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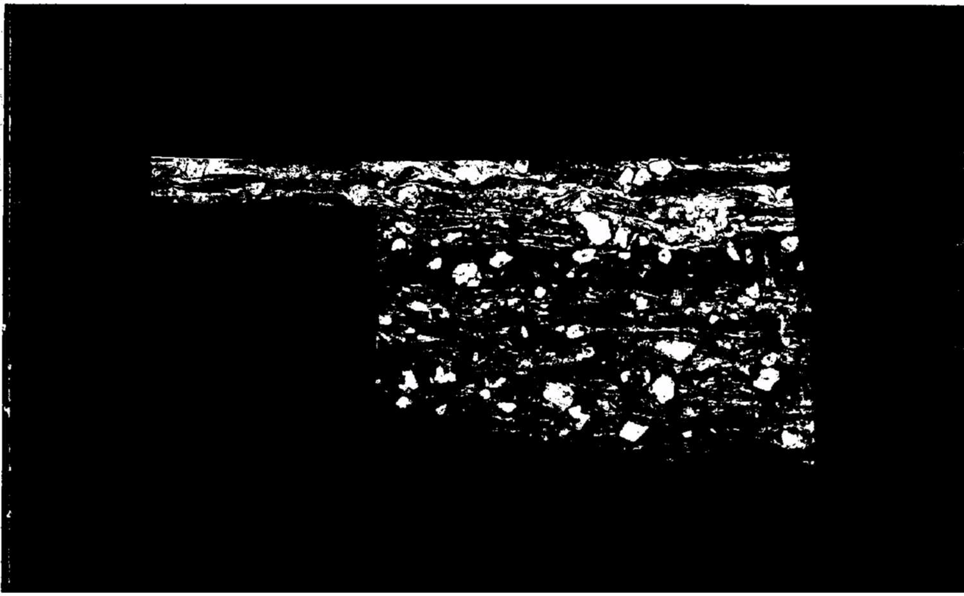
OKLAHOMA GEOLOGY NOTES



VOLUME 26 NUMBER 1 JANUARY 1966

Cover Picture

FLOW-BANDED RHYOLITE

Rhyolite is a fine-grained igneous rock formed from a liquid magma having the chemical composition of granite. The fine grain size, or aphanitic texture, of rhyolite results from rapid cooling of the magma, such as when it is injected as thin sheets or dikes near the Earth's surface, or when it is extruded as surface flows. Quickly cooled rhyolite is composed largely of glass, although earlier formed crystals precipitated in the magma by slow cooling at depth are contained in the rock as phenocrysts. Quartz and orthoclase feldspar are common phenocrysts in rhyolite. Rhyolitic magma poured out upon the surface is highly viscous because of its high silica content, and, as a result, it is likely to have flow lines or flow banding, outlined by a stretching out of colored impurities in the groundmass or by a subparallel alignment of tabular feldspar phenocrysts.

Flow-banded rhyolite is a common basement rock locally in Oklahoma. It underlies the Reagan Sandstone in outcrops of the Arbuckle and Wichita Mountains, and it is present in subsurface over wide areas of southern Oklahoma at depths as great as 40,000 feet. In this region the rhyolite is part of an ancient volcanic field at least a mile thick. Isotopic age determinations of minerals in the rhyolite show that the rock is 525 million years old and therefore that it is probably of Middle Cambrian age.

The cover picture is a photograph (x1.5) of a polished section of this rock, called the Carlton Rhyolite. The occurrence and structural implications of this rock are discussed in Oklahoma Geological Survey Bulletin 95, from which the picture is reproduced (pl. 7, fig. 2).

A second region of widespread rhyolite occurrence is in northeastern Oklahoma. Here it is everywhere present as a subsurface basement rock, beneath the Arbuckle or Reagan Formations, at depths ranging between 2,000 and 4,000 feet. The northeastern rhyolites are dated at 1,200 million years. They are part of a craton which helped to shape the North American continent in Late Precambrian time, establishing a rigidified foundation upon which Paleozoic sediments were later deposited.

—*William E. Ham*

New Species of Cromyocrinids from Oklahoma and Arkansas

Harrell L. Strimple*

INTRODUCTION

The purpose of this study is to record two significant species from Morrowan and Atokan rocks of Arkansas and Oklahoma and to clarify some genera ascribed to the Cromyocrinidae.

Lane (1964b) directed attention to my discussion and description in proposing *Metacromyocrinus* (1961, p. 65, 68) and suggested that the genus be considered a junior subjective synonym of *Parulocrinus* I was aware of some unresolved problems but was unwilling at the time to propose several new genera, which would have been needed. My original objections to the genus *Parulocrinus* have not been resolved and the addition of a new genus, *Synarmocrinus* Lane (1964b), did little to clarify the situation.

Synarmocrinus is distinguished from *Dicromyocrinus* in that the former has two anal plates and the latter has three. The zigzag suture between the arms of *Synarmocrinus* is reputed, by Lane, to represent fusion of the lower arms with the dorsal cup, but I am unable to accept this concept. *Dicromyocrinus ornatus,* the type species of *Dicromyocrinus,* has relatively narrow arms with wedge-shaped brachials. *Synarmocrinus* appears to be more closely related to *Cromyocrinus.*

The evidence given by Lane (1964b) for retention of the genus *Parulocrinus* is useful to demonstrate that *Ulocrinus blairi* (the controversial type species of *Parulocrinus*) is closely related to *Ulocrinus.* The type species of *Ulocrinus* is *U. buttsi* Miller and Gurley, which has a distinctive form ratio (H/W) of 1.09, but if we accept the inclusion of *U. americanus* Weller in the genus, the lower end of the range of the form ratio is 0.64. *U. blairi* has a form ratio of 0.56, which appears distinctive but is only 0.08 less than that of *U. americanus.* A form like *Parulocrinus beedei* has a cup form ratio of 0.48, only 0.08 less than that of *Ulocrinus blairi,* and I consider them congeneric. Although the arms are not known for the species ascribed to *Parulocrinus* in this paper, there is a group that has compatible features. This group does not include such forms as *Parulocrinus compactus,* which has a depressed basal area and appears to be well placed under *Aglaocrinus* by Strimple (1961). Lane (1964b) described *Parulocrinus vetulus,* which has a depressed basal area, two anal plates in the cup, and ten biserial arms, and is from Lower Pennsylvanian rocks. It cannot be referred to *Parulocrinus,* which lacks a basal concavity, but it has the same essential characteristics as *P. marquisi* Moore and Plummer, 1940. I propose the name *Paracromyocrinus,* new genus, for reception of these two forms, with *Parulocrinus vetulus* as the type species of the genus.

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Family CROMYOCRINIDAE Jaekel, 1918

Parulocrinus Moore and Plummer, 1940

Type species.—*Ulocrinus blairi* Miller and Gurley, 1893.

Diagnosis.—Dorsal cup approximately twice as wide as high, mildly constricted at summit; two anal plates; subhorizontal infrabasal circlet; proximal edges of basals form part of basal plane, no basal concavity; no pronounced surface ornamentation; arms unknown.

Remarks.—As noted by Lane (1964b, p. 680), the genus was proposed originally to encompass species that differ from *Ulocrinus* Miller and Gurley in having a " 'generally broad and flat base of the cup, with infrabasals (IBB) not visible or only barely perceptible in side view of the cup' (Moore and Plummer, 1940)." My interpretation of this excludes forms in which the basals curve into a basal concavity, whether the infrabasal circlet is flat or not.

