

An Early *Reticuloceras*
Zone Fauna From the
Hale Formation in
Northwestern Arkansas

GEOLOGICAL SURVEY PROFESSIONAL PAPER 613-A



An Early *Reticuloceras*
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Hale Formation in
Northwestern Arkansas

By MACKENZIE GORDON, JR.

CONTRIBUTIONS TO PALEONTOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 613-A

*Descriptions and illustrations of nine
Lower Pennsylvanian goniatites from the
lower part of the Morrow Series*



UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

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CONTRIBUTIONS TO PALEONTOLOGY

AN EARLY *RETICULOCERAS* ZONE FAUNA FROM THE
HALE FORMATION IN NORTHWESTERN ARKANSAS

BY MACKENZIE GORDON, JR.

ABSTRACT

Nine species of goniatites occur in the upper part of the Cane Hill Member and the basal part of the Prairie Grove Member of the Hale Formation. These species comprise the earliest known cephalopod fauna from the Pennsylvanian rocks of North America. The Arkansas fossils occur in calcareous pebble conglomerate, calcareous sandstone, and sandy limestone. The stratigraphic interval in which all nine species occur and to which five of them appear to be restricted constitutes the *Reticuloceras tiro* Zone. This zone can be correlated approximately with the lowest subdivision of the Lower *Reticuloceras* (R_{1a}) Zone of northwestern Europe including the British Isles.

The species described and figured in this paper are: *Syn-gastrioceras globosum* (Easton), *Bisatoceras paynei* Gordon, *Hudsonoceras moorei* Quinn and Saunders, *Cymoceras adonis* n. sp., *Reticuloceras tiro* n. sp., *Reticuloceras? wainwrighti* Quinn, *Reticuloceras? sp.*, *Branneroceras semiretia* (McCaleb), and *Stenopronorites quinni* n. sp.

INTRODUCTION

The manuscript for the report on the Carboniferous cephaloids of Arkansas (Gordon, 1964) was completed before cephalopods were found in the Cane Hill Member of the Hale Formation. Most of the Cane Hill cephalopod localities were discovered by Professor J. H. Quinn, University of Kansas, and his students; through their indefatigable efforts a sizable collection, totaling some 600 specimens, was amassed. In 1961, Professor Quinn kindly loaned these fossils to the author. Additional supplemental collections, totaling 145 specimens, from the University of Arkansas localities and from one new locality, were made by the writer in company with Professor Quinn and his students or with members of the U.S. Geological Survey. All these collections constitute the basis for the fossil descriptions given here.

STRATIGRAPHIC SETTING

The fauna described in this paper occurs in roughly the upper half of the Cane Hill Member of the Hale Formation and locally in the basal 1-3 feet of the Prairie Grove Member. Most of the ammonoids were found in 1- or 2-foot thick claystone-pebble conglomerate beds, which are associated with calcareous sandstone beds that occur as lenses in the typical shale of the Cane Hill Member. Shells of some of the small species, particularly those of *Reticuloceras*, were generally found incorporated within claystone pebbles; many of the larger shells which occur in the conglomerate matrix, are fragmental. These were death assemblages (thanatocoenoses), but reworking of the fossils is not believed to have mixed species of very different ages, as these ammonoids were approximately contemporaneous inhabitants of the early Morrow Sea.

No ammonoids have been found in the shale, which is silty to finely arenaceous and singularly devoid of fossils. The shale is commonly ripple marked and contains many thin lenticules of fine-grained sandstone that locally weather out as wafers an inch or two in diameter.

At the locality near Cane Hill (fig. 1, loc. 1), this fauna occurs in a 6-foot thick unit consisting of sandy limestone and calcareous sandstone. The fossiliferous unit is separated from the underlying Pitkin Limestone by a 6-foot bed of siltstone containing a basal few inches of shale and lenticular bodies of pebble conglomerate. This lithology resembles that of the Prairie Grove Member of the Hale Formation, but L. G. Henbest (oral commun., 1961) traced the sandstone unit laterally and discovered that it fingers into the typical platy shale lithology of the Cane Hill Member.

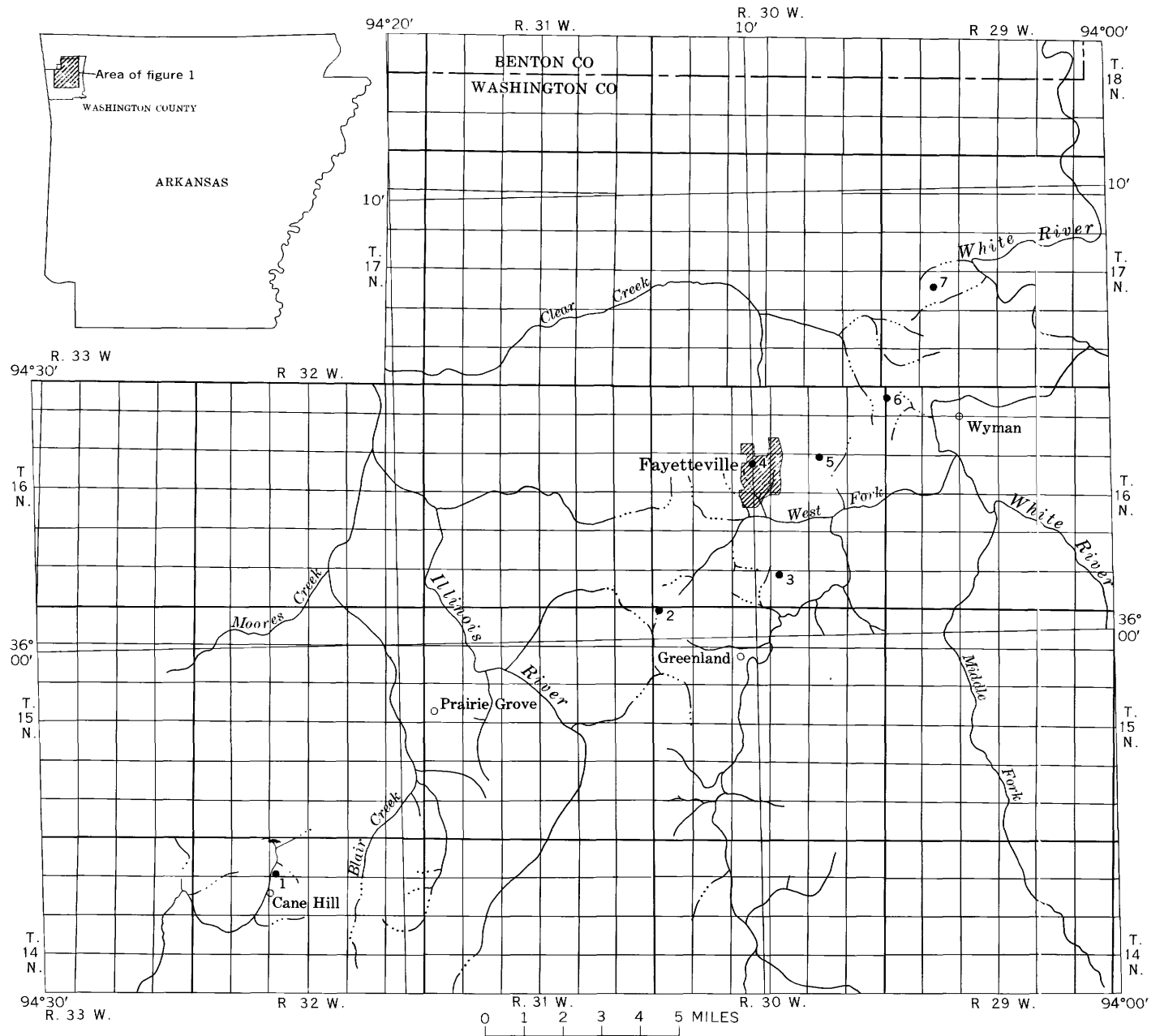


FIGURE 1.—Collecting localities for Lower Pennsylvanian ammonoids. University of Arkansas and U.S. Geological Survey locality numbers for these sites are given in the register of localities (p. A4).

The combined lithologic and faunal evidence indicates that the sediments of the Hale Formation were laid down in relatively shallow water, probably in the shallow part of the neritic zone.

COLLECTING LOCALITIES

The ammonoids described herein come from seven localities in the lower and middle parts of the Hale Formation. The localities, all in Washington County, Ark., are shown on the index map (fig. 1). Five of these are in the Cane Hill Member, and two are probably in the Prairie Grove Member.

CANE HILL MEMBER

At two of the five Cane Hill localities the ammonoids occur in pebble-conglomerate beds associated with calcareous sandstone lenses within typical shale and siltstone of the Cane Hill Member. These two localities are at the Fayetteville Country Club and at Sequoyah (East) Mountain. At the Fayetteville Country Club (fig. 1, loc. 3), the following species have been found.

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	205
<i>Bisatoceras paynei</i> Gordon -----	1
<i>Hudsonoceras moorei</i> Quinn and Saunders ----	2
<i>Reticuloceras tiro</i> n. sp -----	11
<i>Reticuloceras? wainwrighti</i> -----	10
<i>Branneroceras semiretia</i> (McCaleb) -----	29
<i>Cymoceras adonis</i> n. sp -----	18
<i>Stenopronorites quinni</i> n. sp -----	4

Also, on the east slope of Sequoyah (East) Mountain (fig. 1, loc. 5) the following were collected:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	16
<i>Reticuloceras tiro</i> n. sp -----	4
<i>Branneroceras semiretia</i> (McCaleb) -----	3
<i>Cymoceras adonis</i> n. sp -----	3

At a locality (fig. 1, loc. 2) northwest of Greenland, the fossils occurred in a large block of conglomeratic sandstone lying loose in the middle of a moderately thick but largely covered section of shale of the Cane Hill Member. How far the block had moved is not known. This locality has been discussed and figured by Quinn (1966, p. 13, 18, text fig. 2), who believed the block was approximately in place when found. The locality has been obliterated by the construction of a road. Material from this locality is as follows:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	49
<i>Bisatoceras paynei</i> Gordon -----	2
<i>Hudsonoceras moorei</i> Quinn and Saunders ---	1
<i>Reticuloceras tiro</i> n. sp -----	18

	<i>Number collected</i>
<i>Reticuloceras? wainwrighti</i> Quinn -----	6
<i>Reticuloceras? sp</i> -----	1
<i>Branneroceras semiretia</i> (McCaleb) -----	2
<i>Cymoceras adonis</i> n. sp -----	7
<i>Stenopronorites quinni</i> n. sp -----	3

Locality 4 of figure 1 is in the east wall of a railroad cut in the town of Fayetteville. The fossils come from a limestone bed in the lower part of the formation at this locality. However, as the Cane Hill Member is transgressive and unconformably overlies the Fayetteville Shale at this place, it is possible that the lowest beds of the Cane Hill are absent here. The small collection consists of the following species:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	1
<i>Reticuloceras tiro</i> n. sp -----	1
<i>Branneroceras semiretia</i> (McCaleb) -----	3
<i>Cymoceras adonis</i> n. sp -----	5

Locality 1 of figure 1, in a quarry near Cane Hill, has been discussed above. This locality also was described and shown in a photograph and diagrammatic sketch by Quinn (1963, p. 26-28, figs. 1, 2), who regarded the ammonoid-bearing bed as belonging in the Cane Hill Member. The ammonoid fauna collected here is as follows:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	50
<i>Bisatoceras paynei</i> Gordon -----	5
<i>Hudsonoceras moorei</i> Quinn and Saunders ----	1
<i>Reticuloceras tiro</i> n. sp -----	7
<i>Reticuloceras? wainwrighti</i> Quinn -----	5
<i>Branneroceras semiretia</i> (McCaleb) -----	80
<i>Cymoceras adonis</i> n. sp -----	16
<i>Stenopronorites quinni</i> n. sp -----	6

