SUI 42614).—2,7,10. Dorsal, lateral, and ventral views showing marginal siphuncle and sutural configuration, loc. P-6 (paratype, SUI 42508).—4,11,15. Lateral, dorsal, and ventral views of an immature phragmocone, loc. P-7 (holotype, SUI 42494).—6,8,9. Dorsal, ventral, and lateral views showing protoconch, initial camerae, and body chamber, loc. P-6 (paratype, SUI 42495). All ×33.

12-14. S. morrowanensis Mapes, n. gen., n. sp. Lower Pennsylvanian, Morrowan, Genie Autry Formation, loc. P-1. Ventral, dorsal, and lateral views showing variable expansion rates, septal spacing and sutural configurations (holotype, SUI 42535), ×33.
Carboniferous and Permian Bactritoidea in North America

PLATE 40

1,3,5. Annulobactrites trimplei Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Dorsal, lateral, and ventral views showing septal spacing and annulations (holotype, SUI 42626), ×17.

2,7,8,16. ?Bactrites sp. morphotype 28. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Ventral, dorsal, dorsal, and lateral views showing protoconch, initial camerae, and body chamber (SUI 42650), ×33, ×33, ×83, ×33.

4,9,10. ?Bactrites sp. morphotype 27. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-6. Dorsal, ventral, and lateral views showing septal spacing of initial chambers (SUI 42653), ×33.


13,17,18. Rugobactrites variabilis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-7. Ventral, lateral, and dorsal views showing septal spacing and orientation with weak ribs on apical end (paratype, SUI 43528), ×17.

PLATE 41

1-5,7-9,11,12,14-16,21. Globulobactrites loycladyensis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. ———1-5,8. Lateral, dorsal, and ventral views showing partial phragmocone without extensive cameral deposit scars (paratype, SUI 42612), ×33. ———2-4. Ventral, dorsal, and lateral views showing a phragmocone with extensive cameral deposit scars (holotype, SUI 42658), ×33. ———7. Ventral view showing extensive cameral deposit scars (paratype, SUI 42608), ×33. ———9,14,16. Ventral, lateral, and dorsal views showing ventral portion of suture and septal spacing (paratype, SUI 42611), ×33. ———11. Dorsal view showing cameral deposit scars on lateral portions of phragmocone and wrinkle-layer impressions on dorsum (paratype, SUI 42570; for other views see Pl. 24, figs. 4,6,10), ×83. ———12,15,21. Ventral, lateral, and dorsal views with extensive cameral deposit scars and showing beadlike siphuncle (paratype, SUI 42610), ×33.

6,10,13. Rugobactrites variabilis Mapes, n. gen., n. sp. Middle Pennsylvanian, Desmoinesian, Wewoka Formation, loc. P-8. Ventral, lateral, and dorsal views showing variability in taper rate from apical to orad end (paratype, SUI 43532), ×33.

Mapes—Carboniferous and Permian Bactritoidea
Mopes—Carboniferous and Permian Bactritoidea

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