The following species, listed with their form ratios (H/W), are ascribed to the genus *Parulocrinus* pending information as to the nature of their arm structure:

	H/W
Ulocrinus blairi Miller and Gurley	0.56
Parulocrinus beedei Moore and Plummer	0.48
Ulocrinus americanus Weller	0.64
Ulocrinus caverna Strimple (1949)	0.62

Cromyocrinus has a cup form much like that of *Parulocrinus,* but the former has three anal plates in the cup. *Cromyocrinus* is specialized in having reduced its arms to five, which are also primitive in that they are uniserial. The low brachials indicate specialization in that they provide for a greater number of pinnules in a shorter distance than would be the case with longer brachials. I believe that some of the above species will eventually be found to be closely related to *Cromyocrinus.*

Paracromyocrinus Strimple, new genus

Type species.—*Parulocrinus vetulus* Lane, 1964b.

Diagnosis.—Dorsal cup normally more than twice as wide as high, broad base, erect lateral sides, basal plates curve into basal concavity; two anal plates; ten broad, biserial arms.

Remarks.—This genus is proposed for the reception of forms which have been referred to *Parulocrinus* but which have a shallower cup and a decided basal concavity wherein the proximal end of the basal plate curves into and forms the sides of the concavity. *Dicromyocrinus* is somewhat comparable in cup shape other than the base, which has no concavity, but is more primitive in the possession of three anal plates and uniserial arms (cuneiform brachials).

The following species, listed with their cup form ratios (H/W), are assigned to *Paracromyocrinus*:

	H/W
Parulocrinus vetulus Lane	0.37
Parulocrinus marquisi Moore and Plummer	0.51
Parulocrinus compactus Moore and Plummer	0.50
Parulocrinus pustulosus Moore and Plummer	0.43
Ethelocrinus oklahomensis Moore and Plummer	0.50

It will be noted that forms with rugose ornamentation are included here with forms having smooth surfaces. Likely these will eventually be separated into two genera, but I am not prepared to do so at this time.

Dicromyocrinus Jaekel, 1918

Type species.—*Cromyocrinus ornatus* Trautschold, 1879.

Diagnosis.—Infrabasals subhorizontal, cup medium, truncate, globular, without basal depression; anal plates three; arms ten, uniserial, with axillary first primibrach; rugose ornamentation.

Remarks.—The history of nomenclatural difficulties surrounding the genus *Dicromyocrinus* was summarized by Strimple (1961). It was my conclusion that the only valid American species was *D. tapajosi* Strimple (1960a) from Brazil.

Easton (1962) described a species as *D. granularis* Easton, from the Alaska Beach Limestone of Montana, which is properly ascribed to the genus. It has ten uniserial arms, three anal plates in the cup, a flat base, and pronounced surface ornamentation.

Lane (1964a) described a species from Brazil as *D. mendesi* Lane. Lane's species differs from *D. tapajosi* and from *D. ornatus* in having a smooth surface. *D. ornatus* has decided granulation and pustules, and *D. tapajosi* has a shagreen surface and a node on each radial plate.

The form from Scotland called *Dicromyocrinus geminatus* by Wright (1952) has been named *D. wrighti* Yakovlev and Ivanov (1956). Lane (1964a) noted it might not belong to *Dicromyocrinus* and that it was not conspecific with *D. geminatus*. The change in specific name made by Yakovlev and Ivanov was rather informal and easily overlooked. It is proposed that *D. wrighti* be referred to *Mantikosocrinus* Strimple, which is a closely comparable form of Mississippian age. It is further suggested that the smooth forms *D. mendesi* and *D. geminatus* be referred to another genus. The genus *Mooreocrinus* Wright and Strimple was previously proposed with the type species *Dicromyocrinus geminatus* and is revived on a modified basis.

Mooreocrinus Wright and Strimple, 1945

Type species.—*Cromyocrinus geminatus* Trautschold, 1867.

Diagnosis.—Cup medium, globular, greatest width below the summit of the cup, subhorizontal infrabasal circlet, flat base with no concavity involved (other than the columnar cicatrix); sutures impressed, surface of plates essentially smooth; three anal plates in cup; ten uniserial arms branching with first primibrach.

Remarks.—This genus was originally proposed for the reception of species formerly assigned to the genus *Dicromyocrinus* Jaekel (1918), which genus did not have a proper type species. It was subsequently held that reference by Moore and Plummer (1940) to *Cromyocrinus ornatus* Trautschold as the "genotype" constituted a designation of the type species and validated the genus *Dicromyocrinus.* It is intended here to restrict the genus to characters of the type species for both *Dicromyocrinus* and *Mooreocrinus.* The type species of *Mooreocrinus, M. geminatus,* has a proportionately broader cup than *Dicromyocrinus ornatus* and the arms are broader, being composed of lower, more evenly shaped brachials than are those in the latter species. The surface of *D. ornatus* is marked by fine granules and low pustules, and the first primibrach is protruded as a short spine. Some specimens of *Mooreocrinus* have a frosted appearance caused by minute granules, but pustules or nodes are lacking. The first primibrach is proportionately shorter and wider than is that of *Dicromyocrinus ornatus.* In the posterior interradius most observed specimens of *Mooreocrinus geminatus* show the radianal to be dominant, with anal X separated or nearly separated from contact with the posterior basal. In *Dicromyocrinus ornatus* anal X is in full contact with the posterior basal but RX tends to be smaller.

Two species are assigned to *Mooreocrinus* without hesitation: *Cromyocrinus geminatus* from Russia and *Dicromyocrinus mendesi* from Brazil.

As mentioned elsewhere, the form from Scotland ascribed to *Mooreocrinus geminatus* by Wright and Strimple (1945) is referred to *Mantikosocrinus wrighti* (Yakovlev and Ivanov).

Metacromyocrinus Strimple, 1961

Type species.—Metacromyocrinus holdenvillensis Strimple, 1961.

Diagnosis.—Dorsal cup approximately twice as wide as high, constricted at summit, surface ornate; broad, flat to imperceptibly upflared base; three anal plates in cup in older species to two anal plates in younger species; ten broad, biserial arms with well-rounded exteriors.

Remarks.—The original concept of this genus was restricted to forms having two anal plates, but the Morrowan form *Metacromyocrinus gillumi,* new species, has all of the characteristics of the genus yet possesses three anal plates. In such a clear circumstance it seems desirable to modify the generic concept.

Metacromyocrinus gillumi Strimple, new species

Plate I; plate II, figures 5, 6

The crown is moderately long, cylindrical, with stout, closed apposed arms. The surface is marked by small, closely spaced pustules.