PRAIRIE GROVE MEMBER

Collections from two localities come from beds believed to belong in the lower part of the Prairie Grove Member. At one of these localities, near St. Joseph Cemetery, about 3½ miles northeast of Fayetteville (fig. 1, loc. 6), the fossils are from a thin bed of weathered calcareous sandstone a few feet above typical dark-gray siltstone of the Cane Hill type. This bed contains the fauna typical of the upper part of the Cane Hill Member:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	81
<i>Reticuloceras tiro</i> n. sp -----	18
<i>Reticuloceras? wainwrighti</i> Quinn -----	7
<i>Branneroceras semiretia</i> (McCaleb) -----	12
<i>Cymoceras adonis</i> n. sp -----	8

At the other locality (fig. 1, loc. 7), the fossils are in a partly coquinoid limestone grading into

light-gray sandy limestone. It is possible, judging partly from the lithology, that this assemblage represents a slightly higher zone. The species positively identified are those that range higher into the Prairie Grove Member. The ammonoids collected are as follows:

	<i>Number collected</i>
<i>Syngastrioceras globosum</i> (Easton) -----	13
<i>Bisatoceras paynei</i> Gordon -----	1
<i>Reticuloceras? wainwrighti</i> Quinn -----	1
<i>Branneroceras semiretia</i> (McCaleb) -----	9
<i>Cymoceras adonis</i> n. sp. -----	1

REGISTER OF LOCALITIES

UA (UNIVERSITY OF ARKANSAS) LOCALITIES

L14 (fig. 1, loc. 4).—Fayetteville 7½-minute quadrangle. St. Louis and San Francisco Railway cut, east side, 10 feet north of the Maple Street overpass, near center of south line of sec. 9, T. 16 N., R. 30 W., in town of Fayetteville, Ark. Limestone lens in Cane Hill Member of Hale Formation, approximately 15 feet stratigraphically above contact of Fayetteville Shale and Hale Formation. Collector, J. H. Quinn.

L18 (fig. 1, loc. 2).—Fayetteville 7½-minute quadrangle. On east side of dirt road along southwest-trending ridge that lies about midway between Round Top Mountain and south summit of Kessler Mountain, in NE¼NW¼NW¼ sec. 6, T. 15 N., R. 30 W., about 700 feet south of bend in road at township line and 1¾ miles west-northwest of Greenland, Ark. Sandy limestone block in Cane Hill Member of Hale Formation, 28 feet above top of Pitkin Limestone. Collector, L. L. Wainwright.

L59 (fig. 1, loc. 7).—Sonora 7½-minute quadrangle. On east bank of southeast-flowing intermittent stream, 60 feet north of east-west road, in SW¼SE¼NW¼ sec. 21, T. 17 N., R. 29 W., about three-fourths of a mile east of Zion School, Washington County, Ark. Fossils from light-gray sandy limestone, presumably Prairie Grove Member of Hale Formation that rests on ripple-marked siltstone of Cane Hill Member and is beneath lower fossiliferous limestone of Brentwood Limestone Member of Bloyd Formation. Collector, David Metz.

L61 (fig. 1, loc. 3).—Fayetteville 7½-minute quadrangle. Outcrop on east slope of South Mountain, about 950 feet south-southeast of Fayetteville Country Club clubhouse and 125 feet east of dirt road, at approximately 1,500 feet elevation, in NE¼NE¼NW¼ sec. 34, T. 16 N., R. 30 W. Cal-

careous and conglomeratic sandstone lens in Cane Hill Member of Hale Formation; fossiliferous bed 15 feet above top of Pitkin Limestone.

L62 (fig. 1, loc. 6).—Elkins 7½-minute quadrangle. Outcrop in intermittent stream gully just beyond fence at east side of south-trending road, one-fourth of a mile east of St. Joseph Cemetery and one-fourth of a mile south of Arkansas Highway 45, approximately on township line at west side of SW¼SW¼NW¼ sec. 6, T. 16 N., R. 29 W., 3½ miles northeast of Fayetteville, Ark. Fossils from 2- to 4-inch layer of sandy limestone at base of massive calcareous sandstone, presumably Prairie Grove Member of Hale Formation, a little above flaggy ripple-marked siltstone beds of Cane Hill Member. Collector, David Metz.

L77 (fig. 1, loc. 1).—Winslow 30-minute quadrangle. Beds in upper part of east face of quarry, half a mile north of Cane Hill and a little east of Arkansas Highway 45, in SW¼SW¼ sec. 4, T. 14 N., R. 32 W., Washington County, Ark. (Pitkin loc. 16 of Easton, 1943, p. 153.) Fossils from limestone conglomerate about 10 feet above Pitkin-Hale contact. Collectors, J. H. Quinn, George Staley, and B. F. Clardy.

USGS (U.S. GEOLOGICAL SURVEY) LOCALITIES

19700-PC (fig. 1, loc. 6).—Same locality and horizon as UA loc. L62. Collectors M. Gordon, J. H. Quinn, H. E. Garner, George Staley, William Dial, and William Bishop, November 29, 1960.

19701-PC (fig. 1, loc. 7).—Same locality and horizon as UA loc. L59. Collectors, M. Gordon, J. H. Quinn, and others, November 29, 1960.

19702-PC (fig. 1, loc. 3).—Same locality and horizon as UA loc. L61. Collectors, M. Gordon, J. H. Quinn, and others, November 29, 1960.

19981-PC (fig. 1, loc. 1).—Same locality and horizon as UA loc. L77. Collectors, M. Gordon, J. H. Quinn, and John Hutchison, April 1961.

22012-PC (fig. 1, loc. 5).—Fayetteville 7½-minute quadrangle. Outcrop at foot of elm tree on west bank of southeast-trending intermittent drainage on east slope of Mount Sequoyah, approximately in the more western of two powerline lanes, 100 feet downstream from 8-foot waterfall marking base of Prairie Grove Member, NW¼NE¼NW¼NW¼ sec. 14, T. 16 N., R. 30 W., Washington County, Ark. Fossils from 1-foot thick claystone conglomerate below 4 feet of fine-grained slabby sandstone; top of fossiliferous bed is 8 feet stratigraphically below top of Cane Hill Member of

Hale Formation. Collectors, H. D. Miser, M. Gordon, and L. G. Henbest, October 20–21, 1961.

OTHER LOCALITIES

Three other ammonoid localities in the Cane Hill Member of the Hale Formation have been mentioned in the literature, but were not covered in the present study. One locality, which was the source of the holotype and paratype of *Branneroceras semiretia* (McCaleb), is on the east side of a railroad cut of the St. Louis and San Francisco Railway Co. in Fayetteville, Ark., one block east of the campus of the University of Arkansas. It lies about 100 yards south of UA locality L14.

The second locality (UA loc. L117) provided most of the type specimens of *Hudsonoceras moorei* Quinn and Saunders and lies half a block south of UA locality L14 on the same side of the same railroad cut.

The third locality (UA loc. L99) yielded the holotype of *Reticuloceras? wainwrighti* Quinn. The outcrop is in the bed of a small intermittent stream, 100 yards south of the West Fork-Moffet road, about 2½ miles southwest of its junction with U.S. Highway 71 at West Fork, and it is in the SE. cor. sec. 1, T. 14 N., R. 31 W., Washington County, Ark. The fossils occur in a calcareous pebble-conglomerate bed associated with flaggy siltstone and some sandstone. The fossil-bearing bed is overlain by brown-weathering sandstone of the Prairie Grove Member of the Hale Formation, and for mapping purposes, probably should be included with that member. However, the lithologic similarity to ammonoid-bearing conglomerates at the Fayetteville Country Club and Sequoyah Mountain localities indicates that Quinn (1966, p. 18) was probably correct in considering the conglomerate at this locality as part of the Cane Hill Member.

RETICULOCERAS TIRO ASSEMBLAGE ZONE

The ammonoid assemblage collected in the upper part of the Cane Hill Member and locally in the basal part of the Prairie Grove Member of the Hale Formation so far totals nine species, as follows:

Syngastrioceras globosum (Easton)

Bisatoceras paynei Gordon

Cymoceras adonis n. sp.

**Hudsonoceras moorei* Quinn and Saunders

**Reticuloceras tiro* n. sp.

**Reticuloceras? wainwrighti* Quinn

**Reticuloceras?* sp.

**Branneroceras semiretia* (McCaleb)

Stenopronorites quinni n. sp.

These species constitute the *Reticuloceras tiro* assemblage, and that part of the Morrow Series rocks that they occupy can be considered the *Reticuloceras tiro* Assemblage Zone. This zone is stratigraphically the lowest known Pennsylvanian ammonoid zone in the United States. Species marked with an asterisk (*) in the list above are restricted to this zone. The others range higher.

As nearly as can be determined, the *Reticuloceras tiro* Zone is approximately equivalent to the *R. compressum* (R_{1a}) Subzone of the lower *Reticuloceras* (R_1) Zone in the northwest European Carboniferous section. In Europe and the British Isles the Lower *Reticuloceras* Zone immediately succeeds the *Homoceras* (H) Zone; however, neither the genus *Homoceras* nor the *Homoceras* Zone have been positively recognized in the United States. It is possible that in Arkansas the lower part of the Cane Hill Member of the Hale Formation, which so far has yielded no ammonoids, is the temporal equivalent of the *Homoceras* Zone, but it also is possible that the *Homoceras* Zone is Late Mississippian in age.

The *Reticuloceras tiro* Zone is followed stratigraphically by an ammonoid zone in which the most abundant species generally is either *Reticuloceras henbesti* (Gordon) or *Arkanites relictus* (Quinn, McCaleb, and Webb). This assemblage occurs through the greater part of the Prairie Grove Member of the Hale Formation.

DESCRIPTIONS OF SPECIES

Genus *SYNGASTRIOCERAS* Librovitch, 1938

Syngastrioceras Librovitch, 1938, p. 81, 82, 103, 104; Ruzhcevic and others, 1962, p. 376.

Eoasianites, Miller, Furnish, and Schindewolf [part], 1957, p. L61.

Glaphyrites, Gordon [part], 1965 [1964 imprint], p. 218–221.

Diagnosis.—*Glaphyrites*-like conch, globose to subglobose in immature and early mature stages, becoming thickly discoidal in adult in some species, involute to moderately evolute; umbilicus stepped within. Surface smooth, with angular to subangular umbilical shoulder, thickened into spiral cord; spatulate saddles; first lateral lobe protruding slightly further apicad than prongs of ventral lobe.

Type species.—*Gastrioceras orientale* Yin, 1935, by original designation.

Discussion.—The ammonoid group considered under this name is in number of individuals by far the most abundant in the *Reticuloceras tiro* Zone. Although it has been customary in the United States to assign these shells to *Eoasianites*, or to *Glaphyrites* which some paleontologists regard as congeneric with *Eoasianites*, there is some justification for regarding them as a distinct group. They can be recognized by the shape of the suture line and by their ornamentation in the vicinity of the umbilicus. Moreover, shells of this type seem to be confined to Lower Pennsylvanian rocks.

In discussing several natural subdivisions of the shells that he was including in *Glaphyrites*, Gordon (1964, p. 220) singled out in the first group those forms that "have a stepped umbilicus commonly ornamented with a single cord of flat keel along the shoulder, as in *G. morrowensis* (Miller and Moore) and *G. oblatum* Miller and Moore." This group is synonymous with *Syngastrioceras*. Although Yin (1935, p. 20) did not mention a cord or keel along the "apparently angular" umbilical shoulder in *Gastrioceras orientale* Yin, he did mention a "spiral thickening" along the angular umbilical shoulder of the associated and closely related form *G. suborientale* Yin (1935, p. 20). Yin's wording suggests that wear had partly obscured the ornament of the umbilical shoulder in *G. orientale*, and his illustrations of primary types of that species bear this out.

Ruzhentsev and others (1962, p. 376) said that the growth striae in *Syngastrioceras* generally project forward and are indented by an incipient sinus. This is a character that also occurs in typical *Glaphyrites* and does not necessarily distinguish *Syngastrioceras* from other genera similar in form. The principle distinguishing feature of *Syngastrioceras* is its umbilical shoulder which has a single keel or cord, in contrast to the fine transverse riblets ornamenting the umbilical shoulder of both *Glaphyrites* and *Eoasianites*.