Dorsal cup is medium globular, with mildly upflared IBB, albeit almost imperceptible from side view. The cup is asymmetrical in that the area near the junction of RA and the right posterior basal is protuberant. This also causes, or allows, the right posterior basal to be larger than other basals. The cup is oval when viewed from below, the shorter axis being from posterior to anterior. A fairly broad groove is present in the adsutural areas between the basals, with the depression passing onto the proximal portion of the radials in all save the posterior side. A wide shallow depression also marks the adsutural areas of the radials, and the depressions affect the distal tips of the basals ever so slightly. The five IBB form a rather large, pentagonal disk with the central portion sharply impressed for the reception of proximal columnals, which elements would not quite fill the cavity if the full width of the first segment is the same as the cicatrix. Five basals are large, six-sided elements except for those of the posterior which are affected by the anal plates. As noted above, the right posterior basal is unusually large and protuberant. Five radials are medium size, pentagonal, and somewhat wider than long. To the fore of the outer ligament pit is a narrow, flattened area, so that a gaping suture is formed with the first primibrach. The RA is large and occupies some of the area in the right posterior, causing a slight reduction in the size of the right posterior radial. Anal X is rather small and hexagonal, and has a firm contact with the posterior basal. RX is smaller than anal X, is hexagonal, and has more than half its length within the cup. The three anal plates are in normal (primitive) arrangement.

The first primibrach, axillary in all arms, is a low, wide element. A second bifurcation, which takes place with the first secundibrach in the left ray of the right anterior arm, is considered to be adventitious. The arms are biserial and robust with well-rounded exteriors and with flattened lateral sides which are deeply grooved. The brachials are short and wedge-shaped. Some swelling of the secundibrachs is apparent slightly above midlength of the arms.

The entire surface of the crown is covered by small, closely packed pustules, which do not appear to form any pattern.

The proximal columal is rather small and round, with the perimeter marked by well-defined crenulations, and the lumen is small and quinquelobate, as reflected by the cicatrix on the infrabasal disk. Measurement of holotype in millimeters:

Length of crown	79.4
Maximum width of crown (as preserved)	39.2
Height of cup	18.8
Maximum width of cup	31.5
Width of cup at summit	27.8
Width of cup, posterior-anterior axis	23.3
Diameter of columnar cicatrix	4.2
Width of infrabasal circlet	14.8
Length of basal (right anterior)	18.3*
Width of basal (right anterior)	20.4*
Length of basal (left anterior)	14.5*
Width of basal (left anterior)	18.2*
Length of radial to transverse ridge (anterior)	12.5*
Width of radial (anterior)	17.8*
Length of radianal	11.7*
Width of radianal	7.3*
Length of anal X	7.8*
Width of anal X	4.3*
Length of RX (approximate)	4.2*
Width of RX	3.7*
Width of first primibrach	14.8*
Length of first primibrach	4.9*

*Along surface curvature.

Remarks.—*Metacromyocrinus gillumi* is closely comparable to *Metacromyocrinus holdenvillensis,* the type of the genus, in general contour of the cup and structure of the arms. *M. holdenvillensis* has fewer anal plates (two), which is to be expected because it is of late Desmoinesian age, but the older *M. gillumi* (Morrowan age) retains three anal plates. Both species have medium globular cups with broad, mildly upflared infrabasals and robust, biserial arms branching with the first primibrach in all rays. The ornate pustules of *M. holdenvillensis* are larger and not so closely packed as are those of *M. gillumi.*

The specific name is for Gary Gillum, a graduate student in the Department of Geology, University of Arkansas, Fayetteville, who collected the holotype and other crinoids.

Occurrence.—Bloyd Formation, Morrowan, Pennsylvanian, NE¼ sec. 17, T. 14 N., R. 31 W., near Sweetwater Creek, Washington County, Arkansas.

Types.—Holotype SUI 12279 (crown) and paratypes SUI 12280 (dorsal cup) and SUI 12281 (infrabasal disk) are in the geology repository at the State University of Iowa. SUI 12280 was collected by J. H. Quinn, University of Arkansas; SUI 12281 was collected by the author.

Synarmocrinus Lane, 1964

Type species.—*Synarmocrinus brachiatus* Lane, 1964.

Diagnosis.—Dorsal cup approximately twice as wide as high, subhorizontal to mildly downflared infrabasals, base of cup flat?, surface marked by stout elongate tubercles; two anal plates in cup; arms ten, broad, uniserial, branching on first primibrach; segments low, exterior curved.

Remarks.—In Lane's original definition of the genus, the side projections and matching indentations of adjacent arms were taken to represent a fused or fixed condition for the lower arms, which he assumed were incorporated into the dorsal cup. This same type of interlocking of uniserial arms was discussed by Strimple (1961) for species of *Stenopecrinus* Strimple and *Schedexocrinus* Strimple. It represents a protective mechanism for sealing off the interior from other organisms. I do believe the upper arms could be opened to a degree without moving the lower arms, but the presence of pinnules on the lower brachials indicates that the crinoids opened their arms fully when feeding.

A form of Atokan age is described as *Synarmocrinus fundundus,* new species. Lane (1964a) considered *S. brachiatus* to be of Atokan age.

Synarmocrinus fundundus Strimple, new species

Plate II, figures 1-4

The dorsal cup is low, globular, with a broad flattened base. It has an almost imperceptible basal depression, but the infrabasal circlet, aside from the sharply impressed medium section occupied by the columnal cicatrix, is essentially horizontal in position. The distal portion of the cup, starting about midheight, is decidedly constricted.

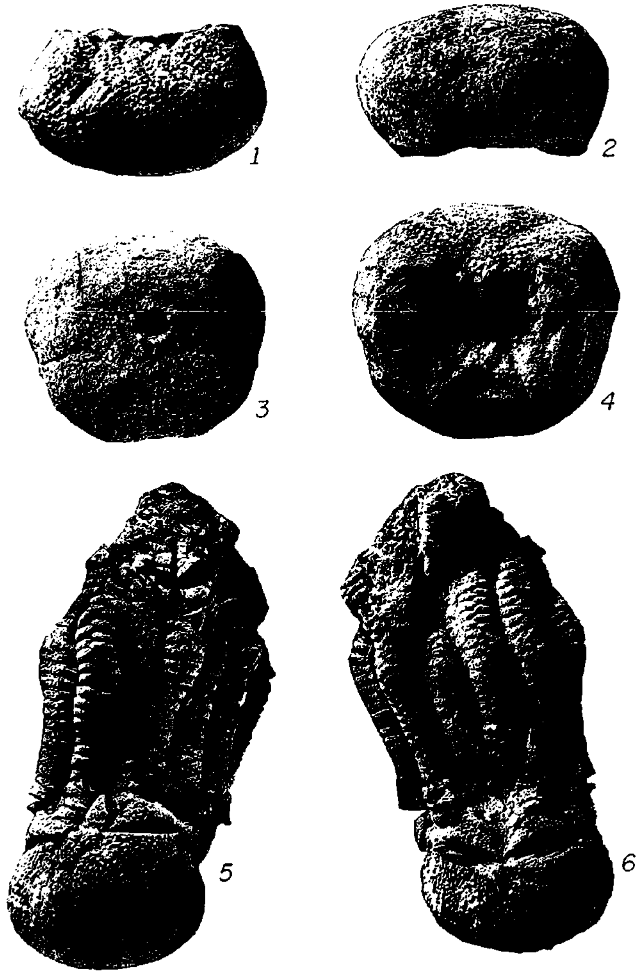

Plate I

Metacromyocrinus gillumi **Strimple, new species, Pennsylvanian Bloyd Formation, Washington County, Arkansas.**

Figures 1-4. Posterior, anterior, basal, and summit views of dorsal cup of paratype SUI 12280, approximately x1.