Included in the genus *Syngastrioceras* are *Glaphyrites depressus* Gordon, *Cravenoceras? morrowense* Miller and Moore [part], *Goniatites nolinenensis* Cox, *Glaphyrites oblatum* Miller and Moore, *Gastrioceras orientale* Yin, *G. suborientalis* Yin, and *Syngastrioceras uralicus* Librovitch. These species are restricted to the Lower Pennsylvanian Morrow Series in the United States and the Bashkirian Stage and equivalent rocks in Europe and Asia.

Syngastrioceras is probably ancestral to the late Morrow and Atoka subgenus *Pseudoparalegoceras*

(*Phaneroceras*), which developed into *Pseudoparalegoceras* s. s. in the Des Moines Series. *Phaneroceras* has a conch with a keeled shoulder, rather similar to that of *Syngastrioceras*. Its suture differs from that of *Syngastrioceras* in that the prongs of the ventral lobe are somewhat larger and deeply divided by the median saddle. The prongs approach though do not attain the size of the first lateral lobe. Typical *Syngastrioceras* apparently do not occur in rocks younger than Morrow in age.

***Syngastrioceras globosum* (Easton)**

Plate 1, figures 1-7; text figure 2A-G

- Eoasianites globosus* Easton, 1943, p. 152, pl. 24, fig. 16;
Clardy, 1962, p. 105, 106, pl. 1, figs. 1, 2, pl. 2, fig. 5.
Eoasianites oblatum (Miller and Moore), Clardy, 1962, p. 106,
pl. 1, fig. 3.
Glaphyrites globosus (Easton), Gordon, 1965 [1964 imprint],
p. 222, 223, pl. 23, figs. 16-18, text fig. 61A, B.

The holotype of this species has been redescribed by Gordon (1964, p. 222), and its characters are fairly well established. The present study, however, based on more than 400 specimens from the lower middle part of the Hale Formation, has demonstrated a surprising range of variation in the species. Two forms can be recognized and are present at all localities. The typical form, represented by the holotype and similar evolute shells, has a barrel-shaped conch with diameters of as much as 1 inch (25 mm) or slightly more; the umbilicus ranges from about one-third to nearly one-half the diameter of the conch. In this form, the width of umbilicus/diameter ratio lessens proportionally with growth and the width/height of whorl ratio lessens markedly once the cadicone (barrel-shaped) stage is passed and the whorl takes on greater height and curvature in cross section. A typical specimen is shown in cross section in text figure 2 A, B.

The other form, much less common than the typical one, is involute; the width of the umbilicus ranges from about one-fifth to a little more than a fourth the diameter of the shell. One of these shells is shown in cross section in text figure 2, C, G. The suture of *Syngastrioceras globosum* has strongly hastate lobes (text fig. 2 B, D, E). The relatively narrow width of the first lateral lobe is the principal distinguishing feature that separates it from *S. oblatum* (Miller and Moore) of the Bloyd Shale. In some specimens of the involute form of *S. globosum*, the first lateral lobe is slightly wider than in the typical form, but this is to be expected because the shell surface traversed

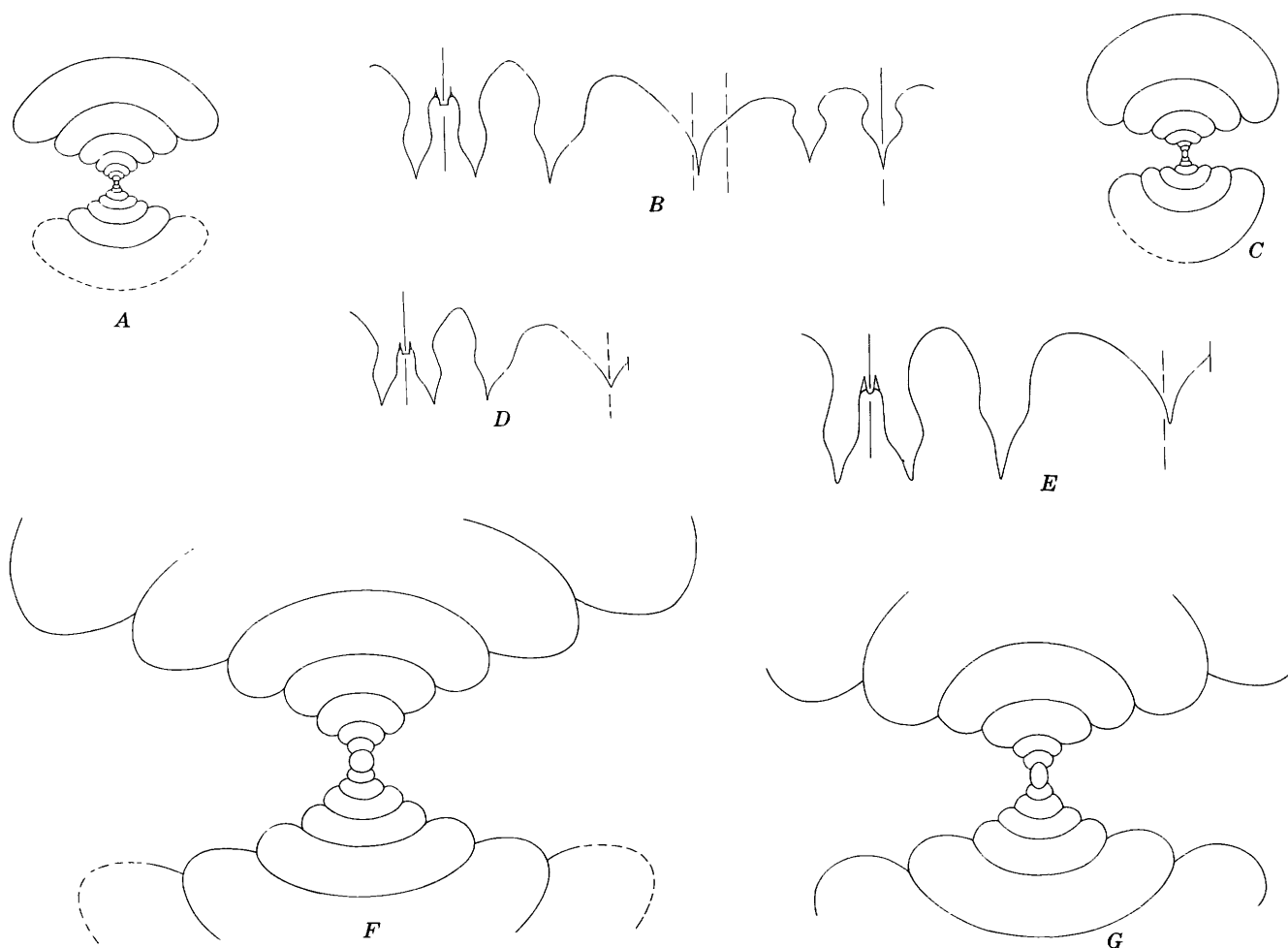


FIGURE 2.—*Syngastrioceras globosum* (Easton). A, F, Cross sections of typical form (USNM 147664), $\times 1\frac{1}{2}$, $\times 5$. B, Suture of typical form (USNM 146381), $\times 2\frac{1}{2}$, where H=8.3 and W=22 mm. C, G, Cross section of involute form (USNM 146383), $\times 1\frac{1}{2}$, $\times 5$. Q, External suture of involute form (USNM 146382), $\times 2$, where D=22, H=11.2, and W=18.2 mm. E, External suture of typical form (USNM) 146379), $\times 2$, where D=33, H=12.3, and W=22 mm. Topotypes include A and F from USGS loc. 19981-PC and E from UA loc. L77; B-D and G are from UA loc. L61.

by the suture is greater in the involute form. In other specimens, however, the first lateral lobe is about the same width in both forms. The two forms have a tendency to intergrade, but there does not seem to be a complete intergradation.

The involute form is considerably scarcer at all localities than the typical evolute one, the overall ratio being 1:6.1 or roughly 16 percent. At the locality where the involute form was relatively the most common (UA loc. L61, USGS loc. 19702-PC),

	Typical form ¹			Involute form ²		
	USNM 146381	USNM 146380	UC 48192 Holotype	USNM 146382	USNM 146383	USNM 146384
Dimensions (mm):						
Diameter (D) -----	55.5	33.5	18	24.2	23.4	21.0
Height of last whorl (H) -----	24.7	13.0	5.5	12.8	11.5	10.8
Width of last whorl (W) -----	39.4	28.0	17	18.7	18.2	16.6
Width of umbilicus (U) -----	16.5	14.5	8.5	6.5	6.5	4.5
Proportions:						
U/D -----	.30	.43	.47	.27	.28	.21
W/D -----	.71	.83	.94	.77	.77	.79
W/H -----	1.60	2.18	3.09	1.46	1.58	1.53

¹ Typical forms are from the type locality, UA loc. L77.

² Involute forms are from UA loc. L61. The holotype, designated by UC48192 (Univ. of Chicago specimen no.), formerly in the Walker Museum, is now in the Chicago Museum of Natural History.

172 specimens of the typical form and 33 of the involute form were found, a ratio of 1:5.2 or 19 percent. At the locality where the involute form was relatively least common (UA loc. L62, USGS loc. 19700-PC), 76 of the typical form and five of the involute form were collected, a ratio of 1:15.2 or not quite 7 percent.

An analogous range of variation is found in the species of *Syngastrioceras* that is abundant in the Brentwood Limestone Member of the Bloyd Shale. The less involute form was described as *Glaphyrites oblatius* Miller and Moore (1938, p. 352 and Gordon, 1964, p. 224). A specimen of the more involute form was included in the syntypes of *Cravenoceras? morrowense* Miller and Moore (1938, p. 346, pl. 43, fig. 1, text fig. 2B), and this form was identified as *Glaphyrites morrowensis* (Miller and Moore) by Gordon (1964, p. 223). It seems, however, that the syntypes of *Cravenoceras? morrowense* included more than one species and genus. A designation of a lectotype for this species is included in a manuscript on the ammonoid fauna of the Bloyd Formation of Arkansas by J. A. McCaleb (unpub. data). The earliest name for the Bloyd species seems to be *Goniatites nolinensis* Cox (1857), but the writer has hesitated to use this name until a primary type or at least a topotype of the Kentucky species can be found.

Types.—Holotype UC 48192; hypotypes USNM 146379-146384, 147664.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L14, L18, L61, L77, USGS locs. 19702-PC, 19981-PC, 22012-PC; probable Prairie Grove Member UA locs. L59, L62, USGS locs. 19700-PC, 19701-PC; Washington County, Ark. The holotype is from Easton loc. 16=UA loc. L77=USGS loc. 19981-PC, Cane Hill, Ark.

Genus BISATOCERAS Miller and Owen, 1937

Bisatoceras paynei Gordon

Plate 1, figures 8-11; text figure 3A, B

Bisatoceras paynei Gordon, 1965 [1964 imprint], p. 249, 250, pl. 28, figs. 40-47, text figs. 74A, B.

Seven specimens from three localities are referred to this species. The specimens show the well-rounded venter merging with very gently rounded flanks. In specimens less than 7 mm in diameter, the flanks slope inward and the umbilicus lies in the center of a broad shallow depression. This depression remains during growth but stays about the same size, so that in adult specimens it is limited to the immediate area of the

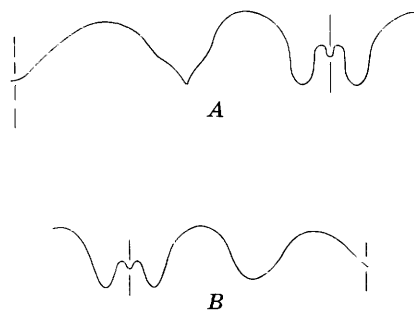


FIGURE 3.—*Bisatoceras paynei* Gordon, external sutures of immature phragmocones. A, Hypotype (USNM 146386), $\times 5$, where $H=6.5$ and $W=9.0$ mm. B, Hypotype (USNM 146387), $\times 14$, where $H=3.5$ and $W=5.5$ mm. A is from UA loc. L18 and B is from UA loc. L77.

umbilicus. The greatest width of the shell occurs just outside of the depressed area. Adult shells are thick discoidal, but early stages are globose to subglobose. One small specimen seems to have a tiny open umbilicus. (See table of measurements below.)

Fine sinuous growth striae separate broader lamellae, which resemble the lamellae in *Cravenoceras*. These growth striae form a very shallow orad bow over the venter, a deeper sinus over each ventrolateral zone, and a shallow orad bow on each flank, as in the holotype. Rarely, on internal molds of immature phragmocones, the growth lamellae are expressed as transverse undulations on the venter and ventrolateral zones. Growth constructions occur sporadically in this species, generally not more than one, or very rarely two, per whorl.

At a shell diameter of 6 mm (text fig. 3B), the suture has a rather short, broad ventral lobe; its sides curving outward and its prongs narrowly rounded at the tip; the first lateral saddle is broadly arched and slightly asymmetrical. The first lateral lobe is also broad and short and ends in a blunt point. At a diameter of 12 mm (text fig. 3A), the sides of the prongs of the ventral lobe of the suture are fairly straight and parallel; the lobes are a little longer and narrower than in the earlier stages, and the first lateral lobe is mamillate. The suture of a specimen at a shell diameter of 18 mm has already been illustrated and described by Gordon (1964, p. 250, text fig. 74B).

This species ranges through most of the Hale Formation. The holotype came from near the top of the Prairie Grove Member and the paratype from 2 to 3 feet above its base (Gordon, 1964, p. 40-42). The present hypotypes are from the

middle and upper parts of the Cane Hill Member. These provide new information as to the shape, dimensions, and configuration of the sutures in less mature specimens.

	¹ L18GR16	¹ USNM 146386	² USNM 146387
Dimensions (mm):			
Diameter (D) -----	22	13.2	6.7
Height of last whorl (H) ----	12.5	6.9	3.6
Width of last whorl (W) ----	13.5	10.3	6.1
Width of umbilicus (U) ----	---	---	0.7
Proportions:			
U/D -----	---	---	.10
W/D -----	.61	.78	.91
W/H -----	1.08	1.49	1.70

¹ USNM 146386 and L18GR16 are from UA loc L18.

² 146387 is from UA loc. L77. All specimen numbers beginning with the letter L in this report are University of Arkansas specimens.

Material studied.—Hypotypes USNM 146385–146387.

Occurrence.—Hale Formation, Cane Hill Member, USGS localities 19701–PC, 19981–PC (1 specimen each) and UA localities L18 (2 specimens), L61 (1 specimen), L77 (2 specimens), Washington County, Ark.

Genus HUDSONOCERAS Moore, 1946

Hudsonoceras moorei Quinn and Saunders

Plate 1, figures 12–16, text figures 4A, B

Hudsonoceras moorei Quinn and Saunders, 1968, p. 398–400, pl. 57, figs. 7–13, text fig. 1.

Diagnosis.—Narrow, discoidal conch with gently convex venter and flanks bearing shallow groove at either side just dorsad of ventrolateral shoulder; surface ornament of fine revolving lirae crossed by sinuous transverse lirae forming fine reticulate pattern. External suture with broad ventral lobe, and its prongs wide and bluntly pointed.

Description.—Discoidal conch having diameter about four times width; whorl section subelliptical in immature shell with rounded ventrolateral shoulders and convex flanks, becoming subrectangular in maturity with subangular ventrolateral shoulders and nearly flat (very gently convex) flanks. Shallow groove, whose boundaries are not well defined, occurs on each outer flank adjacent to ventrolateral shoulder; umbilical shoulder subangular. Diameter of umbilicus about one-sixth that of shell; umbilical wall very slightly convex, sloping rather steeply inward at angle of roughly 120° to flank.

Surface sculpture of fine longitudinal lirae separated by subequal to slightly wider interspaces best developed over venter and outer flanks, crossed by fine transverse growth lirae that curve anteriorly to form ventrolateral salient over ventro-

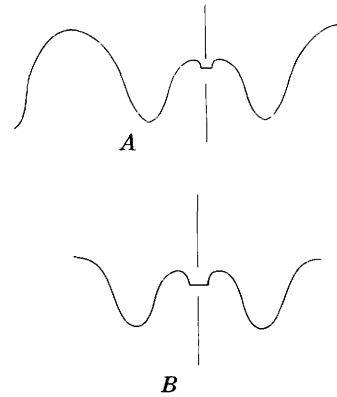


FIGURE 4.—*Hudsonoceras moorei* Quinn and Saunders, incomplete external sutures. A, From fragment of a phragmocone (USNM 146399), $\times 5$, from UA loc. L18. B, Fragment (USNM 146398), $\times 5$, from UA loc. L77.

lateral groove, indistinct in ventral region, forming fine reticulate pattern on some specimens. On one specimen (USNM 146397) longitudinal lirae are spaced three per millimeter on venter and in band 1 mm wide on flanks adjacent to umbilical shoulder, five per millimeter in band 1 mm wide on flanks just outside of first band, and six to seven per millimeter and very faint where preserved on central and outer parts of flanks. No transverse constrictions seen.

External suture (shown in fig. 4 from two fragmental specimens) has broad ventral lobe that possesses rather evenly rounded median saddle, resembling somewhat that of *Gonioloboceras*; prongs of ventral lobe rather wide, slightly asymmetrical, and bluntly pointed. First lateral saddle broadly and rather evenly rounded, slightly subspatulate. First lateral lobe has rather sigmoidal ventrad side; dorsad side convex, curving into broader asymmetric second lateral saddle that crosses umbilical shoulder to short, rather bluntly pointed umbilical lobe located near middle of umbilical wall.

	L-61-7	USNM 146397
Dimensions (mm):		
Diameter (D) -----	25.7	22
Height of last whorl (H) ----	12.8	11.7
Width of last whorl (W) ----	6.2	5.0
Width of umbilicus (U) ----	4.1	3.5
Proportions:		
U/D -----	.16	.16
W/D -----	.24	.27
W/H -----	.49	.43

¹ Incomplete and estimated.

Discussion.—The above diagnosis and description is based upon the recently published original description of this species, as well as the writer's previous study of part of Professor Quinn's material. Specimens from the type locality in the heart of Fayetteville, Ark., have not been examined by the writer. Quinn and Saunders designated a holotype of this species but called all of the rest of their material "figured specimens" and "topotypes." As some of the figured specimens contributed unique fragments of information to the original description and as all of the specimens are germane to their concept of this species, all should be considered paratypes. These figured specimens from the Country Club locality (L61), 3 miles south of Fayetteville, called "topotypes" in the plate descriptions, probably are a little too remote from the type locality to be *bon fide* topotypes, but they are paratypes.

The shells most similar to this species are *Hudsonoceras proteum* (Brown) and *H. ornatum* (Foord and Crick), as pointed out by Quinn and Saunders (1968, p. 399). These species have conches similar to one another, but the suture of *H. ornatum* differs particularly in the broadly sloping sides of the ventral lobe. Direct comparison of the Arkansas species with Irish specimens of *H. proteum* shows both species have similar involute discoidal shells with surface sculpture predominantly of fine longitudinal lirae, and roughly similar external sutures. The longitudinal lirae of *H. proteum*, like those in *H. moorei*, are fairly coarse and few in number on the venter and immediately outside the umbilical shoulder. They are finer and more closely spaced over the flanks. *H. proteum* differs from *H. moorei*, however, in its slightly wider conch, more rounded venter, lack of shallow grooves flanking the ventrolateral zones and by presence of a slightly raised rim at the umbilical shoulder. All the elements of the ventral lobe of *H. proteum* are narrower than those in *H. moorei*; the outline of the median saddle of this lobe is subtrapezoidal in *H. proteum*, instead of being regularly arched as in *H. moorei*. Also, the first lateral saddle in *H. proteum* is narrower and more spatulate than in *H. moorei*.

Five specimens of *H. moorei*, most of them fragmental, were studied.

Figured specimens.—Paratypes, USNM 146397–146399, L-61-7.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L61 South Mountain (2 specimens),

L18 Kessler Mountain (2 specimens), and L77 Cane Hill (1 specimen), Washington County, Ark.

Genus **CYMO CERAS** McCaleb, 1964

Cymoceras McCaleb, 1964, p. 236.

Type species.—*Cymoceras miseri* McCaleb, 1964 [= *Homoceratoides cracens* Gordon, 1965 (1964 imprint)], by original designation.

This genus includes involute, lenticular shells bearing rounded venters and an ornamentation of low, gently rounded, broad sinuous transverse costae. The costae are dichotomous and divide just inside the midflank on most shells. They form broad low salients over the ventrolateral zones and a moderately shallow ventral sinus. The eight-lobed suture has symmetrical to slightly asymmetrical, fairly long pointed lobes and asymmetrical rounded spatulate lateral saddles.

The type species, *C. miseri* McCaleb, is similar to "*Glyphioceras*" *divaricatum* Hind (1905, p. 114) from the Upper Carboniferous of Great Britain, and the two species appear to be congeneric. "*G.*" *divaricatum* is referred by European paleontologists, following Bisat (1924, p. 113), to the genus *Homoceratoides*; the type species of which is *H. prereticulatus* Bisat (1924, p. 112, 113, pl. 1, fig. 3), by original designation—Gordon (1964, p. 241) notwithstanding.

According to Bisat (1924, p. 112), *H. prereticulatus* has a subacute fastigiate venter, and the costae, much narrower than in "*G.*" *divaricatum*, are "di-, tri-, or even quadri-chotomizing at the umbilical edge" at 7 mm diameter; the dichotomizing point moves from the umbilicus up onto the flanks with growth. The suture is not known in *H. prereticulatus*, which prompted Miller and Owen (1939, p. 160) to remark that only the type species could be referred to *Homoceratoides* with certainty.

The lack of anything resembling a subacute fastigiate venter in any Arkansas specimens, except for one cited by Gordon (1964, p. 241), in which the acute venter was believed to be caused by crushing, and the different width and shape of the sinuous ramifying costae suggest that *Cymoceras* deserves recognition as a genus distinct from *Homoceratoides*, certainly until something is known about the suture in *Homoceratoides*. The new species described below has the characteristic sculpture of *Cymoceras* on the early whorls of the phragmocone, but the sculpture becomes faint and disappears on the later whorls.

McCaleb (1964, p. 236) suggested that *C. miseri* might be ancestral to *Neodimorphoceras*, and this seems quite reasonable after examining young spe-

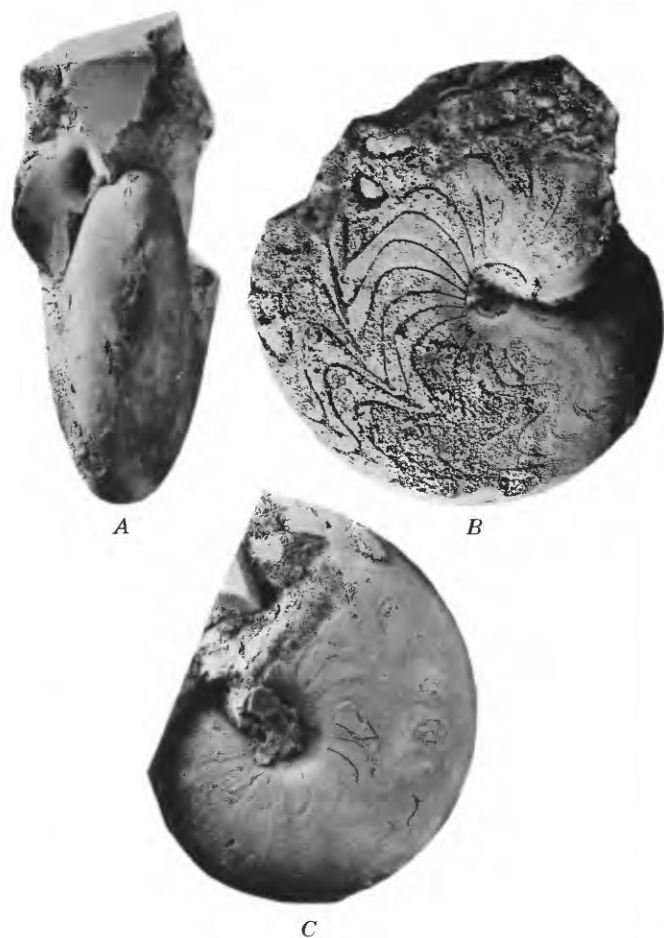


FIGURE 5.—*Cymoceras adonis* n. sp. A–C, front, side, and opposite side views of a paratype (USNM 146395), $\times 1$, from USGS loc. 22012-PC.

cimens of *N. texanum* (Smith); some young specimens were illustrated by Miller and Downs (1950a, p. 200–202, pl. 33, text fig. 4).