Figures 5, 6. Right posterior and left anterior views of crown of holotype SUI 12279, approximately x1.

When viewed from above or below, the cup has an eccentric outline with the long axis from the center of the extended radianal (RA) to about the center of the left anterior basal, and a short axis from the right anterior radial to left anterior basal. Articulating facets of the radials form a subhorizontal shelf, with even the elongate anal X curved sharply inward so as to extend only slightly above the summit of the cup.

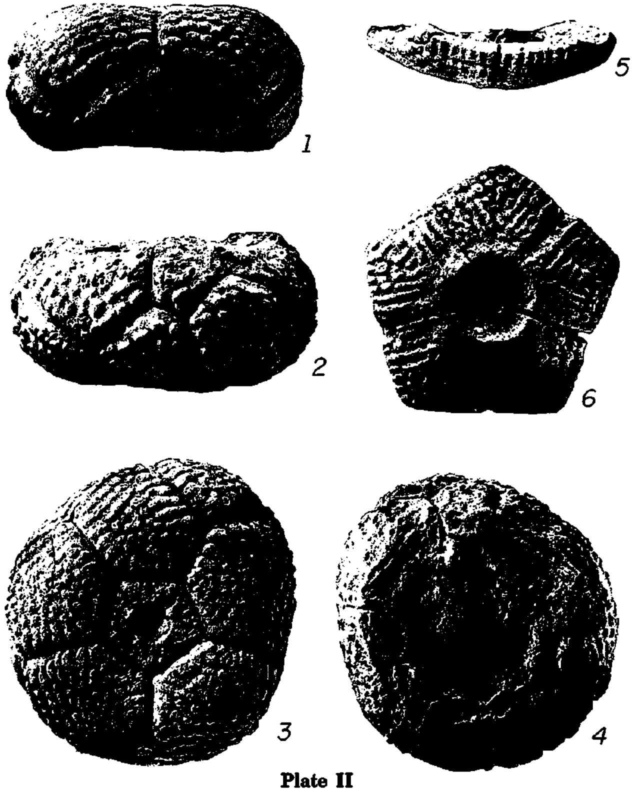

Plate II

Figures 1-4. Synarmocrinus fundundus **Strimple, new species, collected from the Pennsylvanian Atoka Formation, Coal County, Oklahoma. Dorsal cup of holotype SUI 12278 from anterior, posterior, base, and summit, approximately x1.**

Figures 5, 6. Metacromyocrinus gillumi **Strimple, new species, collected from the Pennsylvanian Bloyd Formation, Washington County, Arkansas. Infrabasal circlet of paratype SUI 11281 from side and base, approximately x1.5.**

Five large basals and the radianal form the dominant circlet of the cup. The basals form most of the basal plane and curve sharply upward to form much of the lateral wall of the cup. Each basal is essentially five sided, but an extra facet is present on the proximal end for contact with two infrabasals. The posterior basal has an extra facet for contact with anal X, and the right posterior basal has an extra facet for contact with the large RA. The posterior basal is considerably reduced in width, apparently to accommodate the RA, although the right posterior basal is not affected in size by the large RA. Sutures between basals and between basals and infrabasals are sharply impressed. Sutures between basals and radials and between radials do not attain such a pronounced V-shape. The impressions are accentuated by rows of large nodes parallel to the sutures. Five pentagonal radials are slightly wider than long, with the greatest width at the proximal ends of the lateral sides. Reduction of width at the summit of the plates causes the constricted appearance of the cup. The size of the right posterior radial is somewhat reduced in the area adjacent to the RA. No appreciable shelf is formed to the fore of the outer ligament areas. The facets are not well preserved, but a well-developed outer ligament groove and pit are apparent, and the inner area is relatively short and has a broad intermuscular notch. The radianal is quadrangular and large, with the length only slightly greater than the maximum width, which is at the base of the plate. It is in broad contact with the right posterior basal to the right below, with the posterior basal to the left below, and with anal X to the left. RX is absent as is any indication that one ever existed within the cup. Anal X is rather large, elongate, and curved sharply inward into the adsutural area. It is in firm contact with the posterior basal below and right posterior radial to right above, with RA to right below, and left posterior radial to the left. Provision is present for the reception of two tube plates of unequal size, the smaller being to the right in an almost horizontal position. This anal arrangement probably leads to what has been termed Special Type C (Strimple, 1960b, p. 250), wherein anal X is followed by a single tube plate.

Ornamentation consists of coarse, pustulelike nodes which may become confluent. On the normal basal and radial plates, a pattern is formed which could reflect the growth lines of each plate. The organization suggests two lines forming a broad V culminating in the distal tip of the basal and the proximal tip of the radial. No granulations have been observed.

Measurements of the holotype in millimeters:

Width of cup (maximum)	48.5
Width of cup (minimum)	44.9
Height of cup (average)	22.0
Width of IBB circlet	14.2
Length of basal (right anterior)	27.6*
Width of basal (right anterior)	28.7*
Length of radial to transverse ridge (right anterior)	18.4*
Width of radial (right anterior)	25.9*

*Along surface curvature.

Length of RA	21.0*
Width of RA (maximum)	18.4*
Length of anal X	16.0*
Width of anal X	12.3*
Diameter of stem impression	10.8

*Along surface curvature.

Although the stem is not preserved, the IBB circlet bears a moderately large cicatrix. The perimeter of the cicatrix is marked by about 30 well-defined crenellae, and the lumen appears to be quinquelobate.

Remarks.—Because the arms of *Synarmocrinus fundundus* are not known, some reservation in generic assignment is necessary, but the form of the cup indicates close relationship to *S. brachiatus.*

The name *fundundus* is derived from the Latin *fundus* meaning base with the suffix *undus* referring to its fullness.

Occurrence.—Barnett Hill Member, Atoka Formation, Atokan, near Clarita, Coal County, Oklahoma. The holotype is from near C NW¼ sec. 10, T. 1 S., R. 8 E.; the paratype is from C N½ sec. 28, T. 1 N., R. 8 E.

Types.—Holotype SUI 12278 (dorsal cup) is in the geology repository, State University of Iowa. A plastoholotype (OU 4969) and paratype OU 4970 (partial dorsal cup) are in the paleontology collections, The University of Oklahoma. SUI 12278 was collected by Joe Welch; OU 4970 by Allen Graffham.

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GENUS *Reticuloceras* IN AMERICA

JAMES HARRISON QUINN*

The genus *Reticuloceras* was proposed by Bisat (1924, p. 114-119) with *Goniatites reticulatus* Phillips, 1836, as the type. Bisat (1924, p. 115) included among others *Glyphioceras davisi* Foord and Crick (1897, p. 198) as the "old age form of *R. reticulatum* and *R. inconstans.*"

Reticuloceras is an important zone fossil in England (R_1R_2). With two exceptions it has not been reported from America. Quinn (1962) mentioned a form from the top of the Hale Formation supposedly belonging to the genus. Later he referred the taxon to *Pygmaeoceras* (1965, p. 228-236). Gordon (1964) mentioned the presence of *Reticuloceras* in a collection of fossils from the Cane Hill Member of the Hale Formation belonging to the University of Arkansas and collected by Quinn and University of Arkansas students.