***Cymoceras adonis* n. sp.**

Plate 1, figures 19–22, 25, 26; text figures 5A–C, 6A–F

Homoceratoides (sic) sp. Clardy, 1962, p. 106, pl. 1, fig. 4.

Diagnosis.—Moderately large, involute, subdiscoidal, rounded conch bearing rather flat, sinuous, dichotomous, transverse costae on early whorls of phragmocone that die out on later whorls. Suture bears long, pointed, slightly asymmetrical lobes and strongly spatulate saddles.

Description.—Conch lenticular, subdiscoidal; convex venter rounding without break into gently curved flanks (text fig. 5A). Whorl in adult phragmocone about three-quarters as wide as high; greatest width about one-sixth to one-fifth diam-

eter of shell; umbilical shoulder subangular in immature shells as much as 20 mm diameter, shoulder becoming gently rounded and ill defined on mature phragmocone; umbilical wall well rounded.

Sculpture consists of flat, slightly sinuous, gently convex, transverse lamellae, slightly raised on orad edge, with narrow interspaces. Transverse lamellae form very shallow, broad, orad bow on inner flank, and broad, shallow, ventrolateral salients and intervening ventral and lateral sinuses between bows and salients; visible on internal mold (pl. 1, fig. 22). Lamellae bifurcate along line approximately following dorsad side of first lateral lobe of suture. At shell diameter of 20 mm, approximately seven flat costae occur within a space of 5 mm along venter. At diameters from 25 to 30 mm, costae begin to become faint, and they die out at a diameter of 40 mm or slightly more; mature part of phragmocone smooth, as seen in several patches of shell on holotype.

External suture in adult consists of rather broad ventral lobe possessing prominent long asymmetrical prongs with points slightly dorsad of center; median saddle subtriangular; sides of ventral lobe diverging orad, slightly sigmoidal (fig. 6B, E). First lateral saddle deep, rather narrowly rounded, spatulate. First lateral lobe slightly narrower than first lateral saddle, sides gently convex, pointed tip curving slightly dorsad. Second lateral saddle curving asymmetrically and gently across umbilical shoulder into umbilicus.

	Paratype		Holotype		
	USNM 146395	USNM 146390	USNM 146392	USNM 146391	USNM 146393
Dimensions (mm):					
Diameter (D) -----	52.5	48.4	24.6	22.3	7.0
Height of last whorl (H) -----	30.5	26.2	13.4	14.0	3.5
Width of last whorl (W) -----	22.2	20.0	13.3	11.8	5.9
Width of umbilicus (U) -----	² 10.0	² 10.0	3.6	3.7	2.3
Proportions:					
U/D -----	.19	.22	.15	.17	.33
W/D -----	.42	.41	.54	.53	.84
W/H -----	.73	.76	.99	.84	1.69

¹ Paratype USNM 146395 is from USGS loc. 22012-PC and the rest are from UA loc. L77.

² Approximate.

Cymoceras adonis belongs in the group of "*Glyphioceras*" *divaricatum* Hind which has flattened sinuous riblets that bifurcate about half way between the umbilical shoulder and midventer. The suture of Hind's species, *Homoceratoides divaricatus* as illustrated by Bisat (1924, pl. 10, fig. 10), is similar to that of *Cymoceras adonis* but has shorter, stouter lobes that are a little more sym-

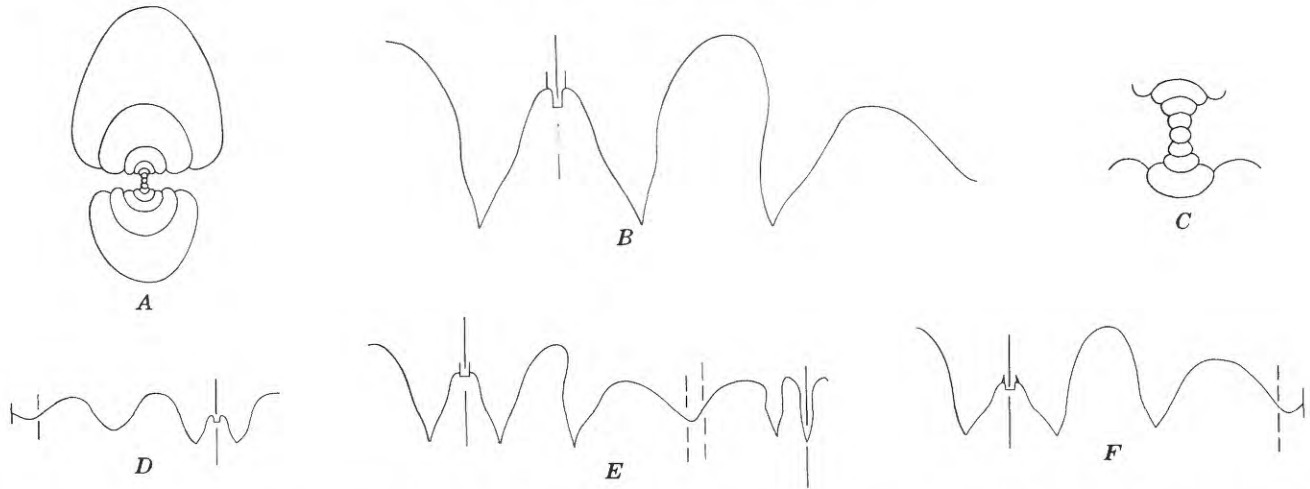


FIGURE 6.—*Cymoceras adonis* n. sp. *A*, *C*, Cross sections of a paratype (USNM 146392), $\times 1\frac{1}{2}$, $\times 5$. *B*, External suture of the holotype (USNM 146390), $\times 2$, where $H=23.3$ and $W=19.6$ mm. *D*, External suture of an immature paratype (USNM 146393), $\times 5$, where $D=6.5$, $H=3.1$, and $W=5.5$ mm. *E*, Suture of a paratype (USNM 146394), $\times 1$, where $H=21$ and $W=19.5$ mm. *F*, External suture of a paratype (USNM 146391), $\times 4$, where $H=6.5$ and $W=8.5$ mm. *A*–*D* and *F* are from UA loc. L77; *E* is from UA loc. L14.

metrical than those of *C. adonis*. Clardy (1962, p. 106, pl. 1, fig. 4) figured one of the paratypes of this species as *Homoceratoides* (sic). Another specimen, an apparently smooth, large internal mold, figured by Clardy (1962, pl. 1, fig. 3) as an undetermined genus, may also belong here.

A recently described Arkansas species of this group is *Cymoceras miseri* McCaleb 1964 [= *Homoceratoides cracens* Gordon 1964]. In that species the lobes of the suture are shorter and wider than in *C. adonis*, and the dichotomous transverse costae continue on to the body chamber in mature shells, instead of becoming faint and dying out fairly early on the phragmocone. *C. miseri* occurs stratigraphically higher than *C. adonis* and is presumably a descendant of it. The phylogenetic change, however, from long to short sutural lobes and from faint to moderately strong adult sculpture, seems to be diametrically opposite to what one might normally expect in the evolution of a phylogenetic stock.

Types.—Holotype, USNM 146390; paratypes USNM 146391–146395, UA L77CH.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L77 (holotype and 11 paratypes) Cane Hill, L14 (paratype) Fayetteville; USGS loc. 22012-PC (paratype) Mount Sequoyah, Washington County, Ark.

***Reticuloceras tiro* n. sp.**

Plate 2, figures 1–13, 35, text figure 7A–D

Diagnosis.—*Reticuloceras* possessing moderately involute subspherical conch; venter broadly rounded, crossed by shallow sinuous transverse lirae and subcontinuous fine faint longitudinal lirae. Ventral lobe of mature suture has moderately long prongs with subparallel sides; first lateral lobe mamillate.

Description.—Conch narrowly subspherical; venter rounding broadly into steeply sloping flanks; widest part of shell at narrowly rounded umbilical shoulder; umbilical wall strongly convex; diameter of umbilicus about one third that of shell (fig. 7A, B).

Conch ornamented by approximately 25 narrow, unequal, transverse nodes per volution along umbilical shoulder, most of which cross umbilical wall on early whorls but become faint on later whorls. Sinuous transverse lirae cross flanks and venter and arise directly or bifurcate from nodes at or near umbilical shoulder; some single lirae intercalated between those arising from nodes. Transverse lirae shallowly sinuous have wider interspaces and form short faint orad bow near umbilical shoulder, wider sinus over each flank, orad bow over each ventrolateral zone, and fairly narrow ventral sinus; nine to 10 transverse lirae within space of 2 mm along venter; approximately three transverse growth constrictions per volution, deep-

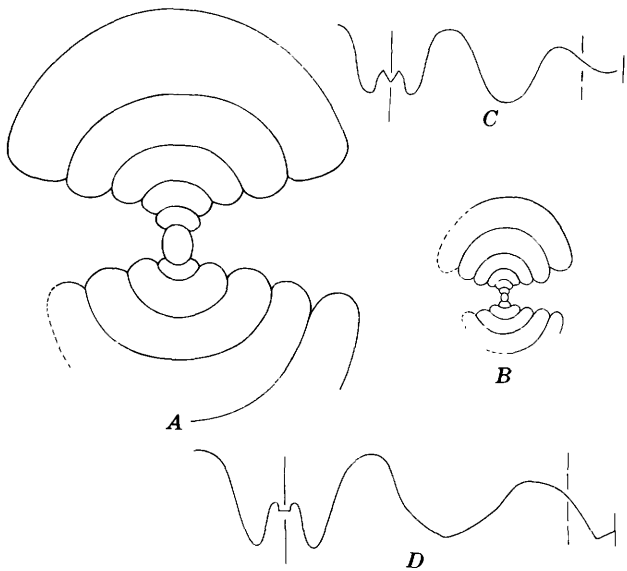


FIGURE 7.—*Reticuloceras tiro* n. sp., cross sections and sutures. A, B, Cross sections of a paratype (USNM 146402), $\times 5$, $\times 1\frac{1}{2}$, C, External suture of a paratype (USNM 146405), $\times 10$, where D=4.8, H=1.9, and W=4.0 mm. D, External suture of a paratype (USNM 146401), $\times 5$, where D=12.5, H=5.7, and W=9.2 mm. USNM 146401 and 146402 are from UA loc. L77; USNM 146405 is from UA loc. L61.

est on flanks. Longitudinal lirae, much weaker than transverse lirae, tiny longitudinal granules occurring at intersections with transversals; transverse lirae indistinct over interspaces.

Suture (fig. 7C, D) has rather short, broad ventral lobe, its sides diverging slightly orad and concave outward, terminating in rather short, bluntly pointed prongs; median saddle with short central projection over siphuncle; first lateral saddle rounded spatulate; first lateral lobe slightly wider, with evenly convex sides, bluntly pointed; second lateral saddle broadly asymmetrical; umbilical lobe short, broad, pointed. Internal suture not known.

	Paratypes		Holotype	Paratypes	
	¹ USNM L18GR	USNM 146401	USNM 146400	USNM 146404	² USNM 146405
Dimensions (mm):					
Diameter (D)	15.2	13.2	11.5	9.0	5.3
Height of last whorl (H)	7.4	6.0	5.0	4.2	2.0
Width of last whorl (W)	10.5	9.7	8.3	6.8	3.9
Width of umbilicus (U)	4.8	4.7	4.0	3.6	2.7
Proportions.					
U/D	.32	.36	.34	.40	.51
W/D	.70	.73	.72	.75	.74
W/H	1.43	1.62	1.66	1.62	1.95

¹ USNM 146401 is from UA loc. L77.

² USNM 146404 and 146405 are from UA loc. L61.

Discussion.—Some variation is shown by the 17 designated paratypes and 22 other specimens of *Reticuloceras tiro* collected from four Washington

County localities, particularly in development of nodes in immature shells, in spacing of the transverse lirae, and in the development of granules on the lirae. Some shells have as few as seven transverse lirae per 10 mm along the venter at diameters of 10 to 15 mm; the granules are very tiny, and the longitudinal lirae in the interspaces are invisible. Venters of some internal molds of phragmocones have short longitudinal depressions, which indicate that at least some individuals of *R. tiro* possessed an intraventral ridge.

Normally, young shells, from 3 to 5 mm in diameter, are rather barrel shaped and bear relatively strong umbilical nodes. USNM shells, from a locality near the now defunct settlement of Thompson, Madison County, Ark., are generally more involute at a diameter of 5 mm, and the nodes are weaker. These specimens, however, are regarded as constituting only a local variant of the typical form.

The most similar species to *Reticuloceras tiro* seems to be *R. compressum* Bisat and Hudson, from the base of the Lower *Reticuloceras* (R_1) Zone in England. In *R. compressum* the width of the conch is one-half the diameter (at 16-mm diam) whereas in *R. tiro* the width is almost three-quarters the diameter.

Immature specimens of *Branneroceras semiretia* (McCaleb) might be confused with *R. tiro*; but, shells of *B. semiretia* are more evolute, with flatter venters in the immature phragmocone, and have stronger nodes and longitudinal lirae, and coarser, more widely spaced, transverse lirae.

Types.—Holotype USNM 146400; paratypes USNM 146401–146406, additional paratypes in University of Arkansas collection.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L77 (holotype, 7 paratypes) Cane Hill, L61 (10 paratypes, 5 others) South Mountain, L18 (2 specimens) Kessler Mountain. Probable Prairie Grove Member, UA loc. L62 St. Joseph Cemetery, Washington County, Ark.

Reticuloceras? wainwrighti Quinn

Plate 1, figures 23, 24; plate 2, figures 14–19, 21–24; text figure 8A–D

Reticuloceras wainwrighti Quinn, 1966, p. 14–19, text figs. 1A–C, G, 3, 4.

Diagnosis.—Thick discoidal conch with rounded venter becoming medially subacute in old age; umbilical shoulder subacute, without nodes in early stages; diameter of umbilicus equal to about

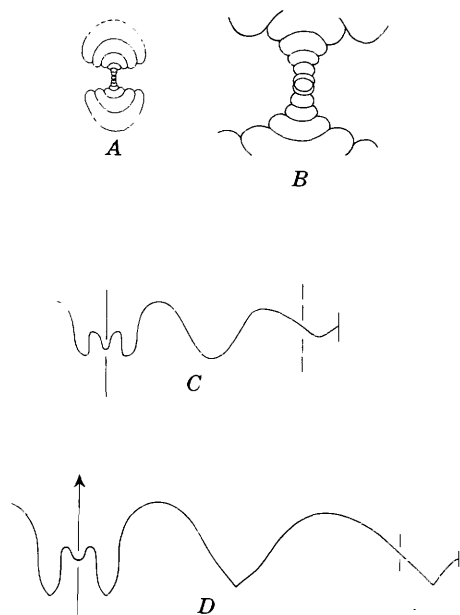


FIGURE 8.—*Reticuloceras? wainwrighti* Quinn. A, B, Cross sections of a hypotype (USNM 146460), $\times 1\frac{1}{2}$, $\times 5$. C, External suture of hypotype (USNM 146457), $\times 10$, where D=7.3 mm. D, External suture of the holotype after Quinn, $\times 2\frac{1}{2}$. A-C are from UA loc. L61.

one-fourth that of shell. Sculpture of sickle-shaped transverse threads locally bunched on umbilical shoulder; faint ventrolateral sulci present in some mature shells. Suture contains ventral lobe of moderate length having narrow straight pointed prongs.

Description.—Conch thick discoidal, moderately involute; venter and ventrolateral zones well rounded during most of growth, venter subacute in old age; flanks gently convex; widest part of shell at subacute to narrowly rounded umbilical shoulders; umbilical walls gently convex. Cross section (fig. 8A, B) shows early whorls planorbitally coiled for about $4\frac{1}{2}$ volutions, widening for about two volutions, then adding more height in later volutions.

Surface of conch ornamented by fine, raised, sinuous, transverse lirae of approximately equal strength over venter, but of unequal strength and locally bunched near umbilical shoulder; interspaces generally wider than lirae; seven to 10 lirae within space of 2 mm along venter at diameters of 15 to 20 mm. Lirae continue closely spaced across umbilical wall, some of them more elevated than others; on inner flanks lirae form a shallow orad bow with narrower shallow sinus over mid

flanks, more prominent orad bow over ventrolateral zones, bounded at either side in some mature specimens by faint shallow longitudinal sulcus but most without sulci. Ventral sinus well rounded, about 2 mm deep at diameters of 15 to 20 mm, measured from farthest orad projection of ventrolateral bows in growth lirae. Internal varices approximately follow configuration of transverse lirae; three to four varices per volution, but not visible where shell surface is preserved.

Suture goniatic; in immature shells (fig. 8C), ventral lobe fairly short, with fairly straight sides diverging slightly outward, indented by small, broadly subrectangular, median saddle into two short subrounded prongs, each with sharp ventrapicad corner; first lateral saddle slightly asymmetrical and spatulate; first lateral lobe rather evenly convex, terminating in blunt point; second lateral saddle rather narrow and asymmetrically rounded to short, sharp, umbilical lobe. Suture in mature shells (fig. 8D) has ventral lobe slightly longer than wide, indented to about half its length by median saddle with narrow prongs terminating in centrally located points. First lateral saddle wider than ventral lobe, asymmetrical, rounded. First lateral lobe narrower than ventral lobe, nearly symmetrical, simply pointed. Second lateral saddle broadly asymmetrical, curving across umbilical shoulder into short pointed umbilical lobe.

	¹ USNM 146455	USNM 146406	L61c177	L61c191	USNM 146458
Dimensions (mm):					
Diameter (D) -----	19	15.2	10.0	8.5	6.8
Height of last whorl (H) ----	8.7	7.5	4.5	2.5	3.0
Width of last whorl (W) ----	10.3	9.4	6.6	4.5	4.4
Width of umbilicus (U) ----	5.0	3.8	3.0	2.0	2.2
Proportions:					
U/D -----	.26	.25	.30	.35	.34
W/D -----	.54	.62	.66	.65	.68
W/H -----	1.18	1.25	1.47	1.57	1.47

¹ The first specimen (USNM 146455) is from UA loc. L18; the rest are from UA loc. L61.

Discussion.—Occurring with *Reticuloceras tiro* n. sp., in collections from all four localities where that species was recorded, are 25 specimens of a similar-sized but narrower shell. This shell differs from *R. tiro* in several particulars and was described by Quinn (1966, p. 14) as *Reticuloceras wainwrighti* n. sp. Quinn's holotype, 37 mm in diameter, is considerably larger than any of the specimens studied here. The specimens in this report, therefore, serve to illustrate the characters of less mature examples of this species, not shown by the characters of less mature examples of this species, not shown by the primary types. Quinn's holotype (UA L99-185) came from a locality not included in the present study. His "old age" paratype (UA

L18-9), however, came from one of the localities in this report.

Because these *R.?* *wainwrighti* shells do not possess longitudinal lirae or umbilical nodes at any stage of growth, the writer originally regarded them as belonging in *Homoceras* or some related genus. However, some specimens of *Reticuloceras tiro*, particularly at locality L61, approach *R.?* *wainwrighti* in shape and sculpture, and the possibility that they might represent sexual dimorphs of *R. tiro* was considered but eventually rejected.

Reticuloceras? *wainwrighti* and *R. tiro* should not be regarded as variants of the same species because of the following differences between the two forms: (1) Immature shells of *R. tiro* have umbilical nodes; those of *R.?* *wainwrighti* do not. (2) The conch of *R. tiro* is somewhat reticulate; that of *R.?* *wainwrighti* lacks longitudinal lirae. (3) The conch of *R. tiro* is proportionally wider than that of *R.?* *wainwrighti*. (4) The umbilicus of *R. tiro* is proportionally larger than that of *R.?* *wainwrighti*. (5) The early planorbitally coiled stage in *R. tiro* lasts slightly more than three volutions, as against $4\frac{1}{2}$ to five in *R.?* *wainwrighti*. (6) The ventral lobe of the adult suture of *R. tiro* has slanting sides; that of *R.?* *wainwrighti* has subparallel sides, except in young specimens.

The gerontic stage of *R.?* *wainwrighti* illustrated by Quinn (1966, text figs. 1B, C and 4) has a subacute, fastigiate venter. Another specimen from the same locality as Quinn's example (UA loc. L18), showing an incipient subangular venter, is figured here (pl. 1, figs. 23, 24). Quinn (1966, p. 13) believes that this venter in gerontic *R.?* *wainwrighti* is similar to that in *Reticuloceras davisii* (Foord and Crick)—which some paleontologists regard as the gerontic form of and therefore synonymous with *R. reticulatum* (Phillips)—and he regards this similarity as "inescapable proof" that *R.?* *wainwrighti* is an American *Reticuloceras*. Various other ammonoids, however, have subacute to acute venters at maturity or in old age, including the type species of *Homoceratoides*, *H. prereticulatum* Bisat, of which, unfortunately, the suture is not known.

The gerontic specimen figured in this report (pl. 1, figs. 23, 24) also exhibits faint longitudinal sulci just within the ventrolateral shoulder. Similar faint ventrolateral sulci are shown also on another figured specimen (pl. 2, fig. 16). These faint sulci bound on the ventral side the orad bow of the transverse lirae over the ventrolateral zones in the specimen cited immediately above. The faint sulci cannot be discerned on internal molds except

in the one living chamber figured (pl. 1, figs. 23, 24). This character apparently was developed rather late in growth; it was variable and probably absent on some specimens.

Less mature shells of this species can be confused with *Weideyoceras matheri* (Gordon) from the upper part of the Hale Formation, but this species is a little narrower and more involute, has much finer and more closely spaced growth lirae, and the first lateral lobe of its suture is narrower and more sharply pointed in young shells.

Types.—Hypotypes, USNM 146455-146460, UA L61c-177, 191.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L18, L61, L77; Prairie Grove Member (?) UA loc. L62; Washington County, Ark.

***Reticuloceras?* sp.**

Plate 1, figures 17, 18; text figure 9

A single incomplete specimen is widely umbilicate, with a prominent umbilical shoulder, sculpture of sinuous crenulated transverse lirae, and a gastrioceran suture. It does not fit easily into any described genus, but seems to be closest to *Reticuloceras tiro* n. sp., although it is much more evolute.