During the fall of 1963 I visited England on an off-campus duty assignment partly for the purpose of examining the possibility of occurrence of *Reticuloceras, Homoceras,* or *Homoceratoides* in the Arkansas collections. Certain of the Arkansas fossils from the Cane Hill Member of the Hale Formation compare closely with specimens of *Reticuloceras,* but none seemed convincing enough to obtain the confidence of Mr. Bisat, Dr. Ramsbottom of the Geological Survey of Great Britain, or, Professor Hodson of Southampton University, or, for that matter, of myself. One of the Arkansas specimens, which is rather "barrel shaped," does possess the reticulate ornamentation of *Reticuloceras* and seemingly was beginning to develop the conch shape of *R. davisi* (figs. 1D-F). It appears to me that the only inescapable proof of an American *Reticuloceras* must rest on the distinctive "old age" stage of shell development comparable to that of *R. davisi.*

The first goniatite assemblage (about 100 specimens) collected from the Cane Hill Member of the Hale Formation was recovered from a block of calcareous conglomerate (fig. 2), probably in place, with beds of siltstone below, which are conglomeratic in places and contain a few goniatites. The horizon is no more than 25 feet above the Pitkin Formation of Mississippian age. The fossils were discovered in 1960 by Laurin Wainwright, graduate student in geology at the University of Arkansas. All of this material was lent to the U. S. Geological Survey but has recently been returned to the University of Arkansas.

In November 1964 I revisited the site, UA L18, and was so fortunate as to discover a fragment of the conch of an unmistakable "old age" *Reticuloceras* (UA L18-9, figs. 1B,C) in a remnant of the original block which had been too adamant to yield to the hammer in 1960. A somewhat smaller specimen was recovered from beds of Cane Hill age at a locality 7 miles due south of UA L18, near West Fork, Arkansas. This fossil (L99-185; fig. 1A) does not represent the "old age"

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configuration in so far as the ventral area is concerned. It is preserved as coarsely crystalline calcite and does retain a small portion of the living chamber. Otherwise, shape of the shell and suture, size of umbilicus, and development of a strong umbilical "flange" indicate the affinities of the fossil.

Because American specimens of *Reticuloceras* do not precisely duplicate described species from the Old World, they may be properly referred to a new taxon named in honor of Laurin Wainwright, the discoverer of the first known Cane Hill goniatite locality.

Reticuloceras wainwrighti, new species

The type of *Reticuloceras wainwrighti* is selected as the second and smaller of the two specimens mentioned above (UA L99-185, figs. 1A, 3). The diameter of the conch is 37 mm and the width is approximately 21 mm. The umbilicus has a diameter of 9 mm; whorl height (umbilicus to venter) is 17.3 mm. According to the Gordon formula (1965, p. 87, fig. 18) the conch is "thick-discoidal" (W/D = 0.595). The ventral region at the greatest diameter has barely begun to develop the acute angle and sloping borders typical of *R. davisi* (fig. 1E). The loss of most of the shell from the outer whorl may contribute to the nearly smooth arch of the venter and to the relative reduction of the diameter of the shell with respect to the dimensions of the umbilicus which does retain the shell material. The lateral areas of the conch are quite concave in relation to the strongly expanded umbilical border. The umbilical shoulder is sharply rounded. The umbilical slope or wall (region between umbilical shoulder and umbilical seam) is perpendicular to the bilateral plane and exceptionally broad, being 5 mm on the most completely preserved side (including shell).

Constrictions are not preserved on the type or the "old age" paratype (UA L18-9). They are present on smaller specimens (fig. 1G) which appear referable to the species. The constrictions are irregularly spaced and incised, with perhaps one or two strong furrows on a whorl, and with two or three faint constrictions discernible on the flanks.

Explanation of Figure 1

Reticuloceras wainwrighti, **new species, and** Reticuloceras davisi **(Foord and Crick), 1897**

A. Reticuloceras wainwrighti, **holotype UA L99-185, x1.3. Side view of shell, diameter 37 mm.** (Photograph by J. H. Quinn)

B-C. Fragment of living chamber of "old age" Reticuloceras wainwrighti, **UA L18-9, x1. Back and side views.** (Photographs by J. H. Quinn)

D-F. Reticuloceras davisi **(Foord and Crick), 1897 (holotype, p. 198, fig. 95), x1. Side, back, and front views.** (Photographs courtesy of M. K. Howarth, British Museum)

G. Reticuloceras wainwrighti, **UA L117-10, x1.3. Side view of small specimen illustrating orientation of constrictions. Locality is the same as that of McCaleb's specimens of** Retites semiretia **(1964, p. 234).** (Photograph by J. H. Quinn)

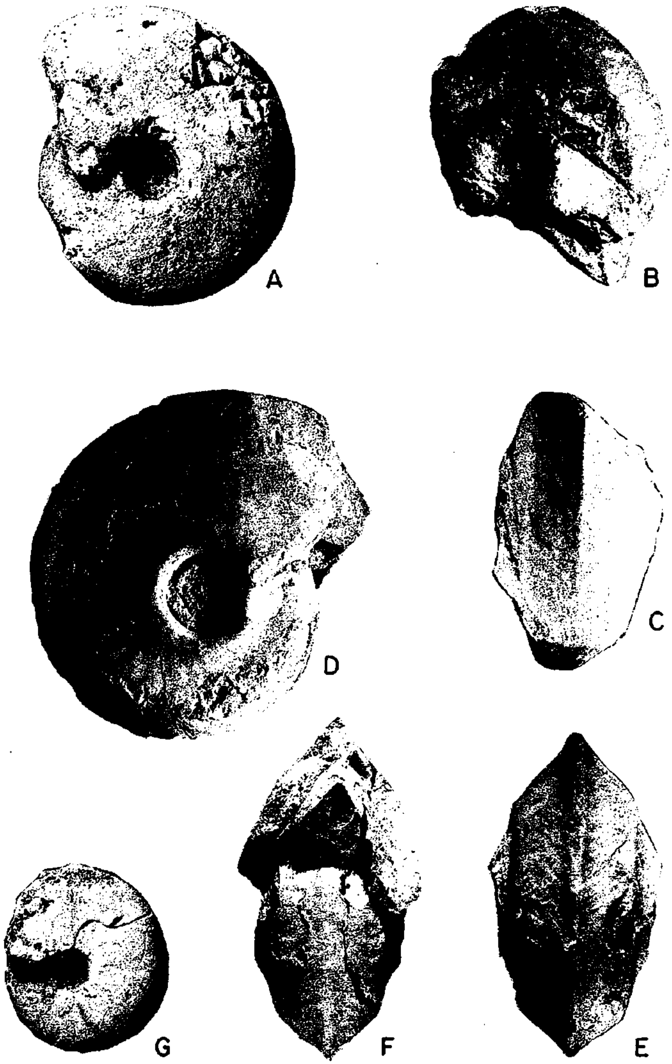

Figure 1.

They extend outward from the umbilicus without flexure but with some forward inclination to a point near the first lateral saddle, where they are deflected slightly forward and then rather sharply backward to form a deep sinus over the venter. No indication of the ventrolateral sulci of Old World forms of *Reticuloceras* is present on any of the Arkansas specimens.

The "old age" paratype UA L18-9 appears to be a mold, lacking the shell. The sculpture is thus much reduced compared to what might be expected of the external surface of the shell. A well-marked raised ridge is present along the ventral border. For a distance of about 8.5 mm on either side, the surface slopes outward at an angle of 30° (fig. 4), with a nearly flat surface ornamented by a shallow groove about one-third of the distance from the ventral ridge. At the outer borders or the ventral "slopes" the surfaces of the flanks of the shell steepen to an angle of about 70°, continuing to a point near the umbilicus where the shell flares outward. This area of the "old age" specimen is somewhat crushed.

The flanks of the shell are without ornament, but faint transverse lines are preserved over the ventral slopes forming well-defined salients external of the shallow grooves (fig. 1c). Beyond that point the transverse lines cross the venter in nearly perfect chevron-shaped sinuses.

The type (UA L99-185) is nearly devoid of ornamentation owing to

Figure 2. Collecting goniatites "Arkansas style" from conglomerate boulder at locality UA L18, summer 1960. George Staley, former graduate student, on left; Ben F. Clardy, Arkansas Geological Survey, on right. The excavation has since been obliterated by road construction.
(Photograph by J. H. Quinn)

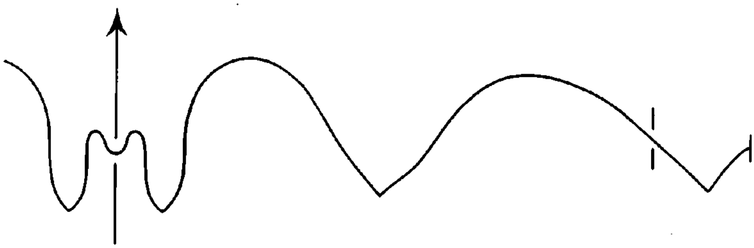

Figure 3. Camera lucida drawing of suture of Reticuloceras wainwrighti, **holotype UA L99-185, x5, at a diameter of 30 mm.**
(Drawn by W. Bruce Saunders)

the loss of the shell material. The little remaining around the umbilicus retains fine transverse and revolving lirae. Earlier whorls of both the type and paratype have small "patches" of shell exposed where the specimens had been broken in freeing them from the enclosing matrix. In both, the transverse lirae are most strongly expressed but closely crowded with little or no expression of revolving lirae and with no reticulation. A number of large specimens of related but more globose forms with large umbilici have extensive areas of shell preserved. In all these the revolving lirae are much finer than the transverse sculpture but do impart a reticulate expression to the shells.

The suture of the type (fig. 3) appears typical of *Reticuloceras* as figured by Foord and Crick (1897, p. 194, fig. 94). The type is probably considerably larger than the specimen from which Foord and Crick obtained their suture drawing. Their figure, described as being enlarged twice, is approximately the same size as that of the type without enlargement. Their figure of the suture of *R. davisi* (p. 198, fig. 95c) at natural size is about the same as that of the type (19 mm). The figures are not exactly comparable because we tend to lengthen our suture diagrams by "straightening" them so that the umbilical border parallels the ventral plane. The suture pattern of *R. wainwrighti* appears to fit somewhere between those of *R. reticulatum* and *R. davisi*. The tendency is for the lobes and saddles to elongate or become broader relative to height. The "old age" stage of *R. davisi* appears to be represented by modification of the secondary features of the lobes, reducing them to simple V's.

The suture of the type of *R. wainwrighti* has been figured (fig. 3) at a point where the shell has a diameter of 30 mm. The prongs of the ventral lobe are narrow, pointed, and incised to about one-half the height of the lobe. The first lateral saddle is somewhat asymmetrical

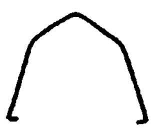

Figure 4. Cross-sectional outline of "old age" shell fragment of Reticuloceras wainwrighti **illustrating roof-shaped, or fastigate, venter.**
(Drawn by W. Bruce Saunders)

but quite uniformly rounded. The first lateral lobe is wide, pointed, and slightly concave on its borders. The second lateral saddle is broad, shallow, and somewhat asymmetrical. The umbilical lobe forms a wide V and is sharply pointed, with the sides slightly concave. The dorsal suture of the type is not exposed. A closely related form from the type locality retains the pattern of the internal suture at a diameter of about 33 mm. The dorsal and dorsolateral lobes are short, V-shaped, and markedly blunt compared to those of most goniatites. In this they resemble *R. reticulatum* (Bisat, 1924, pl. X, fig. 11). The internal suture is not usually considered diagnostic for species, but it may well prove so for purposes of generic distinctions. *Reticuloceras wainwrighti* differs from *R. reticulatum,* which it most closely resembles in shape, by lack of ventrolateral sulci. The ornament differs somewhat also in that the transverse lirae are a little stronger and the revolving lirae are a little weaker, in so far as can be determined from available material.

Occurrence.—The type of *R. wainwrighti* (UA L99-185) was collected from a bed of silt to silty limestone with some vague, flaggy bedding. The surface weathers by scaling off in thin sheets 5 to 20 mm thick. The calcareous bed is perhaps 10 feet thick and probably represents the seaward flank of a reef mound. Fifteen to twenty feet above the calcareous zone, brown sandstone of the Prairie Grove Member of the Hale Formation crops out. The fossil locality is therefore in the upper part of the Cane Hill Member of the Hale Formation, which is as much as 80 feet thick in the vicinity.

The fossils were discovered by Leo Carr, Texaco Inc., who mapped the area as a thesis project in 1963 while a graduate student at the University of Arkansas. The outcrop is in the bed of a small intermittent stream 100 yards south of West Fork-Moffet road and about 2.5 miles southwest of the Highway 71 junction at West Fork, Arkansas (SE cor. sec. 1, T. 14 N., R. 21 W.). The rock is shale and flaggy siltstone with some lenses of fine to medium sandstone and/or limestone. The fossils are in conglomerate, with small pebbles or weathered siltstone and shale wafers as much as 1 inch in diameter.

The paratype UA L18-9 was collected from a block of conglomerate protruding from a low bank along an abandoned road in NW cor. sec. 6, T. 15 N., R. 30 W. The block of conglomerate appears to have been in place (fig. 2) and about 25 feet above the Pitkin Formation of Mississippian age. Exposures of overlying rocks are several hundred yards away and are beds of flaggy siltstone typical of Cane Hill strata. Immediately above the outcrop is a gentle slope without indication of the nature of the underlying rock. The Cane Hill section here should be much thicker than the part preserved, and the fossil horizon is considered to be in the lower part of the unit. *Reticuloceras wainwrighti* has been recovered from several Cane Hill localities but has not been encountered in older or younger deposits.

Remarks.—Forms referable to *Reticuloceras,* from the Cane Hill Member of the Hale Formation, differ greatly. Shapes range from discoidal to globose; shells range from involute to evolute, some with coarse reticulate ornamentation with or without strong umbilical ribs and others nearly smooth; sharply attenuated umbilical borders and sutures seem to foreshadow those of *Gastrioceras*.

Although literally thousands of goniatites have been collected from Cane Hill deposits, none can be referred to *Gastrioceras* or *Branneroceras*. The most primitive *Gastrioceras* appear in rocks in Prairie Grove, Hale age. None of the Prairie Grove goniatites is referable to *Branneroceras*, although some *Gastrioceras* resemble it to some extent.