This specimen is an incomplete internal mold of an evolute phragmocone which has reached a diameter (slightly distorted) of 41 mm. The venter is well rounded, the ventrolateral zones subdued; the venter rounds into the flanks which slope outward at an angle of about 30° to the vertical axis of the shell. The umbilical shoulder is prominent, subangular, and the umbilical wall is nearly flat. No well-defined growth constrictions can be seen, but here and there the flanks near the umbilical shoulder are dimpled by what seem to be vestiges of transverse constrictions that may have become indistinct at this diameter. On the venter, near its orad end, are preserved two small patches of shell showing a surface sculpture of minutely wavy transverse lirae, with interspaces wider than the lirae; six of these lirae occur within the space of 2 mm. They are strongly oblique and outline one side of a moderately deep ventral sinus and a prominent bow orad over the ventrolateral zone. The crenulations of the lirae line up in a rude longitudinal pattern, somewhat reminiscent of *Nuculoceras*, though not definitely longitudinally lirate.

The external suture (fig. 9) has a ventral lobe, the prongs of which are fairly straight on the dorsal side and curved on the ventrad side where they



FIGURE 9.—*Reticuloceras?* sp., external suture from the unique specimen (USNM 146388), $\times 2$, where $H=10$ and $W=21$ mm, from UA loc. L18.

form a subtriangular median saddle of moderate depth. The first lateral saddle is asymmetrically curved dorsad and spatulate. The first lateral lobe is rather symmetrical and mamillate and has convex sides. The second lateral saddle curves asymmetrically to the short sharp umbilical lobe.

Dimensions, in millimeters.—Diameter (D) 36, height of last whorl (H) 11.5, width of last whorl (W) 23, and width of umbilicus (U) 20. These give the following proportions: $U/D=0.56$, $W/D=0.64$, and $W/H=2.0$.

Figured specimen.—USNM 146388.

Occurrence.—Hale Formation, Cane Hill Member, UA loc. L18, Kessler Mountain, Washington County, Ark.

Genus BRANNEROCERAS Plummer and Scott, 1937

***Branneroceras semiretia* (McCaleb)**

Plate 2, figures 20, 25–30; text figures 10A–C, 11

Retites semiretia McCaleb, 1964, p. 234, 235, pl. 1, figs. 1–5, A.

Diagnosis.—Moderately evolute *Branneroceras* having rather primitive suture in which first lateral lobe and prongs of ventral lobe are wider and median saddle shorter than in *B. brameri* (Smith).

Description.—Conch thickly discoidal (fig. 10A, B), narrowing very slightly with growth, evolute; width of umbilicus roughly one-half shell diameter; U/D ratio tending also to diminish slightly with growth. Venter rounded, somewhat flattened in immature and early mature phragmocone, more elevated in mature shell; flanks well rounded in immature phragmocone with greatest width near umbilical shoulder, less rounded in mature conch with greatest width approximately at shoulder.

Ornamentation consists of 27 to 35 radial to slightly protractive elongate nodes on each immature whorl, extending into riblets on later whorls; nodes and riblets giving rise to sinuous transverse lirae forming shallow sinus on each flank; promi-

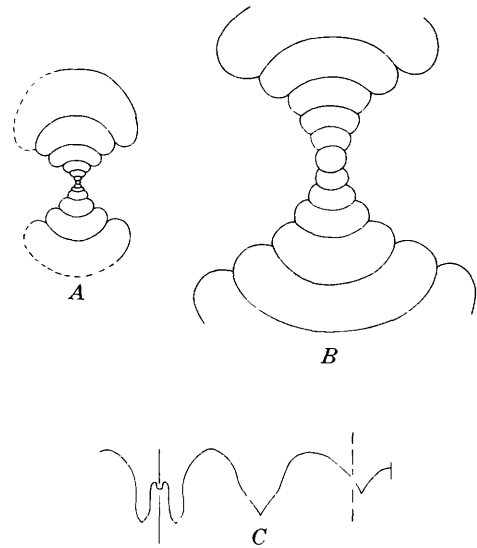


FIGURE 10.—*Branneroceras semiretia* (McCaleb). A, B, Cross section of a hypotype (USNM 146464), $\times 1\frac{1}{2}$, $\times 5$ from USGS loc. 19981-PC. C, External suture from a hypotype (USNM 146462), $\times 2\frac{1}{2}$, where $D=23$, from UA loc. L62.

nent nearly linguiform orad bow on each ventrolateral zone and rather deep U-shaped ventral sinus between. As many as four moderately deep growth constrictions commonly occur on each whorl, paralleling configuration of transverse lirae. Longitudinal sculpture consists of numerous lirae, with interspaces wider than lirae, forming reticulate network with transverse lirae; longitudinal lirae tending to be a little less strong over ventral sinus and inner flanks. Shallow longitudinal groove at either side of ventral sinus in some specimens.

External suture (fig. 10C) with subrectangular ventral lobe, having sides nearly straight but very slightly sigmoidal, its prongs of moderate width, slightly asymmetrical with points a little to dorsad side, divided to not quite one-half of its length by inverted-goblet-shaped median saddle. First lateral saddle very slightly asymmetrical, narrowly arched. First lateral lobe also very slightly asymmetrical and a little wider than first lateral saddle, rather bluntly pointed, curving into second lateral saddle which extends rather straight across shoulder to short, pointed umbilical lobe.

A variant, represented by a rather mature incomplete phragmocone, has a considerably wider first lateral lobe (fig. 11).

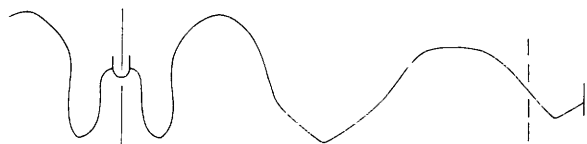


FIGURE 11.—*Branneroceras semiretia* (McCaleb), variant. External suture from a mature phragmocone (USNM 146407), $\times 5$, where $H=9.0$ and $W=15.1$ mm, from UA loc. L77.

	USNM 146461	USNM 146462	USNM 146464	USNM 146463
Dimensions (mm):				
Diameter (D) -----	30.5	26.0	¹ 18	15.0
Height of last whorl (H) -----	11.0	8.3	6.8	4.7
Width of last whorl (W) --	² 15.2	² 15.3	² 11	9.3
Width of umbilicus (U) --	13.8	12.0	7.6	7.2
Proportions:				
U/D -----	.45	.46	.43	.48
W/D -----	.50	.59	.61	.62
W/H -----	1.36	1.84	1.62	1.98

¹ Approximate.

² Twice the half width. For locality data on these specimens see descriptions of figures.

Discussion.—*B. semiretia* is one of the more common ammonoids in the middle part of the Hale Formation; there are 150 specimens in the collections under study. In his original description of this species, McCaleb (1964, p. 233) based a new genus, *Retites*, on it, which is characterized principally by its more primitive suture. In the writer's opinion, the characters that differentiate this species from *Branneroceras branneri* (Smith) are not sufficient to warrant erecting a new genus, separate and distinct from *Branneroceras*, of which *Retites* is here considered a synonym.

Branneroceras branneri differs from *B. semiretia* in having a slightly narrower conch which is consistently subdiscoidal, more regular and consistent lirae on the venter, and the prongs of the ventral lobe and the first lateral lobe are narrower; the ventral lobe is divided to about three-fifths its length by the median saddle compared to a little less than one-half in *B. semiretia*. *B. semiretia* no doubt was ancestral to *B. branneri*, as indicated by McCaleb (1964, p. 233), and was the earliest known representative of the Pennsylvanian ammonoid family Schistoceratidae.

Although McCaleb (1964, p. 234) said the name *semiretia* is derived from the Latin *retia* meaning "netted," the Latin Dictionary discloses no participle nor adjective of this spelling. Instead, *retia* is shown as a feminine noun meaning "net." For this reason the specific name *semiretia* is here re-

garded as a noun in apposition, and the ending does not change when transferring it to *Branneroceras*, a neuter generic name.

Types.—Hypotypes USNM 146461–146464.

Occurrence.—Hale Formation, Cane Hill Member, UA locs. L14, L18(?), L61, L77, and USGS locs. 19702-PC, 19981-PC, and 22012-PC; Prairie Grove Member(?), UA locs. L59, L62, and USGS loc. 19701-PC; Washington County, Ark.

Genus STENOPRONORITES Schindewolf, 1934

Stenopronorites quinni n. sp.

Plate 2, figures 31–34; text figures 12A, B

Diagnosis.—Pronoritid having rounded venter devoid of ribs up to whorl heights as much as 40 mm and perhaps more. Five lateral lobes occur on external suture.

Description.—Conch discoidal, with flat sides, a well-rounded venter, and rounded umbilical shoulder. Early whorls are planorbitally coiled, wider than high; but at a diameter of 10 to 15 mm, whorls increase markedly in height and shell assumes typical pronoritid shape. Phragmocones, 30 to 40 mm in height, show no signs of ventral ribbing. Living chambers not known.

Suture at whorl height of 10 mm (fig. 12B) has ventral lobe and five lateral lobes on each flank, decreasing in height gradually from second lateral lobe, plus two short umbilical lobes. Ventral lobe trifid; first lateral lobe moderately wide and short and rather shallowly divided into two short prongs. Other lateral lobes asymmetrical, slightly club shaped, and pointed. Umbilical lobes rounded, short; inner one incipient.

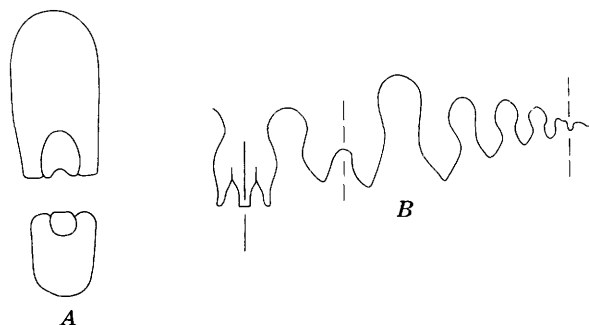


FIGURE 12.—*Stenopronorites quinni* n. sp. A, Incomplete cross section of a paratype (USNM 146466), $\times 1\frac{1}{2}$. B, External suture of the holotype (USNM 146465), $\times 4$, where $H=9.8$ and $W=6.8$ mm. Both specimens are from UA loc. L77.

	Paratypes		Holotype
	¹ USNM 146467	² USNM 146466	² USNM 146465
Dimensions (mm):			
Diameter (D) -----		25.1	---
Height of last whorl (H) --	31.8	13.4	9.5
Width of last whorl (W) --	17.8	8.3	6.8
Width of umbilicus (U) ----		5.5	---
Proportions:			
U/D -----		.22	---
W/D -----		.33	---
W/H -----	.56	.62	.71

¹ USNM 146467 is from UA loc. L18.

² USNM 146465, 146466 from UA loc. L77.

Discussion.—This species is known from a number of incomplete phragmocones in Hale Formation collections. Fifteen fragmental specimens occur in the collections under study. The holotype consists of part of two volutions of a phragmocone.

Stenopronorities quinni n. sp. differs from *S. arkansiensis* (Smith), which occurs in the Bloyd Shale and Atoka Sandstone, by having a more primitive suture and, so far as is known, a conch without marked ventral ribbing. A specimen of *S. arkansiensis* from the Witts Springs Formation on Gaither Mountain, Boone County, Ark., has six lateral lobes at a whorl height of 9 mm. The bifid first lateral lobe of *S. arkansiensis* is a little more deeply divided; the saddle reaches half the length of the lobe in some specimens, whereas in *S. quinni* it does not exceed two-fifths of the length of the lobe. Because no living chambers of *S. quinni* are known, it cannot be claimed that this species is completely devoid of ventral ribbing, but specimens of *S. arkansiensis* examined in this study commonly have developed ribbing by a whorl height of 30 mm. It would seem that *S. quinni* is a somewhat more primitive pronoritid directly ancestral to *S. arkansiensis*.