Both Cane Hill and Prairie Grove rocks contain a discoidal goniatite referred by Gordon (1965, p. 241-242, fig. 69; pl. 25, figs. 25-31) to *Homoceratoides cracens* Gordon. McCaleb (1964, p. 236-237, pl. 1, figs. 6-8) described a form from the type locality of the Brentwood Member of the Bloyd Formation as *Cymoceras miseri*. These two taxa are quite similar and undoubtedly represent a common genus. Careful comparison of a number of perfectly preserved specimens from the Cane Hill assemblage with British materials provided convincing evidence that the American form cannot be referred to *Homoceratoides*. Gordon's type is probably specifically distinct from *C. miseri* and probably was obtained from beds of Hale rather than Bloyd age. The Bloyd localities known to me have furnished only two specimens, those described by McCaleb. Gordon's species, therefore, should be referred to *Cymoceras cracens* (Gordon).

McCaleb (1964, p. 234) described a goniatite from Cane Hill deposits as *Retites semiretia*, which he suggested as a possible ancestor for *Branneroceras*. This animal, unlike most *Branneroceras*, has a sharply angular umbilical shoulder and retains a *Reticuloceras*-like suture. It differs from the latter in that the lobes and saddles are narrower, which may be more a reflection of the globose or "flattened" conch as opposed to the subdiscoidal configuration of the shell of *Reticuloceras*. In specimens of similar width the distance from venter to umbilical shoulder in *Retites* is four-fifths that of *Reticuloceras wainwrighti*. *Retites* most resembles *Branneroceras* in its ornamentation. Both forms possess strong umbilical ribs which bifurcate on the flank of the shell. Almost simultaneously one of the transverse lirae, thus formed, bifurcates again to form three equally pronounced lirae. These triplets are interspersed by intercalated single lirae which end in the valleys between adjacent pairs of ribs. In the larger more mature specimens of *Branneroceras* additional ribs fill in between triplets by further bifurcation and intercalation. Also *Branneroceras* in very late stage (Union Valley, Oklahoma) may have developed the angular umbilical shoulder. It may well be that *Branneroceras* is closely related to *Retites* in having a common ancestry. McCaleb (1964, p. 233, 236) reported that *Retites* occurs in both the Cane Hill and Prairie Grove Members of the Hale Formation. In so far as can be determined, we have not encountered *Retites, Branneroceras,* or *Reticuloceras* in any of several Prairie Grove assemblages. In the Prairie Grove is a primitive *Gastrioceras* which may be mistaken for one of these at small size or where preservation is imperfect.

Acknowledgments.—The opportunity to examine materials of *Reticuloceras* in England was provided by an off-campus duty assignment granted to me in 1963 by the Administration of the University

of Arkansas. The Research Committee of the University kindly provided funds for the binocular microscope and camera lucida used in preparing the suture drawing by W. Bruce Saunders, graduate student at the University of Arkansas. The photographs of *Reticuloceras davisi* were generously provided by M. K. Howarth, curator of paleontology, British Museum (Natural History). I am also indebted to Dr. Howarth for making the collections of the museum available to me, and for disassembling the type of *Homoceratoides* along an old, mended break, enabling a view of the earlier whorls.

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New Theses Added to O. U. Geology Library

The following Master of Science theses were added to The University of Oklahoma Geology Library in November 1965.

Areal geology of southern Dewey County, Oklahoma, by Wayland B. Alexander.

Morrowan sandstones in the subsurface of the Hough area, Texas County, Oklahoma, by Eric Arro.

Paleodepositional environments of the "Cherokee" sands of central Payne County, Oklahoma, by John Mason Clayton.

Areal geology of western Choctaw County, Oklahoma, by Edwin L. Jeffries.

Ostracoda of the Pecan Gap (Cretaceous) Formation of northeastern Texas, by O. D. Presley.

—L. F.

"Petrographic" Unconformities in the Ordovician of Northern Arkansas*

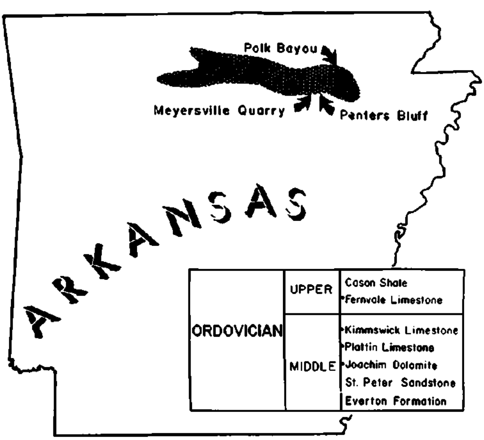
Tom Freeman†

INTRODUCTION

Although the Joachim, Plattin, Kimmswick, and Fernvale Formations (text-fig. 1) have been presented on several maps and discussed in numerous papers and although they are well exposed (pl. I, fig. 1), details of their stratigraphic relationships in Arkansas are not well established. Ulrich, whose conclusions were based upon faunal studies, suggested (*in* Miser, 1922) that unconformities separate each of these four formations one from the other, but physical evidence for these "breaks" has for the most part escaped the attention of field geologists. Miser (1922) reported their contacts as being "even," McKnight (1935) reported only one locality where physical evidence for an unconformity within the Joachim-Fernvale interval could be seen, and Frezon and Glick (1959) reported that unconformities separate each of these formations, but offered only their "very irregular distribution" as evidence.

The purpose of this paper is to document, upon physical bases, the stratigraphic relationships among these four formations.

*Publication authorized by the director, Arkansas Geological Commission.
†University of Missouri, Columbia.



Text-figure 1. Map showing outcrop of Middle and Upper Ordovician in northern Arkansas and reference localities. Asterisks mark formations of this report.

JOACHIM-PLATTIN CONTACT

The Joachim Dolomite is abundantly dolomitic, whereas the Plattin Limestone is only locally dolomitic. Aside from this, however, the two formations are similar. They have similar bedding characteristics, both are replete with mud cracks, and both have laminated beds suggestive of algal mat activity. Field geologists have little or no trouble in picking the boundary between them, but evidence of erosion has gone unnoticed.

In the course of this study features reflecting erosion were found at several places, two of which are shown on plate I, figures 2 and 3. At Penters Bluff (pl. I, fig. 2) beds in the basal 4 feet of the Plattin abut and onlap the top of the Joachim. On the west side of Polk Bayou (pl. I, fig. 3) beds in the basal 1 foot of the Plattin abut and onlap the top of the Joachim. In both cases compaction of basal Plattin beds (presumably soft-sediment type) has produced drape over the Joachim highs.

Generally speaking, channeling at a contact can be explained in terms of submarine erosion (if one is of that persuasion). But local highs are more significant; they indicate widespread removal of beds.

Explanation of Plate I

Penters Bluff and Joachim-Plattin Contact

Figure 1. Penters Bluff along White River affording excellent exposure of Ordovican rocks.

Figure 2. Joachim-Plattin contact at Penters Bluff, sec. 9, T. 14 N., R. 8 W., Izard County, Arkansas. The ink line indicates the contact.

Figure 3. Joachim-Plattin contact on west side of Polk Bayou, sec. 18, T. 14 N., R. 6 W., Independence County, Arkansas. The hammer handle rests on top of the Joachim.