The species most closely related to *S. quinni* seems to be *Uralopronorities mirus* Librovitch (in Ruzhentsev, 1949), from beds of Namurian Age in the Ural Mountains, U.S.S.R. The writer regards *Uralopronorities* Librovitch as a synonym of *Stenopronorities*. The Russian species has a rounded venter and a 20-lobed suture that is approximately in the same stage of evolutionary development as that of *S. quinni*. Although the internal suture of *S. quinni* has not been seen, examination of whorls broken partly along septa indicate that the Cane Hill species has a suture with a total of 20 lobes. Differences between the two species are relatively minor. *Stenopronorities mirus* has a less convex venter and a wider, more asym-

metrically and shallowly notched first lateral lobe than *S. quinni*.

Types.—Holotype USNM 146465, paratypes USNM 146466, 146467. Other paratypes in UA collection.

Occurrence.—Hale formation, Cane Hill Member, UA locs. L77 (holotype and 4 paratypes) Cane Hill, L18 (3 paratypes) Kessler Mountain, L61 (3 specimens) and USGS loc. 19702-PC (1 fragment) South Mountain; Washington County, Ark. Prairie Grove Member(?) UA loc. L62 (3 specimens) St. Joseph Cemetery, Washington County, Ark.

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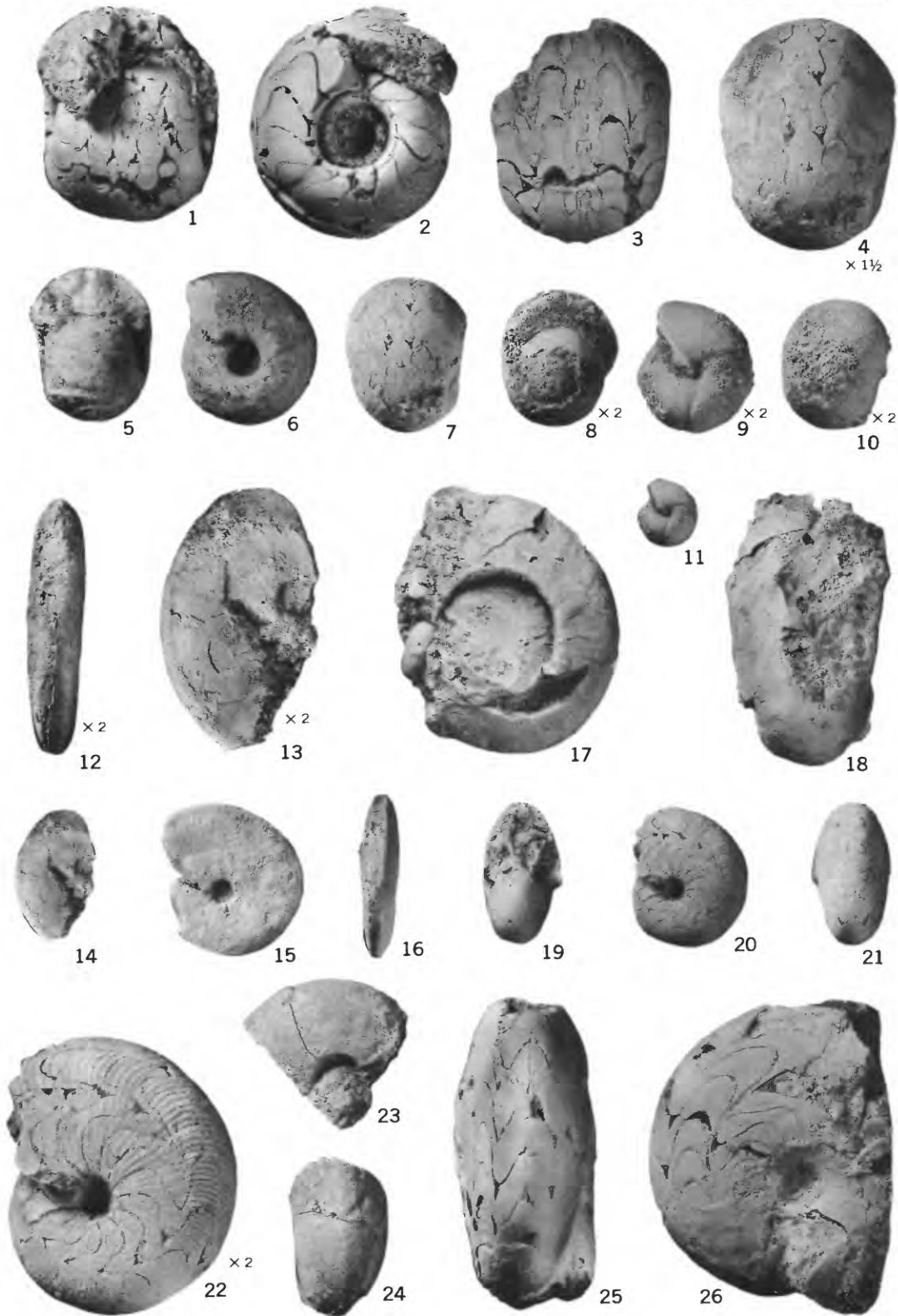
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PLATES 1 and 2

PLATE 1

[All figures natural size except as otherwise indicated on plate.]

- FIGURES 1-7.** *Syngastrioceras globosum* (Easton) (p. A6).
1-3. Front, side, and back views of hypotype; USNM 146379, from UA loc. L77.
4-7. Involute form. Enlarged back view and front, side, and back views of hypotype;
USNM 146382, from UA loc. L61.
- 8-11.** *Bisatoceras paynei* Gordon (p. A8).
Enlarged front, side, and back views and side view of hypotype; USNM 146385,
from USGS loc. 19701-PC.
- 12-16.** *Hudsonoceras moorei* Quinn and Saunders (p. A9).
12-14. Enlarged ventral and side views and a side view of a fragmental paratype;
USNM 146397, from UA loc. L61.
15, 16. Side and back views of a paratype; USNM 146396, from same locality.
- 17, 18.** *Reticuloceras?* sp. (p. A15).
Side and ventral views of a fragmental, unique specimen; USNM 146388, from UA
loc. L18.
- 19-22, 25, 26.** *Cymoceras adonis* Gordon, n. sp. (p. A11).
19-22. Front, side, and back views and enlarged side view of a nearly perfect im-
mature paratype; USNM 146391, from UA loc. L77.
25, 26. Ventral and side views of a larger incomplete phragmocone, the holotype;
USNM 146390, from UA loc. L77.
- 23, 24.** *Reticuloceras? wainwrighti* Quinn (p. A13).
A variant. Fragment of a moderately large shell showing shallow ventrolateral sulci;
USNM 146408, from UA loc. L18.

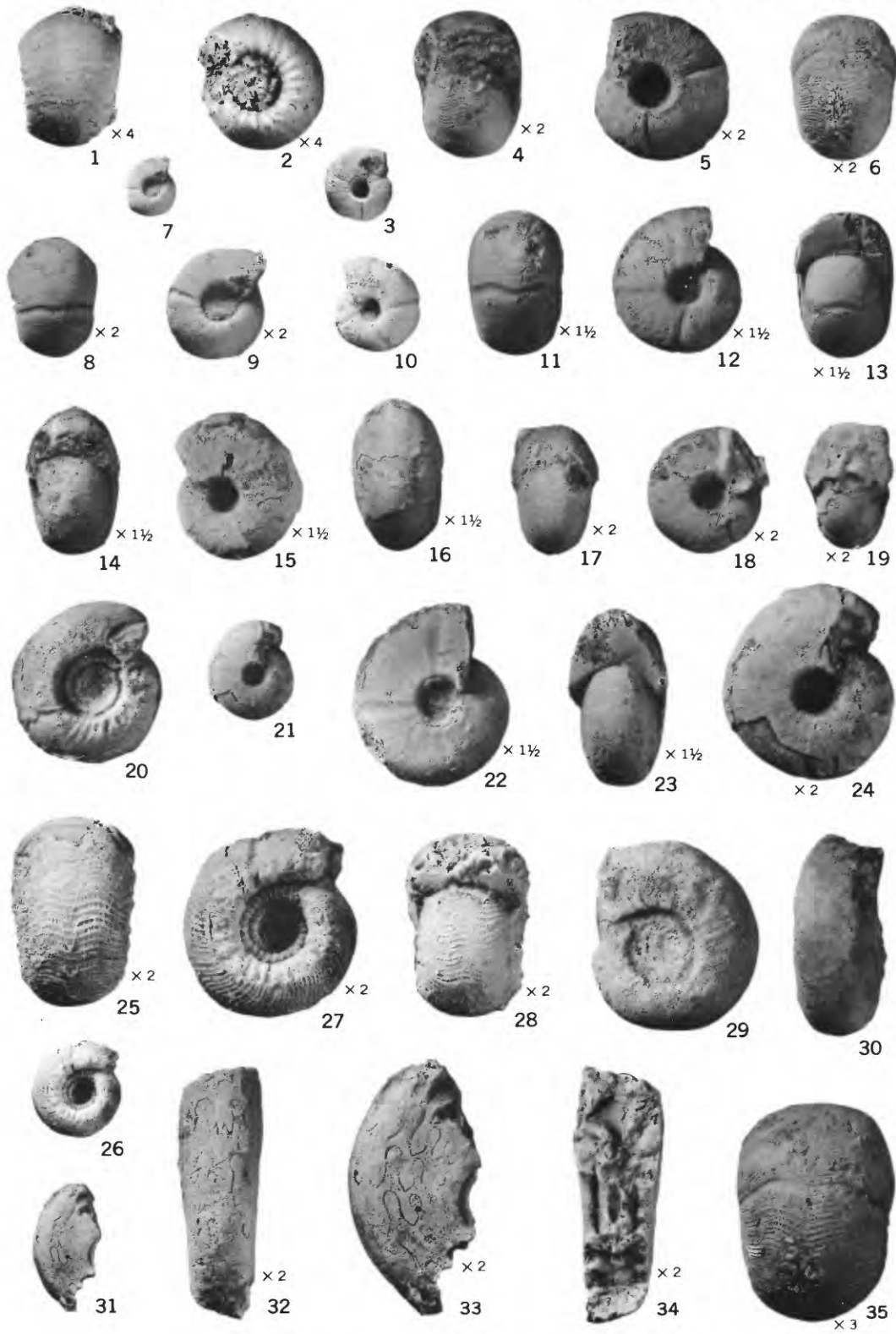


*SYNGASTRIOCERAS, BISATOCERAS, HUDSONOCERAS, RETICULOCERAS?,
AND CYMOCERAS*

PLATE 2

[All figures natural size except as otherwise indicated on plate.]

- FIGURES 1-13, 35. *Reticuloceras tiro* Gordon, n. sp. (p. A12).
1, 2. Enlarged back and side views of small paratype; USNM 146405, from UA loc. L61.
3-6, 35. Side and enlarged front, side, and two back views of holotype; USNM 146400, from UA loc. L77.
7-9. Side and enlarged back and side views of paratype; USNM 146404, from UA loc. L61.
10-13. Side and enlarged back, side, and front views of paratype; USNM 146403, from UA loc. L61.
- 14-19, 21-24. *Reticuloceras? wainwrighti* Quinn (p. A13).
14-16, 21, 24. Enlarged front, side, and back views, side view, and enlarged side view of specimen showing faint ventrolateral sulci; USNM 146406, from UA loc. L61.
17-19. Enlarged back, side, and front views of smaller specimen; USNM 146456, from UA loc. L61.
22, 23. Enlarged side and front views of larger specimen; USNM 146455, from UA loc. L18.
- 20, 25-30. *Branneroceras semiretia* (McCaleb) (p. A16).
20. Side view of a fairly large hypotype; USNM 146462, from UA loc. L62.
25-28. Enlarged back view, side view, and enlarged side and front views of a hypotype; USNM 146463, from UA loc. L59.
29, 30. Side and back views of more mature hypotypes; USNM 146461, from USGS loc. 19702-PC.
- 31-34. *Stenopronorites quinni* Gordon, n. sp. (p. A17).
Side and enlarged ventral, side, and dorsal views of a phragmocone, the holotype; USNM 146465, from UA loc. L77.



*RETICULOCERAS, RETICULOCERAS?, BRANNEROCERAS,
AND STENOPRONORITES*