Plate I

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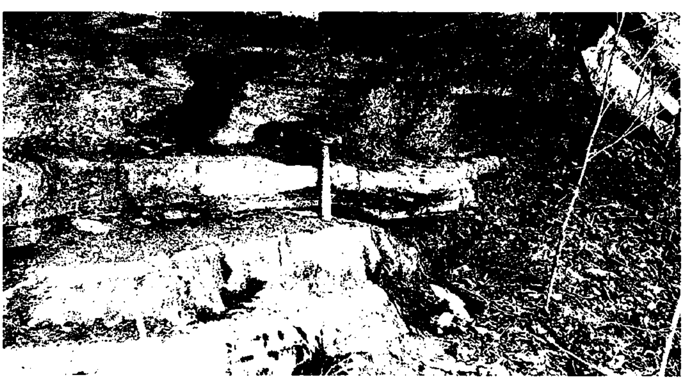

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PLATTIN-KIMMSWICK CONTACT

The Plattin-Kimmswick boundary is a "bedding-plane contact" (pl. II, fig. 1), and nowhere within the limits of an exposure have I found bedding discontinuities. This contact is generally welded, however, and petrographic relationships do indicate pre-Kimmswick erosion of the Plattin. In plate II, figure 2, Plattin fossils are clearly truncated at the contact. If scour of these fossils had occurred in soft sediment, surely the shells would have been brought into relief. The fact that they have not suggests that the matrix was as hard (lithified) as the shell material. Consistent with the idea of pre-Kimmswick erosion is a micro-trash zone just above the Plattin (pl. II, fig. 3).

Explanation of Plate II

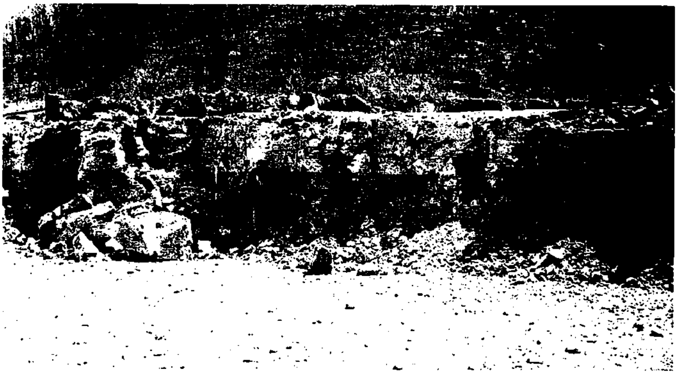
Plattin-Kimmswick Contact

Figure 1. Plattin-Kimmswick contact in the Meyersville quarry, sec. 5, T. 14 N., R. 8 W., Izard County, Arkansas. The geologist has his hand on the contact.

Figure 2. Negative print of an acetate peel across Plattin-Kimmswick contact, x10.5. Arrows mark truncated fossils.

Figure 3. Negative print of an acetate peel across Plattin-Kimmswick contact showing reworked Plattin, x3.2.

Plate II



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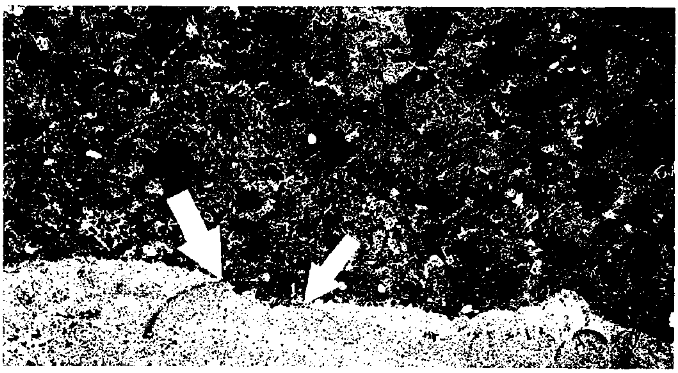

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KIMMSWICK-FERNVALE CONTACT

Like that of the Plattin-Kimmswick, the Kimmswick-Fernvale boundary is also a "bedding-plane contact" (pl. III, fig. 1), and, within the limits of an exposure, bedding discontinuities do not occur. Unlike that of the Plattin-Kimmswick, however, the Kimmswick-Fernvale contact is welded at few places, and only after considerable searching did I find a place where the contact could be "collected," sawed, and examined microscopically. Plate III, figure 2, shows a Fernvale coral encrusting the lip of a Kimmswick burrow. The dark color (light in the negative print) lining the burrow is attributed to organic material. This burrow, which was deep within the Kimmswick before pre-Fernvale erosion, was filled with sparry calcite cement, most of which was removed by solution before Fernvale deposition. A remnant of cement remains under that part of the coral within the burrow. Other "detached" corals occur within the Fernvale along with crinoids and trilobites.

Plate III, figure 3, shows another burrow in the top of the Kimmswick. The fact that the lip of the burrow stands in relief suggests that the organic material reinforced the limestone. Sparry calcite cement still fills one-half of the burrow and supports Fernvale detritus. My interpretation is that (1) the Kimmswick was cemented before Fernvale deposition and (2) some amount of Kimmswick was eroded before Fernvale deposition.

Explanation of Plate III

Kimmswick-Fernvale Contact

Figure 1. Kimmswick-Fernvale contact in the Meyersville quarry, sec. 5, T. 14 N., R. 8 W., Izard County, Arkansas. The arrow marks the contact.

Figure 2. Negative print of an acetate peel across the Kimmswick-Fernvale contact showing coral encrusted on Kimmswick, x3.2.

Figure 3. Negative print of an acetate peel across the Kimmswick-Fernvale contact, x3.2. At the right is a burrow one-half filled with spar cement that supports Fernvale detritus.

Plate III

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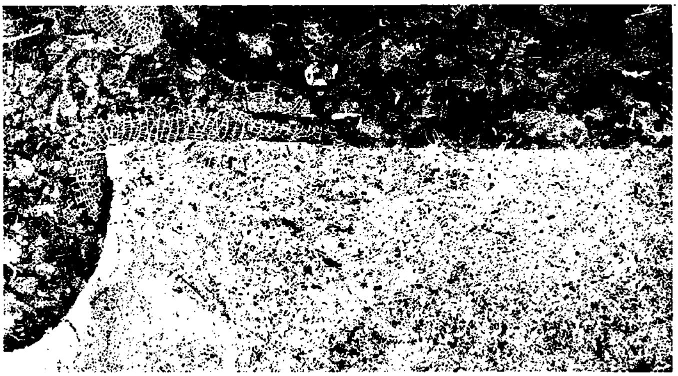

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CONCLUSION

"Breaks" that could have been classified as paraconformities now qualify as unconformities. Although I have illustrated only a few selected samples, I am confident that these relationships characterize the Joachim-Fernvale interval throughout the belt of outcrop in northern Arkansas. The small dimensions of structures reported here should not be taken as a measure of their importance.

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Permian Vertebrates of Oklahoma

The most recent in a series of studies on the Permian vertebrates of Oklahoma was issued by the Oklahoma Geological Survey in December 1965. The report, Bulletin 70, *New Permian Vertebrates from the Chickasha Formation in Oklahoma,* by Everett C. Olson, describes a diverse fauna comprising fishes, amphibians, and reptiles collected from sites in Blaine, Kingfisher, Canadian, Grady, and McClain Counties. It consists of 70 pages, 5 figures, and 8 plates. The price is $2.00 clothbound, $1.25 paperbound.

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